C-139 Basin BMP Evaluation of Above Ground Impoundments (AGI): Hydrologic Assessment of a Modified AGI

Final Report

Submitted to:

South Florida Water Management District

Prepared by:

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Task 4
P.O. No. 4500066799

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Executive Summary

Historical (1997, 2009) and recent (2012) survey data of the modified above-ground impoundment (AGI3) on the property of C&B Farms (Hendry Co., FL) were assembled into one database which consisted of overlays of each individual survey onto an aerial photo of the property. The primary goal was to evaluate the hydrologic data to determine the feasibility of a future tracer study within the modified impoundment.

The historical and recent survey data indicated that short circuits and areas that do not receive flow (isolated zones) exist within the modified AGI3. Based on historical and current surveys, it is recommended that a future tracer study within AGI3 be focused on a subset of the six internal cells (i.e., Cells 6C, 6D, and 6F; or Cells 6D and 6F; or only Cell F).

Introduction

In fiscal years 2009 and 2010, the South Florida Water Management District (District) funded two demonstration projects to improve the performance of above-ground impoundments (AGIs) to reduce phosphorus (P) in discharges. One project evaluated the performance of an AGI built in accordance with Environmental Resource Permitting (ERP) criteria (basic AGI), and another evaluated the performance of an AGI where structural modifications, above and beyond ERP criteria, were implemented to improve P removal (modified AGI). As part of the basic AGI evaluation, completion of a tracer study was proposed. However, the test could not be conducted because of drought conditions. In fiscal year 2012, the District contracted DB Environmental, Inc. (DBE) to complete this study in the basic AGI, thus justifying modifications to improve performance. A final report describing the methodology and results of the hydraulic investigation performed by DB Environmental, Inc. (DBE) during September 2012 was completed in January 2013.

Also, under the same contract (No. 4500066799), part of DBE's effort (Task 4) was to undertake a hydrologic assessment of the modified AGI (AGI3). AGI3 will be a candidate for a tracer and P study during fiscal year 2013 (FY2013). In preparation of an anticipated tracer study in AGI3, historical surveys were reviewed and a limited number of elevations were surveyed by DBE within the AGI.

Objectives

The objectives for Task 4 are as follows:

1. Inventory the existing AGI3 hydrologic database;
2. Conduct site visits to collect additional survey data;
3. Evaluate potential injection and monitoring scenarios for a tracer study in FY2013;
4. Determine monitoring equipment needs.

Location and Description of the AGI3

AGI3 is located within C&B Farms near Clewiston, FL, in Hendry County. The farm totals 1687 acres, and is located at the far southeast corner of the C-139 Basin and immediately west of STA-5 (Figure 1). An aerial photo of the farm and the three AGIs (including AGI3) are shown in Figure 2. The cultivated areas of the farm are characterized by Myakka and Immokalee fine sand soils, while the AGIs contain predominantly Myakka and Basinger fine sands (Shukla et al. 2011). A variety of vegetables and herbs are grown on the farm.

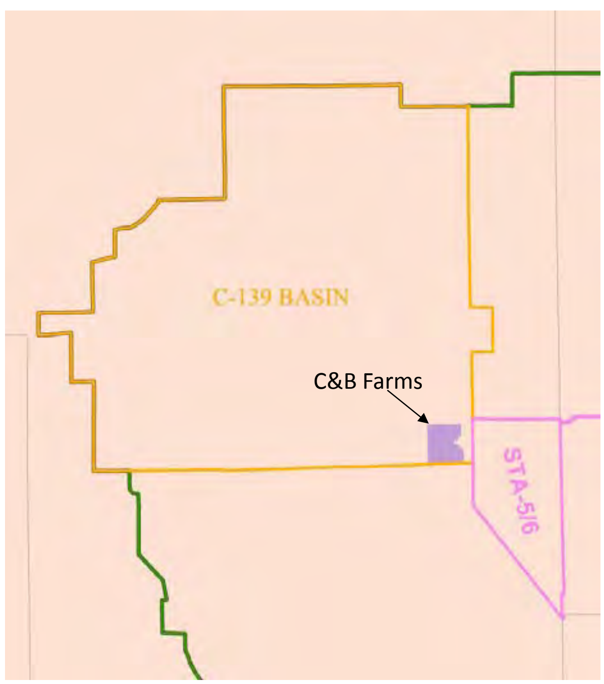

Figure 1. Location of C & B Farms in the C-139 Basin and its relation to STA-5/6 (Shukla et al. 2011)

Figure 2. Aerial photo of the three aboveground impoundments (AGIs) outlined in yellow. AGI3 is the modified AGI. From Shukla et al. (2011).

