Final Task 3 Report

Conceptual Design of C-43 Water Quality Treatment Area Nutrient Removal/Reduction Test Facility

Prepared for

South Florida Water Management District

Date

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Prepared by

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CERTIFICATION

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Acronyms

AGP	Algal Growth Potential
AN	Ammonia N
BAN	Biologically Available N
BOD	Biochemical Oxygen Demand
BMAP	Basin Management Action Plan
C*	Irreducible background concentration
COD	Chemical Oxygen Demand
CRE	Caloosahatchee River and Estuary
DIN	Dissolved Inorganic Nitrogen
DO	Dissolved Oxygen
DON	Dissolved Organic Nitrogen
EMV	Emergent Macrophyte Vegetation
F.A.C.	Florida Administrative Code
FAV	Floating Aquatic Vegetation
FDEP	Florida Department of Environmental Protection
HLR	Hydraulic Loading Rate
N	Nitrogen
nHRT	Nominal Hydraulic Residence Time
NH_3-N	Unionized form of AN
NH_4-N	Ammonium Nitrogen
NOx-N	Nitrate+Nitrite Nitrogen
NNC	Numeric Nutrient Criteria
O&M	Operation and Maintenance
OW	Open Water
PAC	Periphytic Algal-Dominated Community
PSTA	Periphyton Stormwater Treatment Area
SAV	Submerged Aquatic Vegetation
SFWMD	South Florida Water Management District
SRP	Soluble Reactive Phosphorus
STAs	Stormwater Treatment Areas
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Loads
TN	Total Nitrogen
TON	Total Organic Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
WQTA	Water Quality Treatment Area
WSI	Wetland Solutions, Inc.

Section 1.0 Introduction

1.1 Background

Elevated concentrations of nitrogen and phosphorus in the Caloosahatchee River and Estuary (CRE) are contributing to water quality impairments in this system as evidenced by excessive algae blooms and decreased water clarity and dissolved oxygen content (Knight and Steele 2005). The reduction of nutrient concentrations and loads to these water bodies was required by the Northern Everglades and Estuaries Protection Program passed by the Florida Legislature and signed into law in 2007, and by CRE Total Maximum Daily Loads (TMDL) published by the Florida Department of Environmental Protection (FDEP) (Bailey *et al.* 2009) [Rule 62-304.800, Florida Administrative Code (F.A.C.)]. FDEP is currently in the planning stages of the Caloosahatchee Estuary Basin Management Action Plan (BMAP) which is the roadmap to implement the TMDL. Concurrent with the BMAP planning, FDEP is revising the estuary TMDL and developing several tributary and freshwater Caloosahatchee River TMDLs.

The development of numeric nutrient criteria (NNC) is another water quality process with the potential to influence future nutrient targets in the CRE. The United States Environmental Protection Agency (USEPA) and FDEP both have their own rulemaking processes that may or may not be reconciled during design or construction of the test facility. The future of both federal and state criteria implementation is therefore uncertain at this time and the details of this dynamic process are beyond the scope of this report.

In order to increase nutrient reductions to the downstream estuary, the South Florida Water Management District (District or SFWMD) and Lee County have been partnering on the C-43 Water Quality Treatment Area Testing Facility Project (the "C-43 WQTA Project"). The purpose of the C-43 WQTA Project is to investigate and demonstrate cost effective strategies for reducing loadings of total nitrogen (TN) and other constituents, including total phosphorus (TP) and total suspended solids (TSS) to the C-43 Canal (Caloosahatchee River) to improve water quality in the downstream estuarine ecosystems. The District also anticipates that the C-43 WQTA Project will generate strategies that can be applied to estuaries throughout south Florida.

Through a decade of successful operation of Stormwater Treatment Areas (STAs), the District has built an extensive expertise in TP removal from storm water runoff using wetland treatment systems. However, the mechanisms for TN removal via wetland treatment systems have not been studied to the same extent. The existing data from STAs mostly indicate that currently designed wetland treatment systems are not optimized to reduce TN (especially dissolved organic nitrogen, DON) although they can remove dissolved inorganic nitrogen (DIN) with high efficiency, which accounts for, at most, 20% of the TN present in the CRE system. Thus, the District initiated a project to identify the best option(s) for achieving the C-43 WQTA Project's goals of nutrient reduction in CRE and to design a test facility prior to construction of the full-scale C-43 WQTA Project.

Those efforts resulted in several deliverables and recommendations, such as developing constructed wetland treatment systems as the most cost-effective means for nutrient removal. The recommended plan included design, construction, and operation of a multi-scale test/demonstration facility on a 1,750-acre parcel ("Boma" property see Figure 1) purchased by the District and Lee County for the proposed WQTA (CH2M HILL 2010). This test/demonstration facility is intended to provide the basis for design of constructed wetlands to assist with ultimate compliance of the CRE TMDL.

Wetland Solutions, Inc. (WSI) has been selected to provide additional expert technical support to develop the detailed C-43 WQTA Project Testing Plan, including a conceptual design of the proposed test facilities and an operational testing plan. The C-43 WQTA testing plan is intended to provide the flexibility to test multiple nitrogen removal approaches to determine which approaches are most effective.

1.2 Project Goals and Objectives

The goal of this project is to develop a conceptual design for a test facility comprised of mesocosms and test cells that: 1) will test and demonstrate wetland technologies that have the potential to effectively remove and/or reduce background TN loading from the facility's C-43 inflows; 2) identify the range of hydrological loading rates per unit area to achieve optimal removal/reduction rates; 3) is based on a review of available information and sound science; and 4) is implementable and cost effective on larger scales and/or applicable to other south Florida estuarine systems.

The objective of this work is to develop a conceptual design for a testing facility. The C-43 WQTA Test Facility Conceptual Design Project has three tasks:

1. Project Management and Communication
2. Evaluation of Total Nitrogen Reduction Options
3. Conceptual Design of the Testing Facility

WSI has previously completed Tasks 1 and 2. This report provides the results of Task 3, namely an updated conceptual design for the proposed C-43 WQTA Test Facility based on the findings in the Task 2 report (WSI 2012). This conceptual design includes a recommended suite of testing scales including: laboratory bioassays, experimental mesocosms, and field-scale wetland plots. Each testing scale includes testing plans, scientific rationales, and estimated costs for construction, operation and maintenance (O&M), and testing in the proposed conceptual plan.

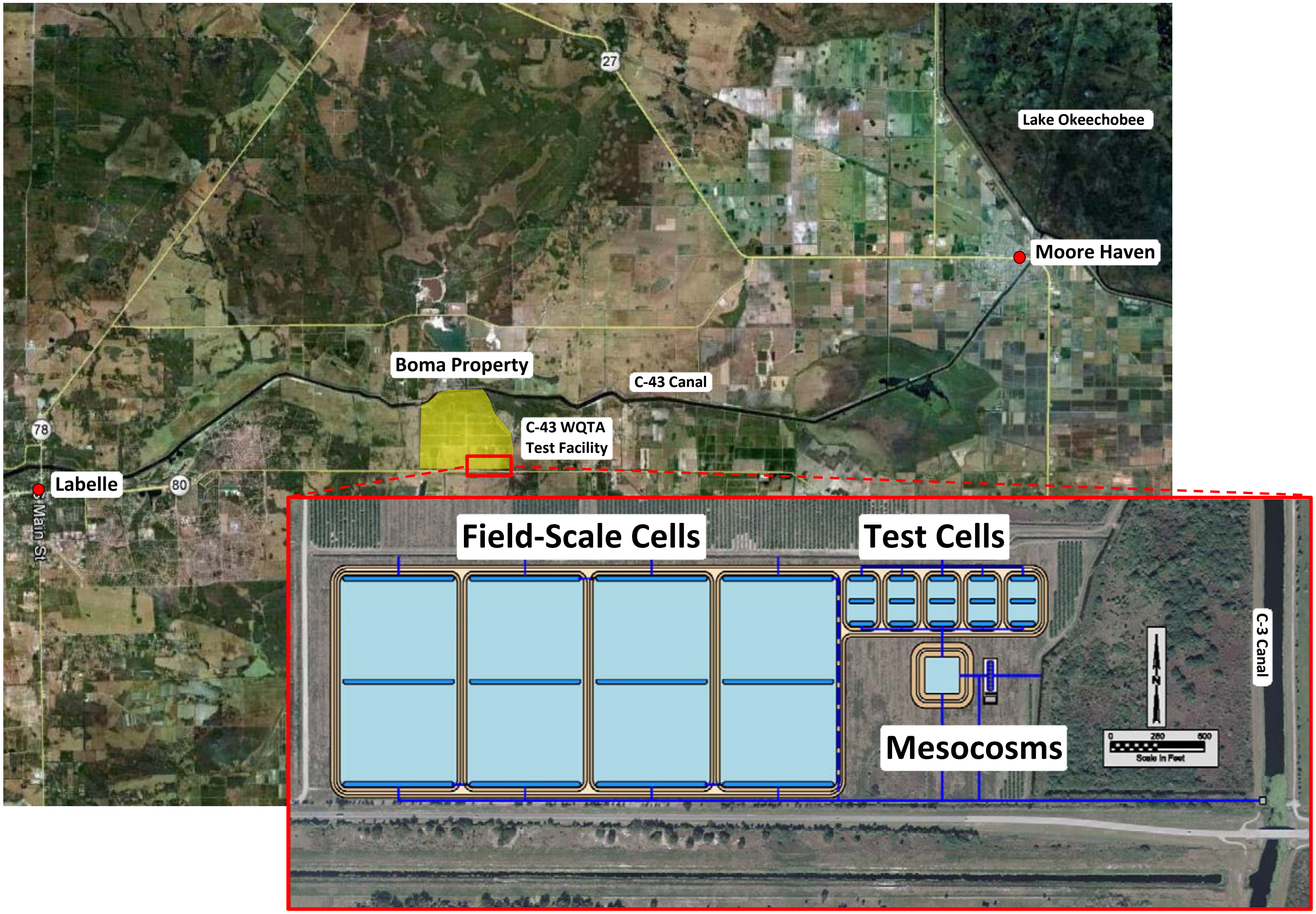


Figure 1. Location of the C-43 Water Quality Treatment and Demonstration Project

1.3 C-43 WQTA Test Facility Conceptual Design

The objective of this task is to recommend a conceptual design of a test facility capable of removing TN with an emphasis on removing various TN fractions, including organic and inorganic forms. This test facility conceptual plan will primarily be based on information presented in WSI (2012): *Evaluation of Total Nitrogen Reduction Options for the C-43 Water Quality Treatment Area Test Facility*. Two additional supporting documents include WSI (2010): *C-43 Water Quality Treatment Area – Technical Expert Review Panel Consolidated Report* and CH2M HILL (2010): *Draft C-43 Water Quality Treatment Area Project Conceptual Plan Technical Memorandum*.

Recent literature and operational data on TN, TP, and TSS removal in Florida constructed treatment wetlands were reviewed and summarized in WSI (2012). Five treatment wetland alternatives were evaluated, including:

- Emergent macrophyte vegetation (EMV)
- Submerged aquatic vegetation (SAV)
- Floating aquatic vegetation (FAV)
- Attached and floating algal-dominated systems (PSTA or periphyton stormwater treatment area)
- Open water (OW)

Evaluation factors included:

- TN, TP, and TSS removal rates;
- Estimated background (C*) values by pollutant and sediment type; and
- Order-of-magnitude cost per unit treatment area and volume.

Based on their review, WSI (2012) concluded that EMV-, SAV-, and PSTA-dominated wetlands are collectively preferred over FAV and OW treatment systems. These preliminary comparisons are based on the assumption that site soils for the C-43 WQTA Project will be sandy or calcareous in nature and will therefore avoid the potentially high C* effect for TON resulting from organic and clayey soils. Existing subsurface profiles, which are limited to the southeast portion of the BOMA test facility site, support this assumption.

This comparison indicated that there is not likely to be a large difference in overall TN cost effectiveness between the top three wetland plant community types: EMV, PSTA, and SAV. Each of these types of wetlands has somewhat similar biogeochemical cycles, dependence on adequate surface area for treatment, and production of ample organic carbon required for effective denitrification of NOx-N. However, where there are differences in performance and cost between wetland alternatives, those differences are used in this Task 3 report to prioritize testing resources.

The C-43 WQTA Expert Panel report (WSI 2010) came to a similar conclusion that, if the District was limited to a single wetland technology, the EMV would be most likely to achieve the lowest TN, TP, and TSS concentrations with the smallest footprint and the lowest construction cost. It is too early however for the District to determine what limit, if any, ought to exist for the number of wetland technologies to be used in the WQTA. A full-scale nitrogen-removal WQTA facility may be a combination of technologies in series with each sized to provide the greatest overall cost effectiveness for the reduction of TN in the CRE.

This Task 3 report details the conceptual plan for the C-43 WQTA test facility. The proposed test facility conceptual plan includes a discussion and rationale for the use of bioassays and mesocosms as compared to larger test cells, recommended test cell treatments, a preliminary operations and monitoring plan, and estimated costs for design, construction, and operation of the proposed test facility. Experimentation of alternative wetland/aquatic plant communities arranged in different sequences will be conducted in the testing facility at the mesocosm level, larger scale test cells, or both. First consideration will be given to treatment trains comprised of conventional wetland and/or aquatic plant community cells that are optimized for the treatment of total nitrogen through natural microbial and photodegradation processes. Should the operation and sampling of the testing facility reveal that these different treatment trains cannot be effectively replicated throughout the watershed to achieve the CRE TMDL, other less conventional TN removal technologies might ultimately be considered.

Section 2.0 General Constructed Treatment Wetland Testing Rationale

2.1 Background

Constructed treatment wetlands include a broad variety of technologies that rely on the use of aquatic and wetland plants and associated microbial communities to provide water quality benefits. All constructed treatment wetlands have the following basic characteristics in common:

- One or more shallow (water depths typically averaging less than three feet) basins that receive, hold, and release water to be treated;
- Treatment processes that primarily rely on the growth of hydrophytes (aquatic and wetland plants) and associated microbial and sediment biogeochemical processes; and
- Relatively large land area requirements necessary to utilize solar input and wind/atmospheric diffusion as the primary energy and raw materials inputs for the treatment process.

There are two basic hydrologic variants of constructed treatment wetlands:

- Surface flow wetlands that route water aboveground; and
- Subsurface flow wetlands where water is primarily below ground.

Subsurface flow constructed wetlands have significant hydrologic and cost constraints and were not considered to be a practical alternative for the C-43 WQTA project (WSI 2012).

The different types of surface flow constructed treatment wetlands are generally similar in design with the exception of water regime (depth and duration of flooding) and the selection of the appropriate plant community that is adapted to the selected water regime. A considerable variety of hydrophytic plant species are available for use in constructed surface flow treatment wetlands in south Florida. Plant selection for constructed treatment wetlands is based on a number of considerations, including:

- Growth form/habit (floating, submerged, rooted, emergent, etc.);
- Flooding tolerance (saturated soil only, periodic flooding, continuous flooding, etc.);
- Salinity tolerance (strictly freshwater, mildly tolerant, halophyte, etc.);
- Pollution tolerance (oligotrophic, mesotrophic, eutrophic, etc.);
- Resistance to frost (intolerant or tolerant);
- Seasonality (annual, perennial, seasonal, etc.);
- Resistance to pests; and
- Value for wildlife habitat (cover, food, nesting, etc.).

By definition, treatment wetlands are constructed to provide water quality treatment. This implies the presence of pollution or wastes above ambient levels in the water source requiring treatment. For the proposed C-43 WQTA Project, the water source is surface waters in the C-43 Canal (channelized Caloosahatchee River) and tributary canals and streams. Elevated concentrations of nitrogen are of principal concern due to the stimulation of algae growth in the CRE system. The primary sources for the elevated nitrogen concentrations in the C-43 Canal include:

- Inflow from Lake Okeechobee
- Fertilizer nitrogen inputs
- Inputs from livestock
- Inputs from domestic and municipal wastewater sources (septic tanks and package treatment plants)
- Releases from drained and tilled soils
- Atmospheric inputs

On average, inputs from the freshwater basin contribute an estimated 50% of the TN loads to the CRE, while Lake Okeechobee (28%), and the estuarine basin (about 21%), contribute less (Knight and Steele 2005).

Treatment wetlands have been proven effective for the removal of a wide range of inorganic and organic pollutants. The following pollutants are being attenuated by constructed treatment wetlands, roughly in order of the number of applications worldwide:

- Biochemical oxygen demand (BOD);
- Total suspended solids (TSS);
- Nitrogen (N) forms – total nitrogen (TN), total organic N (TON), ammonia N (AN), and nitrate+nitrite N (NO_x-N);
- Chemical oxygen demand (COD);
- Phosphorus (P) forms – total phosphorus (TP), inorganic or soluble reactive phosphorus (SRP), particulate P, and organic P;
- Trace metals (e.g., arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc); and
- Trace organics (e.g., pesticides, petroleum, aromatic hydrocarbons, alcohols, aliphatic hydrocarbons, volatile organics, etc.).

The focus of the proposed C-43 WQTA project is the use of constructed treatment wetlands for reduction of TN concentrations and loads. Pollutants of secondary interest for the C-43 WQTA Project are TSS and TP, and these and other pollutants listed above may also be included in the analytical sampling plan for the testing facility.

2.2 Priority Test Questions

The primary goal of the proposed C-43 WQTA Project is the cost-effective removal of TN, with particular reference to the removal of various forms of TON. Secondary goals include ancillary reductions in the concentrations of TP and TSS in the C-43 canal. This section describes the key technical questions that will be addressed by the C-43 WQTA Test Facility project.

There are two principal test questions:

- To what level can various alternative constructed treatment wetland plant communities lower the concentration of TN in the C-43 Basin?
- What will be the combined footprint of full-scale treatment facilities required to achieve the goals of the CRE TMDL?

The straight-forward method for answering the first question above is to lower hydraulic and nutrient loading rates to the point where the hydraulic residence time is long enough and the mass loading rate is low enough so that no additional concentration reduction occurs. The second question can be answered by running large-scale tests so that scale is not an issue and so a range of hydraulic and nutrient loading rates can lead to development of a sizing model that can be extrapolated to the regional watershed basin with time-varying flows and pollutant concentrations. A calibrated, dynamic model is the preferred outcome of this effort due to the varying flows and loads entering the CRE system.

Mass balances will be prepared for all test units to help understand the fate of these pollutants in light of the various design and operational treatments used at the Test Facility. Due to the complex chemistry of nitrogen in surface waters, evaluation of TN removal must include the measurement of the full suite of nitrogen sources, sinks, and transformations that will occur in the treatment unit. Since constructed wetlands are open to the atmosphere and are constructed on the surface of the land, two important sources of additional nitrogen may include atmospheric and sediment inputs. The influence of both nitrogen sources need to be assessed to prepare accurate nitrogen mass balances for the test units.

Direct atmospheric N inputs include both wetfall and dryfall. Wetfall in rain typically includes dissolved organic and inorganic nitrogen forms. Dryfall typically includes particulate organic forms of N. While atmospheric N inputs are expected to be relatively low in comparison to the C-43 water N inputs to the treatment units, this N source will be approximated based on rainfall estimates and periodic bulk rainfall sampling. Another possible atmospheric input of DON into the test units will be nitrogen fixation. This input is expected to be small and will only be assessed through residuals in the N mass balance estimates. Atmospheric inputs of P and particulate solids are also likely to occur at the test units and will be estimated through the bulk rainfall sampling.

The Task 2 report summarized the effects of soil types on C^*_N (background or lowest achievable outlet nitrogen concentration) in various types of treatment wetland systems. Treatment wetlands constructed on organic (peat) soils typically have higher C^*_N values than similar wetlands constructed on mineral (non-organic) soils. The C^*_N for N varies in response to the amount of easily soluble organic and inorganic N that occurs in the antecedent soils. The Task 2 literature review (WSI 2012) and the expert panel report (WSI 2010) both indicated that selection of appropriate soil conditions or possible soil amendments may be critical for achieving the very low TN concentrations required to meet the CRE TMDL. Soil type and previous exposure to nutrients should be an important component of the proposed technical evaluation of wetland treatment alternatives.

A number of design and operational considerations are important for effective pollutant removal in treatment wetlands. The Test Facility will evaluate the potential for the most effective plant community types listed above to provide N, P, and TSS removal. Based on the review of N removal data from existing systems, these highest performing plant communities include constructed ecosystems dominated by EMV, SAV, periphytic algae, and FAV. In addition to initial site preparation and planting, propagation and maintenance of these different plant communities is largely influenced by water depth. For this reason water depth, hydroperiod, and initial plant establishment are key considerations in setting up the Test Facility. Also, inclusion of multiple vegetation zones in series will be incorporated to provide a variety of processes within single test cells.

