DRAFT

MONITORING PLAN
FOR THE
STA-1E CELLS 1-2 PSTA/SAV
FIELD-SCALE DEMONSTRATION PROJECT

PALM BEACH COUNTY, FLORIDA

Prepared for

US Army Corps of Engineers®

JACKSONVILLE DISTRICT

CONTRACT NO. DACA-21-02-D-0004
DELIVERY ORDER CS03

OCTOBER 2005

CONTENTS

FIGURES

TABLES

ACRONYMS

CFS	cubic feet per second
DMSTA	Dynamic Model for Stormwater Treatment Areas
DQO	data quality objective
FCRTF	Flying Cow Road Test Facility
GPS	global positioning System
HLR	hydraulic loading rate
HRT	hydraulic residence time
LNWR	Loxahatchee National Wildlife Refuge
NA	not applicable
PAR	photosynthetically active radiation
POR	Period of Record
PPB	parts per billion
PSTA	periphyton stormwater treatment area
SAV	submerged aquatic vegetation
SFWMD	South Florida Water Management District
STA	stormwater treatment area
STA-1E	Stormwater Treatment Area 1-East
STADG	Stormwater Treatment Area Design Group
TP	total phosphorus
USACE	U.S. Army Corps of Engineers
WCA	Water Conservation Area

1 PROJECT DESCRIPTION AND LOCATION

The C-51/STA-1E Project is part of the Everglades Construction Project to treat urban/agricultural drainage and to provide additional water to the Everglades. As a macrophyte stormwater treatment area (STA), represented in **Figure 1.1**, its purpose is to treat the water so that total phosphorus in the discharge waters is 50 parts per billion (ppb) or less. Natural levels of total phosphorus (TP) within the waters of the Everglades are generally below 10 ppb. Traditional wetlands-based STA technologies cannot reduce phosphorus concentrations to these natural levels. Thus, the C-51/STA-1E Project is designed to demonstrate an innovative treatment technology at a field-scale to improve the water quality by reducing the total phosphorus concentrations in the discharge to levels approaching 10 ppb so that it may be diverted to Water Conservation Area (WCA) 1 in the Loxahatchee National Wildlife Refuge (LNWR), located in Palm Beach County, Florida.

The U.S. Army Corps of Engineers (USACE), Jacksonville District, has been pilot testing a biotechnology known as periphyton stormwater treatment area (PSTA) to achieve a greater reduction in phosphorus. These tests have successfully demonstrated the ability of PSTA to produce effluent water TP concentrations at or below 10 ppb.

Due to the success of the pilot testing, the USACE Jacksonville District is planning to conduct a field demonstration of the PSTA technology within the existing footprint of STA-1E in what is known as Cell 2. Demonstration cells will evaluate three different alternatives for the development of PSTA. The field demonstration, expected to be conducted over a 24-month operation period, will be used to determine the optimum design parameters, operational parameters, and recommendations for full-scale implementation of PSTA for STA-1E.

The conceptual treatment train for the field-scale demonstration of PSTA in STA-1E (Cells 1 and 2) will use floating aquatic vegetation (FAV) in the Eastern Distribution Cell (EDC), emergent aquatic vegetation (EAV) in Cell 1, and a submerged aquatic vegetation (SAV) area and cyanobacteria-dominated periphyton cells in Cell 2, as represented in **Figure 1.2**. A flow diagram showing the FAV in the EDC and the EAV/SAV/PSTA treatment train in Cells 1 and 2 is shown in **Figure 1.3**.

The overall project objective is to obtain TP removal to 10 ppb or less at the outflow of the PSTA cells in Cell 2. The objective of the demonstration cells is to demonstrate and evaluate three different substrates for the development of PSTA. The objective for monitoring of the PSTA Demonstration Cells is to establish their phosphorus removal performance and capabilities under various hydrological conditions, phosphorus loading rates, and seasonal/climatic conditions encountered during the demonstration.

Schematic of STA-1 East (Not to Scale)

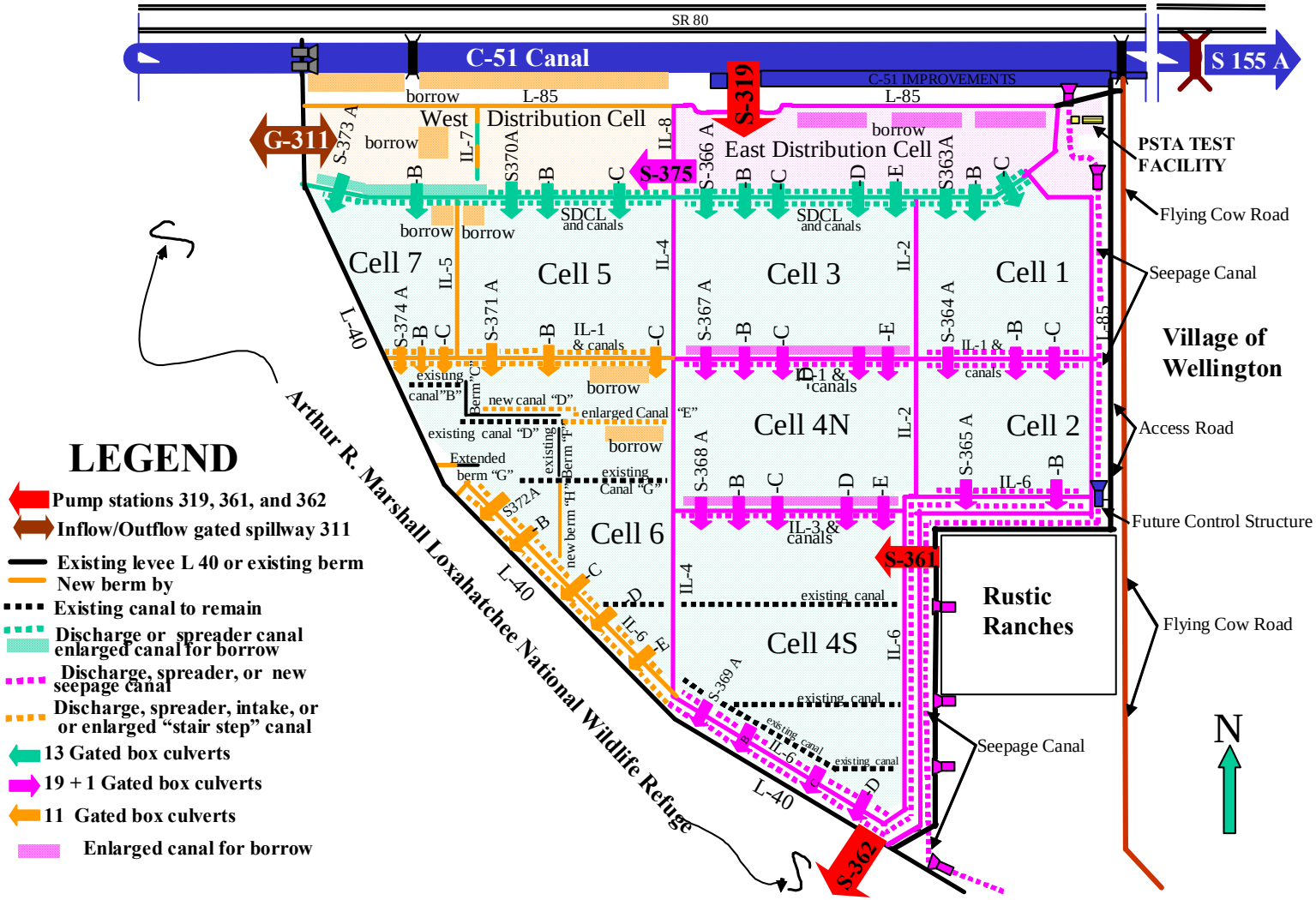

Figure 1.1. STA-1E Schematic Layout (USACE)