The cultivated areas within the farm are irrigated with a combination of drip and seepage irrigation. Both groundwater and surface water are utilized for irrigation. The farm drainage system takes advantage of the same conveyance canal system to route drainage water towards three connected AGIs. The drainage water is pumped into the AGIs by surface water pumps commonly called 'throw-out pumps' that are distributed around the AGIs' perimeter. The farm is divided into drainage basins to more efficiently drain the farm when necessary. By adjusting the flashboards in the risers located in the canals, water is routed to the nearest pump during drainage events. The pumps and the AGIs were designed and sized according to the area of their corresponding drainage basins and the potential runoff (Shukla et al. 2011).

The AGI (AGI3) studied in this project is the last in a series of three flow-through AGIs (Figure 2). AGI3 was designed to receive drainage from a 664-acre farm as indicated in ERP permit No. 26-00303-S. The original footprint of the 193-acre AGI was built in the 1990s, but the construction of the internal berms, relocation of the outflow weir, and interconnecting culverts did not occur until 2009. AGI3 has been modified with a series of six internal cells separated by berms and connected with culverts equipped with weirs and risers. Drainage water is pumped into the AGI via eight diesel-operated surface-water axial flow pumps along the southern and western boundaries (Figure 3). However, because of the internal configuration of the six cells, all farm discharge that enters into the AGI is first distributed to Cell 6A; flow is subsequently routed to other cells. Cell 6A discharges to Cells 6B, 6C, 6D, and 6E; Cell 6C discharges to Cell 6D; and Cells 6B, 6D, and 6E discharge to Cell 6F. The discharge structure of AGI3 (CS-6) is located along the eastern boundary of Cell 6F and consists of two sharp crested weirs set at 19.5’ NGVD29 (18.12’ NAVD88). Once the water leaves the AGI, it can either be recovered by a tail water recovery system or can flow to the S&M Canal.

The perimeter is surrounded by borrow canals except for the northern boundary with AGI 2 (see Figure 3). Inside AGI3, a series of shallow pits were created on both sides of the internal berms during their construction. This avoided the creation of borrow canals that would promote channeling and short circuiting within the cells (Obern 2011).

Methodology

Surveys exist for elevations of the benchmark locations and elevations for the farm (March 2008; RHT Engineering), the outside levees (March 2009; RHT Engineering), the internal berms and culverts (January 22, 2009; RHT Engineering), and bottom topography of AGI3 (L.F. Rooks & Assoc. for Schreuder, Inc.; August 28, 1997). DBE obtained the electronic files of each of the above surveys, which were then overlaid onto each other. The “composite” figure of the combined ground and structural elevations (all referenced to NGVD 29) embedded within a recent aerial photograph assisted in identifying potential short circuits, isolated zones, and locations to “ground truth” (i.e., re-survey) within AGI3. For example, DBE anticipated lower ground elevations along the inside of the levees in AGI3, a result of the construction of the levee system that occurred after the bottom contour survey in 1997.