Other key design considerations that are included in this testing plan include:

- Levee height (to allow for testing of a wide range of water depths as well as to retain all inflows and outflows to control structures, including peak rainfall inputs)
- Aspect ratio (the average length divided by the average width of the flow path)
- Inclusion of deep zones (their depth, width, percent of treatment area)

Key operational considerations in all land-intensive water pollution treatment systems include the following:

- Hydraulic loading rate (the average rate of water application over the wetted treatment area expressed as rainfall equivalent, reported as cm/d or m/yr)
- Hydraulic residence time (nominally the inflow divided by the water volume of the wetland, reported as days)
- Loading frequency (the frequency and duration of pumped inputs, reported as #/yr)
- Inlet pollutant load (the pollutant concentrations multiplied by the hydraulic loading rate, reported as kg/ha/d)

This suggested approach focuses on the inputs and outputs of materials in these natural treatment systems. This “green box” approach has been found to provide reliable information for engineering design of full-scale water quality projects world-wide. Process-level studies to detail the many physical, chemical, and biological processes that will be occurring in these test units are not recommended. While it is certainly preferable to have this information, the cost in terms of schedule and dollars may not justify the ultimate benefit of the additional knowledge gained. If time and budget are available for process studies, then those may be added when the final C-43 WQTA testing plan is prepared.

Finally, there are analytical considerations that are important to this project. For example, due to the complexity and possible recalcitrance of nitrogen forms, a variety of analytical tests are available but not all are necessary for project success. The simplest TN series is recommended for all test systems, including total Kjeldahl nitrogen (TKN – the sum of organic and ammonia N), total ammonia N (a combination of ionized ammonium [NH_4-N] and unionized ammonia

[NH_3-N]), and total nitrate+nitrite N (NOx-N). Since ammonia and nitrate+nitrite N are dissolved compounds there is generally no need to look at filtered (particulate) and filtrate (dissolved) fractions. However, organic N is generally present in both particulate and dissolved forms and this distinction is important for data interpretation. Filtered and unfiltered samples should be evaluated for total and dissolved TKN to highlight the relative proportions of these two fractions.

There is currently no recognized analytical test to fractionate total organic N (TON) from biologically available N (BAN). As used in this report, BAN includes all biologically available N forms, including organic and inorganic compounds. In response to the Expert Panel's recommendation, this test plan recommends further evaluation of the scope and cost to develop a prototype analytical procedure to estimate the BAN fraction of the TON. The Expert Panel conceptualized this test as a modified TKN test with one or more milder oxidants to breakdown the more tractable organic nitrogen compounds to ammonia. The efficacy of this test would be determined through mesocosm and laboratory bioassays as described later in this report.

When possible, standard analytical tests will be used for determination of concentrations of the other pollutants of concern (i.e., TP and TSS). These tests will be modified as needed to obtain adequate sensitivity to detect low concentrations of nutrients and solids.

2.3 Testing Scale

The most appropriate scale for the individual Test Facility components is dependent upon the specific questions to be answered, scale-up issues needed to implement a full-scale project, and cost. Some questions will be answered at a single test scale while others may be answered at multiple scales to provide confirmation that test scale is or is not a critical issue.

Previous experience with the Everglades Advanced Treatment Technologies program indicates that smaller scale Mesocosm units (generally less than 10 to 40 m^2 [108 to 430 ft^2]) are appropriate for testing multiple design elements more cost effectively than building many larger test units. The problem with smaller mesocosm scale test units is that they have unrealistic edge-to-area (surface area-to-volume) ratios compared to full-scale treatment systems. These "edge" effects are sometimes seen in unrealistic plant growth limitations due to shallow soil depth or high walls that result in shading; uncharacteristic cooling or heating by the surrounding environment due to the higher surface area to volume ratio; and the more pronounced influence of stochastic events that would not otherwise be noticed in a larger scale project (e.g., the "alligator in the bath tub" effect). Mesocosms are considered to be an appropriate scale to test the effects of antecedent soil chemistry on C^*_{TN}, plant community effects on C^*_{TN}, plant- and microbial-level biogeochemical processes (biomass production, nutrient storages, nutrient biotransformations, enzyme production, plant uptake kinetics, etc.). Mesocosms are also an appropriate scale for replicated experiments and development of preliminary pollutant removal kinetics (that will be confirmed at larger scales).

Test Cells refer to larger, in-ground test systems, generally in the range of 500 to 4,000 m^2 (0.12 to 1 ac) and are less affected by high surface to volume ratios and provide more realistic plant growth conditions in native soils. Test Cells are small enough to be replicated, although stochastic effects still lead to relatively high variation between cells. Test Cells are most applicable to verification of preliminary findings from Mesocosm scale research. For example, if

Mesocosm data indicate that specific soil properties are critical to achieve low C^*_{TN} then Test Cells could be operated on actual native soils to verify those results prior to implementing the next larger scale. Test Cells may also be the most appropriate scale to develop more robust data sets for performance model calibration/validation. It is important to note that Test Cells are not suitable as the only intermediate scale prior to design and operation of full-scale treatment wetlands. This need is principally due to the issues related to Full-Scale systems concerning higher flow velocities and increased hydraulic head loss.

Field-Scale treatment wetland test systems are typically in the range of 4,000 to 400,000 m^2 (1 to 100 ac) Examples include the PSTA Field-Scale cells as well at the STA-3/4 PSTA cell. These systems are generally not replicated due to their size and cost. When used, they are typically the last stage of work prior to implementation at Full-Scale. Depending on their size, Field-Scale systems may provide realistic data concerning pollutant removal rates and kinetics, effects of soil and climate variation, and construction costs. Their value for Full-Scale design is roughly proportional to their size. Smaller Field-Scale cells do not simulate actual Full-Scale hydraulics very well and therefore are not as reliable for understanding of Full-Scale treatment wetland mixing, head loss, and volumetric efficiency issues.

Section 3.0 Test Facility Description and Treatments

3.1 Test Facility Components

The recommended C-43 WQTA Test Facility will include the following components:

- Pump Station (9,300 m^3/d or 1,700 gpm maximum capacity)
- Supply Force Main (30-cm [12-in] diameter HDPE; 1,900-m length [6,250 ft])
- Mesocosm Head Tank (7 m^3 [247 ft^3])
- Head Cell (4,000 m^2 [1 ac] and 12,200 m^3 [430,510 ft^3])
- Mesocosms (8 at 12 m^2 each [129 ft^2])
- Test Cells (5 at 4,000 m^2 [1 ac])
- Field-Scale Cells (4 at 62,700 m^2 [15.5 ac])
- Cell Inlet Piping, Control Valves, and Flow Meters
- Miscellaneous Water Control and Monitoring Structures

3.1.1 Pump Station and Inlet Force Mains

It is recommended that the intake pump station be located on the C-3 Canal and that the C-43 WQTA Test Facility be built in the southeast corner of the BOMA Site (Figure 2). Electricity must be provided at this site to allow use of electric pumps. The total length of the inlet pipeline is approximately 1,900 m (6,250 ft) (this includes the Head Cell supply and series flow inlet line to FS-1). The pump station is anticipated to include up to three 25-30 horsepower pumps to provide adequate water supply for the project, pending detailed seepage calculations to be performed during final design.

3.1.2 Testing Units

Three testing scales are recommended (Table 1): Mesocosms, Test Cells, and Field-Scale Cells. Mesocosms will be constructed of fiberglass (pre-fabricated). The number of recommended test systems was dictated by the questions to be answered at each scale and the construction and O&M cost for each size unit. Test Cells and Field-Scale Cells will be constructed on-site using native soils without liners. A 4,000 m^2 (1 ac) (12,200 m^3 [3 ac-ft]) Head Cell will be constructed to provide continuous inflows to the Test Cells and Field-Scale Cells (Figure 2). This Head Cell will be constructed with a HDPE liner to reduce seepage losses and will have 3:1 side slopes and an average water depth of about 3 m (10 ft). Figure 3 shows typical cross sections through the Head Cell, a Test Cell, and a Field-Scale Cell.

Table 1. Proposed C-43 WQTA Test Facility plan

Scale	Unit ID	Description	Plant Community[1]	Substrate[2]	Water Depth (cm)	Area (m^2)	Dimensions (m)
Mesocosm	M-1	EMV sand	EMV	Sand	30	12	2.4 x 4.9
Mesocosm	M-2	SAV sand	SAV	Sand	60	12	2.4 x 4.9
Mesocosm	M-3	FAV sand	FAV	Sand	90	12	2.4 x 4.9
Mesocosm	M-4	Algae limestone	Algae	Limestone	60	12	2.4 x 4.9
Mesocosm	M-5	OW sand	OW	Sand	90	12	2.4 x 4.9
Mesocosm	M-6	FAV control	FAV	None	90	12	2.4 x 4.9
Mesocosm	M-7	Algae control	Algae	None	60	12	2.4 x 4.9
Mesocosm	M-8	OW control	OW	None	90	12	2.4 x 4.9
Test Cell	TC-1	EMV shallow	EMV	Native sand	15	4,000	50 x 80
Test Cell	TC-2	EMV deep	EMV	Native sand	45	4,000	50 x 80
Test Cell	TC-3	SAV/FAV	SAV/FAV	Native sand	90	4,000	50 x 80
Test Cell	TC-4	Algae/OW	Algae/OW	Limestone	120	4,000	50 x 80
Test Cell	TC-5	MIX	EMV/SAV/FAV/Algae	Native sand	30-90	4,000	50 x 80
Field-Scale	FS-1	EMV shallow	EMV	Native sand	15	62,700	190 x 330
Field-Scale	FS-2	EMV deep	EMV	Native sand	45	62,700	190 x 330
Field-Scale	FS-3	SAV/FAV	SAV/FAV	Native sand	90	62,700	190 x 330
Field-Scale	FS-4	MIX	EMV/SAV/FAV/Algae	Native sand	30-90	62,700	190 x 330

Notes:

[1] Plant Communities: EMV (emergent vegetation), SAV (submerged aquatic vegetation), FAV (floating aquatic vegetation), Algae (filamentous and macro algae), OW (open water), MIX (mixed plant community)

[2] Substrate: sand (imported, rinsed, medium-grained sand), native sand (on-site soils), limestone (#57 limerock or equivalent)

3.1.2.1 Mesocosms

Eight pre-fabricated fiberglass Mesocosms (2.4x4.9 m [8x16 ft] each) will be installed on a level pad of crushed limestone (Figure 4). A single plastic Head Tank (7 m^3 [247 ft^3]) will be centrally located to provide a constant head inflow to the Mesocosms. The Head Tank will receive inputs from a temporary gas-powered pump until completion of the Head Cell and main pump station. At that time, the Head Tank will receive inputs via gravity from a 10 cm (4 in) PVC supply line from the Head Cell. Excess water will be drained from the Head Tank by use of a fixed overflow from the tank to the return pipeline to an internal irrigation/drainage canal. The eight Mesocosm tanks will be plumbed for parallel operation using 5 cm (2 in) PVC piping and adjustable-level overflow pipes to the drain line. Four of the Mesocosms will receive 30 cm (12 in) of clean (washed) medium-grain sand. One Mesocosm unit will receive 30 cm (12 in) of #57 limestone. Limestone was found to be the best substrate to encourage the growth of calcareous blue green and macrophytic algal species in the Everglades Advanced Technology testing. On peat or mineral soils recruitment by rooted macrophytes precluded good colonization by the desired algal plant community. Three of the Mesocosms will be “controls” with no substrate.

Cattails and bulrush are combined in the deeper EMV treatments while a combination of cattails and spikerush are recommended in shallower EMV treatments. This plant selection is dictated by the general depth tolerance of each species. The purpose of planting these cells is to insure rapid plant colonization and stable water quality performance rather than to produce a specific mix of plant species. Considerable natural recruitment and resulting "self design" of wetland plant communities is anticipated in these test units in response to the controlled water regimes tested. Plant communities in the Mesocosms will be managed by physical removal of unwanted plants.

Mesocosm M-1 will be planted with a mix (1:1) of cattails (*Typha* sp.) and bulrush (*Schoenoplectus* sp.) in a bed of washed sand. The planting density will be on 30-cm centers to provide rapid establishment and grow-in. The target water depth in this Mesocosm will be 30 cm.

Mesocosm M-2 will be planted with a mix of southern naiad (*Najas guadalupensis*) and coontail (*Ceratophyllum demersum*) above a bed of washed sand. The planting density will be 40 liters (10 gallons) of each plant species to provide rapid establishment and grow-in. The target water depth in this Mesocosm will be 60 cm (2 ft).

Mesocosm M-3 will be planted with a mix of water hyacinth (*Eichhornia crassipes*) and duckweed (*Lemna* sp.) above a bed of washed sand. The planting density will be 200 liters (50 gallons) of hyacinths and 4 liters (one gallon) of duckweed to provide rapid establishment and grow-in. This is a preliminary estimate that will allow good coverage of each species and will be adjusted based on the actual plant propagules at hand. The target water depth in this Mesocosm will be 90 cm (3 ft).

Mesocosm M-4 will be planted with a mix of filamentous algae (green and blue-green species) and macrophytic alga stonewort or muskgrass (*Chara* sp.) above a bed of #57 limestone. The planting density will be 40 liters (10 gallons) of each algae type to provide rapid establishment and grow-in. The target water depth in this Mesocosm will be 60 cm (2 ft).

Mesocosm M-5 will not be planted and any macroscopic colonizing plant species will be removed. This Mesocosm will include a bed of washed sand. The target water depth in this Mesocosm will be 90 cm.

Mesocosm M-6 will be planted with a mix of water hyacinth and duckweed with no sediment. The planting density will be 200 liters (50 gallons) of hyacinths and 4 liters (one gallon) of duckweed to provide rapid establishment and grow-in. This is a preliminary estimate that will allow good coverage of each species and will be adjusted based on the actual plant propagules at hand. The target water depth in this Mesocosm will be 90 cm (3 ft). This Mesocosm treatment is intended to provide a control without initial sediment to help separate benthic from plant community effects on nitrogen C* and k values.

Mesocosm M-7 will be planted with a mix of filamentous algae (green and blue-green species) and stonewort or muskgrass without a limestone bed. The planting density will be 40 liters (10 gallons) of each algae type to provide rapid establishment and grow-in. The target water depth in this Mesocosm will be 60 cm (2 ft). This Mesocosm treatment is intended to provide a control without initial sediment to help separate benthic from plant community effects on nitrogen C* and k values.

Mesocosm M-8 will not be planted and any macroscopic colonizing plant species will be removed. This Mesocosm will not include any initial sediment. The target water depth in this Mesocosm will be 90 cm (3 ft). This Mesocosm treatment is intended to provide a control without initial sediment to help separate benthic from plankton effects on nitrogen C* and k values.

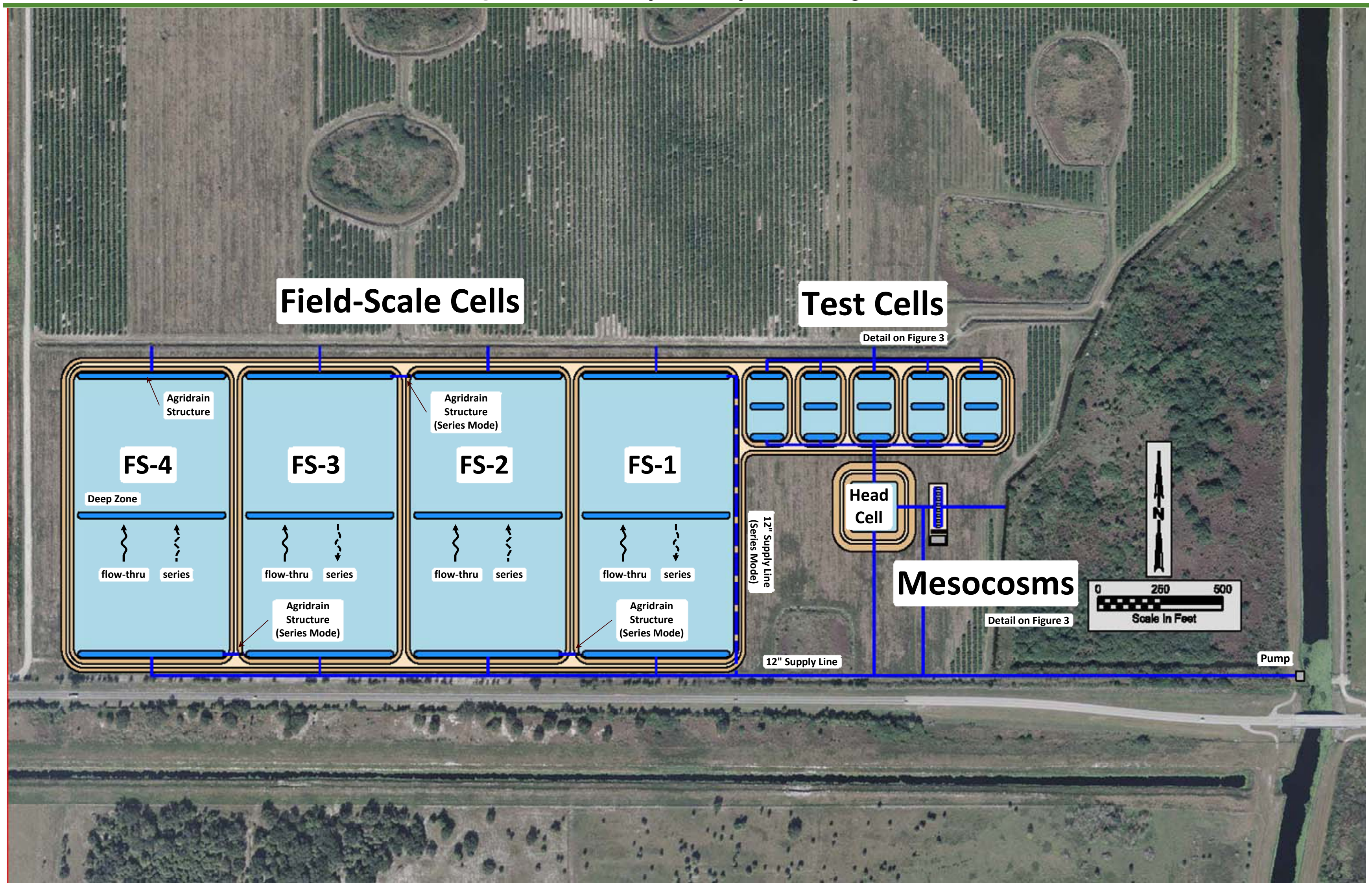
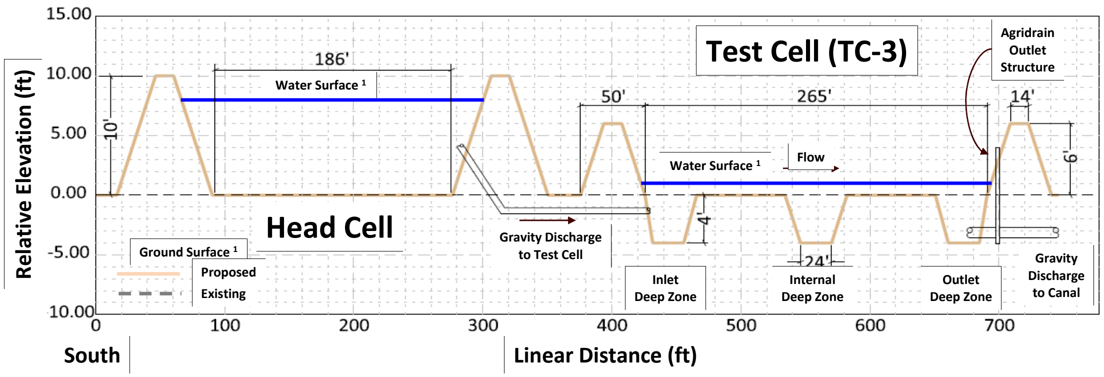