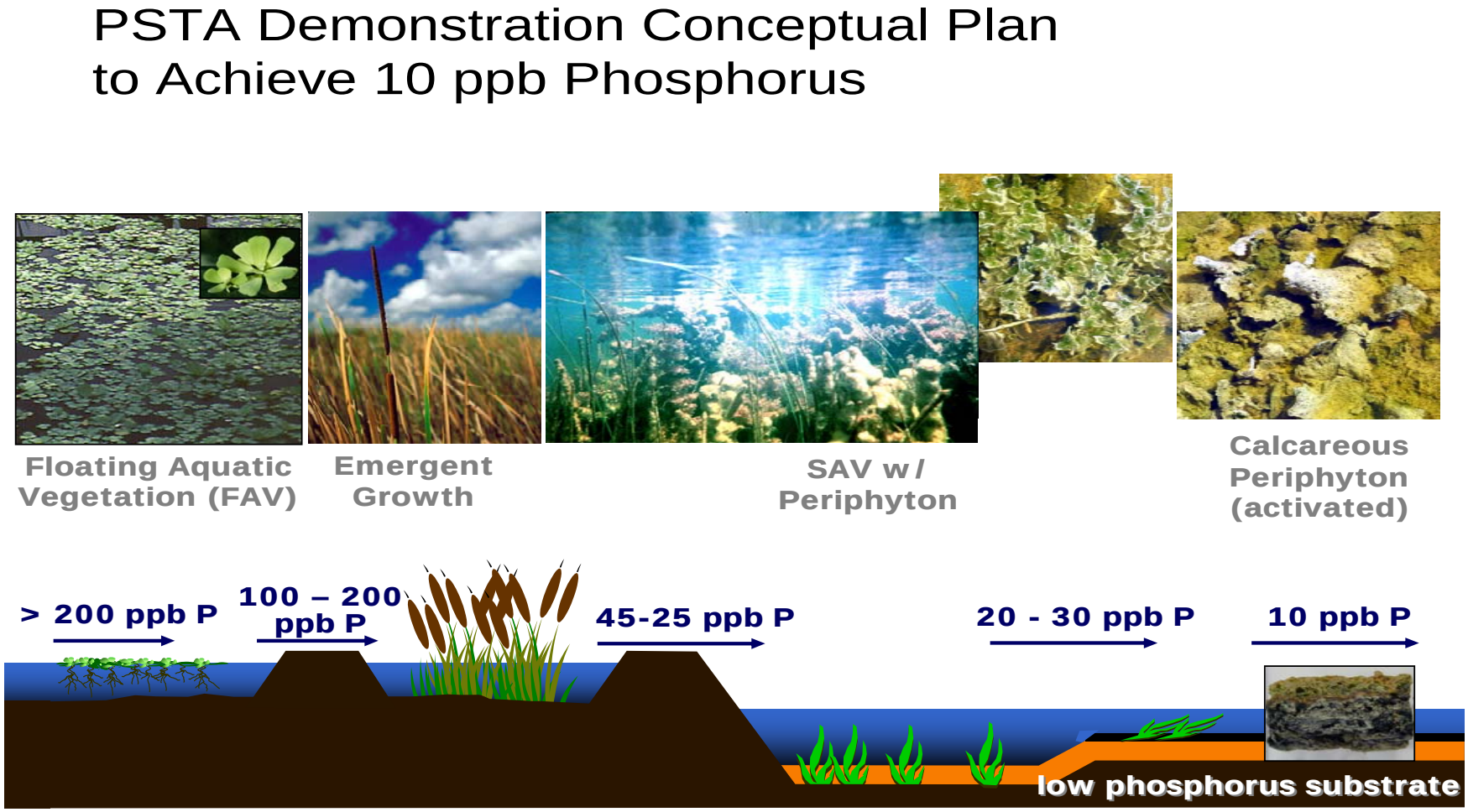

Figure 1.2 STA-1E Conceptual Treatment Train (USACE 2005)

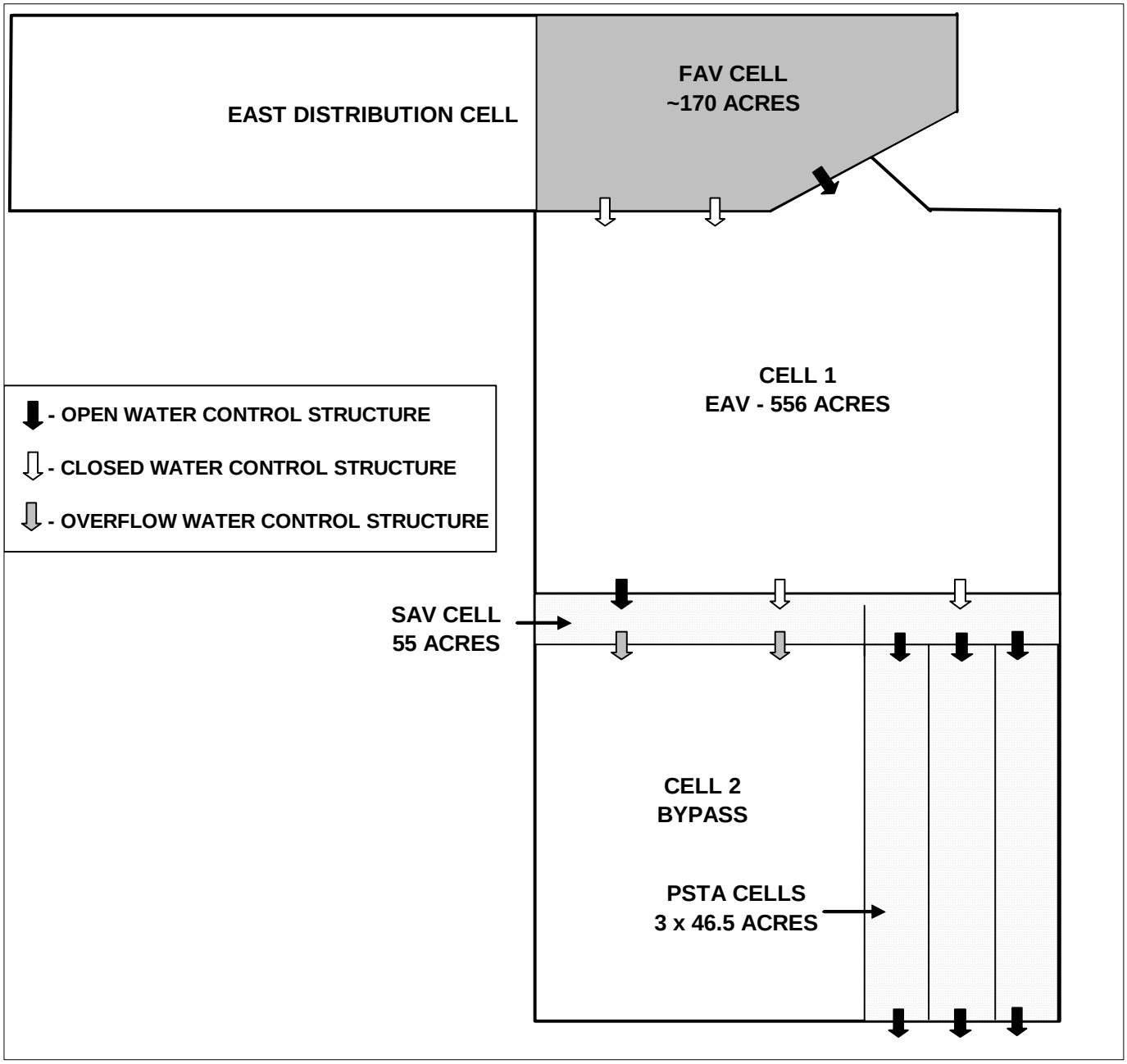

Figure 1.3 Flow Diagram for the STA-1E PSTA/SAV Field Scale Demonstration Project

2 TREATMENT TRAIN OVERVIEW

Sustainable PSTA operations to achieve a long-term 10 ppb TP outflow concentration require inflow water concentrations equal to or less than 50 ppb. Since the inflow concentrations into STA-1E from the C-51 Canal range from 100 to 200 ppb (with even higher spikes), water treatment prior to PSTA cells' inflow is required. No distinct element of the EDC - Cell 1-2 treatment train can provide enough treatment to lower the phosphorous concentrations to 50 ppb TP or below. However, modeling conducted using the Dynamic Model for Stormwater Treatment Areas (DMSTA) has shown that a multi-tiered treatment train consisting of FAV in the Eastern EDC, EAV in Cell 1, and SAV in Cell 2 will accomplish this objective. The treatment train and the associated DMSTA FAV/EAV/SAV modeling results are shown in **Figures 1.3 and 2.1**, respectively. The DMSTA modeling approach and detailed results are presented in the September 2005 Design Analysis Report (**SAIC 2005**).

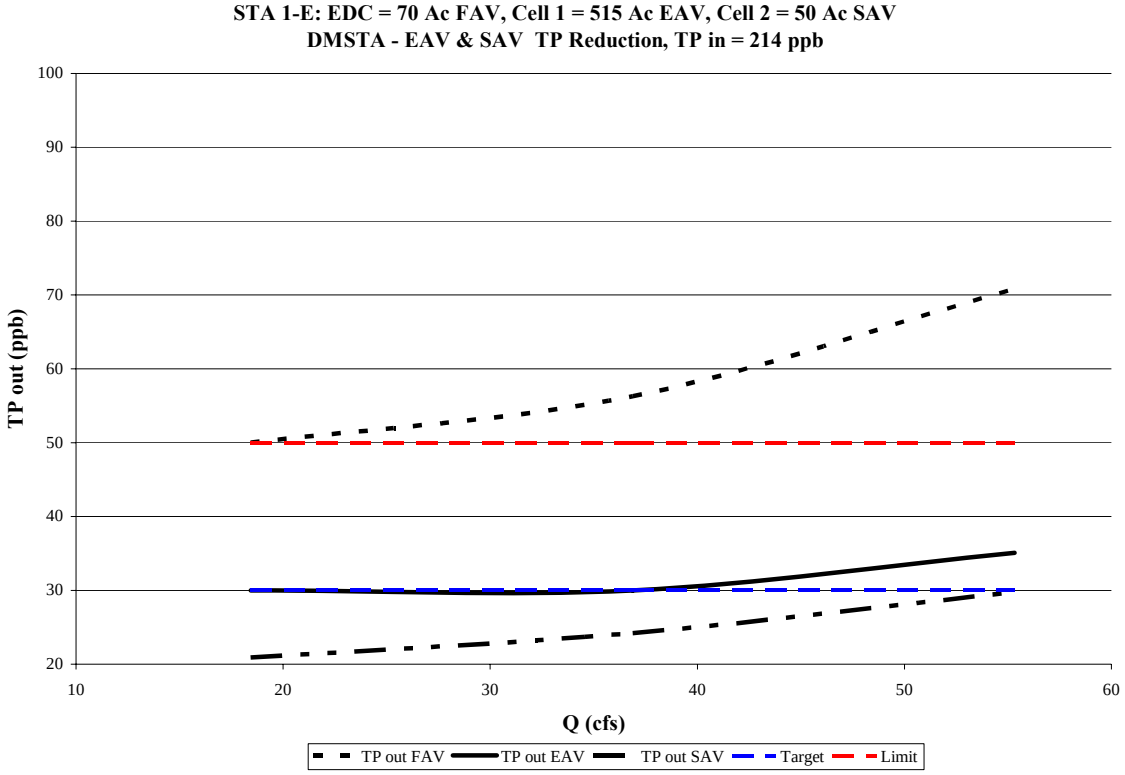

Figure 2.1. Phosphorus Removal in FAV, EAV and SAV Prior to PSTA Cells

2.1 Treatment Train Composition

At the head of the treatment train, in the eastern part of the EDC is, a yet to be built, approximately 170 Ac FAV Cell, supplied with water from the C-51 Canal and covered with *Pistia stratoites* (water lettuce). The FAV cell is expected to treat water from the 100 ppb to 200 ppb TP range to about 70 ppb TP. Following the FAV, there is the already completed and inundated Cell 1 with EAV. Cell 1 is expected to discharge at about 50 ppb TP into a yet to be constructed SAV cell in Cell 2. The SAV cell is designed to deliver flow in the eastern direction toward the inflow points of the three PSTA cells at about 30 ppb TP, which are to discharge to the Cell 2 collection channel and then ultimately discharged from the STA through the S-365B.

