South Lee County Watershed Plan Update
Work Order C-4600000791 WO01-R1
100% Deliverable 1C
Task 1 – Survey Cross Sections and Model Update

South Florida Water Management District

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INTRODUCTION

This report is being submitted as the 100% Deliverable 1C for the Survey Cross Sections and Model Update task of the South Lee County Watershed Plan Update in accordance with Work Order C-4600000791 WO01-R1 issued to Boyle Engineering Corporation on October 17, 2008. The report describes the simulation algorithms and input data processing, calibration of the model, sensitivity analyses of the simulation, problems encountered, and trouble-shooting process during the calibration and verification process. Both an analytical and graphical summary of calibration results is provided.

1.0 SURVEY CROSS SECTIONS

Cross sections were surveyed by Boyle Engineering so that the modeling effort could be representative of existing conditions in the study area. Cross sections were surveyed in locations where significant changes had occurred due to urban development. In addition, cross sections were surveyed in the South Branch of the Estero River at Sanctuary Road (upstream of Three Oaks Parkway) because existing information on this river crossing was not available from prior studies.

Figure 1-1 shows the locations where cross sections were surveyed. There were some adjustments to cross section locations based on a field survey conducted immediately prior to the surveying. A key concern of this study is the peak stages in Halfway Creek within and downstream of the Brooks. As a result, cross sections were surveyed west of Via Coconut Point. A cross section was surveyed along a weir in Halfway Creek just upstream of U.S. 41 (referred to the Halfway Creek Cypress Weir), and three cross sections were surveyed west of U.S. 41. A wooden walkway was constructed just west of U.S. 41, and local engineers reported that Halfway Creek channel bottom elevations appeared to be higher than previously surveyed. Accordingly, a cross section was surveyed at the walkway. Halfway Creek west of this walkway is a dense cypress swamp. An additional cross section was surveyed halfway between the wooden walkway and the FPL crossing (see **Figure 1-1** for location), and a cross section was surveyed at the Williams Road bridge within the West Bay Club.

Stakeholders expressed another concern regarding Brooks outflows north to the South Branch of the Estero River. It has been observed that outflows are restricted due to sediment deposits in the channel north of the Brooks diversion gate just east of the Three Oaks Parkway north of the intersection with Williams Road. A cross section was also surveyed at this location.

Appendix 1 presents detailed maps of cross section locations and drawings of these cross sections.