Figure 2. Proposed C-43 WQTA Test Facility Site plan



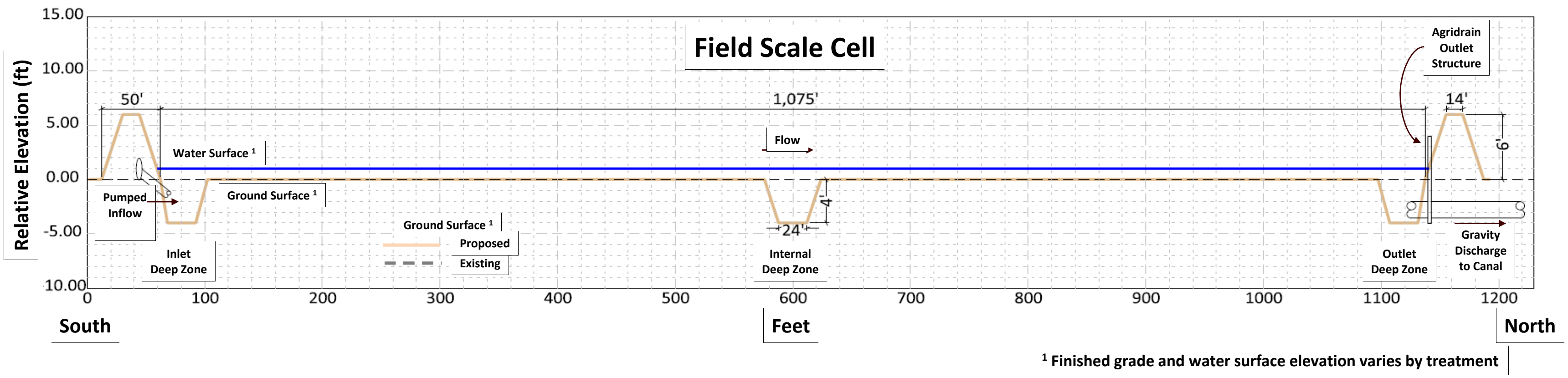


Figure 3. Proposed C-43 Test Facility Typical Cross Sections

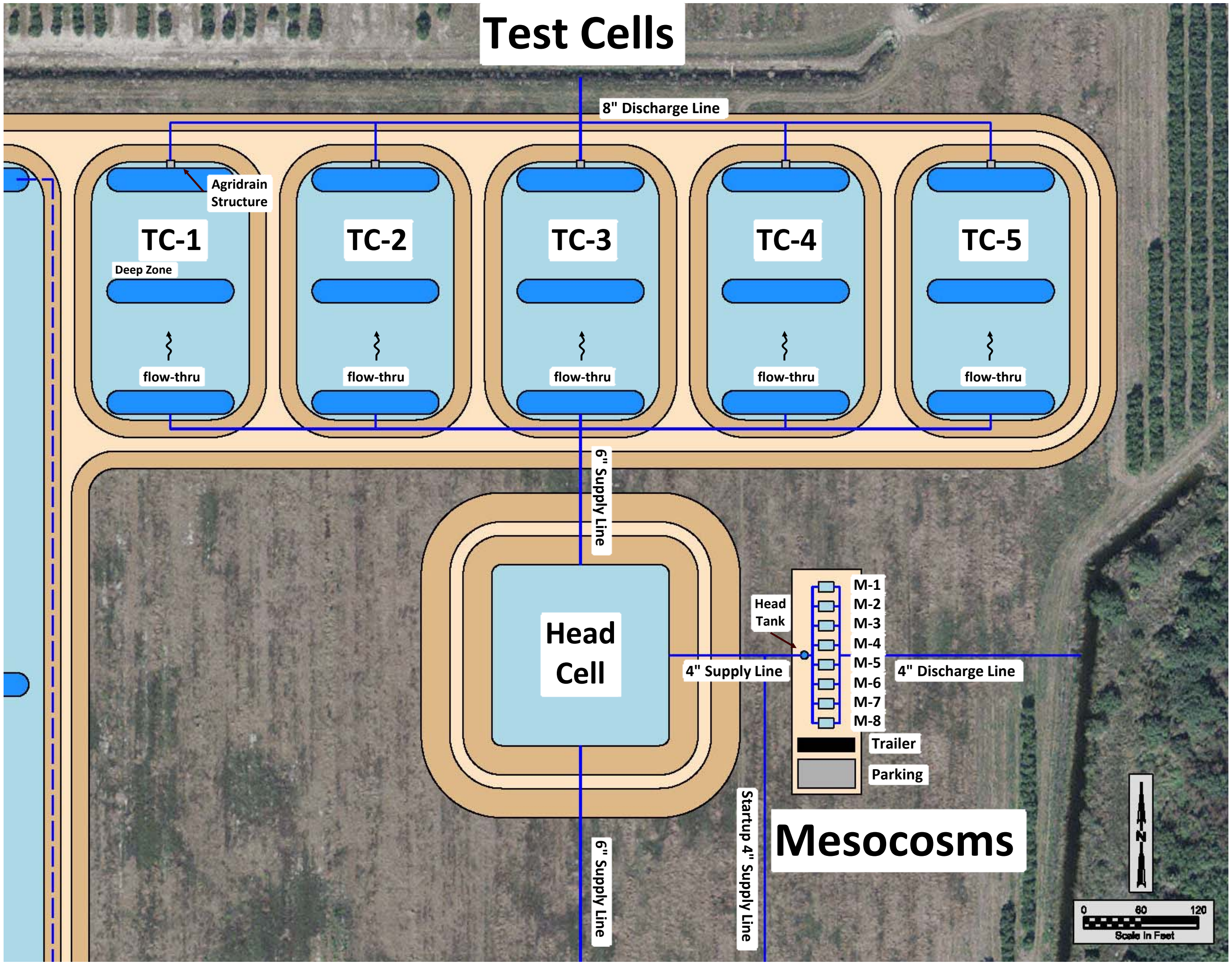


Figure 4. Proposed C-43 WQTA Test Facility Site plan – Test Cells and Mesocosms

3.1.2.2 Test Cells

Five in-ground 4,000 m² (1 ac) (50x80 m [164x262 ft]) Test Cells will be constructed using earthen embankments (Figure 4). Four of these Test Cells will have native soil fill. One Test Cell will be over-excavated and backfilled with 30 cm (12 in) of #57 limestone. Design embankment heights in all five Test Cells will be 1.8 m (6 feet) and constructed with 3:1 side slopes and top width of 4.2 m (14 ft). The maximum water depth proposed in this test plan is 120 cm (about 4 feet), resulting in a minimum of about 60 cm (2 feet) of freeboard in all of the Test Cells. While this height may not be necessary for the Test Cells experiencing shallower water conditions, this consistent cell height is recommended in all cells to allow flexible water depth operation in light of preliminary findings.

Water control structures in these Field-Scale Cells will include inlet, central, and outlet deep zones (bottom width 7.3 m [24 ft] with 3:1 side slopes) and outlet adjustable horizontal weirs (e.g. Agridrain™ or similar inline water control structures). The five Test Cells will be designed only for parallel operation. Embankment properties will be further considered during the design phase to minimize “cross-talk" between cells.

Cattails and bulrush are combined in the deeper EMV treatments while a combination of cattails and spikerush are recommended in shallower EMV treatments. This plant selection is dictated by the general depth tolerance of each species. The purpose of planting these cells is to insure rapid plant colonization and stable water quality performance rather than to produce a specific mix of plant species. Considerable natural recruitment and resulting "self design" of wetland plant communities is anticipated in these test units in response to the controlled water regimes tested. There is no plant removal or harvesting anticipated in the Test Cells. Plant biomass harvesting is not recommended in full-scale treatment wetlands (Kadlec and Wallace 2008) due to the cost and disruption of treatment processes.

Test Cell TC-1 will be planted with a mix (1:1) of cattails and spikerush (*Eleocharis* sp.) in a bed of native sand. The planting density will be on 60-cm (2 ft) centers to provide rapid establishment and grow-in. The target water depth in this Test Cell will be 15 cm (6 in).

Test Cell TC-2 will be planted with a mix (1:1) of cattails and bulrush in a bed of native sand. The planting density will be on 60-cm (2-ft) centers to provide rapid establishment and grow-in. The target water depth in this Test Cell will be 45 cm (18 in).

Test Cell TC-3 will be planted with an equal mix of southern naiad, coontail, water hyacinth, and duckweed over a bed of native sand. The planting density will be 400 liters (100 gallons) of each plant species to provide rapid establishment and grow-in. This is a preliminary estimate that will allow good coverage of each species and will be adjusted based on the actual plant propagules at hand. The target water depth in this Test Cell will be 90 cm.

Test Cell TC-4 will be planted with a mix of filamentous algae (green and blue-green species) and the macrophytic alga stonewort above a bed of #57 limestone. The planting density will be 400 liters (100 gallons) of each algae type to provide rapid establishment and grow-in. The target water depth in this Test Cell will be 120 cm (4 ft).

Test Cell TC-5 will be planted with a diverse mix of emergent wetland and aquatic plants, including spikerush, southern naiad, and stonewort over native soils. A diversity of opportunistic colonizing plant and algal species are expected and will be welcome in this MIX plant community. This plant diversity will be encouraged by engineering a range of water depths within TC-5. The desired range of water depths will be between 30 and 90 cm (1 to 3 ft).

3.1.2.3 Field-Scale Cells

Four in-ground Field-Scale Cells will be constructed for parallel and series operation (Figure 2). These cells will each have a wet area of about 62,700 m² (190x330 m [15.5 ac]) and will have native soil fill. Design embankment height in all cells will be 6 feet with 3:1 side slopes. The maximum water depth proposed in the Field-Scale Cells is 90 cm (about 3 feet), resulting in a minimum of about 90 cm (3 feet) of freeboard in all of the Field-Scale Cells. While this berm height will not be necessary during tests of shallower water plant communities such as EMV, this berm height is recommended in all cells to allow flexible water depth operation in light of preliminary findings. Water control structures in these Field-Scale Cells will include inlet, center, and outlet deep zones (bottom width 7.3 m [24 ft] with 3:1 side slopes) and outlet adjustable horizontal weirs. Inlet and outlet plumbing will allow parallel and series flow as illustrated in Figure 2.

Cattails and bulrush are combined in the deeper EMV treatments while a combination of cattails and spikerush are recommended in shallower EMV treatments. This plant selection is dictated by the general depth tolerance of each species. The purpose of planting these cells is to insure rapid plant colonization and stable water quality performance rather than to produce a specific mix of plant species. Considerable natural recruitment and resulting "self design" of wetland plant communities is anticipated in these test units in response to the controlled water regimes tested. Use of rooted plant windbreaks in the FAV/SAV Field-Scale Cell will be considered during final design. There is no plant removal or harvesting anticipated in the Field-Scale Cells.

Field-Scale Cell FS-1 will be planted with a mix (1:1) of cattails and spikerush in a bed of native sand. The planting density will be on 90-cm (3-ft) centers to provide rapid plant establishment and grow-in. The target water depth in this FS-1 will be 15 cm.

Field-Scale Cell FS-2 will be planted with a mix (1:1) of cattails and bulrush in a bed of native sand. The planting density will be on 90-cm (3-ft) centers to provide rapid plant establishment and grow-in. The target water depth in FS-2 will be 45 cm (18 in).

Field Scale Cell FS-3 will be planted with an equal mix of southern naiad, coontail, water hyacinth, and duckweed over a bed of native sand. The planting density will be 20,000 liters (5,000 gallons) of each plant species to provide rapid establishment and grow-in. This is a preliminary estimate that will allow good coverage of each species and will be adjusted based on the actual plant propagules at hand. The target water depth in FS-3 will be 90 cm.

Field Scale Cell FS-4 will be planted with a diverse mix of emergent wetland and aquatic plants, including spikerush, southern naiad, and stonewort over native soils. A diversity of opportunistic colonizing plant and algal species are expected and will be welcome in this MIX plant community. This plant diversity will be encouraged by engineering a range of water depths within FS-4. The desired range of water depths will be between 30 and 90 cm (1 to 3 ft).

3.2 Experimental Treatments

A total of 84 unique treatments are recommended for the proposed test program. These include 48 treatments at the Mesocosm scale, 20 treatments at the Test Cell scale, and 16 treatments at the Field-Scale units.

3.2.1 Mesocosm Treatments

for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide preliminary estimates of nutrient and solids kinetics for each of the tested plant community/sediment combinations, including three controls with no sediment.

Table 2 summarizes the forty-eight (48) proposed Mesocosm treatments, including their unit and treatment identification labels, their proposed duration in months, their mode of operation, their target plant community, their principal substrate, their design water depth, their design hydraulic loading rate (HLR), their nominal hydraulic residence time (nHRT), their physical dimensions, and their key test variables.

The eight Mesocosms will receive different treatments during each of six sequential six- to 10-month operational phases. It is expected that the Mesocosm construction will require about three months and that these systems will be operational after a Phase 1 six-month construction/startup period (Treatment IDs M1-1 through M8-1 construction and plant grow-in).

Mesocosm Phase 2 (Treatment IDs M1-2 through M8-2) will consist of filling the eight mesocosms to a target overflow level and using minimal inflows to keep water at a fixed depth for a period of six months ("Batch" mode of operation). The purpose of this treatment is to determine the lowest achievable nutrient and particulate solids concentrations in each treatment that can be achieved in the open environment. Surface water in these mesocosms will be sampled on a routine basis for all water quality parameters of interest (see Section 4) as well as for estimation of the BAN. As described below, an analytical surrogate test for BAN may be developed during this Phase 2 study period using mesocosm data for calibration.

Mesocosm Phase 3 (Treatment IDs M1-3 through M8-3) will initiate flow-through operation of the eight Mesocosms. An average low HLR of 1.5 cm/d (4.1 in/week) will be the target for the ten-month Phase 3 Mesocosm operation. Based on the target water depths, the range of nHRTs will be from 20 to 60 days. Surface water in these mesocosms will be sampled on a routine basis for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide preliminary estimates of nutrient and solids kinetics for each of the tested plant community/sediment combinations, including three controls with no sediment.

Mesocosm Phase 4 (Treatment IDs M1-4 through M8-4) will continue flow-through operation of the eight Mesocosms. An average medium HLR of 3.0 cm/d (8.3 in/week) will be the target for the ten-month Phase 4 Mesocosm operation. Based on the target water depths, the range of nHRTs will be from 10 to 30 days. Surface water in these mesocosms will be sampled on a routine basis for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide preliminary estimates of nutrient and solids kinetics for each of the tested plant community/sediment combinations, including three controls with no sediment.

Mesocosm Phase 5 (Treatment IDs M1-5 through M8-5) will continue flow-through operation of the eight Mesocosms. An average high HLR of 6.0 cm/d (16 in/week) will be the target for the ten-month Phase 5 Mesocosm operation. Based on the target water depths, the range of nHRTs will be from 5 to 15 days. Surface water in these mesocosms will be sampled on a routine basis for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide preliminary estimates of nutrient and solids kinetics for each of the tested plant community/sediment combinations, including three controls with no sediment.

Table 2. Proposed C-43 Test Facility Mesocosm Treatments

Unit ID	Treat ID	Phase	Duration (months)	Description	Mode[1]	Plant Community[2]	Substrate[3]	Water Depth (cm)	HLR[4] (cm/d)	Mean nHRT[5] (d)	Area (m^2)	Dimensions (m)	Key Test Variables[6]
M-1	M1-1	1	6	EMV sand startup	Startup	EMV	Sand	30	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-2	M2-1	1	6	SAV sand startup	Startup	SAV	Sand	60	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-3	M3-1	1	6	FAV sand startup	Startup	FAV	Sand	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-4	M4-1	1	6	Algae limestone startup	Startup	Algae	Limestone	60	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-5	M5-1	1	6	OW sand startup	Startup	OW	Sand	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-6	M6-1	1	6	FAV control startup	Startup	FAV	None	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-7	M7-1	1	6	Algae control startup	Startup	Algae	None	60	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-8	M8-1	1	6	OW control startup	Startup	OW	None	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-1	M1-2	2	6	EMV sand batch	Batch	EMV	Sand	30	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-2	M2-2	2	6	SAV sand batch	Batch	SAV	Sand	60	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-3	M3-2	2	6	FAV sand batch	Batch	FAV	Sand	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-4	M4-2	2	6	Algae limestone batch	Batch	Algae	Limestone	60	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-5	M5-2	2	6	OW sand batch	Batch	OW	Sand	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-6	M6-2	2	6	FAV control batch	Batch	FAV	None	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-7	M7-2	2	6	Algae control batch	Batch	Algae	None	60	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-8	M8-2	2	6	OW control batch	Batch	OW	None	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-1	M1-3	3	10	EMV sand low flow-thru	Flow-Thru	EMV	Sand	30	1.5	20	12	2.4 x 4.9	N-k values
M-2	M2-3	3	10	SAV sand low flow-thru	Flow-Thru	SAV	Sand	60	1.5	40	12	2.4 x 4.9	N-k values
M-3	M3-3	3	10	FAV sand low flow-thru	Flow-Thru	FAV	Sand	90	1.5	60	12	2.4 x 4.9	N-k values
M-4	M4-3	3	10	Algae limestone low flow-thru	Flow-Thru	Algae	Limestone	60	1.5	40	12	2.4 x 4.9	N-k values
M-5	M5-3	3	10	OW sand low flow-thru	Flow-Thru	OW	Sand	90	1.5	60	12	2.4 x 4.9	N-k values
M-6	M6-3	3	10	FAV contol low flow-thru	Flow-Thru	FAV	None	90	1.5	60	12	2.4 x 4.9	N-k values
M-7	M7-3	3	10	Algae control low flow-thru	Flow-Thru	Algae	None	60	1.5	40	12	2.4 x 4.9	N-k values
M-8	M8-3	3	10	OW control low flow-thru	Flow-Thru	OW	None	90	1.5	60	12	2.4 x 4.9	N-k values
M-1	M1-4	4	10	EMV sand medium flow-thru	Flow-Thru	EMV	Sand	30	3	10	12	2.4 x 4.9	N-k values
M-2	M2-4	4	10	SAV sand medium flow-thru	Flow-Thru	SAV	Sand	60	3	20	12	2.4 x 4.9	N-k values
M-3	M3-4	4	10	FAV sand medium flow-thru	Flow-Thru	FAV	Sand	90	3	30	12	2.4 x 4.9	N-k values
M-4	M4-4	4	10	Algae limestone medium flow-thru	Flow-Thru	Algae	Limestone	60	3	20	12	2.4 x 4.9	N-k values
M-5	M5-4	4	10	OW sand medium flow-thru	Flow-Thru	OW	Sand	90	3	30	12	2.4 x 4.9	N-k values
M-6	M6-4	4	10	FAV control medium flow-thru	Flow-Thru	FAV	None	90	3	30	12	2.4 x 4.9	N-k values
M-7	M7-4	4	10	Algae control medium flow-thru	Flow-Thru	Algae	None	60	3	20	12	2.4 x 4.9	N-k values
M-8	M8-4	4	10	OW control medium flow-thru	Flow-Thru	OW	None	90	3	30	12	2.4 x 4.9	N-k values
M-1	M1-5	5	10	EMV sand high flow-thru	Flow-Thru	EMV	Sand	30	6	5	12	2.4 x 4.9	N-k values
M-2	M2-5	5	10	SAV sand high flow-thru	Flow-Thru	SAV	Sand	60	6	10	12	2.4 x 4.9	N-k values
M-3	M3-5	5	10	FAV sand high flow-thru	Flow-Thru	FAV	Sand	90	6	15	12	2.4 x 4.9	N-k values
M-4	M4-5	5	10	Algae limestone high flow-thru	Flow-Thru	Algae	Limestone	60	6	10	12	2.4 x 4.9	N-k values
M-5	M5-5	5	10	OW sand high flow-thru	Flow-Thru	OW	Sand	90	6	15	12	2.4 x 4.9	N-k values
M-6	M6-5	5	10	FAV control high flow-thru	Flow-Thru	FAV	None	90	6	15	12	2.4 x 4.9	N-k values
M-7	M7-5	5	10	Algae control high flow-thru	Flow-Thru	Algae	None	60	6	10	12	2.4 x 4.9	N-k values
M-8	M8-5	5	10	OW control high flow-thru	Flow-Thru	OW	None	90	6	15	12	2.4 x 4.9	N-k values
M-1	M1-6	6	6	EMV sand batch	Batch	EMV	Sand	30	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-2	M2-6	6	6	SAV sand batch	Batch	SAV	Sand	60	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-3	M3-6	6	6	FAV sand batch	Batch	FAV	Sand	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-4	M4-6	6	6	Algae limestone batch	Batch	Algae	Limestone	60	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-5	M5-6	6	6	OW sand batch	Batch	OW	Sand	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-6	M6-6	6	6	FAV control batch	Batch	FAV	None	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-7	M7-6	6	6	Algae control batch	Batch	Algae	None	60	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN
M-8	M8-6	6	6	OW control batch	Batch	OW	None	90	0	--	12	2.4 x 4.9	C^*_{TN} ; BAN

Notes:

[1] Operational Mode: startup (includes construction time), batch (make-up water only), flow-thru [at average hydraulic loading rate (HLR)], series (cells-in-series), pulsed (dynamic flow rates)

[2] Plant Communities: EMV (emergent vegetation), SAV (submerged aquatic vegetation), FAV (floating aquatic vegetation), Algae (filamentous and macro algae), OW (open water), MIX (mixed plant community)

[3] Substrate: sand (imported, rinsed, medium-grained sand), native sand (on-site soils), limestone (#57 limerock or equivalent)

[4] HLR (hydraulic loading rate = flow/area)

[5] nHRT (nominal hydraulic residence time = water depth/HLR)

[6] Test Variables: C* (lowest-achievable background concentration), BAN (biologically available nitrogen as determined by treatment system and analytical test), N-kvalues (first-order removal rate constants for TN fractions, including TN, NH_3-N, NO_3+NO_2-N)

Mesocosm Phase 6 (Treatment IDs M1-6 through M8-6) will consist of maintaining the eight mesocosms at their target overflow level and using minimal inflows to keep water at a fixed depth for a final six-month period ("Batch" mode of operation). The purpose of this treatment is to confirm the C* values measured with the younger, startup plant communities and soil conditions in each treatment that can be achieved in the open environment. Surface water in these mesocosms will be sampled on a routine basis for all water quality parameters of interest (see Section 4) as well as for estimation of the BAN.