2.2 Treatment Train Elements

EDC FAV Cell
The purpose of the FAV Cell is to provide initial treatment of the C-51 Canal source water prior to entering the EAV cell.

Cell 1 EAV
Cell 1 is 556-acre treatment cell that is the second step in the PSTA treatment train designated for EAV growth.

Cell 2 SAV Cell
The SAV Cell is a 55-acre treatment cell located along the northern extreme of Cell 2.

PSTA Cells
The PSTA Cells are the final step within this treatment train and consist of three 46.5-acre cells comprising a total area of 139.5 acres.

Cell 2 Bypass
The Cell 2 Bypass is 364 acres located on the western side of Cell 2 and is used for both passing water through the cell and minimizing the head difference between the PSTA Cells and the remainder of Cell 2.

3 MONITORING PURPOSE AND GOALS

The overall purpose for monitoring of the PSTA Demonstration Cells will be to establish their phosphorus removal performance and capabilities under various hydrological conditions, phosphorus loading rates, and seasonal/climatic conditions encountered during the demonstration and, to the greatest extent practical, the conditions during the period of record (POR) (see SAIC Operations Plan, September 2005).

There are four specific monitoring goals for the PSTA demonstration in STA-1E Cell 2. These are:

1. To track, capture, and describe the hydrologic, physiochemical, chemical and biological parameters associated with the PSTA operating conditions (including periphyton mat development, activation, and succession) required to achieve Total Phosphorus discharge concentrations of 10 ppb or better.
2. To describe the hydrologic, physiochemical, chemical and biological parameters associated with the PSTA performance and response to the substrate type.
3. To capture PSTA response and treatment effectiveness for scale up design and for PSTA concentration-based model development.
4. To provide data for mass balance calculations.

The purpose for monitoring of the PSTA pretreatment train is to guide its operations to provide water for the PSTA cells with total phosphorus (TP) concentration of 30 to 50 ppb, and document the conditions associated with TP concentration in excess of 30 ppb.

These goals form the basis for the Data Quality Objectives (DQOs).

The purpose of the Monitoring Plan is to describe the principal monitoring activities required to achieve these goals and provide information required for regulatory permitting and receiving water body needs, such as the Loxahatchee National Wildlife Refuge (LNWR).

3.1 Data Quality Objectives

3.1.1 PSTA Cells

The monitoring data collected will be used to fulfill the monitoring goals described above. In order to do that the data will need to be gathered and used as described in Table 3.1.

Table 3.1 PSTA Cells' Data Quality Objectives

PARAMETER	DATA QUALITY OBJECTIVE	ACTIVITY TO MEET OBJECTIVE	EXPECTED RANGE	DATA USE
Total Phosphorus (PSTA inflow)	Determine the concentration of phosphorus entering the demonstration cells from SAV Cell.	Analyze samples gathered by autosampler located at the input to PSTA test Cells.	10-100 µg/L	Data will be used in conjunction with other data sources to determine the mass balance of phosphorus within the system and the efficiency of the three different substrates.
Total Nitrogen (PSTA inflow)	Determine the concentration of nitrogen entering the test cells from SAV Cell.	Analyze samples gathered by autosampler located at the input to PSTA test Cells.	50-2000 µg/L	Data will be used in conjunction with other data sources to determine the mass balance of nitrogen within the system and the efficiency of the three different substrates.
Total Phosphorus (PSTA - C*/equilibrium concentration(s))	Determine the equilibrium concentration for total phosphorus within each test cell (C*).	Analyze samples gathered from equilibrium enclosures within each PSTA test cell after the water within the enclosure has reached lowest achievable phosphorus concentration.	0-20 µg/L	Value will be used for the development of new PSTA model and as an input to existing STA models.
Total Phosphorus (PSTA effluent)	Determine the concentration of phosphorus exiting each test cell.	Analyze samples gathered by autosampler located at the output of each PSTA test Cell.	0-20 µg/L	Data will be used in conjunction with other data sources to determine the mass balance of phosphorus within the system and the efficiency of the three different substrates.
Mercury (PSTA inflow, effluent, and soil)	Determine the potential for mercury methylation during PSTA operation.	Monitor influent and effluent mercury species.	2-50 ng/l 20-500 ng/gm	Assessment of the potential concentration of methyl mercury leaving STA 1-E.

PARAMETER	DATA QUALITY OBJECTIVE	ACTIVITY TO MEET OBJECTIVE	EXPECTED RANGE	DATA USE
Total Nitrogen (PSTA effluent)	Determine the concentration of nitrogen exiting each test cell.	Analyze samples gathered by autosampler located at the output of each PSTA test cell.	50-2000 µg/L	Data will be used in conjunction with other data sources to determine the mass balance of nitrogen within the system and the efficiency of the three different substrates.
Total Phosphorus (transects)	Determine the total area of the PSTA cells required to achieve phosphorus reduction to levels sufficient to satisfy the Settlement Agreement.	Analyze grab samples gathered along transects on the centerline of each PSTA test cells at intervals of ~100 feet.	0-100 µg/L	Data will be used to develop a model that will guide operations and sizing of full-scale implementation at STA 1-E.
pH	Account for changes in phosphorus removal due to precipitation and other interactions with calcium carbonate within the substrate.	Gather pH data at locations along each test cell.	6-12 SU	Data will be used to isolate this reaction from those that are a result of other factors.
Alkalinity	Account for changes in phosphorus removal due to precipitation and other interactions with calcium carbonate within the substrate.	Gather alkalinity data at locations along each PSTA test cell.	40 – 400 mg/L	Data will be used to isolate this reaction from those that are a result of other factors.
Dissolved Calcium	Determine the change in calcium concentrations within the treated water due to interactions with the substrate and periphyton mats.	Test water gathered at input and output of each PSTA test cell	0.2-300 mg/L	Data will be used to determine the impact of the different substrates and HRTs on any change in calcium concentrations due to the PSTA cells.
Dissolved Oxygen	Determine Primary Productivity of periphyton mats.	Meter dissolved oxygen along the length of the cell for 24 48 hour periods.	1 - 9 mg/L	In conjunction with other parameters this data will be used to determine the productivity of each of the periphyton cells.

PARAMETER	DATA QUALITY OBJECTIVE	ACTIVITY TO MEET OBJECTIVE	EXPECTED RANGE	DATA USE
Total Phosphorus (substrate)	Determine changes in phosphorus levels within test cell substrates	Analyze substrate samples prior to and during PSTA Test cell operations for changes in phosphorus concentrations.	10 –2500 mg/kg	In conjunction with other parameters the data will be used to determine the fate of phosphorus within the system.
Total Phosphorus (periphyton mat)	Determine changes in phosphorus levels within periphyton mats.	Analyze periphyton mats during cell operations for changes in phosphorus concentrations.	100-3500 mg/kg	In conjunction with other parameters the data will be used to determine the fate of phosphorus within the system.
Rainfall	Determine rainfall occurring at STA 1-E.	Continue to log precipitation data at Flying Cow Road Test Facility.	0-20 in/day	Data will be used in conjunction with other data sources to determine the water budget of the system.
Evaporation	Determine evaporation occurring at STA 1-E.	Monitor evaporation occurring at STA 1-E.	0.25-7 in/day	Data will be used in conjunction with other data sources to determine the water budget of the system.
Photosynthetically Active Radiation	Determine amount of solar radiation reaching STA 1-E.	Continue to log solar radiation data at FCRTF.	NA	Data will be used to account for the level of productivity within the cells.
Periphyton Mat Analysis	Determine the species composition, biovolumes and community structure of the periphyton mat.	Microscopic evaluation of the periphyton mat.	NA	Data will be used to evaluate the substrates, determine if indicator species are present and to predict TP removal efficiencies based on organismal characteristics.
Ground survey of EAV and SAV	Determine the natural colonization of EAV and SAV species in the PSTA cells	Quarterly ground surveys to determine EAV and SAV species and distribution	NA	Data will be used to determine if the presence of EAV and SAV contribute to the performance of PSTA. In addition this data will be used to develop a vegetation management plan for the PSTA cells.

3.1.2 Pretreatment Train

Table 3.2 Pretreatment Train Data Quality Objectives

PARAMETER	DATA QUALITY OBJECTIVE	ACTIVITY TO MEET OBJECTIVE	EXPECTED RANGE	DATA USE
Total Phosphorus (C-51/FAV inflow)	Determine phosphorus concentrations of treatment train source water (C-51 canal)	Analyze samples gathered by autosampler located at the input to FAV cell.	100-300 ppb	Determine the effectiveness of FAV cell to remove phosphorus at high concentrations within STA-1E
Total Phosphorus (FAV effluent)	Determine phosphorus concentrations at FAV cell output	Sample at output of FAV Cell	70-200 ppb	Determine the effectiveness of FAV cell to remove phosphorus at high concentrations within STA-1E and compare with design expectations.
Photographic documentation of FAV	Species composition and aerial distribution	Photograph and note species distribution	80% or greater coverage by *Pistia stratoites*	Verify coverage and presence of desired species (*Pistia*)
Total Phosphorus (EAV effluent)	Determine phosphorus concentrations at EAV cell output	Sample at output of EAV Cell		Track the effectiveness of EAV cell in removing phosphorus and compare with design expectations
Photographic documentation of EAV	Species composition and aerial distribution	Photograph and note species distribution	NA	Track functionality and P removal performance of the treatment cell
SAV Composition/Coverage	Determine SAV coverage to +/- 5% and species over 10%	Quarterly field surveys	NA	Determine the need for management actions within SAV Cell.