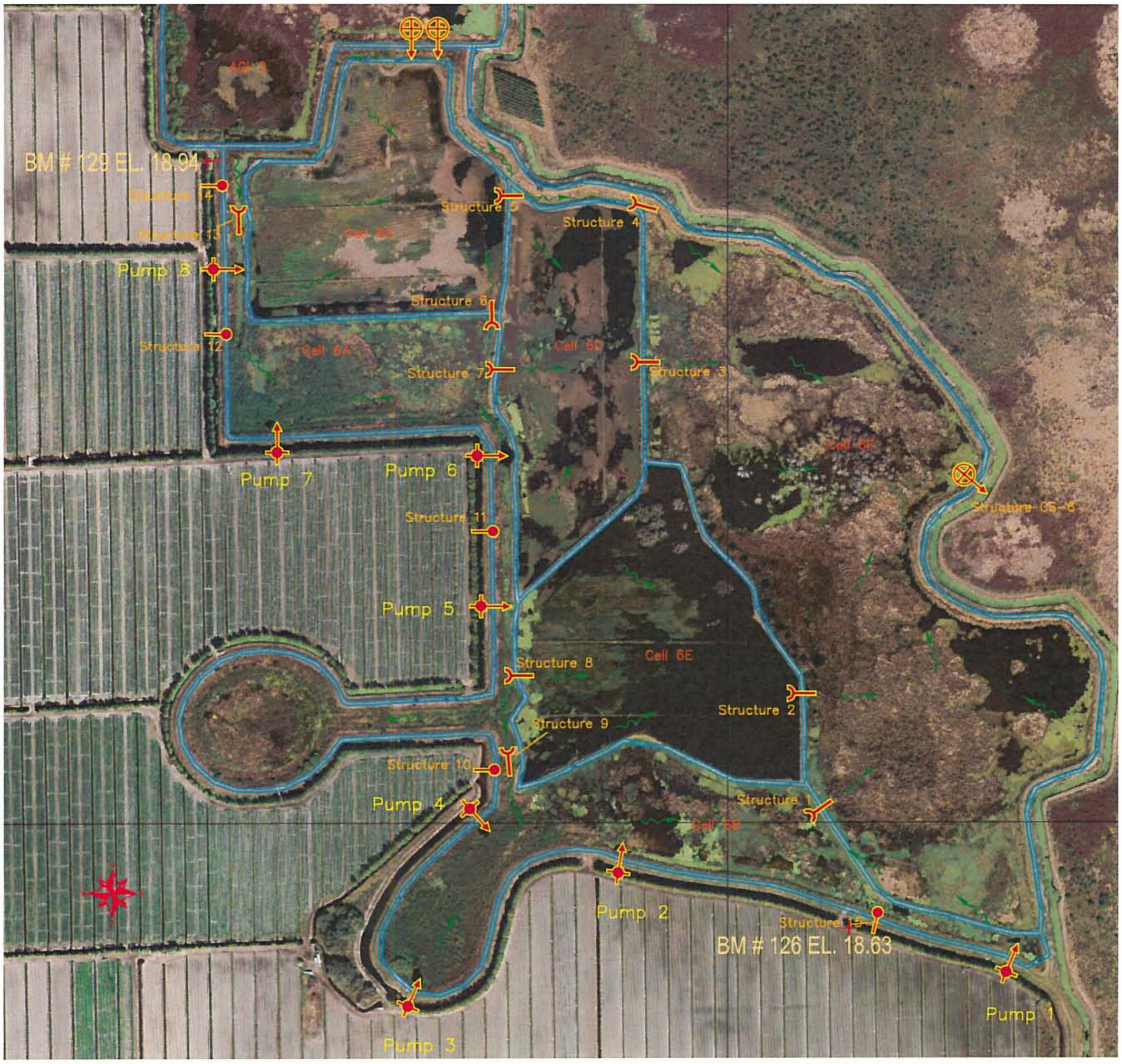

Figure 3. Aerial photo of AGI3 showing the eight inflow pump stations, the internal culvert with weirs (structures 1-16), the berms (in blue) separating the six internal cells, and the inflow from the upstream AGI (located along the northern most boundary) and outflow (located along the western boundary) control structures. The green arrows indicate flow paths. Benchmark 129 at an elevation of 18.94 ft (NGVD 29), used for the DBE survey in 2012, is shown in the northwest corner.

Using BM 129 (elevation 18.94 NGVD 29), DBE surveyed ground elevations within Cells 6A (8 survey points) and 6D (17 survey points) (Figure 4). The purpose of this limited survey was to: i) determine the change in ground elevations from 1997 when the previous survey had been done, and ii) evaluate the extent of suspected lower ground elevations adjacent to the internal levees, which are likely short-circuit flow paths. DBE also surveyed pipe inverts for structures 3, 6, and 7.

