C-139 BASIN BEST MANAGEMENT PRACTICES (BMP)
DEMONSTRATION GRANT 2008 – 2011

C & B FARMS – LITTLE CYPRESS CHEMICAL PRECIPITATION TREATMENT

TASK 2.10: FINAL REPORT

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October 2011

1.0 Introduction

The C-139 Basin is the second largest tributary of phosphorus (P) to the Everglades Protection Area (EPA). Since 2002, landowners in the C-139 Basin have participated in a mandatory Best Management Practices (BMPs) program for P control based on standard statewide practices. However, the South Florida Water Management District (District) recognizes that traditional BMPs for water quality control are not sufficient for compliance with the Everglades Forever Act (EFA) requirements in the C-139 Basin. Also, that there are opportunities for BMP optimization that need to be explored to addressed basin-specific challenges. BMP optimization consists of improving BMP implementation techniques or infrastructure towards maximizing the effectiveness of a farm BMP Plan to reduce P in discharges.

In that regard, the District created the C-139 Basin BMP Demonstration and Effectiveness Grant (Demonstration Grant) to cost-share projects that are focused on innovation or optimization of traditional BMPs, focusing on implementation techniques that will result in the greatest water quality improvement under basin-specific conditions based on available technical information. In August 2008, after a request for proposals (RFP) was made and projects were evaluated by a review committee, two projects were approved: The Surface Water Impoundment Optimization and the Chemical Precipitation Treatment projects.

This report describes the activities completed during the project titled "C & B Farms – Little Cypress Chemical Precipitation Treatment". Activities include project implementation and analysis of BMP performance based on the water quality and quantity data collected, as well as a discussion of the factors that could potentially affect BMP effectiveness.

C & B Farms – Little Cypress is located in Hendry County on the southeast corner on the C-139 Basin in the proximity of the District Stormwater Treatment Area (STA) 5 (see Figure 1). The total farm acreage is approximately 680.66 acres under cultivation (primarily vegetables).