3.2 Marsh Readiness

In the context of the Everglades Restoration, the term "Marsh Readiness" refers to the chemical composition of the solutes and particulates matter in the water discharged into the Everglades Protection Area. Water that causes no imbalance of flora and fauna is considered to be marsh ready. This concept was developed due to concerns with chemical treatment being used as an advanced treatment technology. Since PSTA and the upstream treatments (FAV, EAV, and SAV) are all constructed marshes there is no need to perform Marsh Readiness analysis. However, since concern has been expressed with respect to the concentration of Calcium, Magnesium and Alkalinity of the water entering the LNWR from PSTA, therefore, the monitoring of these parameters has been included in this monitoring plan.

3.3 Transect Studies for Model Development

In addition to the monitoring necessary to evaluate the performance of PSTA under different operating conditions, it will be necessary to collect an additional data set for TP, TN, Alkaline Phosphatase, and physical parameters at a greater frequency for the development of a concentration based model. This data set will be analyzed using different techniques that allow more rapid processing and greater sensitivity. For example for TP a MDL of less than 0.5 ppb will be required.

Along with the above parameters, a conservative tracer study will be necessary to track the movement of a non-reactive solute to compare with TP.

Transect data collected for performance, operation, and design will also be used for the modeling effort. These parameters and their measuring frequency are detailed in Sections 6 of this document.

4 INSTRUMENTATION

This section describes the major instrumentation needed during the monitoring of the PSTA Cells and the pretreatment system.

The major instrumentation needed to accomplish the goals of this monitoring plan is listed in Table 4.1.

Table 4.1 Monitoring Instrumentation

Instrument	Quantity
Automatic Water Sampler	12 (+2 spares)
Multi-Parameter Submersible, Data-Logging Meters	12 (+2 spares)
Stage Recorders	11
Staff Gauges	12
Submersible PAR sensor	2
Flow Meters (Doppler)	3
Flow Meters (Mechanical)	3
Submersible Turbidity Meter	2

Automatic Water Sampler – ISCO 6712 Full Size Portable Sampler or equivalent autosampler. These samplers will require two different configurations 1) nine of the samplers should be equipped to handle 24-bottles and 2) three of the samplers should be configured for 2/4-bottles. Additionally, these samplers will require a supply of the appropriately sized (1000 ml and 2 gallon) LDPE sampling bags.

Multi-Parameter Submersible Meters – YSI 6600 EDS or equivalent data logging multi-parameter meters. The meters should be equipped to monitor the following parameters: dissolved oxygen, pH, temperature, conductivity, turbidity, and oxidation-reduction potential.

Stage Recorders – Data-Logging and with resolution of 0.01 ft or better.

Staff Gauges – The height required for these staff gauges will depend on the portion of the treatment train where they are to be installed. A 6-foot staff gauge should be sufficient for all applications. The gauges should be graduated to a hundredth of a foot with elevations labeled every tenth of a foot.

Submersible PAR sensors – 2D with differential capabilities.

Flow Meters – 3D Doppler with data-logging capabilities and resolution to 0.01cm/s. Mechanical or thermal units with resolutions of 1.0 cm/sec.

Figures 4.1 and 5.1 show the field placement along the treatment train of the various instruments.

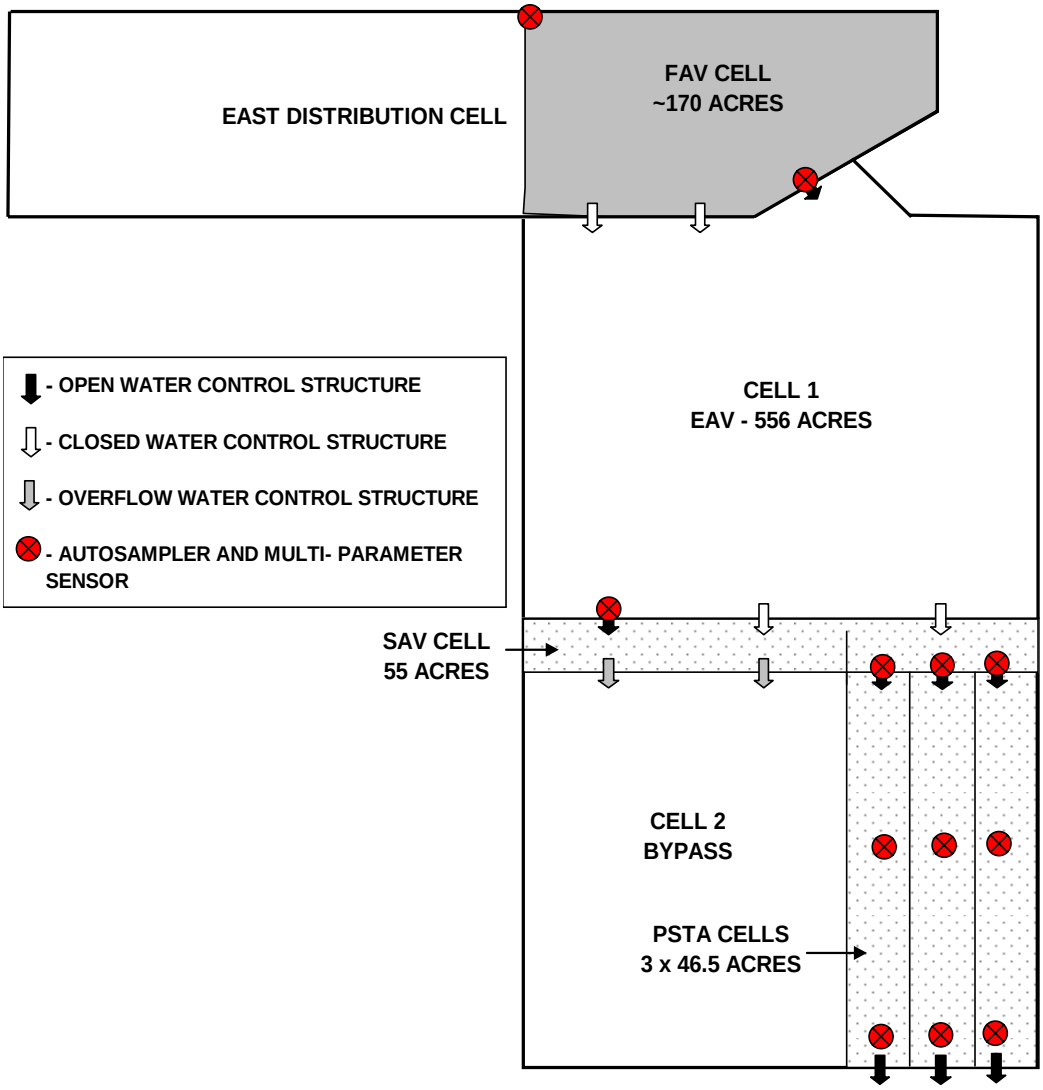

Figure 4.1 Fixed Monitoring Point Locations Along the Treatment Train

5 METEOROLOGICAL AND HYDROLOGICAL PARAMETERS

Various Meteorological and Hydrological data will need to be collected to track the PSTA Cells water budget. The water budget will be calculated as follows:

$$V_{\Delta} = V_i - V_o + V_r - V_e + V_b - V_s$$

where:

$\mathbf{V_{\Delta}}$ Change of water volume within PSTA cells
$\mathbf{V_b}$ Infiltration from Cell 2 bypass volume
$\mathbf{V_e}$ Evaporated volume
$\mathbf{V_i}$ Input volume
$\mathbf{V_o}$ Output volume
$\mathbf{V_r}$ Rainfall volume
$\mathbf{V_s}$ Seepage loss volume (levee and groundwater losses)

These parameters will need to be collected to track the PTSA Cells water budget.

5.1 Meteorological Parameters

Meteorological data is important in the development of the water balance of the PSTA cells and the pretreatment system. This section describes the available and required sources of meteorological data. A meteorological station is located at the FCRTF and provides continuous monitoring of all of the proposed parameters with the exception of evapotranspiration.

5.1.1 Rainfall

Rainfall data will be managed as inches/day. Rainfall stations near the demonstration site will be used to estimate rainfall at the PSTA cells and include:

- Flying Cow Road Test Facility
- S-5A
- G-300
- SFWMD West Palm Beach Field Station

5.1.2 Evapotranspiration

Evapotranspiration data from STA-1W will be used as a proxy for the values within the demonstration facility. This data will be managed in a similar nature to rainfall.

5.1.3 Photosynthetically Active Radiation

Photosynthetically active radiation (PAR) is a measure of light useful to plants during photosynthesis. This parameter will be measured in using two different methods. The first will be an onsite differential measurement of PAR. To accomplish this one sensor is placed at the surface of the water column and the second sensor is placed on the bottom of the water column and the difference as a percentage of surface PAR is recorded. This measurement will most realistically depict the light that reaches the periphyton mat accounting for losses due to reflection, refraction and absorption within the water column. The second PAR data set will be

collected from existing station at STA-1W and the FCRTF. PAR data will be managed as the daily average in micromoles/m2/s.