3.2.2 Test Cell Treatments

Table 3 summarizes the 20 proposed Test Cell treatments, including their unit and treatment identification labels, their proposed duration in months, their mode of operation, their target plant community, their principal substrate, their design water depth, their design hydraulic loading rate (HLR), their nominal hydraulic residence time (nHRT), their physical dimensions, and their key test variables.

Table 3. Proposed C-43 Test Facility Test Cell treatments

Unit ID	Treat ID	Phase	Duration (months)	Description	Mode[1]	Plant Community[2]	Substrate[3]	Water Depth (cm)	HLR[4] (cm/d)	Mean nHRT[5] (d)	Area (m^2)	Dimensions (m)	Key Test Variables[6]
TC-1	TC1-1	1	12	EMV shallow startup	Startup	EMV	Native sand	15	0	--	4,000	50 x 80	C^*_{TN} ; BAN
TC-2	TC2-1	1	12	EMV deep startup	Startup	EMV	Native sand	45	0	--	4,000	50 x 80	C^*_{TN} ; BAN
TC-3	TC3-1	1	12	SAV/FAV startup	Startup	SAV/FAV	Native sand	90	0	--	4,000	50 x 80	C^*_{TN} ; BAN
TC-4	TC4-1	1	12	Algae/OW startup	Startup	Algae/OW	Limestone	120	0	--	4,000	50 x 80	C^*_{TN} ; BAN
TC-5	TC5-1	1	12	MIX startup	Startup	EMV/SAV/FAV/Algae	Native sand	30-90	0	--	4,000	50 x 80	C^*_{TN} ; BAN
TC-1	TC1-2	2	12	EMV shallow low flow-thru	Flow-Thru	EMV	Native sand	15	1.5	10	4,000	50 x 80	N-k values
TC-2	TC2-2	2	12	EMV deep low flow-thru	Flow-Thru	EMV	Native sand	45	1.5	30	4,000	50 x 80	N-k values
TC-3	TC3-2	2	12	SAV/FAV low flow-thru	Flow-Thru	SAV/FAV	Native sand	90	1.5	60	4,000	50 x 80	N-k values
TC-4	TC4-2	2	12	Algae/OW low flow-thru	Flow-Thru	Algae/OW	Limestone	120	1.5	80	4,000	50 x 80	N-k values
TC-5	TC5-2	2	12	MIX low flow-thru	Flow-Thru	EMV/SAV/FAV/Algae	Native sand	30-90	1.5	40	4,000	50 x 80	N-k values
TC-1	TC1-3	3	12	EMV shallow medium flow-thru	Flow-Thru	EMV	Native sand	15	3	5	4,000	50 x 80	N-k values
TC-2	TC2-3	3	12	EMV deep medium flow-thru	Flow-Thru	EMV	Native sand	45	3	15	4,000	50 x 80	N-k values
TC-3	TC3-3	3	12	SAV/FAV medium flow-thru	Flow-Thru	SAV/FAV	Native sand	90	3	30	4,000	50 x 80	N-k values
TC-4	TC4-3	3	12	Algae/OW medium flow-thru	Flow-Thru	Algae/OW	Limestone	120	3	40	4,000	50 x 80	N-k values
TC-5	TC5-3	3	12	MIX medium flow-thru	Flow-Thru	EMV/SAV/FAV/Algae	Native sand	30-90	3	20	4,000	50 x 80	N-k values
TC-1	TC1-4	4	12	EMV shallow high flow-thru	Flow-Thru	EMV	Native sand	15	6	2.5	4,000	50 x 80	N-k values
TC-2	TC2-4	4	12	EMV deep high flow-thru	Flow-Thru	EMV	Native sand	45	6	7.5	4,000	50 x 80	N-k values
TC-3	TC3-4	4	12	SAV/FAV high flow-thru	Flow-Thru	SAV/FAV	Native sand	90	6	15	4,000	50 x 80	N-k values
TC-4	TC4-4	4	12	Algae/OW high flow-thru	Flow-Thru	Algae/OW	Limestone	120	6	20	4,000	50 x 80	N-k values
TC-5	TC5-4	4	12	MIX high flow-thru	Flow-Thru	EMV/SAV/FAV/Algae	Native sand	30-90	6	10	4,000	50 x 80	N-k values

Notes:

[1] Operational Mode: startup (includes construction time), batch (make-up water only), flow-thru [at average hydraulic loading rate (HLR)], series (cells-in-series), pulsed (dynamic flow rates)

[2] Plant Communities: EMV (emergent vegetation), SAV (submerged aquatic vegetation), FAV (floating aquatic vegetation), Algae (filamentous and macro algae), OW (open water), MIX (mixed plant community)

[3] Substrate: sand (imported, rinsed, medium-grained sand), native sand (on-site soils), limestone (#57 limerock or equivalent)

[4] HLR (hydraulic loading rate = flow/area)

[5] nHRT (nominal hydraulic residence time = water depth/HLR); average depth of 60 cm used to calculate nHRT for TC5

[6] Test Variables: C* (lowest-achievable background concentration), BAN (biologically available nitrogen as determined by treatment system and analytical test), N-kvalues (first-order removal rate constants for TN fractions, including TN, NH_3-N, NO_3+NO_2-N)

The five Test Cells will receive different treatments during each of four sequential twelve-month operational phases. It is expected that the Test Cell construction will require up to six months to complete and that these systems will be operational after a Phase 1 twelve-month batch-mode startup period (Treatment IDs TC1-1 through TC5-1 construction and plant grow-in). WSI's prior experience indicates that the treatment units may reach a quasi-steady state in terms of performance within one two years. The large-scale treatments are each twelve months to allow adequate time for internal biological readjustments following changes in HLR, water depth, or nHRT. A four-year operational time span is generally supported as adequate based on the evidence from the full-scale treatment wetlands reviewed in the Task 2 report.

Test Cell Phase 2 (Treatment IDs TC1-2 through TC5-2) will initiate flow-through operation of the five Test Cells. An average low HLR of 1.5 cm/d (4.1 in/week) will be the target for the twelve-month Test Cell Phase 2 operation. Based on the target water depths, the range of nHRTs will be from 10 to 80 days. Surface water in these Test Cells will be sampled on a routine basis for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide refined estimates of nutrient and solids kinetics for each of the tested plant community/sediment combinations.

Test Cell Phase 3 (Treatment IDs TC1-3 through TC5-3) will continue flow-through operation of the five Test Cells. An average medium HLR of 3.0 cm/d (8.3 in/week) will be the target for the twelve-month Test Cell Phase 3 operation. Based on the target water depths, the range of nHRTs will be from 5 to 40 days. Surface water in these Test Cells will be sampled on a routine basis for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide refined estimates of nutrient and solids kinetics for each of the tested plant community/sediment combinations.

Test Cell Phase 4 (Treatment IDs TC1-4 through TC5-4) will continue flow-through operation of the five Test Cells for the final twelve-month operational period. An average high HLR of 6.0 cm/d (16 in/week) will be the target for the twelve-month Test Cell Phase 4 operation. Based on the target water depths, the range of nHRTs will be from 2.5 to 20 days. Surface water in these Test Cells will be sampled on a routine basis for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide refined estimates of nutrient and solids kinetics for each of the tested plant community/sediment combinations.

3.2.3 Field Scale Treatments

Table 4 summarizes the 16 proposed Field Scale treatments, including their unit and treatment identification labels, their proposed duration in months, their mode of operation, their target plant community, their principal substrate, their design water depth, their design hydraulic loading rate (HLR), their nominal hydraulic residence time (nHRT), their physical dimensions, and their key test variables.

The four Field-Scale Cells will receive different treatments during each of four sequential twelve-month operational phases. It is expected that the Field-Scale Cell construction and plant grow-in will require up to twelve months for completion, and that these systems will not be fully operational until the end of the Phase 1 startup period (Treatment IDs FS1-1 through FS4-1). These Field-Scale Cells will be operated in batch mode during Phase 1.

Field-Scale Phase 2 (Treatment IDs FS1-2 through FS4-2) will initiate flow-through operation in parallel to the four Field-Scale cells. An average low HLR of 1.5 cm/d (4.1 in/week) will be the target for the twelve-month Field-Scale Phase 2 operation. Based on the target water depths, the range of nHRTs will be from 10 to 60 days. Surface water in these Field-Scale Cells will be sampled on a routine basis for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide refined estimates of nutrient and solids kinetics for each of the tested plant community/sediment combinations.

Table 4. Proposed C-43 Test Facility Field-Scale treatments

Unit ID	Treat ID	Phase	Duration (months)	Description	Mode[1]	Plant Community[2]	Substrate[3]	Water Depth (cm)	HLR[4] (cm/d)	Mean nHRT[5] (d)	Area (m^2)	Dimensions (m)	Key Test Variables[6]
FS-1	FS1-1	1	12	EMV shallow startup	Startup	EMV	Native sand	15	0	--	62,700	190 x 330	C^*_{TN} ; BAN
FS-2	FS2-1	1	12	EMV deep startup	Startup	EMV	Native sand	45	0	--	62,700	190 x 330	C^*_{TN} ; BAN
FS-3	FS3-1	1	12	SAV/FAV startup	Startup	SAV/FAV	Native sand	90	0	--	62,700	190 x 330	C^*_{TN} ; BAN
FS-4	FS4-1	1	12	MIX startup	Startup	EMV/SAV/FAV/Algae	Native sand	30-90	0	--	62,700	190 x 330	C^*_{TN} ; BAN
FS-1	FS1-2	2	12	EMV shallow flow-thru	Flow-Thru	EMV	Native sand	15	1.5	10	62,700	190 x 330	N-k values
FS-2	FS2-2	2	12	EMV deep flow-thru	Flow-Thru	EMV	Native sand	45	1.5	30	62,700	190 x 330	N-k values
FS-3	FS3-2	2	12	SAV/FAV flow-thru	Flow-Thru	SAV/FAV	Native sand	90	1.5	60	62,700	190 x 330	N-k values
FS-4	FS4-2	2	12	MIX flow-thru	Flow-Thru	EMV/SAV/FAV/Algae	Native sand	30-90	1.5	40	62,700	190 x 330	N-k values
FS-1	FS1-3	3	12	EMV shallow series	Series	EMV	Native sand	15	6	2.5	62,700	190 x 330	N-k values
FS-2	FS2-3	3	12	EMV deep series	Series	EMV	Native sand	45	6	7.5	62,700	190 x 330	N-k values
FS-3	FS3-3	3	12	SAV/FAV series	Series	SAV/FAV	Native sand	90	6	15	62,700	190 x 330	N-k values
FS-4	FS4-3	3	12	MIX series	Series	EMV/SAV/FAV/Algae	Native sand	30-90	6	10	62,700	190 x 330	N-k values
System		3	12		Series		Native sand	15-90	1.5	35	250,800	190x1320	N-k values
FS-1	FS1-4	4	12	EMV shallow series pulsed	Series/Pulsed	EMV	Native sand	15	2-12	1.3-7.5	62,700	190 x 330	N-k values
FS-2	FS2-4	4	12	EMV deep series pulsed	Series/Pulsed	EMV	Native sand	45	2-12	3.8-23	62,700	190 x 330	N-k values
FS-3	FS3-4	4	12	SAV/FAV series pulsed	Series/Pulsed	SAV/FAV	Native sand	90	2-12	7.5-45	62,700	190 x 330	N-k values
FS-4	FS4-4	4	12	MIX series pulsed	Series/Pulsed	EMV/SAV/FAV/Algae	Native sand	30-90	2-12	5-30	62,700	190 x 330	N-k values
System		4	12		Series/Pulsed		Native sand	15-90	0.5-3	17.5-105	250,800	190x1320	N-k values

Notes:

[1] Operational Mode: startup (includes construction time), batch (make-up water only), flow-thru [at average hydraulic loading rate (HLR)], series (cells-in-series), pulsed (dynamic flow rates)

[2] Plant Communities: EMV (emergent vegetation), SAV (submerged aquatic vegetation), FAV (floating aquatic vegetation), Algae (filamentous and macro algae), OW (open water), MIX (mixed plant community)

[3] Substrate: sand (imported, rinsed, medium-grained sand), native sand (on-site soils), limestone (#57 limerock or equivalent)

[4] HLR (hydraulic loading rate = flow/area)

[5] nHRT (nominal hydraulic residence time = water depth/HLR); average depth of 60 cm used to calculate nHRT for FS5

[6] Test Variables: C* (lowest-achievable background concentration), BAN (biologically available nitrogen as determined by treatment system and analytical test), N-kvalues (first-order removal rate constants for TN fractions, including TN, NH_3-N, NO_3+NO_2-N)

Field-Scale Phase 3 (Treatment IDs FS1-3 through FS4-3) will continue flow-through operation in series through the four Field-Scale Cells. The purpose of this test is to document how low nitrogen and phosphorus concentrations can be driven through multiple cells-in-series. An average system-wide HLR of 1.5 cm/d (6 cm/d per cell [4.1 in/week overall and 16 in/week per cell]) will be continued during the twelve-month Field-Scale Phase 3 operation. Based on the target water depths, the range of nHRTs will be from 2.5 to 15 days or 35 days for the four-cell system. Surface water in these Field-Scale Cells will be sampled on a routine basis for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide refined estimates of nutrient and solids kinetics for each of the tested plant community/sediment combinations.

Field-Scale Phase 4 (Treatment IDs FS1-4 through FS4-4) will continue series flow-through operation of the four Field-Scale Cells for the final twelve-month operational period. Inflows to these cells will be pulsed (system HLR between 0.5 and 3 cm/d [1.4 to 8.3 in/week]) to provide a twelve-month period of dynamic operation. Based on the target water depths, the range of average cell nHRTs will be from 1.3 to 45 days and the system nHRT will range from 17.5 to 105 days. Surface water in these Field-Scale Cells will be sampled on a routine basis for all water quality parameters of interest (see Section 4). Data collected during this operational phase will be used to provide refined estimates of nutrient and solid kinetics for each of the tested plant community/sediment combinations under dynamic operational conditions. These data are critical for calibrating a dynamic nitrogen model that would be useful during full-scale design.

Section 4.0 Implementation, Sampling, and Analysis Plan

4.1 Introduction

This report recommends a five to six-year period for implementation and completion of the C-43 WQTA Test Facility project (Figure 5). Key phases of the proposed timeline of activities necessary to complete this project include the following (some phases can be completed concurrently):

- System Final Design and Contracting (6 to 12 months)
- System Construction and Startup (12 months)
- System Operation and Monitoring (36 months)
- Final Data Analysis and Reporting (12 months)
- Abandonment and Decommissioning (6 months)

Assuming data are favorable and adequate, the next step after this testing period should be full-scale C-43 WQTA project implementation.

4.2 Test Facility Final Design and Permitting

The final design of the C-43 WQTA Test Facility will include the following components:

- Final site selection
- Grading plan
- Pumping and piping plan
- Mechanical/electrical plan
- Planting plan
- Facilities plan (e.g., fencing, field office, equipment storage, etc.)

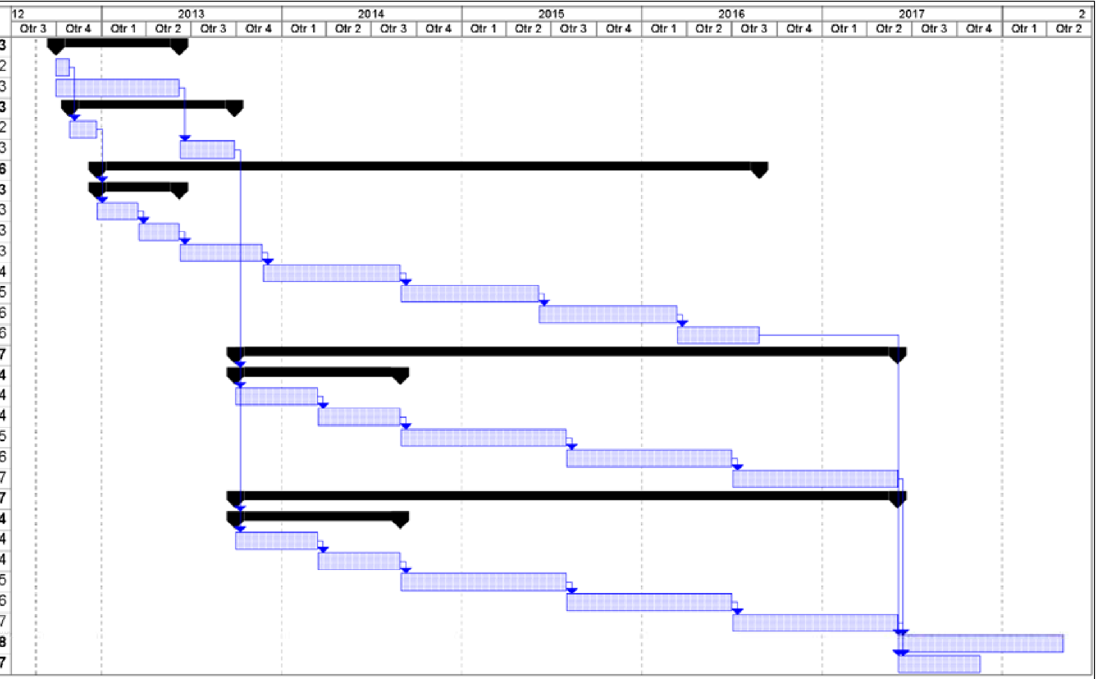
System design can be completed as one unit or can be phased into two parts:

- Mesocosm construction
- Test Cell and Field-Scale Cell construction

Final site selection will need to consider the best location on the BOMA property for the Test Facility in terms of access, water source and discharge point, constructability, and permitting. All necessary federal, state, and local permits will need to be applied for and received prior to project construction.

Figure 5. Proposed C-43 Water Quality Treatment and Demonstration Project Schedule

ID	Task Name	Duration	Start	Finish
1	**System Design**	**9 mons**	**Mon 10/1/12**	**Fri 6/7/13**
2	Mesocosms	1 mon	Mon 10/1/12	Fri 10/26/12
3	Test Cells / Field Scale Cells	9 mons	Mon 10/1/12	Fri 6/7/13
4	**Bidding, Purchasing**	**12 mons**	**Mon 10/29/12**	**Fri 9/27/13**
5	Mesocosms	2 mons	Mon 10/29/12	Fri 12/21/12
6	Test Cells / Field Scale Cells	4 mons	Mon 6/10/13	Fri 9/27/13
7	**Mesocosm Cells**	**48 mons**	**Mon 12/24/12**	**Fri 8/26/16**
8	Phase 1	**6 mons**	**Mon 12/24/12**	**Fri 6/7/13**
9	Construction	3 mons	Mon 12/24/12	Fri 3/15/13
10	Startup	3 mons	Mon 3/18/13	Fri 6/7/13
11	Phase 2	6 mons	Mon 6/10/13	Fri 11/22/13
12	Phase 3	10 mons	Mon 11/25/13	Fri 8/29/14
13	Phase 4	10 mons	Mon 9/1/14	Fri 6/5/15
14	Phase 5	10 mons	Mon 6/8/15	Fri 3/11/16
15	Phase 6	6 mons	Mon 3/14/16	Fri 8/26/16
16	**Test Cells**	**48 mons**	**Mon 9/30/13**	**Fri 6/2/17**
17	**Phase 1**	**12 mons**	**Mon 9/30/13**	**Fri 8/29/14**
18	Construction	6 mons	Mon 9/30/13	Fri 3/14/14
19	Startup	6 mons	Mon 3/17/14	Fri 8/29/14
20	Phase 2	12 mons	Mon 9/1/14	Fri 7/31/15
21	Phase 3	12 mons	Mon 8/3/15	Fri 7/1/16
22	Phase 4	12 mons	Mon 7/4/16	Fri 6/2/17
23	**Field Scale Cells**	**48 mons**	**Mon 9/30/13**	**Fri 6/2/17**
24	**Phase 1**	**12 mons**	**Mon 9/30/13**	**Fri 8/29/14**
25	Construction	6 mons	Mon 9/30/13	Fri 3/14/14
26	Startup	6 mons	Mon 3/17/14	Fri 8/29/14
27	Phase 2	12 mons	Mon 9/1/14	Fri 7/31/15
28	Phase 3	12 mons	Mon 8/3/15	Fri 7/1/16
29	Phase 4	12 mons	Mon 7/4/16	Fri 6/2/17
30	**Final Data Analysis and Reporting**	**12 mons**	**Mon 6/5/17**	**Fri 5/4/18**
31	**Decommissioning**	**6 mons**	**Mon 6/5/17**	**Fri 11/17/17**



Project: C43 WQ Test Facility
Date: Mon 8/20/12

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Additional soil testing may be needed to estimate potential infiltration rates for final site selection. The goal is to keep steady-state infiltration rates in the Test Cells and Field-Scale Cells less than about one fourth to one half of the lowest HLR to be tested (0.25x1.5 cm/d = 0.38 cm/d to 0.5x1.5 cm/d = 0.75 cm/d). If estimated steady-state infiltration rates are higher than the 0.75 cm/d target, then the test HLRs can be increased or site soils can be amended with finer soils to reduce rates. Preliminary water balance estimates are recommended for each experimental treatment during final design.