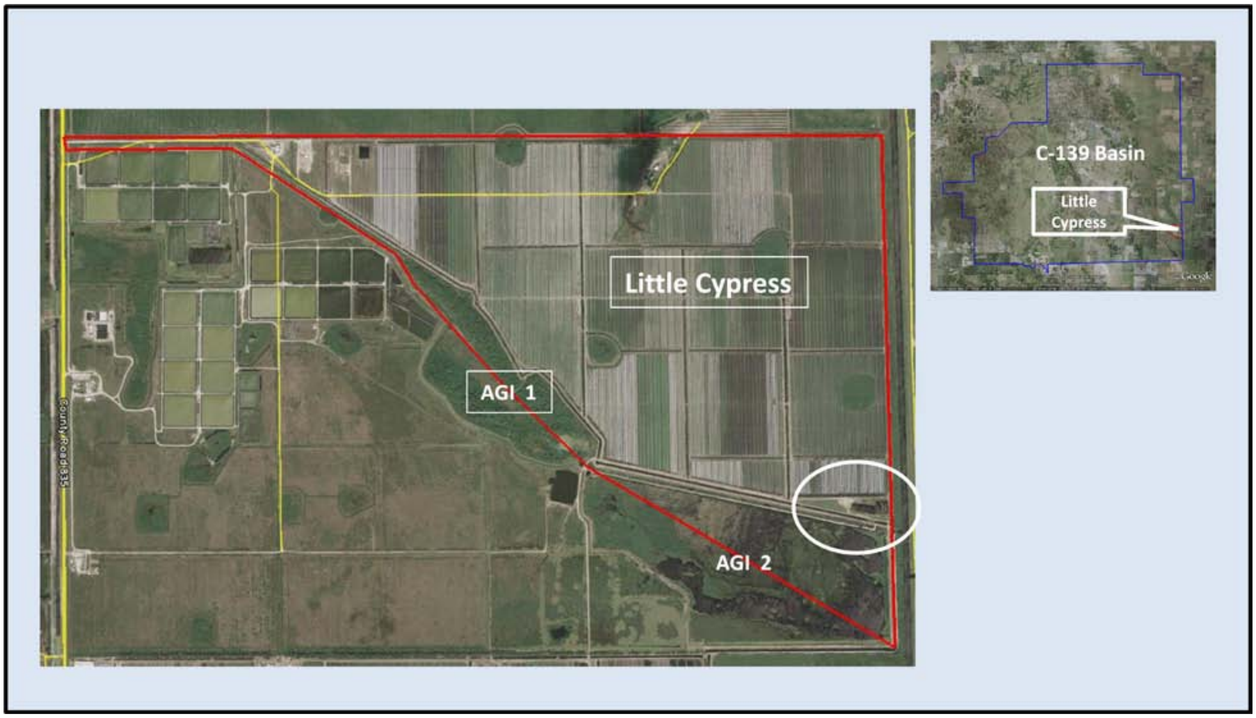

Figure 1. Project Location

Water quality treatment is provided by two above ground impoundments (AGIs) connected in series. Technical literature indicates that AGIs are most effective in removing the particulate phosphorus (P) fraction. However, water quality monitoring in the C-139 Basin shows that the dissolved P fraction is largely prevalent in discharges (SFER, 2010). The objective of this project is to demonstrate in the field a practical method to remove dissolved P fraction from the farm discharges through chemical precipitation.

2.0 Project Description

Chemical flocculation/precipitation has been used to remove the inorganic and particulate forms of P by the addition of a coagulant. The metal salts most commonly used are associated with calcium, aluminum and iron. In order to identify the most appropriate reactive compounds, the form (liquid or solid), the rates and effectiveness of the treatment, the project was divided in two phases: a laboratory phase and a field implementation phase.

2.1 Laboratory Phase

Environmental Research &Design, Inc. (ERD) was contracted to conduct the laboratory jar testing and selection of the optimum coagulant chemical and dose. Table 1 summarizes the coagulants used during the laboratory jar testing. Four separate coagulants were utilized, including two aluminum-based compounds (alum and aluminum chloride), along with ferric sulfate and lime. Note that ferric sulfate was selected over ferric chloride due to the rapidly increasing cost and erratic availability. The alum, aluminum chloride, and ferric sulfate coagulants were obtained in liquid form, with varying percentages of active metal product. The lime was obtained in a dry powder form and a slurry was developed for use in the laboratory testing.

Table 1. Summary of Coagulants used for Jar Testing

Coagulant	Formula	Form	Source
Alum	$Al_2(SO_4)$ p14H_2O	Liquid (4.4% Al)	General Chemical
Aluminum Chloride	$AlCl_3$	Liquid (5.7% Al)	General Chemical
Ferric Sulfate	$Fe_2(SO_4)_3$	Liquid (13.06% Fe)	Kemira Water Solutions
Lime	$Ca(OH)_2$	Dry Powder (> 99%)	Chemical Lime Corp.

A summary of coagulant doses use for the jar testing is given in Table 2. The doses used were based upon the range of chemical concentrations required for efficient treatment of agricultural water in previous laboratory jar testing conducted by ERD. The solution molarities (M) (in mMole/liter) are also provided and were calculated in terms of available free metal ion.

Table 2. Coagulant Doses used for Jar Testing

Coagulant	Doses Tested	
	mg/l as Metal	**Molarity (mMole metal ion/liter)**
Alum	5, 7.5, 10, 12.5, 15	0.185, 0.278, 0.370, 0.463, 0.556
Aluminum Chloride	5, 7.5, 10, 12.5, 15	0.185, 0.278, 0.370, 0.463, 0.556
Ferric Sulfate	10, 15, 20, 25, 30	0.185, 0.278, 0.370, 0.463, 0.556
Lime	7.4, 11.1, 14.8, 18.5, 22.2	0.185, 0.278, 0.370, 0.463, 0.556

2.1.1 Jar Test Procedure

Two water samples (Site A and Site B) were collected on February 5, 2009, at the discharge side of the control structure from AGI 2. Approximately, 10 gallons of water were collected for each sample. The samples were chilled prior to transport and placed on ice until reaching the ERD laboratory in Orlando.

Laboratory jar testing was conducted on each of the two test waters using each of the four coagulants summarized in Table 1 at five (5) separate doses per coagulant (see Table 2). A sample of the raw untreated water was also evaluated to estimate performance efficiency for each coagulant. This testing resulted in a total of 21 (4 coagulants x 5 doses/coagulant + 1 raw sample) separate samples analyzed for each of the two test waters (42 samples total).

All jar testing was performed with a Phipps and Byrd Model 97-400 stirrer with illuminated based plate with a volume sample of 2 liters for each test. To begin the test, the appropriate volume of coagulant was added to the 2-liter water samples, and the coagulant and water mixture was mixed in the jar test apparatus at 60 rpm for one minute. After the 1-minute mixing period, the paddles were removed from the test beakers, and the samples were allowed to settle under quiescent conditions for a period of 24 hours simulating settling processes which would occur within a floc settling pond. During the floc settling process, observations were made concerning the rate of floc formation, floc size, and approximate settling time. At the end of the 24-hour settling period, the clear supernatant is decanted for laboratory analysis.