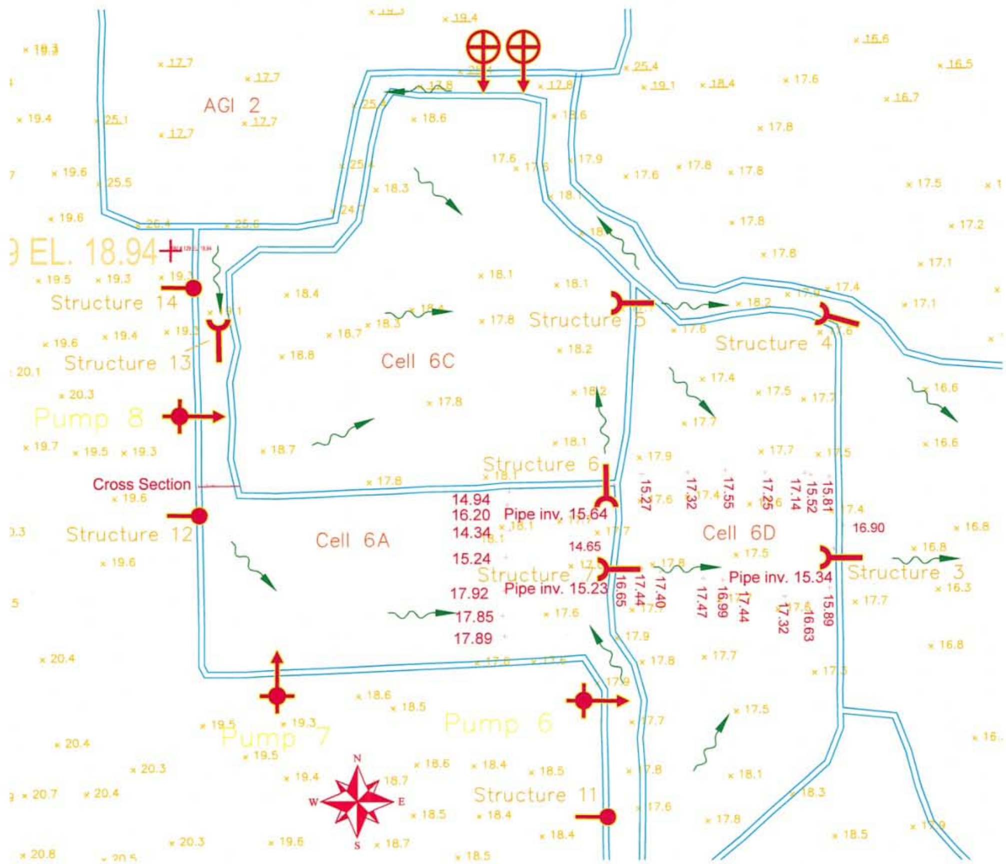

Figure 4. Cells 6A and 6D within AGI3 showing the surveyed points by DBE in 2012. Surveyed ground elevations (NGVD 29) are by DBE (purple) in 2012 and by Rook and Assoc. (yellow) in 1997 (prior to construction of internal berms and placement of culverts with weirs). DBE's surveyed upstream culvert inverts are also shown for Structures 3, 6, and 7. Also shown is the location where a cross-sectional profile of the north-south internal canal was surveyed. Blue lines represent external and internal berms. The green arrows indicate flow paths.

DBE also surveyed the cross-section of a transect perpendicular to the internal north-south perimeter canal at a location south of discharge Pump 8 (Figure 4), which is where there is currently flow monitoring and water quality sampling. The location of this cross-sectional profile coincided with a possible tracer injection point that was being considered.

A CST Berger laser level and survey rod (Figure 5), and a Trimble Geoexplorer 6000 GPS, were the equipment used in DBE's survey of AGI3 in 2012. The accuracy of DBE's elevations was validated to be within 3/8 inch at 800 ft before and after the survey.