The pumping and piping plan will include the specific location and design of the inlet pump station; pump selection and power needs; pipeline materials, sizes, and alignments; and inlet and outlet structures.

The grading plan will include all site excavation and grading. This will include a graded pad area for the Mesocosms, a graded location for on-site field office and equipment storage, inlet and outlet canals (if needed), excavation and grading of the earthen Test Cells and Field-Scale Cells, and berm construction. Additional soil testing may be required during final design to evaluate the potential for seepage through the berms between and outside of the Test Cells and Field-Scale Cells. If seepage or cross-talk between cells is expected to be excessive, the berms may need to be lined, constructed with lower-permeability cores, or extended in width.

The mechanical/electrical plan will need to include electric service for pumps, on-site field-office (if needed), and monitoring equipment.

The planting plan will include the species of plants, desired propagules, the number of plant propagules, and the desired planting density and methods.

The facilities plan will include the size and type of a temporary field office and associated utilities (e.g., water supply, sewage storage and disposal, power, etc.), and on-site equipment storage.

4.3 System Construction and Startup

Mesocosm construction will require site selection, clearing and grading, installation of a relatively small pump (fuel-powered) and inlet and outlet water lines, purchase of a pre-fabricated head tank and multiple fiberglass Mesocosm tanks, and installation of soils and plants in the Mesocosms. This work can probably be completed in as little as three months. Following an estimated six-month construction/startup period the Mesocosms should be ready for Batch-mode testing. A longer startup period would likely be required if the system construction is completed during the late fall or winter months.

Construction of the larger test systems (Test Cells and Field-Scale Cells) will take longer and can proceed at a slower pace without limiting startup of the Mesocosms. Site preparations should only take about two months following notice-to-proceed. Preliminary grading for this scale project (total construction footprint of about 40 ha (100 ac) will require about three to five months of favorable weather. Final grading will take another two to three months and planting will require about two weeks. Mechanical, electrical, pumping, and piping can be completed concurrently with the earthwork construction activities. These test systems will require about twelve months for construction and initial operational startup.

4.4 System Operation and Monitoring

The test facility treatments were described in Section 3 above. This section of the conceptual design report describes the proposed system operation and monitoring plan.

System operation and monitoring will include the following specific activities:

- Pump station operation and maintenance
- Water flow and level control
- Field data collection
- Analytical sample analysis
- Data entry and validation
- Data storage and processing

4.4.1 Site Operation and Maintenance

The Site Manager will be responsible for pump station operation and maintenance. Depending on reliability of the pump station and electric service, this activity will need to be daily, to no less than three times per week. Routine checks will require observation of pumped inflows, including reading of the inflow totalizer(s); checks for leaks or losses; and routine and as-needed pump and pipeline maintenance. A Pump Station Field Log will be kept to document all visits made by the Site Manager.

Grounds maintenance will include mowing and/or weed eating grassed areas, trash collection and removal, and facility cleaning.

4.4.2 Test System Monitoring

The Site Manager will have the responsibility to check all inflows and water levels in the 17 individual test systems at least three times weekly. If inflows are measured manually, one measurement per week is adequate as long as inflow pump volumes are within specified tolerance limits. An Inflow and Levels Field Log will be kept to document all observations made by the Site Manager.

Field data collection (water temperature, pH, specific conductance, and dissolved oxygen) will be measured at one or more surface water stations weekly in all test units. Table 5 provides a summary of all data collection activities at the C-43 WQTA Test Facility. Detailed tables showing the recommended number of samples for each parameter are included in Appendix A. Continuous field data recording sondes may be used at both inflow and outflow stations and selected interior locations, if budget is adequate. Weekly field parameter measurements at inflow and outflow stations are also recommended. A Field Water Quality Data Log with calibration backup will be kept by the Site Manager to document all measurements of field water quality data.

Water quality and sediment samples collected for off-site laboratory analysis will be collected as per the attached schedule in Table 5. The recommended sampling frequency is based on WSI's experience with similar projects as well as cost considerations. These frequencies should be adequate to develop reliable model parameters for full-scale project design.

Figure 6 identifies the water quality sampling locations for each of the testing units. Routine analytical parameters, standard methods for analysis, preservation, and their holding times are summarized in Table 6. Figure 7 identifies the field equipment monitoring locations for each of the testing units.

In addition to the field and analytical parameters described above, the following types of physical and biological data collection efforts are also recommended:

- Weather data (continuous total insolation, air temperature, air speed, relative humidity, and rainfall) to be collected at the existing station at S-78
- Water levels (continuous recorders in all test units with two each in the Test and Field-Scale cells)
- Tracer study (annual study in the Test Cell and Field-Scale Cells)
- Plant species and cover estimates (weekly visual surveys; quarterly survey using aerial photography [Field Scale Cells])
- Faunal observations (weekly field notes of faunal uses of the test systems)
- Atmospheric N inputs will be estimated from monthly grab samples at three on-site locations.

4.4.3 Rapid Assessment of Biologically-Available Nitrogen

The District may wish to consider using the C-43 WQTA Test Facility as a platform for developing a new analytical or biological test for rapid estimation of BAN. Such a test could ultimately allow screening of raw water sources for BAN as a first step in full-scale compliance with the CRE TMDL. Two possible approaches to developing a rapid assessment test are described.

The first and ultimately the most cost effective BAN quantification approach might be an analytical laboratory test. The Expert Panel recommended development of a modified standard method for TKN analysis to only oxidize the potentially available organic nitrogen fractions to ammonium without oxidizing the more recalcitrant organic nitrogen forms. A series of weak acids should be considered and tested and the results of these tests compared to the surface water samples from the batch Mesocosm treatments described above. For example, a series of aliquots of a C-43 inflow water sample to the Mesocosms could be partially digested in the laboratory with a series of sulfuric acid dilutions, and the ammonium measured in these subsamples could be compared to the ammonium produced by TKN analysis of the same inflow sample. The difference in concentration between the TKN and each serial acid dilution might provide a range of ammonium concentrations, with the lower concentrations at more dilute digestions and higher concentrations at higher digestion concentrations. This range of concentrations would be compared to the TKN in outflow samples from the various Mesocosm batch treatments to determine which acid treatment most closely predicted the actual level of BAN in the Mesocosms. WSI does not have specific experience developing analytical tests for this purpose. However WSI has worked with the University of Florida (UF) Soil and Water Science Department on utilizing complex analytical procedures for fractionating P forms in the environment. We would recommend that UF or a similar lab be used to conduct the analytical work with input from project scientists.

Table 5. C-43 Test Facility Monitoring Activities

Parameter	Mesocosms		Test Cells		Field Scale Cells	
	In/Out	Internal	In/Out	Internal	In/Out	Internal
Field Sampling						
Flow	C(I), W	---	C(I)	---	C(I)	---
Water Stage	---	C(I)	C(I)	---	C(I)	---
Field Parameters (Temp, DO, pH, Cond)	C(I), W	W	C(I), W	W	C(I), W	W
Surface Water Quality						
Nitrogen (N) Series	W	---	W	M, Q	W	W, M
Phosphorus (P) Series	M	---	M	Q	W	M
Total organic carbon	M	---	M	Q	W	M
Total suspended solids	W	---	W	M, Q	W	M
Calcium	M	---	M	Q	W	M
Alkalinity	M	---	M	Q	W	M
Sulfate, Total	M	---	M	Q	W	M
Rainfall / Atmospheric Inputs						
Nitrogen (N) Series	M		M		M	
Phosphorus (P) Series	M		M		M	
Tracer Study						
Lithium	---	---	A	---	A	---
Biological Analyses						
Periphyton Cover	W	W	W	W	W	W
Macrophyte Cover	W	W	M	M	M, Q	M, Q
Faunal Observations	---	---	W	W	W	W
Sediments						
Total Kjeldahl N	Q	Q	Q	Q	Q	Q
Phosphorus (P) Series	Q	Q	Q	Q	Q	Q
Total organic carbon	Q	Q	Q	Q	Q	Q
Bulk density	Q	Q	Q	Q	Q	Q
Solids (percent)	Q	Q	Q	Q	Q	Q
Sulfate, Total	Q	Q	Q	Q	Q	Q

Notes:

C(I) = continuous with instrument
W = weekly
M = monthly
Q = quarterly
A = annually

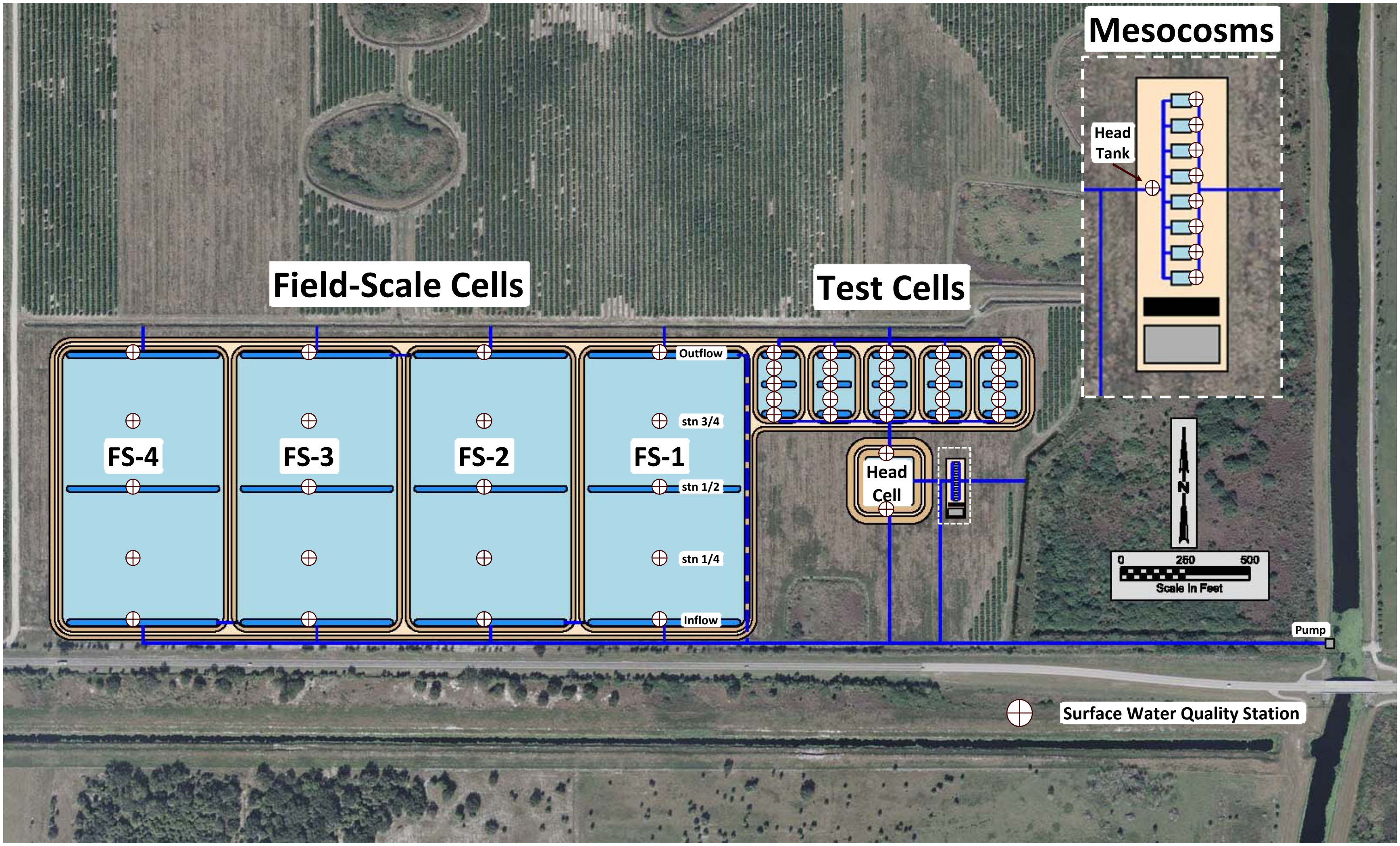


Figure 6. C-43 Test Facility Water Quality Monitoring Stations

Table 6. C-43 Test Facility Analytical Parameters

Parameter	Method	Preservative	Holding Time
Surface Water Quality			
Ammonia N, Total	EPA 350.1	H_2SO_4 to pH<2; cool (4°C)	28 days
Kjeldahl N, Total	EPA 351.2	H_2SO_4 to pH<2; cool (4°C)	28 days
Nitrate+Nitrite N, Total	EPA 353.2	H_2SO_4 to pH<2; cool (4°C)	28 days
Total P	EPA 365.3 (Spec)	H_2SO_4 to pH<2; cool (4°C)	28 days
Soluble Reactive P	EPA 365.2	cool (4°C)	48 hrs
Total Dissolved P	EPA 365.3 (Spec)	H_2SO_4 to pH<2; cool (4°C)	28 days
Total organic carbon	SM5310B	HCl to pH<2; cool (4°C)	28 days
Total suspended solids	EPA 160.2 - 500mL	cool (4°C)	7 days
Calcium	EPA 200.7/6010 (ICP)	HNO_3 to pH<2; cool (4°C)	180 days
Alkalinity	EPA 310.1	cool (4°C)	14 days
Lithium	EPA 200.7	HNO_3 to pH<2; cool (4°C)	180 days
Sulfate, Total	EPA 375.4	cool (4°C)	28 days
Sediments			
Total Kjeldahl N	EPA 351.2	cool (4°C)	28 days
Total P	EPA 365.4	cool (4°C)	28 days
Total Inorganic P	EPA 9056	cool (4°C)	48 hrs
Total organic carbon	EPA 415.1/9060	cool (4°C)	28 days
Bulk density	ASTM C1277	cool (4°C)	28 days
Solids (percent)	SM2540G	cool (4°C)	7 days
Sulfate, Total	EPA 375.4	cool (4°C)	28 days

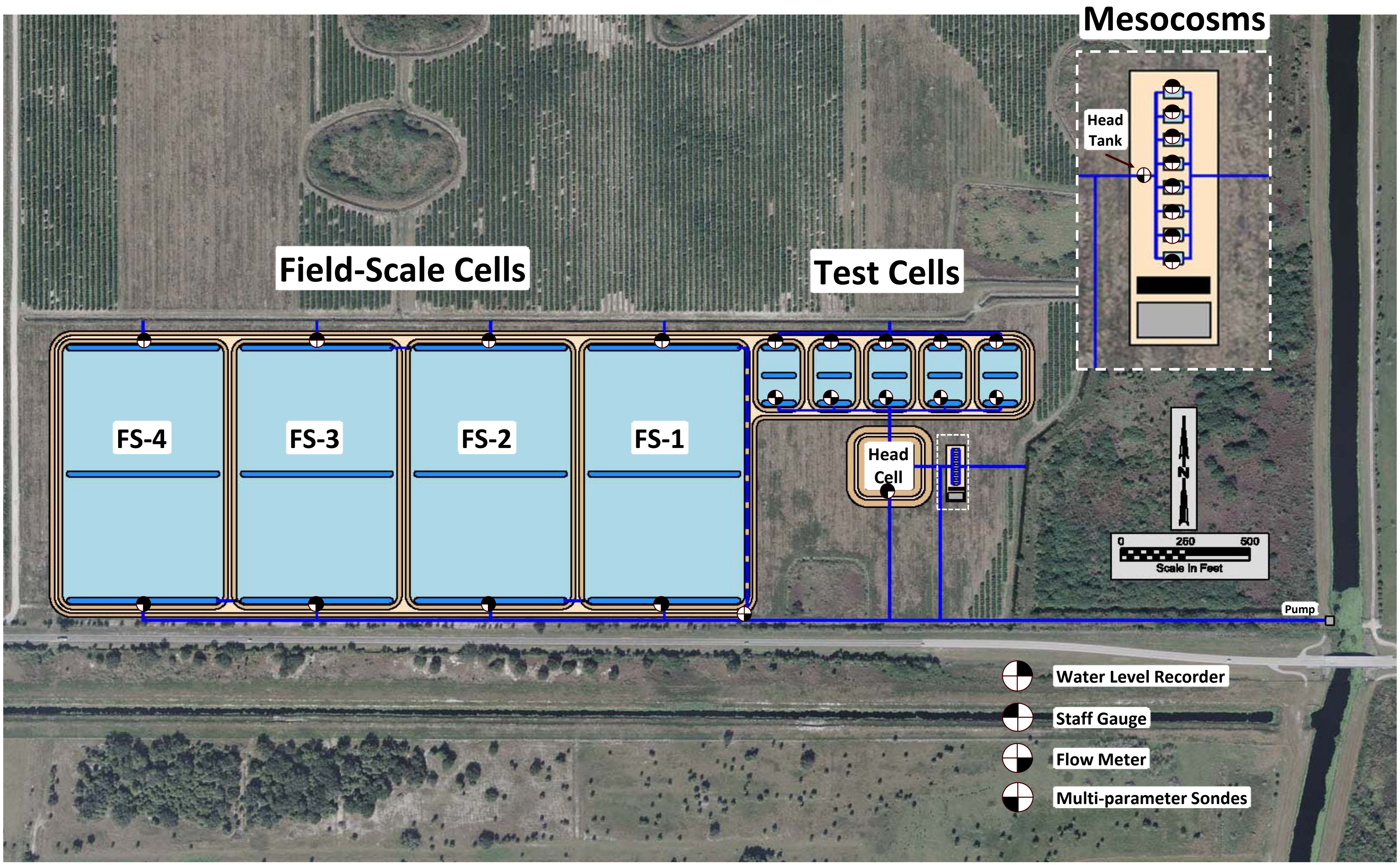


Figure 7. C-43 Test Facility Field Equipment Monitoring Locations

The second possible method recommended by the Expert Panel to better predict the BAN was the use of a modified FDEP Algal Growth Potential (AGP) test. Based on FDEP's web site (http://www.dep.state.fl.us/labs/biology/aalimnut.htm):

> *"The FDEP Biology Laboratory conducts Algal Growth Potential and Limiting Nutrient algal assays. Algal Growth Potential (AGP) tests and Limiting-Nutrient assays are the most direct and effective ways to determine the amount of nutrients available to organisms in surface waters, and the eutrophication potential of an aquatic system. These methods provide information on the biologically-available nutrients in the water. Few other laboratories in Florida have the capacity or the staff able to perform these highly useful tests. Algal Growth Potential (AGP) assays determine the maximum amount of algal growth that the nutrients in a water sample can support. This test provides a better indication of the potential for algal blooms than can be determined by chemical measurement of nutrient concentrations, because all nutrients in the water are not in a form that can be used by algal. Additionally, there may be substances present in the water that inhibit algal growth. In nature, other factors than nutrient availability can limit the growth of algae, such as the amount of light available, water temperature, or the amount of algal being consumed by algae-eating organisms. However, the AGP assay alerts officials to the potential for algal blooms."*

The AGP test incubates the planktonic alga *Selenastrum capricornutum* for fourteen days in flasks filled with sample water under artificial light in a laboratory. At the end of the fourteen-day incubation, the number of algal cells is quantified by use of an automated particle counter. The standard AGP test compares this algal growth between this sample, a deionized water control, and a sample with nitrogen and phosphorus added to allow maximum growth. For the proposed modified AGP test to estimate BAN, the algal growth in a range of surface water samples from the inflow to the outflow of the C-43 Mesocosms would be compared to growth of the algae in the DI control. The difference in algal cell multiplication between these samples would indicate how much algal growth potential might result from any BAN in the water samples. A complete revision of the AGP test for the purpose of the C-43 WQTA Project is not recommended. WSI suggests a discussion between DEP and SFWMD scientists to assess the costs and benefits of adapting this test (with or without modifications) to the specific needs of the C-43 WQTA project.

These two alternative approaches should be critically examined and discussed by District and FDEP staff before inclusion in the C-43 WQTA Test Facility Project. Development of a BAN rapid assessment protocol as part of this project might help with data interpretation and subsequent adaptive management but is not considered critical for developing design guidance and achieving project success. Additional effort beyond the scope of the conceptual plan will be needed to provide a cost estimate for one or both of these suggested assessment methods. For example, development of this cost estimate would include development of a detailed scope of work and budget in cooperation with a research-level analytical laboratory. If a BAN rapid assessment technique can be developed cost effectively within the project budget, then it is recommended.