Also, during the jar testing, measurements of pH were conducted initially in the raw sample and at times of one minute, one hour, and 24 hours after chemical addition to document changes in pH which typically occur after addition of coagulants. An important element of the laboratory testing is to determine if the water has sufficient buffering capacity to allow the use of the coagulant chemical alone, or whether an additional buffering agent may be necessary to maintain a minimum pH level. For purposes of this evaluation, it is assumed that the addition of alum, aluminum chloride, or ferric sulfate coagulants can't decrease the pH of the water more than one unit below the initial raw sample pH, with a minimum acceptable pH of 6.0. For coagulation using lime, the addition of lime may not increase the pH more than one unit above the raw water up to a maximum pH of 8.5. if the coagulant dose for a particular coagulant resulted in an unacceptable reduction or increase in pH, then sodium hydroxide (NaOH) or hydrochloric acid (HCl) would be added respectively as a buffer until the pH reached an acceptable range. This analysis was conducted based upon the pH readings conducted one minute following coagulant addition.

2.1.2 Laboratory Analyses

The raw and treated samples were analyzed in the ERD laboratory for pH, alkalinity, soluble reactive P (SRP), dissolved organic P, particulate P and total P (TP) (see Table 3).

The results obtained in the jar tests indicate that: a) Aluminum chloride and alum provided the best removal, being nearly identical with the alum requiring a longer settling time, b) the 15 mg/l dosing rate in both coagulants showed the best results, c) the ferric sulfate results were extremely varied ranging from 8.2% to 96.8%, d) the second set of lime samples showed a good removal efficiency when sufficient lime was added to raise the pH of the water to 10.5; however, HCl was required to lower the pH back to an acceptable level for discharge into the Works of the District canal.

Aluminum chloride and alum were selected to be demonstrated in the field implementation phase. The cost of alum is approximately 2/3 of the aluminum chloride cost. Note that a water quality monitoring program will be conducted in association with the demonstration project to assess any incidental water quality impacts (e.g., sulfur when using alum)

2.2 Field Implementation Phase

2.2.1 Engineering Design and Construction

RHT Engineering, Inc. took care of the designing and permitting (modification of Environmental Resource Permit (ERP)) aspects of the project, while Interlaken, Inc. did all the construction part. The original project proposed that the coagulant application and sedimentation could be provided within the existing AGI. However, the contract was amended to be able to use an existing borrow pit for treatment. The borrow pit is adjacent to the AGI discharge structure and to the overflow structure of the tail water recovery system (See Figure 2).