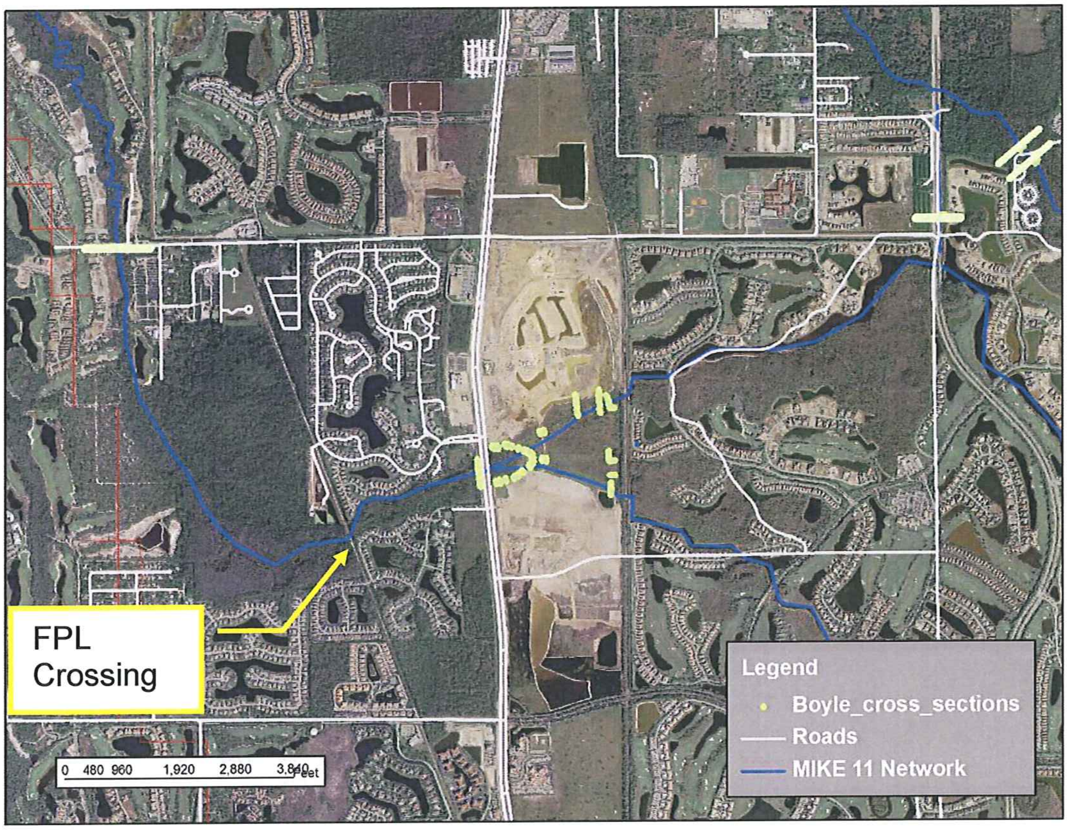


Figure 1-1 – Map of Cross Sections Surveyed by Boyle Engineering

2.0 MODEL UPDATE

MIKE SHE/MIKE 11 is an integrated surface/ground water modeling software package that is being used for a number of hydrologic/hydraulic modeling projects in southwest Florida. This modeling tool allows for a simultaneous assessment of stream flow and groundwater dynamics. The model also has the capability to simulate overland flow outside of river networks, such as in the wetlands east of I-75 between Corkscrew Road and the Imperial River. Lee County is conducting an assessment of water resource impacts of a number of mining proposals within an area east of I-75 and south of State Route 82 called the Density Reduction Groundwater Resource (DRGR) area, and MIKE SHE/MIKE 11 Version 2008 SP2 is being used for this assessment (DHI, Inc., 2008). The MIKE SHE/MIKE 11 model developed by DHI, Inc. covers all of Lee County, but the focus of the model was lands east of I-75, therefore a number of bridges, culverts and weirs in the Estero River, Halfway Creek, Spring Creek, and Imperial River basins were not included in the initial model. In order to maintain consistency, it was decided to use the MIKE SHE/MIKE 11 Lee County model for the South Lee County Watershed Plan Update, to add more detailed information on bridges, culverts, weirs, and gates west of I-75 and to utilize more recent information to modify the cross section database in the model. This memorandum summarizes the changes made to the model as part of the Update.

2.1 Calibration Data

Additional calibration data for 2008 was obtained from Lee County for groundwater wells, USGS for calibration wells and surface water stations (stage and flow data), SFWMD for wells in DBHYDRO, and Lee County DOT for gate level measurements and headwater and tailwater stage data for the Kehl Canal gate. Johnson Engineering provided measured stage data for Halfway Creek, and the District Manager for the Brooks Community Development Districts confirmed that the Brooks emergency gate remained closed in 2008.

Measured ground elevations and horizontal coordinates were obtained for each groundwater well used in the calibration, and these elevations were compared to the elevation in the MIKE SHE digital elevation model (DEM) at that location. There were significant differences for some calibration wells, and these differences can affect the calibration accuracy because all simulated groundwater elevations are relative to the DEM ground elevation. **Table 2-1** lists the elevation differences for the groundwater calibration wells. Surficial well L-5844 has a surveyed ground elevation that is 6.6 feet lower than the DEM elevation. The DEM elevation is an average elevation for a 750x750 foot grid cell, and that elevation is calculated from a LIDAR-generated topographic map. The LIDAR-based DEM may not be representative of actual ground elevations, particularly in forested areas that have rapidly changing elevations. The area surrounding L-5844 is one such well that is located in a ravine north of the Estero River just west of U.S. 41, and the DEM elevation for that cell is clearly incorrect. As will be discussed later in section 3.2, calibration accuracy for that well is not good.

Well ID	DEM Elevation (ft NAVD)	Surveyed Elevation (ft NAVD)	Elevation Difference (ft)
Imperial 49-GW3	27.09	26.80	-0.29
Imperial 49-GW6	17.29	18.00	0.71
Imperial 49-GW7	16.73	17.10	0.37
Imperial 49-GW8	16.25	15.62	-0.63
Imperial 49-GW9	15.93	14.90	-1.03
Imperial 49-GW10	12.51	12.90	0.39
Imperial 49-GW11	13.36	12.40	-0.96
Imperial 49-GW12	11.10	11.50	0.40
Imperial 49-GW14	12.29	12.10	-0.19
Imperial 49-GW15	10.30	8.60	-1.70
Leitner 49L-GW1	13.42	12.50	-0.92
FP2_GW1	17.37	16.30	-1.07
FP3_GW1	16.85	13.70	-3.15

FP4_GW1	16.92	13.95	-2.97
FP5_GW1	16.57	13.50	-3.07
FP6_GW1	16.82	13.45	-3.37
FP7_GW1	16.74	15.60	-1.14
FP8_GW1	16.59	13.30	-3.29
FP9_G	16.51	15.20	-1.31
L-5667	16.33	N/A	N/A
FP10_G	16.71	15.00	-1.71
HF1_G	21.02	17.48	-3.54
HF2_G	21.11	17.80	-3.31
HF3_G	22.09	19.44	-2.65
HF4_G	22.28	18.46	-3.82
HF7_G	20.69	17.48	-3.21
ST1_G	28.12	25.39	-2.73
ST2_G	28.39	25.39	-3.00
ST3_G	27.77	25.06	-2.71
WF3_G	28.35	27.70	-0.65
WF4_G	27.89	27.70	-0.19
WF5_G	28.36	27.70	-0.66
WF6_G	27.76	27.70	-0.06
WF7_G	27.55	27.32	-0.23
L-5844	12.20	5.60	-6.60

Table 2-1 – Comparison of Surveyed and DEM Elevations (ft-NAVD) for Groundwater Calibration Wells

Certain wells used in the DRGR calibration do not have measured data for 2006 – 2008. These wells are Imperial 49-GW3, Imperial 49-GW8, FP4_GW1, L-5667, WF1_G, and L-5649.