4.4.4 Data Management and Quality Control

Data entry and validation will need to be conducted on a routine (weekly) basis. All data will be entered into Excel spreadsheets and uploaded into an Access database for long-term storage and data manipulation/query. Data validation will include a quality control check to see if data entries from laboratory reports to the database are accurate.

Data storage and processing will be the responsibility of the Site Manager. Data analysis and reporting will need to be conducted by staff with advanced experience.

4.5 Data Analysis and Reporting

Data analysis will proceed concurrently with monitoring. This will allow an adaptive management approach to determining performance and adjusting system management to maximize information gained. Quarterly data summaries are recommended as well as interim and final annual reports.

Types of data analyses that should be accomplished include:

- Data trend plots and analyses
- Water balances by treatment
- Pollutant mass balances
- Calculation of kinetic rate constants
- Non-parametric statistical analyses to detect significant treatment differences and temporal trends

All analyses will be compared to data expectations from similar systems in the literature and in the review of existing systems (Task 2 report).

4.6 Development of a Dynamic Nitrogen Model

The District routinely uses the Dynamic Model for Stormwater Treatment Areas Version 2 (DMSTA2, Walker and Kadlec 2008) to design STAs for phosphorus removal and to forecast future performance based on changes in dominant vegetation community, expansions of treatment area, and/or changing inflow volumes and concentrations. The DMSTA2 provides an excellent framework to begin the development of a dynamic nitrogen model because it already includes a highly flexible water balance component. In theory, the phosphorus dynamics module could be replaced with a nitrogen module. Data sets from the proposed project, and other systems, could be used to calibrate the nitrogen module for the different vegetation community types.

Development of a dynamic nitrogen model is not critical for full-scale design. For example, early STA design relied on more simplistic steady-state models that can be calibrated based on the data to be collected as described above. However the ability to optimize the full-scale design would likely be improved by development of a dynamic nitrogen model using the data collected from the proposed test facility. Additional effort beyond this conceptual design will be needed to provide a realistic cost estimate for model development. If determined to be cost effective and within the overall project budget, it is recommended that the District plan to develop a dynamic nitrogen model, based on DMSTA2, concurrently with the construction and operation of the C-43 Test Facility. It is reasonable to assume that the proposed nitrogen model could be developed and tested within the same five to six year time span of this testing project.

Section 5.0 Conceptual-Level Cost Estimates for Construction, Operation, and Testing

5.1 Introduction

The proposed C-43 WQTA Test Facility described in this report will require a significant financial investment to implement. WSI has considered cost impacts associated with all of the conceptual design elements in this report, including the selection of monitoring stations, parameter lists, and sample collection frequency and the duration of the proposed study. Clearly, costs for this test program could be reduced by cutting back on both the size and complexity of the various test units as well as reducing the sampling and analysis efforts. Costs could also be greatly increased above those estimated in this section by adding design complexity and numbers of sampling stations, increasing sampling frequency and project duration, and increasing lists of analytical parameters to be sampled. Since no target testing budget was provided, the sampling design recommendations in this report are based on WSI's best professional judgment and will need to be refined by the District in light of actual budget constraints.

5.2 Test Facility Conceptual Cost Estimate

Table 7 provides a summary of the conceptual-level capital (engineering and construction) cost estimate for the proposed test facilities described in Section 3 of this report. Unit costs are based on multiple sources including FDOT Item Average Unit Costs (2011 Statewide), vendor quotes and price sheets, WSI's past experience with similar projects, and other sources (CH2M HILL 2010). Appendix B provides an expanded summary table with the cost basis for each line item as well as additional relevant cost data. The estimated total capital cost is $5.06 million with $340,000 estimated for engineering and permitting and $4.72 million for construction. Key assumptions of the cost estimate include the following:

- Earthwork
  - Embankments are 1.8 m (6 feet) above natural grade with 4.2 m (14-ft) top width and 3:1 side slopes
  - Earthwork volumes are based on a flat existing grade; actual site topography was not used
  - Earthwork was not optimized to balance cut and fill
  - Excess cut material can be stockpiled on the BOMA property
- Sitework
  - A stabilized access road is included (4.5 m [15-ft width], 1,980 m [6600-ft] length)
  - Embankment tops are stabilized

- A shellrock pad (22.5 m [75-ft] x 70 m [230-ft]) is included for the site trailer, mesocosm tanks, and parking area
- The site perimeter (3,000 m [10,000 linear feet]) will be fenced with chain-link and 3-strand barb wire
- Embankment side slopes will be hydroseeded
- Monitoring boardwalks will be constructed from painted steel scaffold frames with aluminum deck boards

- Buildings
  - A site trailer and pump house/electrical building are included
- Pumping
  - The master pump station will be a vendor-provided package system complete with controls. The pump station will be enclosed in a building.
  - A temporary, fuel-powered pump will be used for interim water supply to the Mesocosm facilities.
- Piping and Appurtenances
  - Primary force main is above grade 30-cm (12-in) diameter HDPE except at road crossings and embankment penetrations
  - All embankment pipe penetrations will include seepage collars
  - Field-scale inflows consist of 15-cm (6-in) HDPE pipe with control valves and flow meters
  - Field-scale outflows and series-flow connections consist of 45-cm (18-in) diameter HDPE culvert with Agridrain Inline Water Control Structures
  - Head Cell inflow piping will consist of 165 m (550 feet) of 15-cm (6-in) HDPE force main with a control valve
  - Head Cell outflow piping will consist of a 6-inch PVC header with 7.5-cm (3-in) PVC supply lines to each Test Cell
  - Test Cell inflows will be outfitted with flow meters and control valves
  - Test Cell outflows will consist of 20-cm (8-in) PVC pipe with Agridrain Inline Water Control Structures
  - All cell drainage lines will discharge to the east-west irrigation ditch immediately north of the proposed project footprint
- Wetland Planting
  - Cells will be planted with nursery-grown or field-harvested material as described in Section 3.1
- Miscellaneous Equipment

  - Costs are included for likely monitoring equipment needs such as a weather station, water quality sondes, autosamplers, refrigerator, water level recorders, and staff gauges

Field-Scale flow meters include one each on the main pumped supply lines, and one on the auxiliary line to Cell FS-1 when in series-flow. There is one flow meter for each Test Cell. Based on past experience with the SFWMD's PSTA mesocosms, there are no reliable flow meters available that operate at such low flows. Mesocosm flow rates will be measured manually with a stop watch and graduated cylinder. The five autosamplers are intended to be rotated around the site, primarily for tracer studies. Stage recorders are proposed at the head cell (n=1), at the upstream and downstream ends of each Field-Scale Cell (n=8), at the downstream end of each Test Cell (n=5), and in each mesocosm (n=8) for a total of 22.

5.3 Operation, Maintenance, and Test Facility Management Cost Estimate

Operation and maintenance cost estimates include both routine O&M as well as the costs for sample collection and preliminary data analysis. As described above in Section 4, routine O&M will include pump operation and maintenance, maintenance of a weather station, site security, mowing, cleaning, and water level control. Sample collection and data analysis activities were also described in Section 4 above.

It is estimated that two full-time staff will be needed to effectively operate the C-43 WQTA Test Facility and complete all of the O&M and site/data management functions described in this plan. The Site Manager should have a M.S./M.E. degree or equivalent in environmental science/engineering and no less than five years of applicable experience. The second full-time equivalent person should have a job title equivalent to Site Technician and should have a minimum of a B.S./B.E. in environmental science/engineering and at least three years of prior applicable experience. Estimated burdened (3.0 multiplier) rates for these two full-time employees are $225,000 and $135,000 per year, respectively, for an estimated total annual labor cost of about $360,000. Costs for higher-level personnel management and data analysis/reporting are not included in this estimate.

Other O&M costs that are anticipated to be necessary include the following:

- Electrical power consumption for the site trailer;
- Electrical power consumption for the pump station;
- Potable and sanitary services for the site trailer; and
- Phone/internet service for the site trailer.

Estimates for these items are not included in this report.

5.4 Estimated Laboratory Costs

Table 8 summarizes estimated costs for laboratory analytical services[1]. These estimates do not include costs for development of an AGP or analytical rapid BAN test. Total estimated analytical costs are approximately $1.6 million for the 4-year study period. Analytical costs by system scale are estimated to be $418,000 for the Mesocosms, $444,000 for the Test Cells, and $763,000 for the Field-Scale Cells. Detailed costs by testing scale are included in Appendix A. At this time, analytical costs have not been included for trace metals or organics. These parameters can be added at the District's discretion.

5.5 Dynamic Nitrogen Model Development Costs

Costs for development of a dynamic nitrogen model are not included in this report.

[1] Analytical unit costs estimates from Advanced Environmental Laboratories, Inc.

Table 7. C-43 Test Facility Conceptual Capital Cost Estimate

Category	Description	Quantity	Units	Unit Price	Amount
Earthwork					**$ 1,353,000.00**
	Excavation	180,400	CY	$ 3.00	$ 541,200.00
	Backfill	120,650	CY	$ 4.50	$ 542,925.00
	Hauling	59,750	CY	$ 4.50	$ 268,875.00
Sitework					**$ 956,933.33**
	Access Road	11,000	SY	$ 10.00	$ 110,000.00
	Berm Stabilized Surface	26,300	SY	$ 10.00	$ 263,000.00
	Shellrock Pad	2,000	SY	$ 10.00	$ 20,000.00
	Chain Link Fence with 3-strand	10,000	LF	$ 20.00	$ 200,000.00
	Gates	1	LS	$ 2,500.00	$ 2,500.00
	Head Cell Liner	6,667	SY	$ 11.00	$ 73,333.33
	Hydroseeding	590,000	SF	$ 0.05	$ 29,500.00
	Mesocosm Tanks	8	EA	$ 6,000.00	$ 48,000.00
	Head Tank (1,550 gal)	1	EA	$ 1,000.00	$ 1,000.00
	Head Tank Stand	1	EA	$ 2,000.00	$ 2,000.00
	Agridrain (8'x18" PVC)	12	EA	$ 4,000.00	$ 48,000.00
	Boardwalks	5,700	LF	$ 28.00	$ 159,600.00
Buildings					**$ 70,000.00**
	Site Trailer	1	LS	$ 35,000.00	$ 35,000.00
	Pump/Electrical Building	1	LS	$ 35,000.00	$ 35,000.00
Pumping Facilities					**$ 152,500.00**
	Master Pump Station and Controls	1	LS	$ 150,000.00	$ 150,000.00
	Temporary Mesocosm Pump	1	LS	$ 2,500.00	$ 2,500.00
Piping and Appurtenances					**$ 423,250.00**
	Main Supply (12" HDPE)	4,600	LF	$ 45.00	$ 207,000.00
	Field Scale Inflows (6" HDPE)	1,500	LF	$ 30.00	$ 45,000.00
	Field Scale Outflows (18" HDPE)	400	LF	$ 50.00	$ 20,000.00
	Field Scale Series Connections (18" HDPE)	300	LF	$ 50.00	$ 15,000.00
	Head Cell Inflow (6" HDPE)	550	LF	$ 30.00	$ 16,500.00
	Head Cell Outflow (6" PVC)	1,000	LF	$ 20.00	$ 20,000.00
	Test Cell Inflows (3" PVC)	150	LF	$ 3.00	$ 450.00
	Test Cell Outflows (8" PVC)	1,100	LF	$ 30.00	$ 33,000.00
	Head Tank Temporary Supply (4" PVC)	550	LF	$ 3.00	$ 1,650.00
	Mesocosm Supply Piping	1	LS	$ 2,000.00	$ 2,000.00
	Mesocosm Discharge (4" PVC)	300	LF	$ 3.00	$ 900.00
	Seepage Collars	25	EA	$ 150.00	$ 3,750.00
	Field Scale Inflow Control Valves	5	EA	$ 4,000.00	$ 20,000.00
	Field Scale Flow Meters	5	EA	$ 2,000.00	$ 10,000.00
	Field Scale Outflow Gate Valves (18")	10	EA	$ 1,000.00	$ 10,000.00
	Field Scale Inflow Gate Valves (6")	4	EA	$ 400.00	$ 1,600.00
	Head Cell Inflow Control Valve	1	EA	$ 4,000.00	$ 4,000.00
	Head Cell Gate Valve (6")	1	EA	$ 400.00	$ 400.00
	Test Cell Inflow Control Valves	5	EA	$ 250.00	$ 1,250.00
	Test Cell Flow Meters	5	EA	$ 1,500.00	$ 7,500.00
	Test Cell Inflow Gate Valves (3")	5	EA	$ 50.00	$ 250.00
	Test Cell Outflow Gate Valves (8")	5	EA	$ 600.00	$ 3,000.00
Electrical					**$ 100,000.00**
	Power Supply to Site and Pump Station	1	LS	$ 100,000.00	$ 100,000.00
Wetland Vegetation					**$ 190,000.00**
	Emergent Plants	40	AC	$ 4,000.00	$ 160,000.00
	Submerged Aquatic Vegetation	20	AC	$ 500.00	$ 10,000.00
	Floating Aquatic Vegetation	20	AC	$ 1,000.00	$ 20,000.00
Miscellaneous Equipment					**$ 126,700.00**
	Truck	1	EA	$ 30,000.00	$ 30,000.00
	Multi-parameter Sondes	5	EA	$ 8,000.00	$ 40,000.00
	Autosampler	5	EA	$ 4,000.00	$ 20,000.00
	Refrigerator	1	EA	$ 1,000.00	$ 1,000.00
	Vented Water Level Recorder	22	EA	$ 1,500.00	$ 33,000.00
	Staff Gauges	27	EA	$ 100.00	$ 2,700.00
Construction Total					**$ 3,372,383.33**
	Overhead	10%			$ 337,238.33
	Profit	5%			$ 168,619.17
	Mobilization/Demobilization/Bonding	5%			$ 168,619.17
	Contingency	20%			$ 674,476.67
	Engineering and Permitting	10%			$ 337,238.33
Capital Cost Total					**$ 5,058,575.00**

Table 8. C-43 Test Facility Analytical Laboratory Cost Estimate

Parameter	Number of Samples: Mesocosms	Number of Samples: Test Cells	Number of Samples: Field Scale Cells	Number of Samples: Total	Analytical Cost: Mesocosms	Analytical Cost: Test Cells	Analytical Cost: Field Scale Cells	Analytical Cost: Total
Field Sampling								
Flow	3,328	C(I)	C(I)	3,328	$ -	$ -	$ -	$ -
Water Stage	C(I)	C(I)	C(I)	C(I)	$ -	$ -	$ -	$ -
Water temperature	4,992	3,120	2,496	10,608	$ -	$ -	$ -	$ -
Dissolved oxygen	4,992	3,120	2,496	10,608	$ -	$ -	$ -	$ -
pH	4,992	3,120	2,496	10,608	$ -	$ -	$ -	$ -
Conductivity	4,992	3,120	2,496	10,608	$ -	$ -	$ -	$ -
Total Dissolved Solids	4,992	3,120	2,496	10,608	$ -	$ -	$ -	$ -
Surface Water Quality								
Nitrogen (N) Series								
Total N	2,246	2,074	2,938	7,258	$ -	$ -	$ -	$ -
Organic N, Total	2,246	2,074	2,938	7,258	$ -	$ -	$ -	$ -
Ammonia N, Total	2,246	2,074	2,938	7,258	$ 31,450	$ 29,030	$ 41,126	$ 101,606
Kjeldahl N, Total	2,246	2,074	2,938	7,258	$ 51,667	$ 47,693	$ 67,565	$ 166,925
Nitrate+Nitrite N, Total	2,246	2,074	2,938	7,258	$ 38,189	$ 35,251	$ 49,939	$ 123,379
Total Dissolved N	2,246	2,074	2,938	7,258	$ -	$ -	$ -	$ -
Organic N, Dissolved	2,246	2,074	2,938	7,258	$ -	$ -	$ -	$ -
Ammonia N, Dissolved	2,246	2,074	2,938	7,258	$ 31,450	$ 29,030	$ 41,126	$ 101,606
Total Kjeldahl N, Dissolved	2,246	2,074	2,938	7,258	$ 51,667	$ 47,693	$ 67,565	$ 166,925
Nitrate+Nitrite N, Dissolved	2,246	2,074	2,938	7,258	$ 38,189	$ 35,251	$ 49,939	$ 123,379
Phosphorus (P) Series								
Total P	2,246	1,882	2,170	6,298	$ 42,682	$ 35,750	$ 41,222	$ 119,654
Soluble Reactive P	518	730	2,170	3,418	$ 9,850	$ 13,862	$ 41,222	$ 64,934
Total Dissolved P	518	730	2,170	3,418	$ 9,850	$ 13,862	$ 41,222	$ 64,934
Total organic carbon	518	730	2,170	3,418	$ 10,368	$ 14,592	$ 43,392	$ 68,352
Total suspended solids	2,246	2,074	2,170	6,490	$ 22,464	$ 20,736	$ 21,696	$ 64,896
Calcium [1]	518	730	2,170	3,418	$ 15,552	$ 21,888	$ 65,088	$ 102,528
Alkalinity	518	730	2,170	3,418	$ 7,776	$ 10,944	$ 32,544	$ 51,264
Sulfate, Total	518	730	2,170	3,418	$ 8,813	$ 12,403	$ 36,883	$ 58,099
Rainfall / Atmospheric Inputs								
Nitrogen (N) Series								
Total N	58	58	58	173	$ -	$ -	$ -	$ -
Organic N, Total	58	58	58	173	$ -	$ -	$ -	$ -
Ammonia N, Total	58	58	58	173	$ 806	$ 806	$ 806	$ 2,419
Kjeldahl N, Total	58	58	58	173	$ 1,325	$ 1,325	$ 1,325	$ 3,974
Nitrate+Nitrite N, Total	58	58	58	173	$ 979	$ 979	$ 979	$ 2,938
Total Dissolved N	58	58	58	173	$ -	$ -	$ -	$ -
Organic N, Dissolved	58	58	58	173	$ -	$ -	$ -	$ -
Ammonia N, Dissolved	58	58	58	173	$ 806	$ 806	$ 806	$ 2,419
Total Kjeldahl N, Dissolved	58	58	58	173	$ 1,325	$ 1,325	$ 1,325	$ 3,974
Nitrate+Nitrite N, Dissolved	58	58	58	173	$ 979	$ 979	$ 979	$ 2,938
Phosphorus (P) Series								
Total P	58	58	58	173	$ 1,094	$ 1,094	$ 1,094	$ 3,283
Soluble Reactive P	58	58	58	173	$ 1,094	$ 1,094	$ 1,094	$ 3,283
Total Dissolved P	58	58	58	173	$ 1,094	$ 1,094	$ 1,094	$ 3,283
Tracer Study								
Lithium [1]	0	1,440	1,152	2,592	$ -	$ 43,200	$ 34,560	$ 77,760
Biological Analyses								
Periphyton Cover	1,664	1,248	240	3,152	$ -	$ -	$ -	$ -
Macrophyte Cover	1,664	288	240	2,192	$ -	$ -	$ -	$ -
	0	0	16	16	$ -	$ -	$ 40,000	$ 40,000
Faunal Observations	0	1,040	832	1,872	$ -	$ -	$ -	$ -
Sediments								
Total Kjeldahl N	154	96	154	403	$ 3,533	$ 2,208	$ 3,533	$ 9,274
Phosphorus (P) Series								
Total P	154	96	154	403	$ 5,376	$ 3,360	$ 5,376	$ 14,112
Total Inorganic P	154	96	154	403	$ 3,840	$ 2,400	$ 3,840	$ 10,080
Total organic carbon	154	96	154	403	$ 11,520	$ 7,200	$ 11,520	$ 30,240
Bulk density	154	96	154	403	$ 7,680	$ 4,800	$ 7,680	$ 20,160
Solids (percent)	154	96	154	403	$ 2,304	$ 1,440	$ 2,304	$ 6,048
Sulfate, Total	154	96	154	403	$ 3,840	$ 2,400	$ 3,840	$ 10,080
Totals	63,507	50,106	63,517	177,130	$ 417,562	$ 444,499	$ 762,688	$ 1,624,749

Notes:
C(I) = continuous with instrument
[1] = price includes laboratory metals prep charge