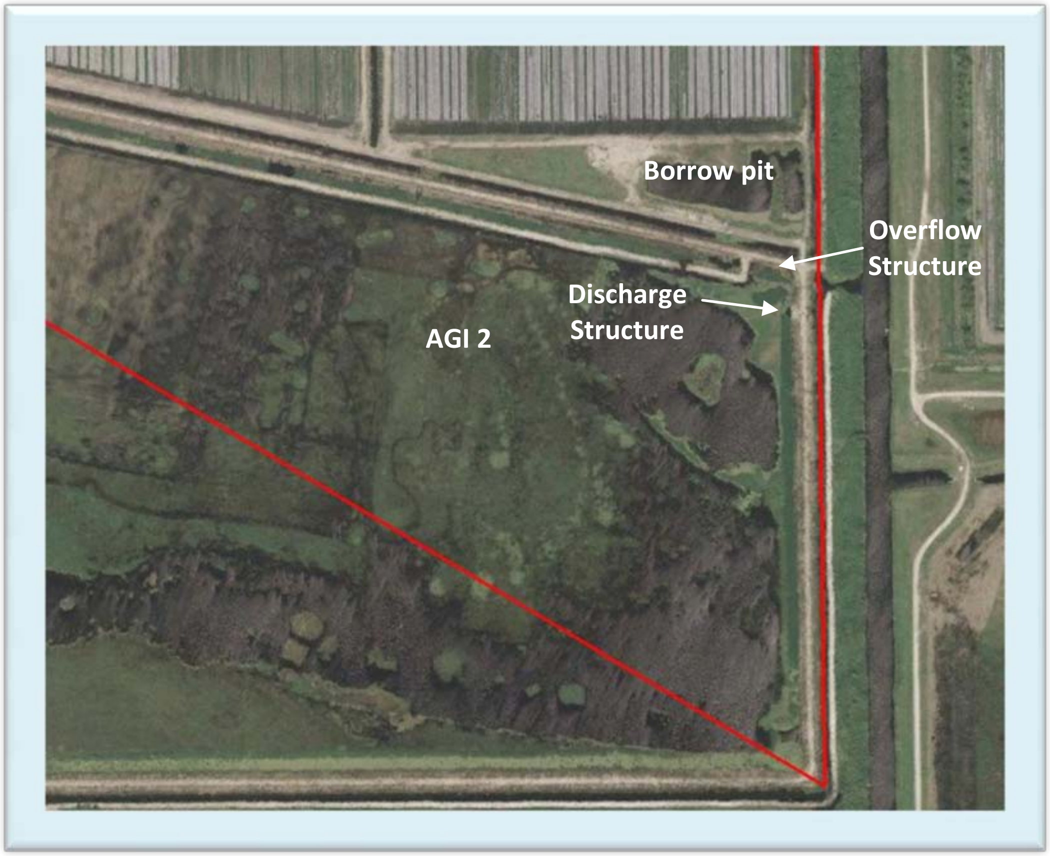

Figure 2. Borrow Pit Location

The design was chosen to minimize the amount of runoff needing chemical treatment as only the runoff that leaves the AGI and cannot be recovered back into the farm will be treated with chemical precipitation. It also avoids any interference with the AGI water quality management and wetland conservation functions. The borrow pit added 2.25 acre to the “source control treatment train” currently comprised by the AGI and the tail water recovery system. This translated in an additional 5.6 acre-feet of retention and detention on-farm (see Figure 3), as serve as a flocculation pond when the coagulant is applied. The routing of water through the borrow pit maximizes the travel path for retention time, slows velocity, and acts as a sediment sump, as water must flow from deeper to shallower areas within the pit to discharge off-site via gravity.

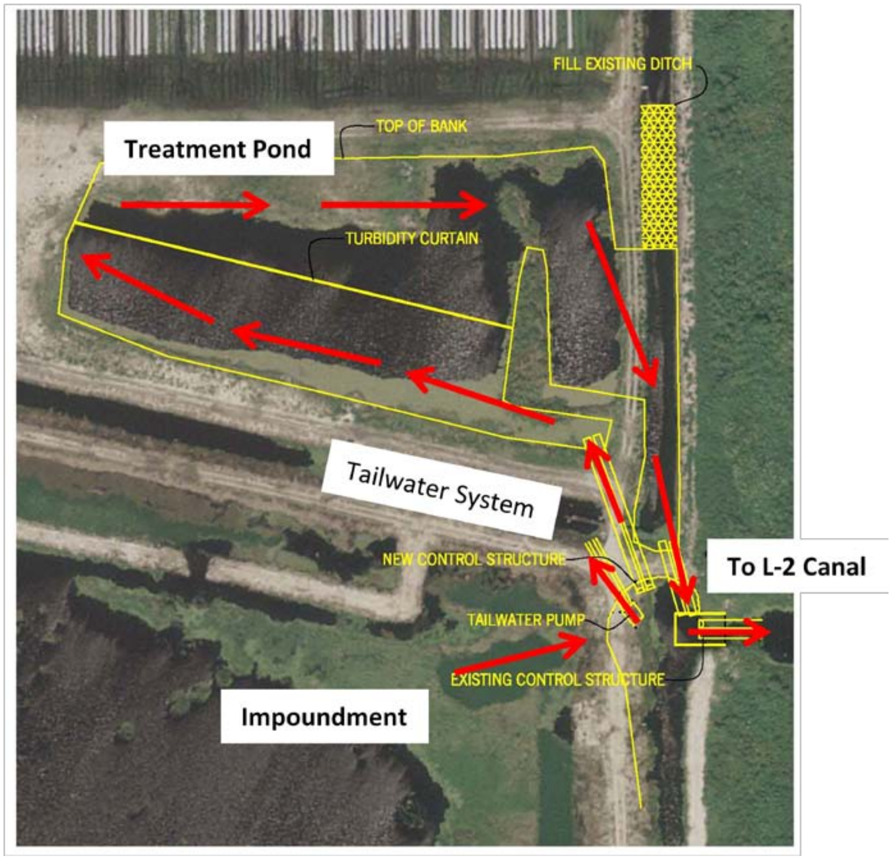

Figure 3. Source Control Treatment Train

2.2.2 *Monitoring Plan*

Autosamplers (flow proportional) along with water table level loggers were installed in at the discharge sides of the AGI control structure and the borrow pit so data can be compared and effectiveness of the treatment can be determined.