2.2 Model Input Data

OneRain grid rainfall data for 2006-2008 was obtained from Lee County, and SFWMD provided evapotranspiration data for 2008. **Figure 2-1** presents cumulative rainfall for 2006 from the OneRain grid rainfall file. The MIKE SHE model domain and the MIKE 11 river network is also shown on **Figure 2-1**. Lee County Utilities provided groundwater pumpage information for the Green Meadows, Corkscrew, and SFWMD provided data for the Pinewoods well field. Florida Governmental Utilities Authority provided Lehigh Acres well field pumpage data for 2008. Bonita Springs Utilities provided pumpage data for 2008. Boundary time series data was obtained from the SFWMD DBHYDRO data base.

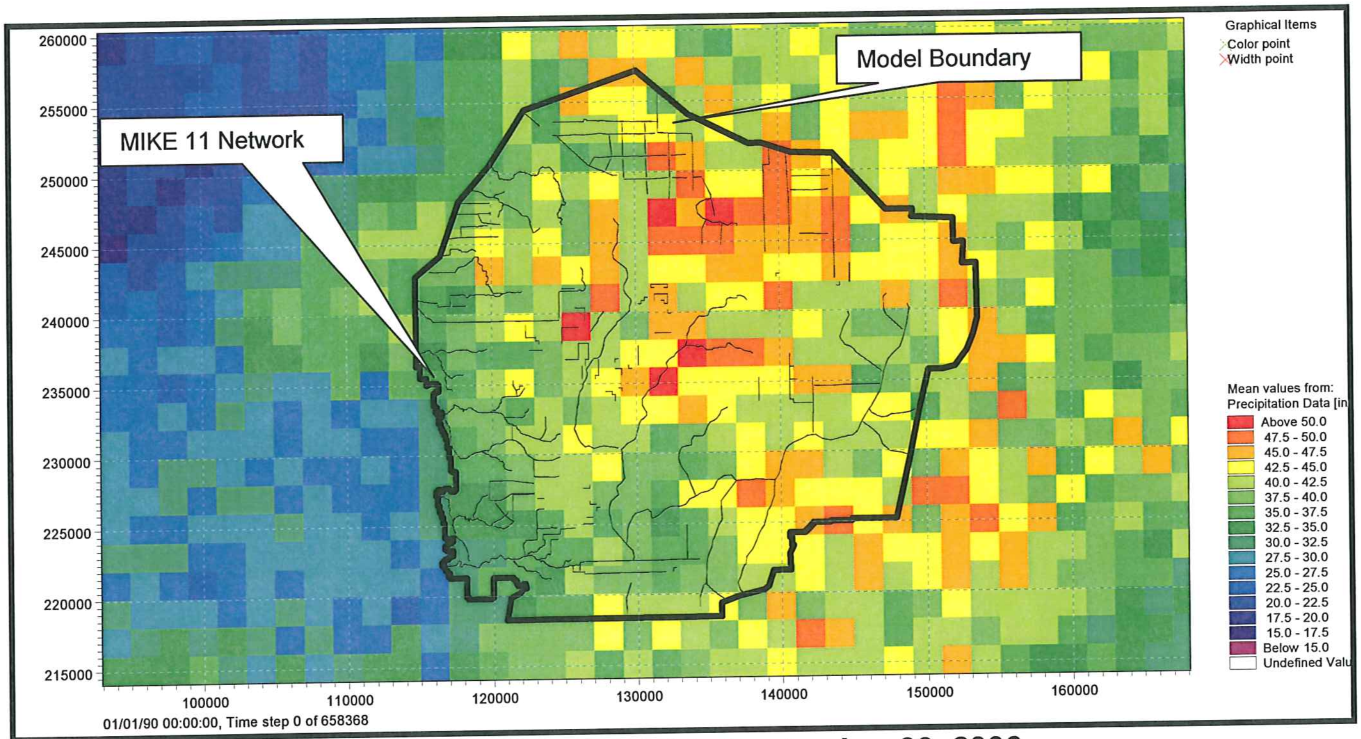


Figure 2-1 – Total Rainall (inches) for June 1 to September 30, 2006

2.3 MIKE 11 Changes

The following list documents the additions made to the surface water channels and flow-ways. There is some MIKE 11 modeling terminology used, as explained below. A river or channel reach is referred to as a Branch. Branches are lines representing the centerline of a river, channel, or flow-way. Position along the branch is shown as chainage (abbreviated as ch.), and typically chainage is 0 feet at the upstream end and increases in a downstream direction. Cross sections (abbreviated as XS) are required upstream and downstream of any culvert, weir, or gate. **Figures 2-2a and 2-2b** provide maps of the study area with structure names, roads, and general features. The changes to the MIKE 11 files are summarized below:

1. North Branch of the Estero River, Branch EsteroI75
    a. Modified culvert dimensions to be consistent with bridge conveyance, ch. 450 ft
2. North Branch of the Estero River, Branch EsteroRiv
    a. Added another set of culverts under Three Oaks since there are two sets of culverts, ch. 1600
    b. Added culverts inside Rookery Development, ch. 2006
    c. Modified cross sections to accommodate these culverts
    d. Added a culvert with capacity equivalent to the existing bridge in Village of Country Creek, ch. 4980