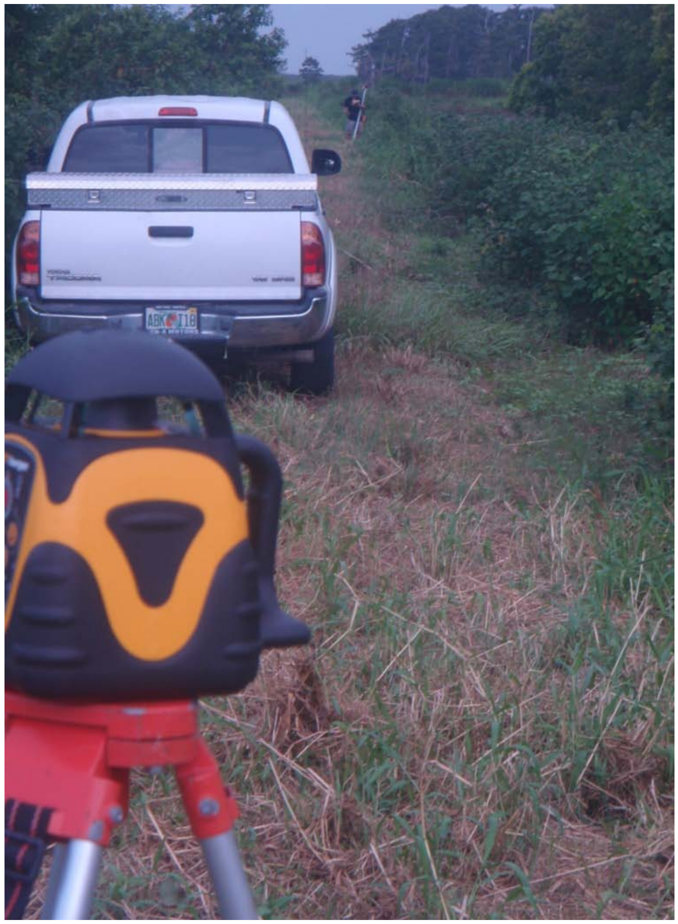

Figure 5. Survey of ground elevations on a berm bordering AGI3 on August 23, 2012. The CST Berger laser level is shown in the foreground.

Results

Hydrologic Data Review

DBE overlaid elevations, flow paths, and structure locations from previous surveys onto an aerial photo to produce a composite map of all the known survey data as layers. DBE also added as one of the layers the survey data collected by DBE in Cells 6A and 6D in 2012. The electronic files of the layered surveys are named AGI3_AllCells_Survey and AGI3_Cells6A,6C&6D_Survey. The program allows users to delete or add various “survey layers”, as well as the aerial photograph, to focus on a particular survey(s) or view the chronological sequence of the survey data.

Based on the historical (1997; 2009) and recent (DBE, 2012) surveys, there are areas within some of the cells where isolated zones and short-circuited flow paths exist (Table 1). In addition, the wetlandassociated with Cell 6A in the southwest of the AGI represents a cul-de-sac zone (inflow and outflow occur at the same location). Cells 6B and 6F appear to have the control structures distributed in locations that promote more of the cell area for treatment and less short-circuit flow paths compared to Cells 6C, 6D, and 6E (Figure 3).

Table 1. List of cells in AGI3 where short circuits and isolated zones are present.

Cell	Short-circuit path	Isolated zone(s)
6A	None	Cul-de-sac
6C	From inflow to outflow culverts along eastern levee	Central and western areas
6D	From inflow to outflow cluverts in middle of cell	Southern area
6E	From inflow to outflow culverts in middle of cell	Northern area

DBE Survey

DBE surveyed the cross-sectional profile of the north-south perimeter canal at the location shown in Figure 4 on September 12, 2012 (Figure 6). The underwater cross-sectional area at the time of the survey was 106 ft^2 (water surface elevation (17.42 ft NGVD29)).