During periods of discharge, water quality composite samples are collected by the autosamplers and preserved. The composite sample is a) removed from the sample collection site and delivered to the laboratory no later than 7 days from the time the individual first samples was drawn, and b) analyzed for total phosphorus (TP) no later than 28 days from the time the first individual sample was drawn. Additionally, grab samples are collected when the composite sample is retrieved and analyze for total dissolved phosphorus, pH, alkalinity and sulfate.

2.2.3 Evaluation Method

The pre-BMP condition of the project is represented by the water quality and quantity data collected at the discharge side of the AGI control structure. The post BMP condition is represented by the data (water quality and quantity) that leaves the farm (discharge side of the borrow pit overflow structure).

3.0 Project Results

Construction of the treatment area (enlargement of the borrow pit, additional structures, monitoring equipment, injection pump) was completed in February 2010, and monitoring started in May 2010. However, due to drier than normal conditions in the area, limited data was collected (only 3 discharge events). Table 3 provides a summary of the results obtained when Alum was used as the coagulant to treat runoff coming from the AGI.

Table 3. Water Quality Results using Alum

	TP (ppb)		TDP (ppb)		Alkalinity (mg/l)		Sulfate (mg/l)		Treatment Efficiency	
Date	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**TP**	**TDP**
8/30/2010	276	252	219	163	0.1	30.3	0.1	30.3	9%	26%
9/10/2010	2303	249	97	123	203.0	197.0	30.3	30.3	826%	-27%
9/21/2010	3867	193	3688	170	205.0	193.0	34.6	30.8	1903%	95%

Due to limited data collected and great variability among the results, it is recommended to extend the water quality monitoring period for one year for a more robust and reliable data set.

4.0 Project Costs

Item	Unit Price	No. Units	Total[1]
ENGINEERING SERVICES			
Engineer	$130.00	169.7	$22,061.00
LABORATORY PHASE			
Analysis & Reporting	-	-	$22,500.00
FIELD IMPLEMENTATION PHASE			
Project Design	-	-	$2,000.00
Construction			
Mobilization	$3,503.00	1	$3,503.00
Dewatering	$6,883.00	1	$6,883.00
Excavation	$3,700.00	1	$3,700.00
Overflow Structures (2 each)	$23,560.00	1	$23,560.00
Type C Riprap	$6,783.00	1	$6,783.00
Outflow Culverts (2 each)	$14,480.00	1	$14,480.00
Structure Backfill	$3,894.00	1	$3,894.00
Containment Wall	$22,746.00	1	$22,746.00
Turbidity Barrier	$4,552.00	1	$4,552.00
Earthern Plug (1 each)	$3,194.00	1	$3,194.00
Final Grading	$3,511.00	1	$3,511.00
Monitoring			
Datalogger	$1,372.70	1	$1,372.70

Item	Unit Price	No. Units	Total[1]
Radio	$492.90	1	$492.90
Mount	$26.50	1	$26.50
Power Supply Battery	$259.70	1	$259.70
Solar Panel (10-watt)	$233.20	1	$233.20
Sealed White Fiberglass Enclosure	$307.40	1	$307.40
Polyphaser Surge Protector w/18-inch jumper	$137.80	1	$137.80
Antenna Cable (LMR 400)	$89.04	1	$89.04
Antenna	$184.44	1	$184.44
Sampler Control Cable	$184.44	2	$368.88
ISCO Sampler	$2,438.00	2	$4,876.00
20-Watt Solar Panel, Regulator, Mount, 10 ft Cable	$477.00	1	$477.00
Pressure Transducer	$775.13	2	$1,550.25
LMI Metering Pump	$689.00	1	$689.00
Shipping/Handling	-	-	$191.22
Reports			
Final Report	-	-	$5,000.00
Totals			
Total Project Cost	-	-	$159,623.03
Funding provided by District	-	-	$151,562.00
Paid by the Grantee	-	-	$8,061.03

[1]Taxes (6%) included

5.0 Conclusions and Recommendations

- ✓ Before implementation of any structural modifications (like the ones made in this study), consultation with the regulatory agency is advised due to possible changes to the environmental resource permit (ERP).
- ✓ It is recommended extending the water quality monitoring period for one more year to determine the BMP effectiveness, the feasibility as well as any factors potentially affecting BMP performance.