5.1.4 Wind

Wind speed and direction data from the FCRTF will be used during this project. This data along with observations of the periphyton mat in the demonstration cells and measurements of turbidity, total suspended solids, and TP will help in the understanding of wind induced turbulent mixing has on the performance of the periphyton community as well as the reflux of phosphorus and other nutrients into the surface water component.

5.2 Hydrologic Parameters

5.1.5 Water Depth

Figure 5.1 displays the locations of the 11 stage recorders to be installed as a part of this project. The stage recorders associated with each of the STA-1E structures within the treatment train will also be utilized. Stage recorders installed as part of this project will collect water surface elevation data every ten minutes. Depth will be calculated utilizing the surface water elevations provided by the stage recorders and the predetermined ground surface elevation. The impact of water depth extends beyond flow and seepage; the impacts of depth diminished light and other depth effects on the periphyton community will also be investigated.

5.2.2 Flow

The flow of water in and out of the PSTA cells is the only flow measurement relevant for monitoring. The flow of water through the cells will be calculated utilizing headwater and tailwater elevations data from the stage recorders and weir height settings within the in-line risers.

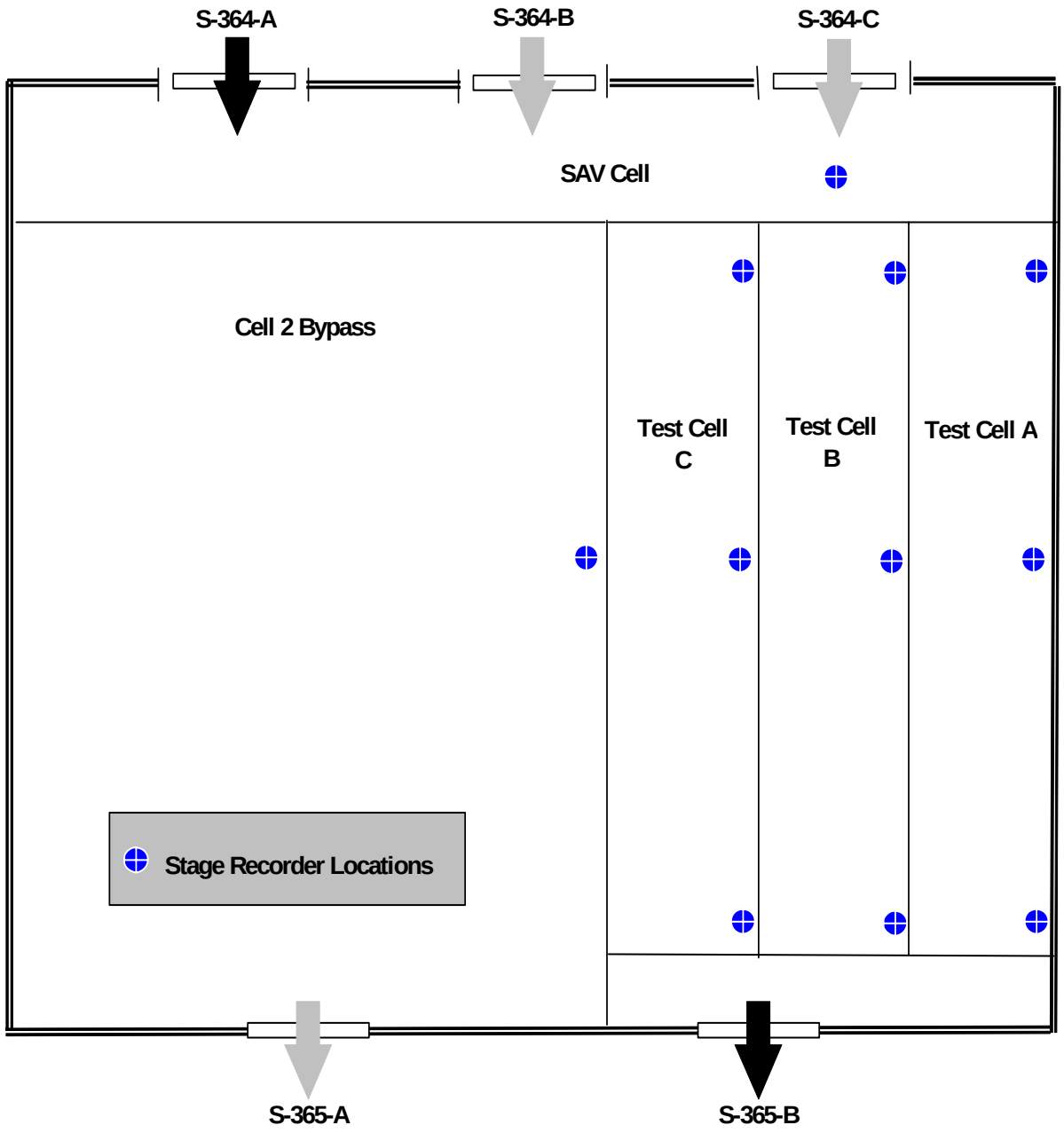

Figure 5.1 Locations of Project Stage Recorders

6 TREATMENT TRAIN MONITORING

6.1 Cell 2 – PSTA Monitoring

The objectives of monitoring of the PSTA cells within Cell 2 of STA 1-E include 1) understanding the impacts of different cell substrates on periphyton growth, emergent plant growth, and phosphorus removal performance at a relatively large-scale, 2) developing a total phosphorus mass balance for the demonstration cells, 3) forecast long-term impacts of phosphorus loading on this oligotrophic system, 4) determine flow, depth, mass loading, hydraulic loading, and other factors impact on sizing of full-scale PSTA systems.

6.1.1 Water Quality

The objectives of water quality monitoring are two-fold, 1) understanding the dynamics of phosphorus removal within the demonstration cells, 2) monitoring of other constituents at a lesser magnitude to quantify interactions impacting phosphorus removal and to answer questions regarding the make-up of the water discharged from a PSTA. Phosphorus dynamics within the demonstration cells will be elucidated through a tiered sampling approach that samples transect through the system (**Figures 6.1, 6.2, 6.3, 6.4**). The relationships will be incorporated into a multi-parametric concentration based model that will assist in PSTA sizing and operations. The grab sampling schematic in the Figures provides for a multi-tiered approach that can be adjusted to meet experimental needs. Tier I (**Figure 6.1**) is the lowest intensity sampling effort and is collocated with shallow groundwater wells, multi-parameter meters, automatic samplers and stage recorders. Tiers II, III and IV sampling locations will be identified by small flags and will be used to identify sites for surface water, substrate and periphyton mat sample collection. Higher number Tiers are inclusive of lower number Tiers. For an example, Tier IV stations include Tier I, II and III stations. Sampling stations not included on the center line will be used to determine if water flow through the levees is impacting water quality.

Table 6.1 lists project analytic parameters, preferred analytic methods, detection limits, precision, accuracy and the priority of the parameter if resource limitations arise.

Table 6.2 lists project field parameters, preferred field methods, precision, and accuracy.