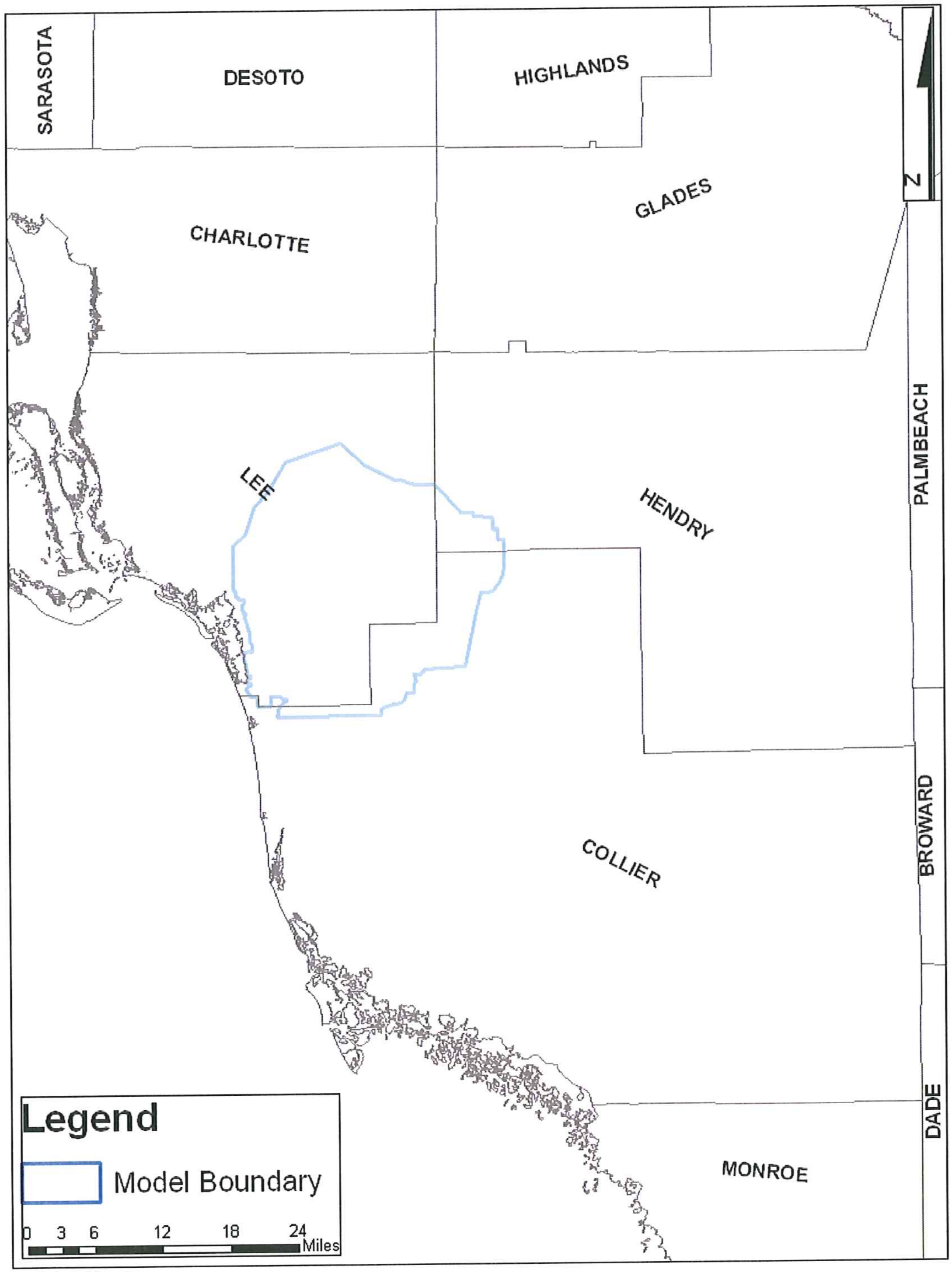


Figure 2-2a – General Map of SLCWP Study Area and Model Domain

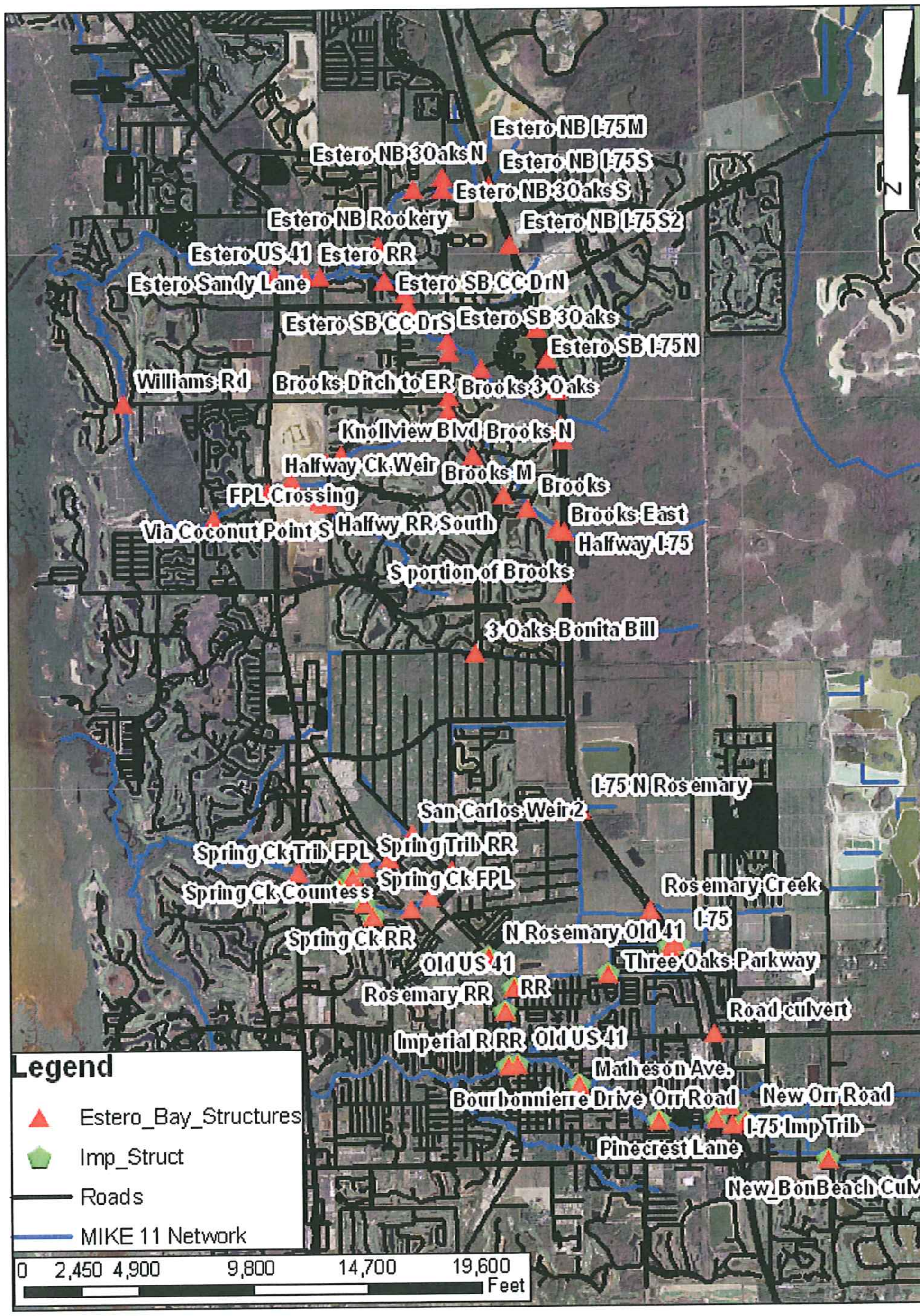


Figure 2-2b – Map of SLCWP Study Area

3. South Branch of the Estero River, Branch ESTERORIVS
    a. Added a culvert with the capacity equivalent to the existing Monty Run bridge at I-75, ch. 252.6.
    b. A branch was added to represent runoff from the Stonybrook development.
    c. Moved Sanctuary Road culverts to the correct location (ch. 4200) and put in correct dimensions from Boyle survey. Added Boyle surveyed cross sections upstream and downstream.
    d. Put in Village of Country Creek bridges 1 and 2 from permit drawings and deleted culverts (ch. 9,680 and 11,250).
4. Three Oaks Branch - ThreeOaks
    a. Deleted existing cross sections and replaced them with Boyle surveyed cross sections plus more detailed information from Three Oaks permit.
    b. Modified weir at north end of branch.
5. Estero River – Branch EsteroRiv
    a. Put in Sandy Lane bridge (ch. 10,056 ft).
    b. Modified cross sections to accommodate bridge.
6. Halfway Creek Upstream of I-75 – Branch HalfwayUp
    a. Modified cross sections downstream of I-75 culvert and added culverts at the east end of the Brooks (ch. 6,300 and 7,700). Note that the culverts under I-75 have a reduced capacity to reflect sediment accumulations observed in the summer of 2008. This will be modified for the alternatives analysis.
    b. Cross sections in the Brooks taken (with modifications) from HEC-RAS files.
7. Halfway Creek from east of Three Oaks to Outfall Weir – Branch HalfwayCr
    a. Culverts at Three Oaks not added yet
    b. Added 3 sets of culverts within the Brooks (ch. 800, 2,600, and 8486.53).
    c. Weir at outfall of Brooks modified to be consistent with permit drawings (ch. 10,400 ft).
8. Spring Creek Headwaters Tributary – Branch SpringHW
    a. This branch was added to allow flows to pass under I-75 from areas near the southern end of the Brooks. This branch may be used to evaluate alternatives intended to direct additional flows to Spring Creek.
    b. This branch looks as if it should enter Spring Creek, but it is directed north to Halfway Creek upstream of the Brooks based on input from Johnson Engineering.
    c. Cross sections estimated using best engineering judgment. Added box culvert (4.36 ft wide x 2.25 ft high) which is equivalent to two 30" dia. culverts. Culvert information from I-75 design drawings (ch. 5218.15 ft). Note that the I-75 design drawings show a 72" diameter culvert, however this culvert does not exist (confirmed by Richard Dun, ACCI/API Joint Venture, 11/12/08 e-mail).