Section 6.0 References

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Appendix A

C-43 WQTA Test Facility Sampling Plan

Appendix A. C-43 Test Facility – Mesocosm Sampling Plan and Analytical Costs

Parameter	Sampling Period (years)	Sample Frequency: Head Tank Outflow	Sample Frequency: Inflow	Sample Frequency: 1/2	Sample Frequency: Outflow	Samples Collected: Head Tank Outflow	Samples Collected: Inflow	Samples Collected: 1/2	Samples Collected: Outflow	Samples Collected: Total	Number of Samples: Field	Number of Samples: QC	Number of Samples: Total	Analytical Cost: Unit ($/sample)	Analytical Cost: Total ($)
Field Sampling															
Flow	4.0	---	W	---	W	0	208	0	208	3,328	3,328	0	3,328	$ -	$ -
Water Stage	4.0	---	---	C(I)	---	0	0	0	0	0	0	0	0	$ -	$ -
Water temperature	4.0	C(I)	W	W	W	0	208	208	208	4,992	4,992	0	4,992	$ -	$ -
Dissolved oxygen	4.0	C(I)	W	W	W	0	208	208	208	4,992	4,992	0	4,992	$ -	$ -
pH	4.0	C(I)	W	W	W	0	208	208	208	4,992	4,992	0	4,992	$ -	$ -
Conductivity	4.0	C(I)	W	W	W	0	208	208	208	4,992	4,992	0	4,992	$ -	$ -
Total Dissolved Solids	4.0	C(I)	W	W	W	0	208	208	208	4,992	4,992	0	4,992	$ -	$ -
Surface Water Quality															
Nitrogen (N) Series															
Total N	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ -	$ -
Organic N, Total	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ -	$ -
Ammonia N, Total	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ 14	$ 31,450
Kjeldahl N, Total	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ 23	$ 51,667
Nitrate+Nitrite N, Total	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ 17	$ 38,189
Total Dissolved N	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ -	$ -
Organic N, Dissolved	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ -	$ -
Ammonia N, Dissolved	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ 14	$ 31,450
Total Kjeldahl N, Dissolved	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ 23	$ 51,667
Nitrate+Nitrite N, Dissolved	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ 17	$ 38,189
Phosphorus (P) Series															
Total P	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ 19	$ 42,682
Soluble Reactive P	4.0	M	---	---	M	48	0	0	48	432	432	86	518	$ 19	$ 9,850
Total Dissolved P	4.0	M	---	---	M	48	0	0	48	432	432	86	518	$ 19	$ 9,850
Total organic carbon	4.0	M	---	---	M	48	0	0	48	432	432	86	518	$ 20	$ 10,368
Total suspended solids	4.0	W	---	---	W	208	0	0	208	1,872	1,872	374	2,246	$ 10	$ 22,464
Calcium [1]	4.0	M	---	---	M	48	0	0	48	432	432	86	518	$ 30	$ 15,552
Alkalinity	4.0	M	---	---	M	48	0	0	48	432	432	86	518	$ 15	$ 7,776
Sulfate, Total	4.0	M	---	---	M	48	0	0	48	432	432	86	518	$ 17	$ 8,813
Rainfall / Atmospheric Inputs															
Nitrogen (N) Series															
Total N	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ -	$ -
Organic N, Total	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ -	$ -
Ammonia N, Total	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ 14	$ 806
Kjeldahl N, Total	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ 23	$ 1,325
Nitrate+Nitrite N, Total	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ 17	$ 979
Total Dissolved N	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ -	$ -
Organic N, Dissolved	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ -	$ -
Ammonia N, Dissolved	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ 14	$ 806
Total Kjeldahl N, Dissolved	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ 23	$ 1,325
Nitrate+Nitrite N, Dissolved	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ 17	$ 979
Phosphorus (P) Series															
Total P	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ 19	$ 1,094
Soluble Reactive P	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ 19	$ 1,094
Total Dissolved P	4.0	M	---	---	---	48	0	0	0	48	48	10	58	$ 19	$ 1,094
Biological Analyses															
Periphyton Cover	4.0	---		W		0		208		1,664	1,664	0	1,664	$ -	$ -
Macrophyte Cover	4.0	---		W		0		208		1,664	1,664	0	1,664	$ -	$ -
Sediments															
Total Kjeldahl N	4.0	---		Q		0		16		128	128	26	154	$ 23	$ 3,533
Phosphorus (P) Series															
Total P	4.0	---		Q		0		16		128	128	26	154	$ 35	$ 5,376
Total Inorganic P	4.0	---		Q		0		16		128	128	26	154	$ 25	$ 3,840
Total organic carbon	4.0	---		Q		0		16		128	128	26	154	$ 75	$ 11,520
Bulk density	4.0	---		Q		0		16		128	128	26	154	$ 50	$ 7,680
Solids (percent)	4.0	---		Q		0		16		128	128	26	154	$ 15	$ 2,304
Sulfate, Total	4.0	---		Q		0		16		128	128	26	154	$ 25	$ 3,840
Totals											**58,192**	**5,315**	**63,507**		**$417,562**

Notes:

Number of cells =	8
Number of rainfall stations =	1
Sampling period (years) =	4

W = weekly
M = monthly
Q = quarterly
A = annually
C(I) = continuous with instrument
QC = Field QC measures consist of field generated equipment blanks (EB), field-cleaned equipment blanks (FCEB), field blanks (FB), split samples (SS), and replicate samples (RS).
[1] = price includes laboratory metals prep charge

Appendix A. C-43 Test Facility – Test Cell Sampling Plan and Analytical Costs

Parameter	Sampling Period (years)	Sample Frequency: Head Cell Outflow	Inflow	1/4	1/2	3/4	Outflow	Samples Collected: Head Cell Outflow	Inflow	1/4	1/2	3/4	Outflow	Total	Number of Samples: Field	QC	Total	Analytical Cost: Unit ($/sample)	Total ($)
Field Sampling																			
Flow	4.0	---	C(I)	---	---	---	C(I)	0	0	0	0	0	0	0	0	0	0	$ -	$ -
Water Stage	4.0	---	C(I)	---	---	---	C(I)	0	0	0	0	0	0	0	0	0	0	$ -	$ -
Water temperature	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	3,120	3,120	0	3,120	$ -	$ -
Dissolved oxygen	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	3,120	3,120	0	3,120	$ -	$ -
pH	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	3,120	3,120	0	3,120	$ -	$ -
Conductivity	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	3,120	3,120	0	3,120	$ -	$ -
Total Dissolved Solids	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	3,120	3,120	0	3,120	$ -	$ -
Surface Water Quality																			
Nitrogen (N) Series																			
Total N	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ -	$ -
Organic N, Total	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ -	$ -
Ammonia N, Total	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ 14	$ 29,030
Kjeldahl N, Total	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ 23	$ 47,693
Nitrate+Nitrite N, Total	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ 17	$ 35,251
Total Dissolved N	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ -	$ -
Organic N, Dissolved	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ -	$ -
Ammonia N, Dissolved	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ 14	$ 29,030
Total Kjeldahl N, Dissolved	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ 23	$ 47,693
Nitrate+Nitrite N, Dissolved	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ 17	$ 35,251
Phosphorus (P) Series																			
Total P	4.0	W	Q	Q	Q	Q	W	208	16	16	16	16	208	1,568	1,568	314	1,882	$ 19	$ 35,750
Soluble Reactive P	4.0	M	Q	Q	Q	Q	M	48	16	16	16	16	48	608	608	122	730	$ 19	$ 13,862
Total Dissolved P	4.0	M	Q	Q	Q	Q	M	48	16	16	16	16	48	608	608	122	730	$ 19	$ 13,862
Total organic carbon	4.0	M	Q	Q	Q	Q	M	48	16	16	16	16	48	608	608	122	730	$ 20	$ 14,592
Total suspended solids	4.0	W	Q	Q	M	Q	W	208	16	16	48	16	208	1,728	1,728	346	2,074	$ 10	$ 20,736
Calcium [1]	4.0	M	Q	Q	Q	Q	M	48	16	16	16	16	48	608	608	122	730	$ 30	$ 21,888
Alkalinity	4.0	M	Q	Q	Q	Q	M	48	16	16	16	16	48	608	608	122	730	$ 15	$ 10,944
Sulfate, Total	4.0	M	Q	Q	Q	Q	M	48	16	16	16	16	48	608	608	122	730	$ 17	$ 12,403
Rainfall / Atmospheric Inputs																			
Nitrogen (N) Series																			
Total N	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ -	$ -
Organic N, Total	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ -	$ -
Ammonia N, Total	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 14	$ 806
Kjeldahl N, Total	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 23	$ 1,325
Nitrate+Nitrite N, Total	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 17	$ 979
Total Dissolved N	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ -	$ -
Organic N, Dissolved	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ -	$ -
Ammonia N, Dissolved	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 14	$ 806
Total Kjeldahl N, Dissolved	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 23	$ 1,325
Nitrate+Nitrite N, Dissolved	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 17	$ 979
Phosphorus (P) Series																			
Total P	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 19	$ 1,094
Soluble Reactive P	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 19	$ 1,094
Total Dissolved P	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 19	$ 1,094
Tracer Study																			
Lithium [1]	4.0	---	---	---	---	---	A	0	0	0	0	0	240	1,200	1,200	240	1,440	$ 30	$ 43,200
Biological Analyses																			
Periphyton Cover	4.0	W			W			208			208			1,248	1,248	0	1,248	$ -	$ -
Macrophyte Cover	4.0	M			M			48			48			288	288	0	288	$ -	$ -
Faunal Observations	4.0	---			W			0			208			1,040	1,040	0	1,040	$ -	$ -
Sediments																			
Total Kjeldahl N	4.0	---			Q			0			16			80	80	16	96	$ 23	$ 2,208
Phosphorus (P) Series																			
Total P	4.0	---			Q			0			16			80	80	16	96	$ 35	$ 3,360
Total Inorganic P	4.0	---			Q			0			16			80	80	16	96	$ 25	$ 2,400
Total organic carbon	4.0	---			Q			0			16			80	80	16	96	$ 75	$ 7,200
Bulk density	4.0	---			Q			0			16			80	80	16	96	$ 50	$ 4,800
Solids (percent)	4.0	---			Q			0			16			80	80	16	96	$ 15	$ 1,440
Sulfate, Total	4.0	---			Q			0			16			80	80	16	96	$ 25	$ 2,400
Totals															**44,784**	**5,322**	**50,106**		**$444,499**

Notes:

Number of cells = 5
Number of rainfall stations = 1
Sampling period (years) = 4
W = weekly
M = monthly
Q = quarterly
A = annually
C(I) = continuous with instrument
QC = Field QC measures consist of field generated equipment blanks (EB), field-cleaned equipment blanks (FCEB), field blanks (FB), split samples (SS), and replicate samples (RS).
[1] = price includes laboratory metals prep charge

Appendix A. C-43 Test Facility – Field Scale Cell Sampling Plan and Analytical Costs

Parameter	Sampling Period (years)	Sample Frequency: Head Cell Outflow	Sample Frequency: Inflow	Sample Frequency: 1/4	Sample Frequency: 1/2	Sample Frequency: 3/4	Sample Frequency: Outflow	Samples Collected: Head Cell Outflow	Samples Collected: Inflow	Samples Collected: 1/4	Samples Collected: 1/2	Samples Collected: 3/4	Samples Collected: Outflow	Samples Collected: Total	Number of Samples: Field	Number of Samples: QC	Number of Samples: Total	Analytical Cost: Unit ($/sample)	Analytical Cost: Total ($)
Field Sampling																			
Flow	4.0	---	C(I)	---	---	---	C(I)	0	0	0	0	0	0	0	0	0	0	$ -	$ -
Water Stage	4.0	---	C(I)	---	---	---	C(I)	0	0	0	0	0	0	0	0	0	0	$ -	$ -
Water temperature	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	2,496	2,496	0	2,496	$ -	$ -
Dissolved oxygen	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	2,496	2,496	0	2,496	$ -	$ -
pH	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	2,496	2,496	0	2,496	$ -	$ -
Conductivity	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	2,496	2,496	0	2,496	$ -	$ -
Total Dissolved Solids	4.0	C(I)	W	---	W	---	W	0	208	0	208	0	208	2,496	2,496	0	2,496	$ -	$ -
Surface Water Quality																			
Nitrogen (N) Series																			
Total N	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ -	$ -
Organic N, Total	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ -	$ -
Ammonia N, Total	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ 14	$ 41,126
Kjeldahl N, Total	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ 23	$ 67,565
Nitrate+Nitrite N, Total	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ 17	$ 49,939
Total Dissolved N	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ -	$ -
Organic N, Dissolved	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ -	$ -
Ammonia N, Dissolved	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ 14	$ 41,126
Total Kjeldahl N, Dissolved	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ 23	$ 67,565
Nitrate+Nitrite N, Dissolved	4.0	W	M	M	W	M	W	208	48	48	208	48	208	2,448	2,448	490	2,938	$ 17	$ 49,939
Phosphorus (P) Series																			
Total P	4.0	W	M	M	M	M	W	208	48	48	48	48	208	1,808	1,808	362	2,170	$ 19	$ 41,222
Soluble Reactive P	4.0	W	M	M	M	M	W	208	48	48	48	48	208	1,808	1,808	362	2,170	$ 19	$ 41,222
Total Dissolved P	4.0	W	M	M	M	M	W	208	48	48	48	48	208	1,808	1,808	362	2,170	$ 19	$ 41,222
Total organic carbon	4.0	W	M	M	M	M	W	208	48	48	48	48	208	1,808	1,808	362	2,170	$ 20	$ 43,392
Total suspended solids	4.0	W	M	M	M	M	W	208	48	48	48	48	208	1,808	1,808	362	2,170	$ 10	$ 21,696
Calcium [1]	4.0	W	M	M	M	M	W	208	48	48	48	48	208	1,808	1,808	362	2,170	$ 30	$ 65,088
Alkalinity	4.0	W	M	M	M	M	W	208	48	48	48	48	208	1,808	1,808	362	2,170	$ 15	$ 32,544
Sulfate, Total	4.0	W	M	M	M	M	W	208	48	48	48	48	208	1,808	1,808	362	2,170	$ 17	$ 36,883
Rainfall / Atmospheric Inputs																			
Nitrogen (N) Series																			
Total N	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ -	$ -
Organic N, Total	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ -	$ -
Ammonia N, Total	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 14	$ 806
Kjeldahl N, Total	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 23	$ 1,325
Nitrate+Nitrite N, Total	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 17	$ 979
Total Dissolved N	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ -	$ -
Organic N, Dissolved	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ -	$ -
Ammonia N, Dissolved	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 14	$ 806
Total Kjeldahl N, Dissolved	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 23	$ 1,325
Nitrate+Nitrite N, Dissolved	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 17	$ 979
Phosphorus (P) Series																			
Total P	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 19	$ 1,094
Soluble Reactive P	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 19	$ 1,094
Total Dissolved P	4.0	---	M	---	---	---	---	0	48	0	0	0	0	48	48	10	58	$ 19	$ 1,094
Tracer Study																			
Lithium [1]	4.0	---	---	---	---	---	A	0	0	0	0	0	240	960	960	192	1,152	$ 30	$ 34,560
Biological Analyses																			
Periphyton Cover	4.0	M			M			48			48			240	240	0	240	$ -	$ -
Macrophyte Cover	4.0	M			M			48			48			240	240	0	240	$ -	$ -
Macrophyte Cover (Aerial)	4.0	---			Q			0			16			16	16	0	16	$ 2,500	$ 40,000
Faunal Observations	4.0	---			W			0			208			832	832	0	832	$ -	$ -
Sediments																			
Total Kjeldahl N	4.0	---	Q				Q	0	16				16	128	128	26	154	$ 23	$ 3,533
Phosphorus (P) Series																			
Total P	4.0	---	Q				Q	0	16				16	128	128	26	154	$ 35	$ 5,376
Total Inorganic P	4.0	---	Q				Q	0	16				16	128	128	26	154	$ 25	$ 3,840
Total organic carbon	4.0	---	Q				Q	0	16				16	128	128	26	154	$ 75	$ 11,520
Bulk density	4.0	---	Q				Q	0	16				16	128	128	26	154	$ 50	$ 7,680
Solids (percent)	4.0	---	Q				Q	0	16				16	128	128	26	154	$ 15	$ 2,304
Sulfate, Total	4.0	---	Q				Q	0	16				16	128	128	26	154	$ 25	$ 3,840
Totals															**55,232**	**8,285**	**63,517**		**$762,688**

Notes:

Number of cells = 4

Number of rainfall stations = 1

Sampling period (years) = 4

W = weekly

M = monthly

Q = quarterly

A = annually

C(I) = continuous with instrument

QC = Field QC measures consist of field generated equipment blanks (EB), field-cleaned equipment blanks (FCEB), field blanks (FB), split samples (SS), and replicate samples (RS).

[1] = price includes laboratory metals prep charge

Appendix B

C-43 WQTA Test Facility Construction Cost Data

Appendix B. C-43 Test Facility – Basis for Construction Unit Costs

Category	Description	Unit Price	Unit Cost Basis	Notes
Earthwork				
	Excavation	$ 3.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	Regular excavation
	Backfill	$ 4.50	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	Embankment
	Hauling	$ 4.50	CH2M HILL 2010 Estimate	Initial estimate increased from $4.41 to $4.50; stockpiled on site
Sitework				
	Access Road	$ 10.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	
	Berm Stabilized Surface	$ 10.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	
	Shellrock Pad	$ 10.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	
	Chain Link Fence with 3-strand	$ 20.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	8' Fence with 3-strand and concrete for posts
	Gates	$ 2,500.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	12' Dbl and 6' Pedestrian
	Head Cell Liner	$ 11.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	PVC Impermeable Liner
	Hydroseeding	$ 0.05	WSI professional judgment	
	Mesocosm Tanks	$ 6,000.00	Dolphin Fiberglass Products, Inc.	16' x 7'10" x 4'
	Head Tank (1,550 gal)	$ 1,000.00	USA BlueBook	1,550 gal Green Water Storage Tank
	Head Tank Stand	$ 2,000.00	WSI professional judgment	
	Agridrain (8'x18" PVC)	$ 4,000.00	Agridrain Corporation	Inline WCS 8' x 8' PVC, material cost doubled for installation
	Boardwalks	$ 28.00	Scaffoldmart.com	5x5 frames, 7' cross braces, leg bases, and aluminum planks
Buildings				
	Site Trailer	$ 35,000.00	WSI professional judgment	
	Pump/Electrical Building	$ 35,000.00	WSI professional judgment	
Pumping Facilities				
	Master Pump Station and Controls	$ 150,000.00	Watertronics Technical Services	
	Temporary Mesocosm Pump	$ 2,500.00	USA BlueBook	3" self priming trash pump, gas powered
Piping and Appurtenances				
	Main Supply (12" HDPE)	$ 45.00	WSI professional judgment	
	Field Scale Inflows (6" HDPE)	$ 30.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	Utility Pipe, F&I, PE, Water/Sewer, 8-19.9"
	Field Scale Outflows (18" HDPE)	$ 50.00	WSI professional judgment	Culvert
	Field Scale Series Connections (18" HDPE)	$ 50.00	WSI professional judgment	Culvert
	Head Cell Inflow (6" HDPE)	$ 30.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	Utility Pipe, F&I, PE, Water/Sewer, 8-19.9"
	Head Cell Outflow (6" PVC)	$ 20.00	WSI professional judgment	Mostly above grade
	Test Cell Inflows (3" PVC)	$ 3.00	WSI professional judgment	Above Grade
	Test Cell Outflows (8" PVC)	$ 30.00	FDOT Item Average Unit Cost from 2011/01/01 to 2011/12/31 (Statewide)	Utility Pipe, F&I, PE, Water/Sewer, 8-19.9"
	Head Tank Temporary Supply (4" PVC)	$ 3.00	WSI professional judgment	Above Grade
	Mesocosm Supply Piping	$ 2,000.00	WSI professional judgment	Above Grade
	Mesocosm Discharge (4" PVC)	$ 3.00	WSI professional judgment	Above Grade
	Seepage Collars	$ 150.00	Agridrain Corporation	6'x6' collar
	Field Scale Inflow Control Valves	$ 4,000.00	Cla-Val	E-40 Series
	Field Scale Flow Meters	$ 2,000.00	USA BlueBook	Seametrics WMX Series 104
	Field Scale Outflow Gate Valves (18")	$ 1,000.00	Agridrain Corporation	PVC Slide Gate Valve VV18 with extensions
	Field Scale Inflow Gate Valves (6")	$ 400.00	Agridrain Corporation	6" Slide Valterra Valve
	Head Cell Inflow Control Valve	$ 4,000.00	Cla-Val	E-40 Series
	Head Cell Gate Valve (6")	$ 400.00	Agridrain Corporation	6" Slide Valterra Valve
	Test Cell Inflow Control Valves	$ 250.00	USA BlueBook	3" Union ball valve
	Test Cell Flow Meters	$ 1,500.00	USA BlueBook	Seametrics Paddlewheel Insertion Flow Sensor and FT415 Totalizer
	Test Cell Inflow Gate Valves (3")	$ 50.00	Agridrain Corporation	3" Slide Valterra Valve
	Test Cell Outflow Gate Valves (8")	$ 600.00	Agridrain Corporation	8" Slide Valterra Valve
Electrical				
	Power Supply to Site and Pump Station	$ 100,000.00	CH2M HILL 2010 Estimate	Initial estimate rounded up
Wetland Vegetation				
	Emergent Plants	$ 4,000.00	WSI professional judgment	
	Submerged Aquatic Vegetation	$ 500.00	WSI professional judgment	
	Floating Aquatic Vegetation	$ 1,000.00	WSI professional judgment	
Miscellaneous Equipment				
	Truck	$ 30,000.00	WSI professional judgment	Std. pickup truck purchased
	Multi-parameter Sondes	$ 8,000.00	WSI professional judgment	YSI 6920 with pH/ORP, specific conductance, temp, optical DO
	Autosampler	$ 4,000.00	Fondriest Environmental	Sigma SD900 with 24 1 L bottles
	Refrigerator	$ 1,000.00	WSI professional judgment	
	Vented Water Level Recorder	$ 1,500.00	Ben Meadows	YSI Level Scout (2MB) with cable and installation
	Staff Gauges	$ 100.00	Ben Meadows	Style A 0 - 3.33' and 3.33 - 6.66' each plus mounting