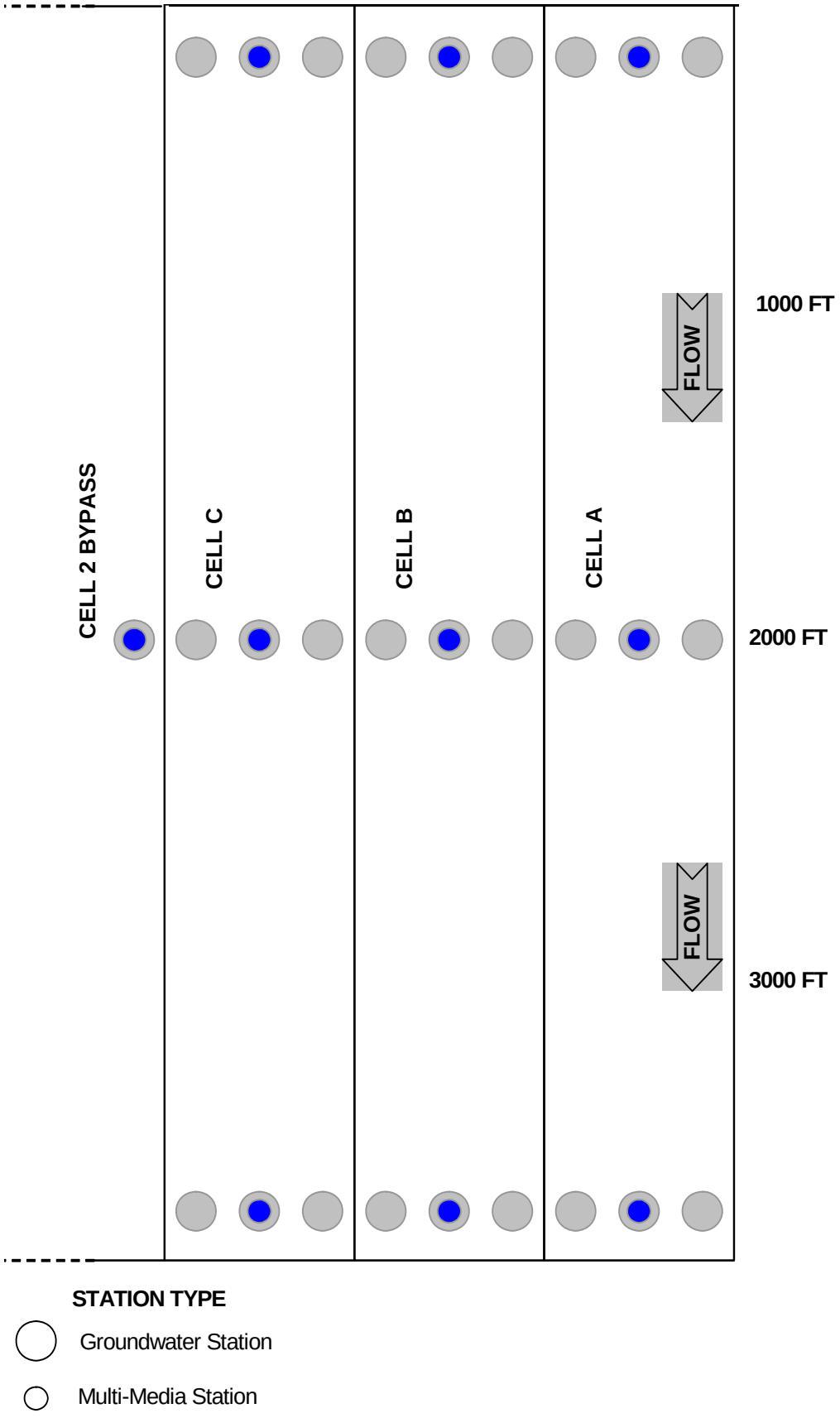

Figure 6.1 Tier I PSTA Cell Monitoring Sites

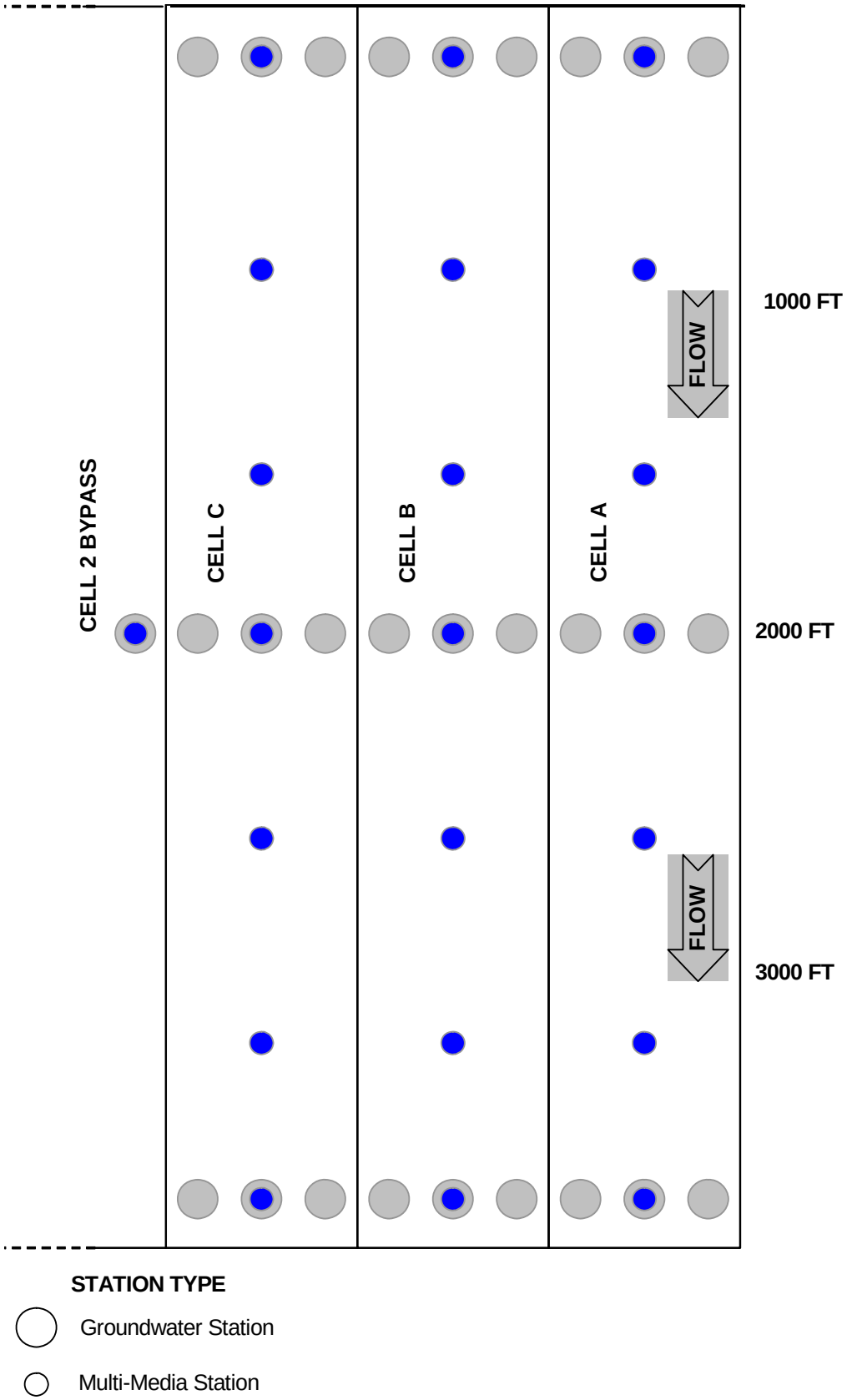

Figure 6.2 Tier II PSTA Cell Monitoring Sites

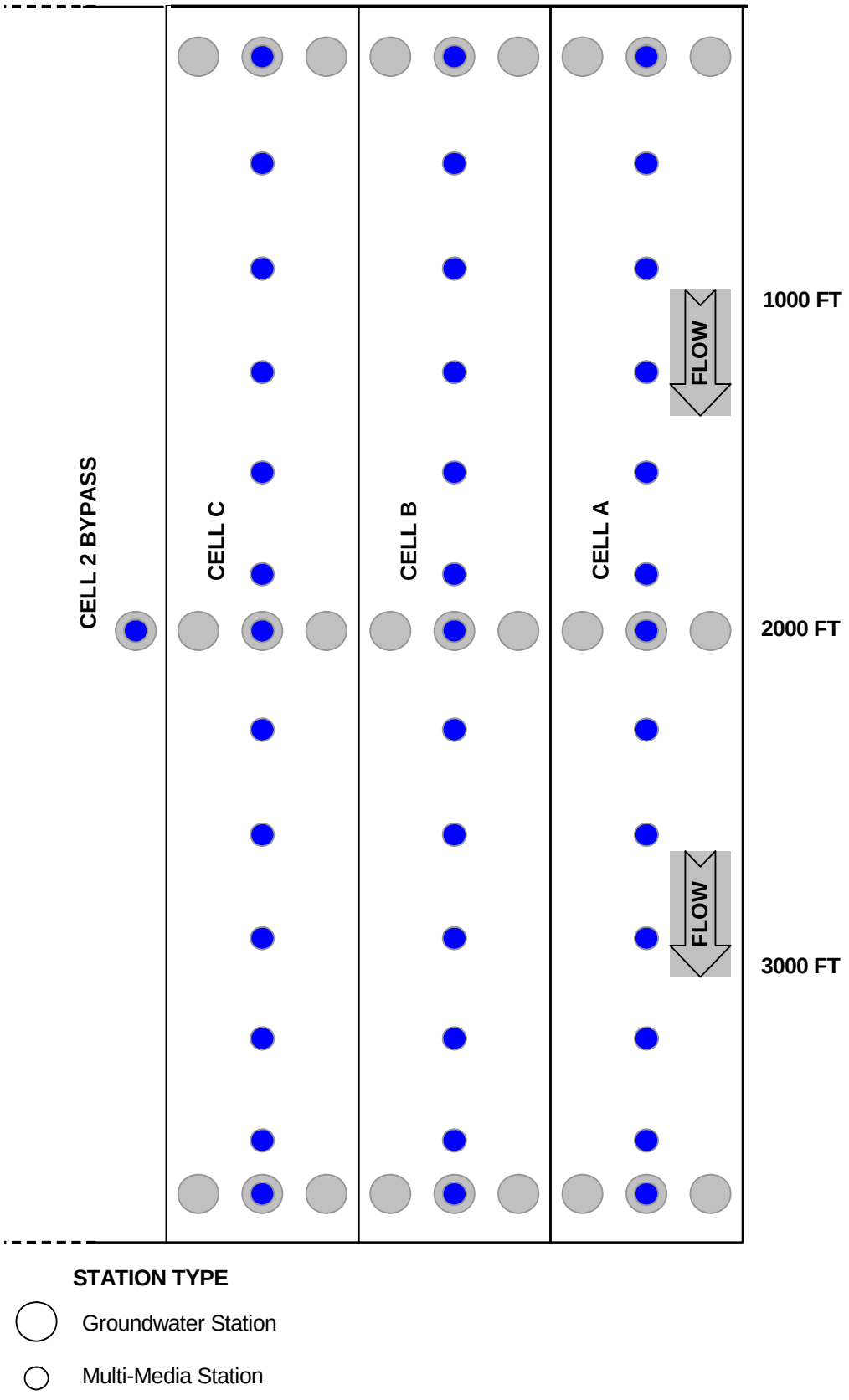

Figure 6.3 Tier III PSTA Cell Monitoring Sites

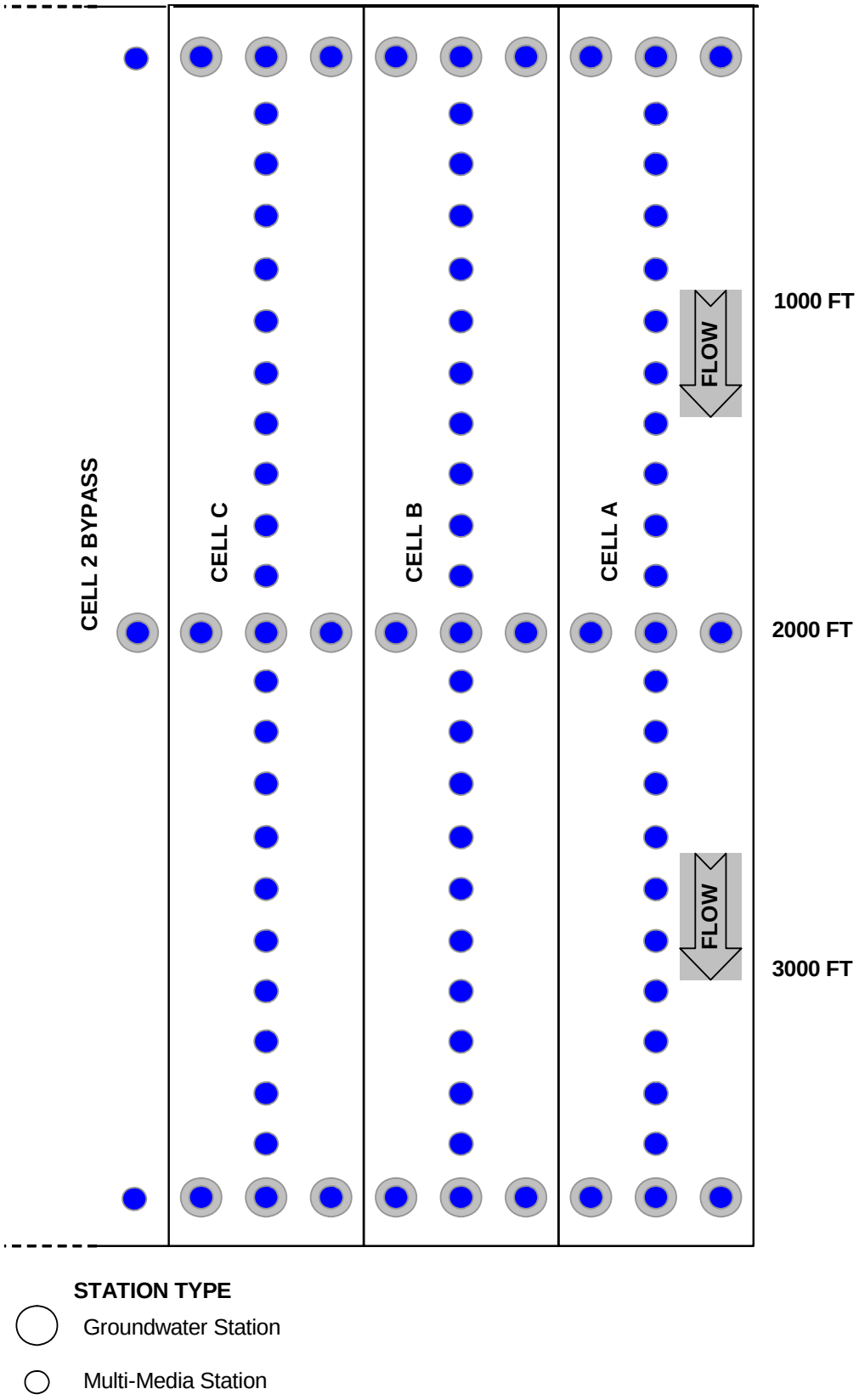

Figure 6.4 Tier IV PSTA Cell Monitoring Sites

Table 6.1 Surface Water Monitoring Parameters

Parameter		Filtered	Preferred Method	Preferred Detection Limit	Precision (% RPD)	Accuracy (% Recovery)	Priority
Alkaline Phosphatase	APA	No	SFWMD 3160.1	1 nM/min	<10	NA	high
Alkalinity	ALK	No	EPA 310.1	1 mg/L	<10	90-110	low
Ammonia	NH4	Yes	SM4500NH3H	0.009 mg/L	<10	90-110	low
Calcium	CA	Yes	SM3120B	0.2 mg/L	<10	90-110	low
Chloride	CL	Yes	EPA 300.0	0.1 mg/L	<10	90-110	very low
Color	COLO	Yes	SM2120B Modified	1 PT-Co unit	<5	90-110	medium
Dissolved Organic Carbon	DOC	Yes	EPA 415.1	1 mg/L	<10	90-110	medium
Iron	FE	No	SM3111B	3.0 ug / L	<10	90-110	low
Magnesium	MG	Yes	SM3120B	0.1 mg/L	<10	90-110	very low
Mercury	HG	No		0.001ng/L	<20%	90-110	required
Nitrite	NO2	Yes	SM4500-NO_2^-B	0.004 mg/L	<10	90-110	low
Nitrite +Nitrate	NOX	Yes	SM4500-NO_3^-F	0.004 mg/L	<10	90-110	low
Ortho Phosphate	PO4	Yes	SM4500-P F	0.004 mg/L	<10	90-110	low
Potassium	K	Yes	SM3120B	0.1 mg/L	<10	90-110	very low
Silica	SI	Yes	SM4500-Si D Modified	0.05 mg/L	<10	90-110	low
Sodium	NA	Yes	SM3120B	0.2 mg/L	<10	90-110	very low
Sulfate	SO4	Yes	EPA 300.0	0.1 mg/L	<10	90-110	very low
Total Dissolved Kjeldahl Nitrogen	TDKN	Yes	EPA 351.2 ATP	0.05 mg/L	<10	90-110	low
Total Dissolved Phosphorus	TDP	Yes	SM4500-P F	0.002 mg/L	<10	90 – 110	medium
Total Dissolved Solids	TDS	No	SM2540C	22 mg/L	<10	NA	low
Total Kjeldahl Nitrogen	TKN	No	EPA 351.2 ATP	0.05 mg/L	<10	90-110	medium
Total Organic Carbon	TOC	No	EPA 451.1	1.0 mg/L	<10	90-110	medium
Total Phosphorus	TP	No	SM4500-P F	0.002 mg/L	<10	90-110	required
Total Suspended Solids	TSS	No	EPA 160.2	3 mg/L	<20	NA	low
Turbidity	TURB	No	SM2130B	0.1 NTU	<5	90-110	high

Table 6.2 Field Monitoring Parameters

Parameter	Preferred Method	Precision	Accuracy
Dissolved Oxygen	FDEP SOP FT1500	0.01	± 0.3 mg/L
Oxidation Reduction Potential	FDEP SOP FT2100	Meter specific parameter	Meter specific parameter
pH	FDEP SOP FT1100	0.01	± 0.2 pH units
Specific Conductivity	FDEP SOP FT1200	0 .1	± 5 %
Temperature	FDEP SOP FT1400	0.01	± 0.5 º C *
Turbidity	FDEP SOP FT1600	Meter specific parameter	Meter specific parameter
Velocity	FDEP SOP FT1800	Meter specific parameter	Meter specific parameter

The frequency of surface sample laboratory analysis is shown in **Table 6.3**. The parameter frequencies have been ranked from required to very low depending on their importance to address the previously mentioned project goals. Some parameters are necessary but fall outside of the primary goals of the demonstration. The transect frequencies shown in Table 6.3 refer to the parameters that will be analyzed when a transect sampling event is conducted.