9. Halfway Creek South Branch – Branch HalfwayS to South Weir
   a. This is a new branch added to MIKE 11 starting west of Three Oaks.
   b. Cross sections within Brooks are best engineering estimates.
   c. No culverts added.
   d. South Brooks weir added (ch. 7555).
   e. Railroad culverts added to model (ch. 7700), but Via Coconut Point culverts not added as conveyance in these culverts is larger than the railroad culverts.
10. Via Coconut Point Ditch
    a. This is a new branch that connects HalfwayCr with HalfwayS.
    b. Cross sections from Boyle survey
11. Halfway Creek and South Tributary from Brooks outfall to Williams Rd
    a. Location of main branch moved using aerial survey information.
    b. Cross sections west of Via Coconut Point are from Boyle survey.
    c. Culverts at Via Villagio for Halfway Ck (ch 12,000 on HalfwayCr) and South Branch (ch. 9,410 on HalfwayS) are from permit drawings.
    d. Halfway Creek Cypress weir east of U.S. 41 added from Boyle survey (ch. 12,400).
    e. U.S. 41 culverts moved to correct location (ch. 12,870 ft).
    f. Halfway Creek cross section west of U.S. 41 at wooden walkway is from Boyle survey (ch. 13,500 in SWMM XS folder). The effect of the walkway is also included as the walkway is modeled as a bridge.
    g. Another newly surveyed cross section by Boyle was added west of the walkway cross section.
    h. Halfway Creek cross section at FPL crossing was obtained from Hole Montes FPL pipeline crossing design drawings (ch. 15,338.7 ft)
    i. Williams Road bridge added using information from Boyle survey (ch. 23,447.8 ft).
12. Spring Creek – Branch SpringCr
    a. Added culverts at railroad (ch. 3,253 ft), FPL crossing (ch. 3,900), and Cedar Creek Road (ch. 4,400 ft) (source: Exceptional Engineering, 2008).
    b. Cross sections modified to accommodate culverts.
13. Rosemary Creek Tributary (Branch RosemaryTrib)
    a. The I-75 culvert was added at ch. 1,700 ft).
14. Imperial River – Branch Imperial
    a. Culverts were added for Poor Man's Pass Road, a farm ford between Poor Man's Pass Road and Vincent Road, and Vincent Road culverts were added. Invert elevations for the farm ford and Vincent road culverts and road elevation were estimated using best engineering judgment.
    b. Culverts at I-75 (ch. 4,888 ft) were replaced by bridges using information from the I-75 design.
    c. Matheson Road bridge (ch. 14,291) was simulated as a culvert. The conveyance of the culvert is consistent with the bridge conveyance.

This approach is sometimes used to overcome model instabilities and is valid as long as the culvert dimensions are the same as the part of the bridge that conveys water.

d. Bonita Grande Drive and Orr Road were simulated as culverts in the DRGR model, however dimensions were incorrect. The correct dimensions were entered into the model files.
e. The old Imperial Bonita Estates bridge or Bourbonnibiere bridge from the MIKE 11 DRGR model was updated to reflect new bridge dimensions.
f. Bridges at Old 41 and the railroad were not added to the model.

Note: While MIKE 11 is a proprietary computer program, all input and output model files can be viewed without a user license. The software can be downloaded from www.dhisoftware.com, however it is easier to request a DVD from DHI (contact Janice Kutsmeda at jak@dhi.us).

2.4 MIKE SHE Changes

The MIKE SHE changes include modifications to flood codes (which define exchanges between branches and overland flow), land use information, and rainfall data. Changes were implemented to improve the calibration, reduce model instability, and in general to update information where available. For example flood codes were added to allow the channels to spill over on the flood plains where appropriate. Flood codes were removed where it was evident that a barrier (e.g. a berm prevented water from spilling over. In some instances flood codes were replaced by the spillage option (an alternative to flood codes) to reduce model instabilities. These changes are summarized below.

Flood Code Changes

1. Estero River North Branch – Branches EsteroRivN, EsteroI75, and EsteroTrib
   a. Removed flood codes on the east side of EsteroTrib.
   b. Added flood codes just west of EsteroI75 to allow overland flow from wetlands east of I-75 to reach the branch.
   c. Added flood codes to EsteroRivN.
2. Halfway Creek – Branch HalfwayUp
   a. Modified flood codes so that lands east of I-75 have a different flood code than lands west of I-75.
3. Spring Creek Headwaters – Branch SpringHW
   a. Added flood code cells for lands east of I-75.
4. Halfway Creek South Tributary – Branch HalfwayS
   a. Added a flood code for lands east of the south weir.
5. Halfway Creek Main Stem – Branch HalfwayCrDS
   a. Flood codes were not used downstream of the Brooks outfall weir, but the spillage option is used for exchanges between the overland

flow plane to the river network. This approach was used because the spacing of roads that restrict overland flow is closer than can be simulated using flood codes.