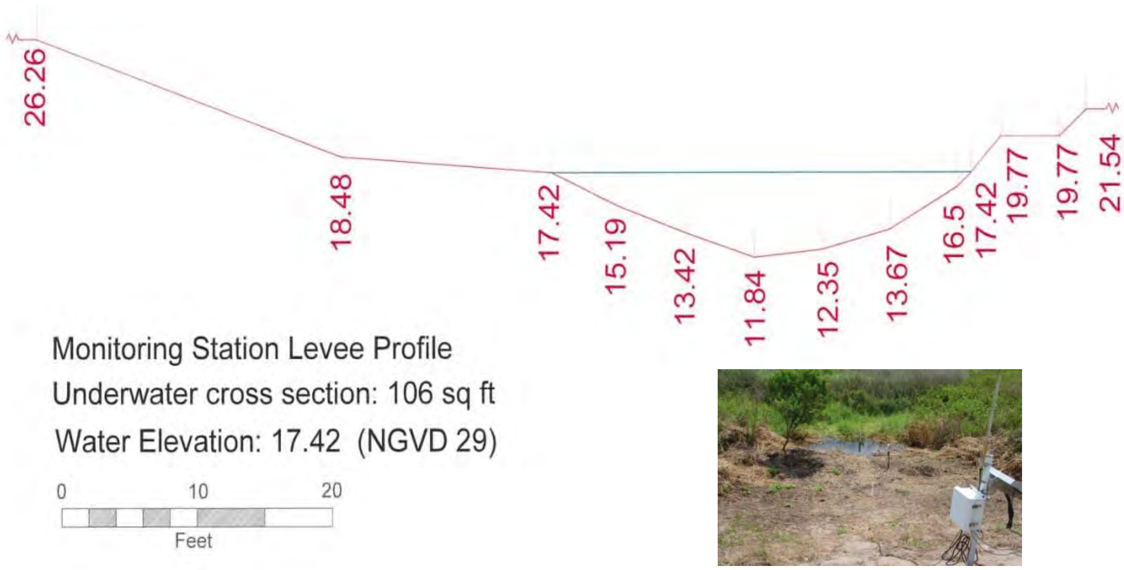

Figure 6. Cross-sectional profile of perimeter canal surveyed on September 12, 2012. The blue line indicates the water surface elevation (17.42 ft NGVD29) at time of survey. See Figure 4 for location of canal cross-section. Inset photo was taken on May 9, 2012.

The ground elevations along the north-south survey line (7 points) in Cell 6A were lower for the four northern survey points than nearby elevations from the Rook's and Assoc. 1997 survey (Figure 4). However, a closer agreement between DBE's 2012 and the 1997 surveys was achieved for Cell 6D (Figure 4). The range of ground elevations for the closest 11 surveyed points to DBE's 2012 survey points in the 1997 survey was 17.4-17.9 ft (NGVD 29), with a mean of 17.6 ft. This compares to DBE's ten interior surveyed points of 17.0-17.6 ft and a mean of 17.3 ft. The six points closest to the internal berms, which ranged from 15.3 to 16.6 ft in elevation in DBE's survey in 2012 (Figure 4) were excluded in the 1997 vs. 2012 ground elevation comparison. Soil oxidation during periods when the cell was dry over the 15 intervening years likely accounted for the mean difference of 0.3 ft between the 1997 and 2012 surveys.

DBE also surveyed the upstream inverts of structures (culverts) nos. 3, 6, and 7 (see Figure 4 for location). The culvert invert elevations are critical in calculating a cell's water depth and flows into and out of the cell. DBE's survey data for the upstream inverts are 0.57-0.86 ft lower than those reported in the 2009 RHT survey (Table 2). The reason for this disparity is not apparent, but downward displacement of the culverts after their installation in 2009 may have occurred.

Table 2. Elevation comparisons between RHT Engineering and DBE for upstream inverts of selected internal structures in AGI3. All elevation data are in ft (NGVD 1929).

Structure No.	RHT (2009)	DBE (2012)	Δ
6	16.5	15.64	0.86
7	15.8	15.23	0.57
3	16.1	15.34	0.76

Tracer Injection and Monitoring Alternatives

There are numerous considerations that need to be weighed when considering the best approach for conducting a tracer study in AGI3. What follows is a list of tracer injection and monitoring alternatives in descending order of cost and effort:

1. *Inject tracer at each of the eight inflow pumps (Nos. 1-8)*. This is the least desirable alternative because this approach would:
   a. require flow-calibrating and injecting tracer at each pump;
   b. expose some of the tracer to being "trapped" inside the cul-de-sac wetland;
   c. require a large quantity of tracer at a cost of $23,000, as well as deployment of large numbers of monitoring equipment (e.g., as many as nine autosamplers and weir flow measuring devices (e.g., pressure transducers or stage level recorders);
   d. likely take a month or more for the tracer response curve to return to background levels.
2. *Inject tracer into the supply canal just south of inflow Pump 8.* The designated injection spot has been surveyed by DBE (see above) and cross-sectional areas of the canal for given water depths can be determined. Combining the cross-sectional area by the linear velocity of the flow will determine the volumetric flow rate, from which the tracer dosage time can be calculated. In this scenario, all eight of the inflow pumps would be operating. The apparatus to deliver the flow would consist of a submersible hose or PVC pipe containing an array of openings for the tracer to escape into the flow path within the canal. A mixing tub would be positioned on the levee road which would contain the tracer, and flow to the underwater diffuser would be either by gravity or by pumping. The advantage of monitoring the flow at this cross-sectional location is that the eight inflow pumps would not need to be calibrated, and tracer injection would only

need to occur at that location instead of the eight inflow pumps. The disadvantages are the same as b. through d. above in Alternative no. 1.