Table 6.4 is analogous to Table 6.3 except that Table 6.4 parameters will be measured in the field.

Table 6.3 Laboratory Sample Collection Monitoring Frequencies

Parameter	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 4**
Alkaline Phosphatase	BW	Transect	Transect	Transect
Alkalinity	M	Q	A	
Ammonia	BW	M	Q	
Calcium	M	Q		
Chloride	M	Q		
Color	BW	M	Q	
Dissolved Organic Carbon	BW	M	Q	
Iron	M	Q		
Magnesium	M	Q		
Mercury	A			
Nitrite	BW	M	Q	
Nitrite + Nitrate	BW	M	Q	
Ortho Phosphorus	BW	M	Q	

Parameter	Tier 1	Tier 2	Tier 3	Tier 4
Potassium	M	Q		
Silica	M	Q		
Sodium	M	Q		
Sulfate	M	Q		
Total Dissolved Kjeldahl Nitrogen	M	Q	A	
Total Dissolved Phosphorus	M	Q	A	
Total Dissolved Solids	BW	M	Q	
Total Kjeldahl Nitrogen	M	Q	A	
Total Nitrogen	BW	Transect	Transect	Transect
Total Organic Carbon	BW	M	Q	
Total Phosphorus	Composite	Transect	Transect	Transect
Total Suspended Solids	BW	M	Q	
Turbidity	M	Q	A	
BW – Biweekly M – Monthly Q – Quarterly A – Annually				

Table 6.4 Field Monitoring Frequencies

Parameter	Tier 1	Tier 2	Tier 3	Tier 4
Flow Rate	Continuous*			
Dissolved Oxygen	Continuous	Transect	Transect	Transect
pH	Continuous	Transect	Transect	Transect
Photo Documentation		Transect	Transect	Transect
Redox Potential	Continuous	Transect	Transect	Transect
Specific Conductance	Continuous	Transect	Transect	Transect
Turbidity	Continuous	Transect	Transect	Transect
Water Depth	Continuous	Transect	Transect	Transect
Water Temperature	Continuous	Transect	Transect	Transect

* weir settings will be calibrated

6.1.2 Groundwater

Figure 6.1 also shows the PSTA cell groundwater monitoring sites. The frequency of sampling will be determined during sampling based on results of the early sampling. The parameters to be examined include all of those in Table 6.2, total phosphorus, water velocity and direction. The sampling wells will be 10 feet deep and screened from -1ft to -10 ft. They will be constructed

from 4 in PVC to allow the insertion of the Doppler flow meters and the Multi-parameter meters. In addition to these wells there are additional wells located adjacent to the seepage canal along the east side of the STA. These wells will be sampled as necessary or to provide additional information on seepage loss and control.

6.1.3 Biological Analysis

Sampling and analysis will be conducted to determine changes in the periphyton mat through time and as it relates to hydraulic and phosphorus loading. **Table 6.5** provides periphyton mat sampling frequencies. Tier 1 sampling will be used to determine the short-term impacts of changes in loading on this dynamic community while the remaining sampling magnitudes will track long-term changes.