6. Spring Creek tributary Bonita Bill Canal – Branch SpringCkNE
    a. Added a flood code for a section of Bonita Bill Canal east of Old U.S. 41 that flows to and from a large wetland area north of Strike Lane in the vicinity of Amarillo Street.
7. Rosemary Creek – Branches Rosemary and RosemaryTrib
    a. Reduced the extent of flood code 77 (lands west of I-75) and added flood codes 110 (Rosemary) and 109 (RosemaryTrib).
8. Imperial River
    a. Reduced extent of flood code 30 so that only lands west of I-75 are covered, and added flood code 108 for lands east of I-75 and west of Boca Grande Drive.
    b. At Kehl Canal weir, the flood codes were modified to separate flood code 30 from 36, and additional flood code cells (code 36) north of Kehl Canal were added.

2.4.1 Land Use Changes

Land use files from the Lee County DRGR were checked against known 2008 land use information. The MIKE SHE land use files were found to be accurate in most areas, as evidenced by the land use details within the Brooks development. In the MIKE SHE land use file, the areas with lakes, hardwood forest, and wetlands are indicated by appropriate land use codes, and the developed areas with roads and houses are shown as medium density urban land use. It was noted that the land use file for some areas west of the Brooks and east of U.S. 41 were shown as undeveloped land, while the current land use is the Coconut Point Mall (see **Figure 2-3**). The land use file used in the Lee County DRGR MIKE SHE/MIKE 11 model was calibrated using stream flows and water levels from 2001 through 2006, therefore the land use file was determined to be representative for the period of interest for the DRGR study. However, for the South Lee County Watershed Plan Update, the calibration focuses on conditions from 2006 through 2008, therefore these undeveloped areas were converted to high density urban.

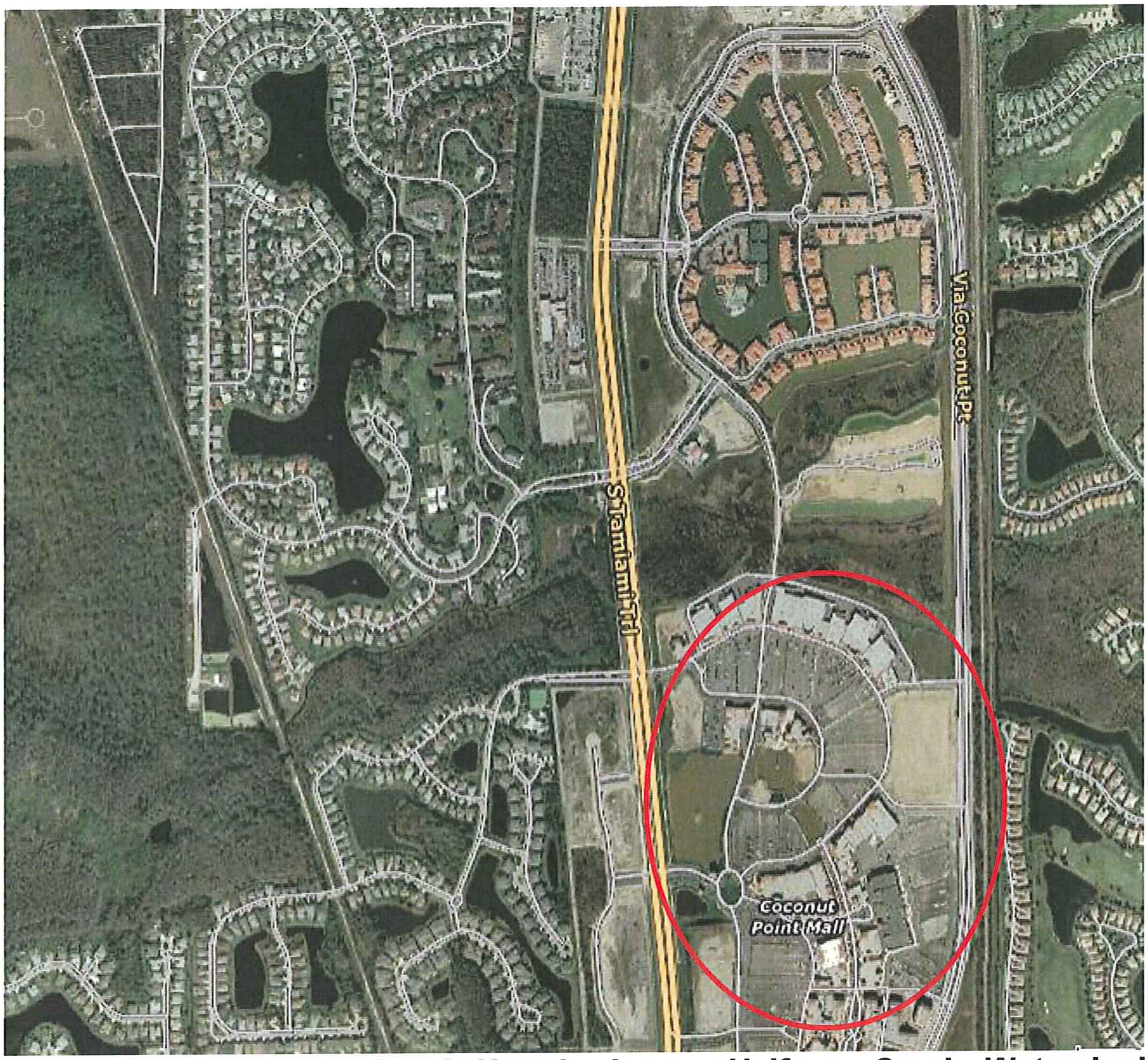


Figure 2-3 – Current Land Use in Lower Halfway Creek Watershed Highlighting the Coconut Point Mall (source: www.mapquest.com)