DOLPHIN FIBERGLASS PRODUCTS, INC. Manufacturer of Aquaculture Tanks

Miami, FL Tel.: (305) 247-1748 - Fax: (305) 247-8750 - Email: dolphinfbg@aol.com

RECTANGULAR & SQUARE TANKS WITH FLAT BOTTOM

OUTSIDE LENGTH	OUTSIDE WIDTH	HEIGHT	GALLONS	PRICE
12'	2'	2'	290	$ 1,155
11'8"	4'4"	2'	658	$ 1,735
12'4"	3'8"	2'	452	$ 1,620
12'6"	3'10"	3'	704	$ 2,130
12'8"	4'	4'	972	$ 3,220
12'4"	5'8"	2'	738	$ 2,190
12'6"	5'10"	3'	1,135	$ 2,810
12'8"	6'	4'	1,565	$ 3,940
12'4"	7'6"	2'	1,024	$ 2,655
12'6"	7'8"	3'	1,568	$ 3,350
12'8"	7'10"	4'	2,161	$ 4,560
13'8"	3'8"	2'	537	$ 1,810
13'10"	3'10"	3'	835	$ 2,340
14'	4'	4'	1,152	$ 3,520
13'8"	5'8"	2'	875	$ 2,425
13'10"	5'10"	3'	1,345	$ 3,075
14'	6'	4'	1,855	$ 4,290
13'8"	7'6"	2'	1,216	$ 2,865
13'10"	7'8"	3'	1,860	$ 3,655
14'	7'10"	4'	2,560	$ 4,940
15'8"	3'8"	2'	622	$ 2,065
15'10"	3'10"	3'	965	$ 2,670
16'	4'	4'	1,332	$ 3,985
15'8"	5'8"	2'	1,015	$ 2,740
15'10"	5'10"	3'	1,555	$ 3,465
16'	6'	4'	2,145	$ 4,815
15'8"	7'6"	2'	1,408	$ 3,300
15'10"	7'8"	3'	2,152	$ 4,100
16'	7'10"	4'	2,959	$ 5,510
18'	4'8"	2'8"	1,312	$ 3,500
20'5"	6'6"	2'	1,800	$ 4,025
23'	7'2"	6'	6,400	$14,640
23'2"	7'4"	8'	8,500	$24,265

NOTE: Dimensions are based on overall outside measurements. The inside dimensions may be up to 10" smaller due to the heavy flange around the top of the tank that is necessary to prevent bowing. Call if the inside measurements are critical. Tanks over 24" high are cored on the sides with foam of various thicknesses to prevent bowing and provide insulation. The bottom, of most large tanks, is cored with ¾" thick foam with a protective fiberglass outer layer, therefore, no concrete slab is required. All tanks listed above are one-piece construction, free standing, and self-supporting with no cross bracing. For proper installation tanks must be fully supported on the bottom. Extra heavy lay-up and box legs are available as options. Other options include skimmer boxes, viewing windows, insulation and lids. Any of the above tanks can be made with less height. A recessed dimple can be fabricated in the tank bottom to flush mount a bulkhead fitting at no additional cost.

NOTE: We can custom build square & rectangular tanks to your specifications. Please call for a quote.

CLA-VAL

MODEL — **40 Series** (Full Internal Port) / **640 Series** (Reduced Internal Port)

Rate of Flow Control Valve

Model 40-01/640-01

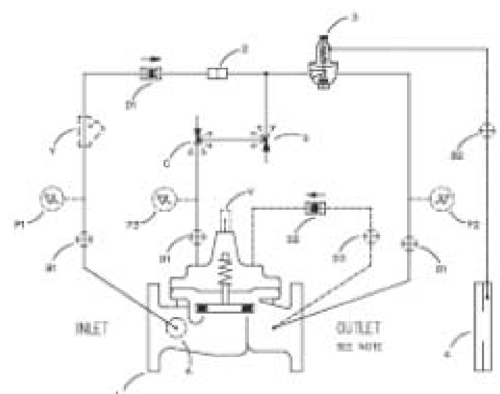
- **Accurately Limits Flow Rate**
- **Completely Automatic Operation**
- **Includes Orifice Plate with Holder**
- **Optional Check Feature**
- **Easily Adjusted**

The Cla-Val Model 40-01/640-01 Rate of Flow Control Valve prevents excessive flow by limiting flow to a preselected maximum rate, regardless of changing line pressures. It is a hydraulically operated, pilot controlled, diaphragm valve. The pilot control responds to the differential pressure produced across an orifice plate installed downstream of the valve. Accurate control is assured as very small changes in the controlling differential pressure produce immediate corrective action of the main valve. Flow rate adjustments are made by turning an adjusting screw on the pilot control.

The Model 40-01/640-01 includes an orifice plate with a holder that should be installed one to five pipe diameters downstream of the valve. If the check feature option is added and a pressure reversal occurs, the downstream pressure is admitted into the main valve cover chamber and the valve closes to prevent return flow. See X52E data sheet for sizing selection.

Schematic Diagram

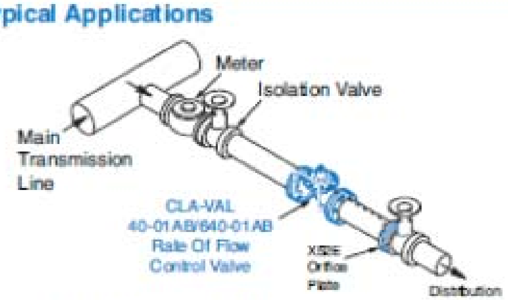
Item	Description
1	Hytrol (Main Valve)
2	X58C RestrictionFitting
3	CDHS18 Differential Control
4	X52E Orifice Plate Assembly



Optional Features

Item	Description
A	X46A Flow Clean Strainer
B	CK2 (Isolation Valve)
C	CV Flow Control (Closing)
D	Check Valves with Isolation Valve
P	X141 Pressure Gauge
S	CV Speed Control (Opening)
V	X101 Valve Position Indicator
Y	X43 "Y" Strainer

Typical Applications



The 40-01/640-01 is typically installed where water supply to a system must be limited to a preset maximum flow rate. The valve is easily set to maintain the maximum allowable flow rate.

The 40-01/640-01 is typically installed as a pressure type filter effluent control valve where a constant flow rate is maintained as head loss through the filter varies.

CLA-VAL

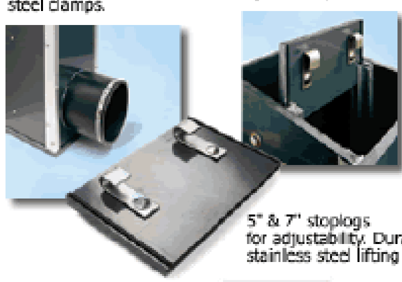
Installation Instructions (PDF Format)

Valves & Gates
Check Valves
Slide Gates Valves
Flap Gates
Inline Water Level Control Structure
Inlet Water Level Control Structure
Large Diameter Water Level Control Structure
Fish Screens

Agri Drain CORPORATION Inline Water Level Control Structure™

Inline Water Level Control Structure

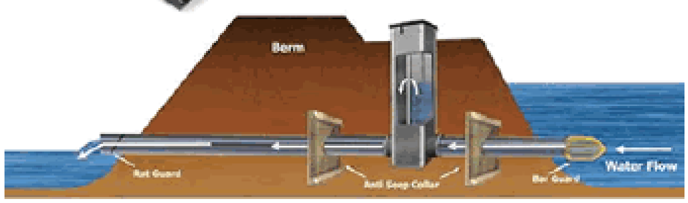
- Structures can be used to manage water level in a variety of applications including ponds, wetlands, manure management, drainage water management, and saturated buffers.
- Rugged 1/2" PVC structure with lockable top.
- Stainless steel screws and custom anodized aluminum corner extrusions are used for strength and durability.
- Stoplogs made of 1/2" PVC, in 5" & 7" heights for adjustability.
- Flexible couplers allow PVC, Corr. HDPE plastic pipe, or other materials to be easily attached. *(Please specify type of pipe when ordering)*
- Annual maintenance of stoplogs is recommended. Remove stoplogs and lubricate the o-ring on each board with white lithium grease. Ensure that there is no debris in the tracks or along the bottom of the structure. Replace your stoplogs after greasing.
- 5-Year Warranty on all standard structures.
- Customized or special orders will carry a 1-Year warranty on workmanship and material and have no return policy.
- Please allow up to 2 weeks for shipment.



Flexible rubber connectors with heavy duty stainless steel clamps.

Rubber seal assures a tight fit to prevent leakage.

5" & 7" stoplogs for adjustability. Durable stainless steel lifting hooks.



Typical Installation and Recommended Component Items--

Installing a **bar guard** on our inlet pipe helps prevent debris, rodents, fish and turtles from entering your inlet.

An **anti seep collar** should be installed on both the inlet and outlet side of your structure to prevent water from cutting a path along your pipeline causing erosion.

A **slide gate valve** (not pictured above) installed in front of your structure on the inlet side allows you to completely shut off your water flow allowing you to remove all of your stoplog boards for maintenance and/or cleaning (annual maintenance of stoplogs is recommended).

A **rat guard** needs to be installed on your outlet pipe to avoid rodent entry.

PVC Fish Screens Also Available. See web page or call for details.

more info

Item# Price	Description	List
INLINE02X04P	Inline WCS 2'x4" PVC	$416.05
INLINE02X06P	Inline WCS 2'x6" PVC	$424.79

Hours:
Mon-Fri 7am-5pm cst

Location:
1462 340th St.
Adair, IA 50002

Phone:
1-800-232-4742
1-641-742-5211

Fax:
1-800-282-3353
1-641-742-5222

Email:
info@agridrain.com

INLINE02X08P	Inline WCS 2'x8" PVC	$452.09
INLINE02X10P	Inline WCS 2'x10" PVC	$498.96
INLINE02X12P	Inline WCS 2'x12" PVC	$602.15
INLINE02X15P	Inline WCS 2'x15" PVC	$703.38
INLINE02X18P	Inline WCS 2'x18" PVC	$956.08
INLINE03X04P	Inline WCS 3'x4" PVC	$470.65
INLINE03X06P	Inline WCS 3'x6" PVC	$479.39
INLINE03X08P	Inline WCS 3'x8" PVC	$525.25
INLINE03X10P	Inline WCS 3'x10" PVC	$590.81
INLINE03X12P	Inline WCS 3'x12" PVC	$709.88
INLINE03X15P	Inline WCS 3'x15" PVC	$855.79
INLINE03X18P	Inline WCS 3'x18" PVC	$1,143.46
INLINE03X24P	Inline WCS 3'x24" PVC	$1,456.22
INLINE03X24PT	Inline WCS 3'x24" PL Tile	$1,708.48
INLINE04X04P	Inline WCS 4'x4" PVC	$525.25
INLINE04X06P	Inline WCS 4'x6" PVC	$532.90
INLINE04X08P	Inline WCS 4'x8" PVC	$597.32
INLINE04X10P	Inline WCS 4'x10" PVC	$683.80
INLINE04X12P	Inline WCS 4'x12" PVC	$816.48
INLINE04X15P	Inline WCS 4'x15" PVC	$1,009.39
INLINE04X18P	Inline WCS 4'x18" PVC	$1,329.62
INLINE04X24P	Inline WCS 4'x24" PVC	$1,707.29
INLINE04X24PT	Inline WCS 4'x24" PL Tile	$1,959.55
INLINE05X04P	Inline WCS 5'x4" PVC	$578.76
INLINE05X06P	Inline WCS 5'x6" PVC	$588.59
INLINE05X08P	Inline WCS 5'x8" PVC	$704.02
INLINE05X10P	Inline WCS 5'x10" PVC	$814.44
INLINE05X12P	Inline WCS 5'x12" PVC	$970.42
INLINE05X15P	Inline WCS 5'x15" PVC	$1,162.99
INLINE05X18P	Inline WCS 5'x18" PVC	$1,444.75
INLINE05X24P	Inline WCS 5'x24" PVC	$1,958.35
INLINE05X24PT	Inline WCS 5'x24" PL Tile	$2,210.62
INLINE06X04P	Inline WCS 6'x4" PVC	$634.45
INLINE06X06P	Inline WCS 6'x6" PVC	$642.10
INLINE06X08P	Inline WCS 6'x8" PVC	$743.65
INLINE06X10P	Inline WCS 6'x10" PVC	$867.51
INLINE06X12P	Inline WCS 6'x12" PVC	$1,082.34
INLINE06X15P	Inline WCS 6'x15" PVC	$1,316.60
INLINE06X18P	Inline WCS 6'x18" PVC	$1,701.94
INLINE06X24P	Inline WCS 6'x24" PVC	$2,208.20
INLINE06X24PT	Inline WCS 6'x24" PL Tile	$2,461.69
INLINE08X04P	Inline WCS 8'x4" PVC	$779.69
INLINE08X06P	Inline WCS 8'x6" PVC	$788.86
INLINE08X08P	Inline WCS 8'x8" PVC	$934.48
INLINE08X10P	Inline WCS 8'x10" PVC	$1,104.97
INLINE08X12P	Inline WCS 8'x12" PVC	$1,307.39
INLINE08X15P	Inline WCS 8'x15" PVC	$1,622.60
INLINE08X18P	Inline WCS 8'x18" PVC	$2,075.48
INLINE08X24P	Inline WCS 8'x24" PVC	$2,710.34
INLINE08X24PT	Inline WCS 8'x24" PT Tile	$2,962.60
INLINE10X04P	Inline WCS 10'x4" PVC	$894.35
INLINE10X06P	Inline WCS 10'x6" PVC	$903.52
INLINE10X08P	Inline WCS 10'x8" PVC	$1,088.12
INLINE10X10P	Inline WCS 10'x10" PVC	$1,299.06
INLINE10X12P	Inline WCS 10'x12" PVC	$1,532.43
INLINE10X15P	Inline WCS 10'x15" PVC	$1,928.61
INLINE10X18P	Inline WCS 10'x18" PVC	$2,447.79
INLINE10X24P	Inline WCS 10'x24" PVC	$3,211.24
INLINE10X24PT	Inline WCS 10'x24" PL Tile	$3,464.74
INLINE12X04P	Inline WCS 12'x4" PVC	$1,009.01
INLINE12X06P	Inline WCS 12'x6" PVC	$1,017.04
INLINE12X08P	Inline WCS 12'x8" PVC	$1,241.77
INLINE12X10P	Inline WCS 12'x10" PVC	$1,493.14

Agri Drain CORPORATION MAIN PRODUCTS SERVICE & AFFILIATES INSIDE TRADER CONVENTIONS NEW ITEMS SMART DRGE SYS

Valves & Gates
- Check Valves
- Slide Gates Valves
- Flap Gates
- Inline Water Level Control Structure
- Inlet Water Level Control Structure
- Large Diameter Water Level Control Structure
- Fish Screens

VALTERRA Gate Valves

Inexpensive valve for industrial, agricultural, and commercial markets.

- Well suited as a drain valve to tanks.
- Attaches to SCH40 PVC pipe.
- Unrestricted flow.
- Quick opening.
- Trouble free simplicity.
- 100% water tested at factory.
- Low cost.
- Quick shut off in low pressure or vacuum lines.
- Sizes available: 1 1/2", 2", 3", 4", 6", 8", 10", and 12"

Extension Rods Now Available!

Extension Rod for 1 1/2" - 4" Valve
- Available in 12", 24", and 36".
- Aluminum tube with 3 1/2" stud female thread x male thread.
- Easily threads onto the valve shaft.
- Handle threads onto the stud.

Extension Rod for 6" - 8" Valve
- Available in 12", 36", and 72".
- Stainless steel rod with cotter pin(s) for assembly.
- Can attach multiple extensions together to achieve greater height.

Extension Rod for 10" - 12" Valve
- Available in 36".
- Stainless steel rod with cotter pin(s) for assembly.
- Can attach multiple extensions together to achieve greater height.

Hours:
Mon-Fri 7am-5pm cst

Location:
1462 340th St.
Adair, IA 50002

Phone:
1-800-232-4742
1-641-742-5211

Fax:
1-800-282-3353
1-641-742-5222

Email:
info@agridrain.com

Agri Drain CORPORATION Slide Gate Valves

Heavy Duty Quality

- All parts are made out of super tough high density PVC and high quality stainless steel for maximum durability and corrosion resistance.
- Not pressure rated (Approx 8 lbs.).
- All PVC material is 1/2" thick.
- Stubs are SDR 35 PVC Male.
- Sizes Available: 15" and 18". Stubs 4" in length.

Item# Price	Description	List
	24" Ext. for 1 1/2" - 4" Valve	$8.89
	12" Ext. for 1 1/2" - 4" Valve	$6.26
TX12T	12" Ext. for 1 1/2" - 4" Valve	$6.26
TX24T	24" Ext. for 1 1/2" - 4" Valve	$8.89
TX36T	36" Ext. for 1 1/2" - 4" Valve	$12.22
TX48T	48" Ext. for 1 1/2" - 4" Valve	$13.64
VV01.5	1.5" Slide Valterra Valve	$14.53
VV02	2" Slide Valterra Valve	$31.75
VV03	3" Slide Valterra Valve	$36.44
VV04	4" Slide Valterra Valve	$92.83
VV06	6" Slide Valterra Valve	$379.61
VV08	8" Slide Valterra Valve	$531.46
VV10-40	10" Slide Valterra Valve	$940.00
VV12-40	12" Slide Valterra Valve	$987.50
VV15	15" Slide Gate Valve	$665.60
VV18	18" Slide Gate Valve	$750.62
X12-36	36" Ext. for 10" & 12" Valve	$60.32
X8-12	12" Ext. for 6" & 8" Valve	$44.42
X8-36	36" Ext. for 6" & 8" Valve	$56.36
X8-72	72" Ext. for 6" & 8" Valve	$86.31

Records 1 to 20 of 20

WATERTRONICS TECHNICAL SERVICES

PUMP REPAIR - MOTOR REWINDING - DYNAMIC BALANCING - MACHINE SHOP SERVICE - PREVENTATIVE MAINTENANCE SERVICE - CRANE TRUCK SERVICE

June 28, 2012

Chris Keller, PE
Wetland Solutions, Inc
2809 NW 161 Court
Gainesville, FL 32609

Subject: Wetland project

Dear Chris,

The following is my review of our discussion and my preliminary sizing of the pump station based on that information.

Maximum flow rate 1700 GPM
Vertical elevation - static head = 20 feet
Force main 4600 feet, using HDPE SDR-11 12" velocity at 1700 GPM =< 5.00 fps

Static head (elevation) =		20 feet	
Friction head at 1700 GPM = 20.24 lbs/ 46.7 ft		47 ft	
Suction lift	= 10 feet	10 ft	
Station losses	= 5 PSI	12 ft	
TOTAL Dynamic head		89 ft	Round off to 90' TDH

Selection: Horizontal Centrifugal triplex using three pumps 600 GPM at 90' TDH each. Our model # HCV-25/25/25
I added the optional items that would normally recommend that should be included. Those options can be taken out to reduce the station price.

Items included; Single VFD to operate primary pump, Premium surge protection, space heaters in motors, Air conditioner for panel cooling of VFD, Electronic Butterfly Valve (EBV) backup of VFD for pressure control, Magnetic flow meter, individual HDPE suction lines (40 ft) for each pump with flotation units and foot valves.

Price, net FOB factory with freight included to jobsite, also includes setup at site and formal startup & testing, $104,830.00

Optional items that I did not include; VFD for each (2 extra) motor $6,100.; Line reactors for VFD's $1510.00; WaterVision 5 with Radio modems $ 7090.00

This will give you a preliminary overview of your pump station requirements. I can provide formal specifications, drawings and details for any of the information provided above.

Thank you for the opportunity to provide this information. If I may provide additional information or assistance please do not hesitate to contact this office.

Sincerely,

Watertronics Technical Services

Roger L. Gibson

Florida District Manager

(desktop/wetland Solutions)

1612 Cooling Ave., Melbourne, FL 32935 • Phone: 321-255-3700 • Fax: 321-255-8982
email rgibson@watertronics.com