Monitoring of EAV and SAV coverage and species composition within the PSTA cells will occur but relatively infrequently and should be further detailed within the field sampling plan.

Table 6.5 Periphyton Mat Monitoring Frequencies

Parameter	Tier 1	Tier 2	Tier 3	Tier 4
Alkaline Phosphatase	BW	Q	A	
Ash-Free Dry Weight	BW	Q	A	A*
Bulk Density	BW	Q	A	
Calcium (as $CaCO_3$)	BW	Q	A	A*
Chlorophyll a	BW	Q	A	
Mat Thickness	BW	Q	A	
Percent Water	BW	Q	A	
Periphyton Species Composition	BW*	Q	A	A*
Photo Documentation	BW	Q	A	
Total Carbon	BW	Q	A	A*
Total Nitrogen	BW	Q	A	A*
Total Organic Carbon	BW	Q	A	A*
Total Phosphorus	BW	Q	A	A*
BW - Biweekly Q - Quarterly A - Annually				

* samples will be collected, preserved and analyzed as necessary

6.1.4 Substrate

Understanding the changes in the PSTA substrates is important both for calculating phosphorus balances but also for gauging long-term changes within a PSTA cell. **Table 6.6** provides the frequency of substrate sampling and analysis. Tier 2 sampling will be conducted prior to operations to develop a baseline condition prior to phosphorus loading and periphyton mat development.

Table 6.6 Substrate Monitoring Frequencies

Parameter	Tier 1	Tier 2	Tier 3	Tier 4
Total Phosphorus	Q	A	A*	A*
Bulk Density	Q	A		
Calcium (as $CaCO_3$)	Q	A	A*	A*
Non-Reactive Phosphorus	Q	A		
Organic Matter	Q	A	A*	A*
Percent Solids	Q	A	A*	A*
Soluble Reactive Phosphorus	Q	A		
Total Nitrogen	Q	A	A*	A*
Total Organic Carbon	Q	A	A*	A*
Q - Quarterly A - Annually				
* samples will be collected, preserved and analyzed as necessary				

6.2 Cell 2 – Submerged Aquatic Vegetation Monitoring

The SAV Cell is a 55-acre treatment cell located along the northern extreme of Cell 2. This cell is both the third step in the PSTA pretreatment train and provides the hydraulic head to provide the flows into the PSTA Demonstration Cells. The ground surface elevation of the SAV Cell within Cell 2 has been designed to be 15.0 ft NGVD with a target water surface elevation of 18.0 ft NGVD with short-term increases to 19.1 ft NGVD during high flow events.

6.2.1 Water Quality

The monitoring within this treatment cell will include water elevation, nutrient concentrations at the 364-A structure. Table 6.7 provides the frequency of sampling at this location.

Table 6.7 SAV Cell Monitoring Frequencies

Parameter	Frequency
Flow Rate	Continuous*
Dissolved Oxygen	Continuous
pH	Continuous
Photo Documentation (entire cell)	Quarterly
Redox Potential	Continuous
Specific Conductance	Continuous
Total Phosphorus	Composite
Turbidity	Continuous
Water Depth	Continuous
Water Temperature	Continuous

* weir settings will be calibrated

6.2.2 Biological Analyses

The biological analyses within this cell will be confined to vegetation monitoring required for maintenance and operation of this cell. The tracking and understanding of changes in the species present and the area that they occupy will help guide cell operations to optimize treatment within the cell. Additionally, certain undesirable species may need to be removed when they are discovered.

The initial monitoring of this cell will require a ground survey by boat to describe and locate (using the Global Positioning System (GPS)) the SAV and EAV species' coverage. Surveys should be conducted on a quarterly basis. Subsequent surveys could be expedited by taking photographs from an airplane or helicopter to locate areas within the cell that have changed since the previous ground survey. These photographs could allow for ground surveying to be targeted if changes appear to be isolated.

6.3 Cell 1 – Emergent Aquatic Vegetation

Cell 1 is a 556-acre treatment cell that is the second step in the PSTA treatment train and is designated for EAV as the dominant vegetation. Monitoring within this cell will be conducted to assist with the treatment train management and operations.

6.3.1 Water Quality

The Monitoring within this treatment cell will include water elevation, nutrient concentrations at the 363-C structure. Table 6.8 provides the frequency of sampling at this location.

Table 6.8 EAV Cell Monitoring Frequencies

Parameter	Frequency
Flow Rate	Continuous*
Dissolved Oxygen	Continuous
pH	Continuous
Photo Documentation (entire cell)	Quarterly
Redox Potential	Continuous
Specific Conductance	Continuous
Total Phosphorus	Composite
Turbidity	Continuous
Water Depth	Continuous
Water Temperature	Continuous

* gate/pump settings and flows will be calibrated

6.3.2 Biological Analyses

Biological analyses will not be conducted within this cell, however, period visual inspections with photographic archiving will be performed to observe major changes within the cell, if any.

6.4 EDC - FAV Cell Monitoring

The FAV Cell is a ~170 acre treatment cell located in the eastern portion of the East Distribution Cell and delivers water to the EAV in Cell 1. This cell is both the first step in the PSTA pretreatment train and provides the hydraulic head to provide the flows into the remainder of the PSTA treatment train. The ground surface elevation of the FAV Cell within the EDC and the target surface water elevations have yet to be fully identified.

6.4.1 Water Quality

The monitoring within this treatment cell will include water elevation, nutrient concentrations at the as yet to be determined input structure(s) in the northwest corner of the FAV Cell. Table 6.9 provides the frequency of sampling at this location.

Table 6.9 FAV Cell Monitoring Frequencies

Parameter	Frequency
Flow Rate	Continuous*
Dissolved Oxygen	Continuous
pH	Continuous
Photo Documentation	Quarterly
Redox Potential	Continuous
Specific Conductance	Continuous
Total Phosphorus	Composite
Turbidity	Continuous
Water Depth	Continuous
Water Temperature	Continuous

* gate settings will be calibrated

6.4.2 Biological Analyses

The biological analyses within this cell will be confined to vegetation monitoring required for maintenance and operation of this cell. The tracking and understanding of changes in the species present and the area that they occupy will help guide cell operations to optimize treatment within the cell. Additionally, certain undesirable species may need to be removed when they are discovered.

The initial monitoring of this cell will require a ground survey by boat to describe and locate (using the Global Positioning System (GPS)) the FAV species' coverage. Surveys should be conducted on a quarterly basis. Subsequent surveys could be expedited by taking photographs from an airplane or helicopter to locate areas within the cell that have changed since the previous ground survey. These photographs could allow for ground surveying to be targeted if changes appear to be isolated.

7 SCHEDULE OF ACTIVITIES

1. Develop a Field Sampling Plan

In order to implement this Monitoring Plan a field sampling plan (FSP) will need to be developed. The plan should utilize this monitoring plan as a guide. Protocols and standard operating procedures (SOP) for collection of samples and field measurements of sediments, surface waters, and biological parameters including periphyton will need to be developed. In addition to sample collection for laboratory analysis and field measurements, SOPs for flow rates, water depths, weather, and general observations will also need to be developed. Samples for all matrices shall be collected in accordance with Florida Department of Environmental Protection (FDEP) Agency's standard operating procedures, where applicable. The sampling procedures can be downloaded from the Internet at the following URL: http://www.floridadep.org/labs/qa/sops.htm. Alternatively samples may be collected in accordance with the Marsh Sampling Protocol, (Nearhoof, 1996), and the FDEP Quality Assurance Rule, 62-160.200 & 62-160.320, F.A.C. For sampling procedures that are not covered by FDEP SOPs, or where the procedure is inappropriate alternative procedures need to be proposed.

The FSP must be prepared in accordance with Requirements for the Preparation of Sampling and Analysis Plans, USACE EM 200-1-3, February 1, 2001 (EM 200-1-3). The guidance document can be viewed and downloaded from the Internet at: http://www.usace.army.mil/inet/usace-docs/eng-manual/em200-1-3/toc.htm.

2. Pre-Operational Sampling and Photographic Documentation

Prior to flooding the PSTA cells and the initiation of operational sampling it will be necessary to establish the baseline conditions for the 3 test substrates. Of principal concern are TP content and existing emergent vegetation. Thus it will be necessary to collect sample of the substrates for chemical and physical properties and to photographically document the cells.

3. Installation of Ground Water Wells

This needs to be done prior to the initiation of operations.

4. Instillation of Automatic Water Samplers

This needs to be done prior to the initiation of operations.

5. Installation of Staff Gauges and Stage Recorders

This needs to be done prior to the initiation of operations.

6. Post Operational (Destructive) Sampling and Monitoring

In order to better understand the mass balance of TP, marl accretion rate, and the periphyton community structure, sampling of 10 M^2 plots at the Tier II or III level will be necessary. The parameters to be considered can be found in Tables 6.1.3 and 6.1.4.

8 QUALITY ASSURANCE

A quality control program that is standard in the industry for collecting the appropriate number of field duplicates, equipment blanks, matrix spikes, matrix spike duplicates, etc. will need to be developed as part of the FSP. The FSP will need to include the collection of quality assurance (QA) split samples for analysis by and independent third party laboratory.

9 ANALYTICAL LABORATORY SELECTION CRITERIA

The laboratory or laboratories will be selected based on their ability to meet the requirements of Tables 6.1 and 6.2. The laboratory(s) must have the applicable certifications required by the State of Florida's accreditation authority under National Environmental Laboratory Accreditation Program (NELAP) for the analytical parameters and analytical methods listed. In addition, the analytical laboratory performing the analysis of total phosphorous and mercury must participate in the FDEP round robin program. Information about the round robin program and participating labs can be found on the Internet at http://www.floridadep.org/labs/everglades/index.htm. Where applicable, all analytical methods utilized for this project must be NELAP approved methods.