3. *__Inject tracer into culverts from AGI2 to AGI3 and close off Structure 4 to prevent short circuiting of the tracer in Cell 6F__*. Flow through the twin inflow culverts from AGI2 would then be directed to the west and then south into Cell 6A. To keep the flow from migrating into the cul-de-sac wetland along the southwest portion of AGI3, a boom-and-barrier turbidity curtain would be installed just south of Structure 8. Structure 8 itself would be open wide for routing into Cell 6E any of the remaining tracer that didn't enter into Cell 6A. The outer perimeter Pumps 1-5 would be turned off to prevent backflow toward the north within the supply canal and under the turbidity curtain. This approach would direct tracer through Cells 6A, 6C, 6D, 6E, and 6F (but not Cell 6B). A modification would be to close off Structure 8, and moved the turbidity curtain north in the supply canal, which would exclude Cell 6E from the flow path of the tracer. However, this approach, with and without including Cell 6E, would still be costly with respect to tracer costs, which is estimated as $17,500 and $14,950, respectively. Also, an added capital cost would be the numerous automatic sampling equipment and stage recorders that would be required to monitor chemistry and water levels at Structures 3, 5, 6, 7, 13, (without including Cell 6E) and outflow control structure (CS-6) and additional Structures 2 and 8 (including Cell 6E).
4. *__With flow routed into AGI3 from AGI2 as above, inject the tracer into the downstream side of Structure 13__*. Flow paths and cells receiving the tracer would be the same as No. 3 above, with the exception that Structure 4 could be left open. The costs of tracer and additional equipment would also be the same as in Alternative No. 3 above.
5. *__Inject tracer at one to three of the interior structures to reduce the number of cells receiving the tracer, and consequently reduce the cost and length of monitoring period__*.
    a. One possibility would be to inject the tracer downstream of Structure 7 (Cell 6A)and monitor the tracer response in Cell 6D at Structure 3 and at the outflow control structure (CS-6) in Cell 6F. Tracer cost would be $12,500, and only two autosamplers and three stage recorders/pressure transducers would be required.
    b. A more realistic approach would be to apply the tracer at the the downsteam ends of Structures 6 and 7 in Cell 6A, and monitor the tracer at Structures 3 and 5, and the outflow control structure (CS-6). This would add Cell 6C in addition to Cells 6D and 6F to the flow paths of the tracer. Tracer cost would be $15,125, and would add one

additional autosampler and stage recorder/pressure transducer to total three and four, respectively.

c. Focus on only Cell 6F since it is the back-end cell in the AGI treatment train, and is responsible for polishing the effluent prior to discharge off-site. It also occupies about the same area as all of the area of the remaining cells combined (excluding the cul-de-sac wetland). Tracer would be dosed at the downstream ends of all four structures (1-4) draining into Cell 6F. Tracer and hydrologic monitoring would occur at the outflow control structure (CS-6). Tracer cost would be $9,075. The equipment needed would be two autosamplers (one as a backup) at the outflow control structure (CS-6) and five stage recorders/pressure transducers.

Conclusions

Only the cost associated with the tracer (LiCl) purchase and shipping has been considered in this report. Combining the tracer cost with the other costs for purchase and deployment of additional equipment (autosamplers, pressure transducers, stage recorders), chemical analyses, and labor would be performed as part of a Work Plan for a tracer study in AGI3. However, realistically only either options a, b, or c under Alternative No. 5 would be viable if the budget for a FY2013 tracer study of AGI3 is $50,000.

References

Obern, C. 2011. Impoundment Optimization Demonstration Project Final Report. C-139 Basin Best Management Practices Demonstration Grant 2008-2011. Final Report Submitted to South Florida Water Management District, West Palm Beach, FL.

Shukla, S., J.M. Knowles, and A. Shukla. 2011. Evaluation of Agricultural Impoundments for Reducing Farm-scale P Discharge in South Florida. Final Report Submitted to South Florida Water Management District, West Palm Beach, FL.