2.4.2 Rainfall Data

The Lee County DRGR study uses daily rainfall data, and the focus of the South Lee County Watershed Plan Update is peak flow conditions, therefore OneRain grid rainfall files from Lee County were used. The information was provided in 15-minute intervals that was then grouped into an hourly time interval. The rainfall period used is 2006 through October, 2008.

3.0 MODELING RESULTS

The model was run for 2002 through 2006 using daily rainfall data to evaluate the impact of the changes described above on the calibration. The next step was to document the calibration using hourly rainfall data from 2006 through October,

2008. This report describes initial calibration results, steps taken to improve the calibration, and the calibration results following adjustment of model parameters.

3.1 Initial Model Calibration

The model development and calibration process for this project involves the following steps:

1. Verification of the physical information.
2. Use of daily rainfall data to make sure the model runs smoothly.
3. Checking of calibration results to determine where improvements are necessary.
4. Adjustment of model parameters that influence the rainfall runoff process such as detention storage, drainage depth, and vegetation evapotranspiration parameters.
5. Review and check physical data if necessary.
6. Utilize hourly rainfall and refine the calibration.

When daily rainfall data is used and the groundwater time step is less than 24 hours, MIKE SHE divides the daily rainfall by the groundwater time step to calculate the rainfall amount. This under-estimates the rainfall amount for summer tropical thunderstorms. In general, hourly rainfall is needed for MIKE SHE/MIKE 11 models of urban watersheds.

The initial calibration using daily rainfall data was generally good for flow at the North Branch of the Estero River, and simulated stage follows the pattern of the measured stage. An updated cross section was obtained from the USGS which improved the stage calibration. Calibration is generally good for both stage and flow for the South Branch of the Estero River, however both simulated peak stages and flows were higher than measured values for most events. Improving the flow calibration for the North and South Branch of the Estero River was a focus during the calibration process.

Spring Creek initial simulated stages were generally good, however simulated flows were much less than measured flows. Increasing runoff was a focus during the calibration process. It was found that the initial conceptualization of the canal network was incorrect and that the north and south branches of Spring Creek needed to be connected within San Carlos Estates to correct this problem. Additionally, it was discovered during calibration that certain cross sections in Spring Creek downstream of the Old U.S. 41 USGS gaging station were necessary, and additional cross sections were obtained from the City of Bonita Springs who conducted a rapid-response surveying effort.

Initial simulated stages were good for the Imperial River at Orr Road, however simulated flows were less than measured flows. Increasing runoff in the Imperial

River was a focus during the calibration process. The steps taken to address these calibration challenges are discussed below in the next section.

3.2 Final Calibration Results

This section describes the calibration process without providing results files for each of over 50 calibration runs conducted. Rather, a summary of the changes is provided with some comparison of performance for key parameter changes. This section also provides calibration plots, statistics, and water balance information. Note that the calibration effort addressed most of the challenges discussed above in Section 3.1.

3.2.1 Calibration Process

A broad range of calibration parameters were reviewed during the calibration process. In many cases, the original parameters were maintained, however certain parameters were modified. Parameters that were modified temporarily or permanently are described below.

Overland flow and channel Manning's n values were modified for MIKE 11 and for overland flow in portions of the model to increase flow from the Green Meadows Branch to the Kehl Canal and also to calibrate stages in the Estero River, Halfway Creek, Spring Creek, and the Imperial River. **Table 3-1** provides a summary of the changes made to overland flow Manning's n values and **Figures 3-1 through 3-4** provide maps of MIKE 11 Manning's n values used in this model. The MIKE 11 and overland flow Manning's n values were modified in certain locations during calibration to further attenuate peak flows determined to be too high when compared to measured data. One such location is the South Branch of the Estero River (**see Figure 3-1**) just upstream of I-75 that has a high river Manning's n value to account for a dense stand of Melaleuca just east of I-75. **Figure 3-3** shows areas of higher Manning's n values in Halfway Creek where resistance is high due to dense stands of cypress (downstream of U.S. 41) and willow (upstream of Via Villagio). **Figures 3-5 and 3-6** provide photographs of vegetation at these two locations that have high Manning's n values.

In the overland flow Manning's n file, the urban categories including areas around Estero River and Halfway Creek were modified by multiplying the original values by 4.0. These values were modified to account for the large number of ponds that have restrictive features such as culverts and weirs, and bleed down systems that were not included explicitly in the model.

Land Use Category	DRGR Mannings n	SLCWP Update 2009 Mannings n
Urban High Density	0.11	0.44
Urban Medium Density	0.12	0.48
Urban Low Density	0.14	0.56

Table 3-1 – Summary of Changes to Overland Flow Manning's n Values

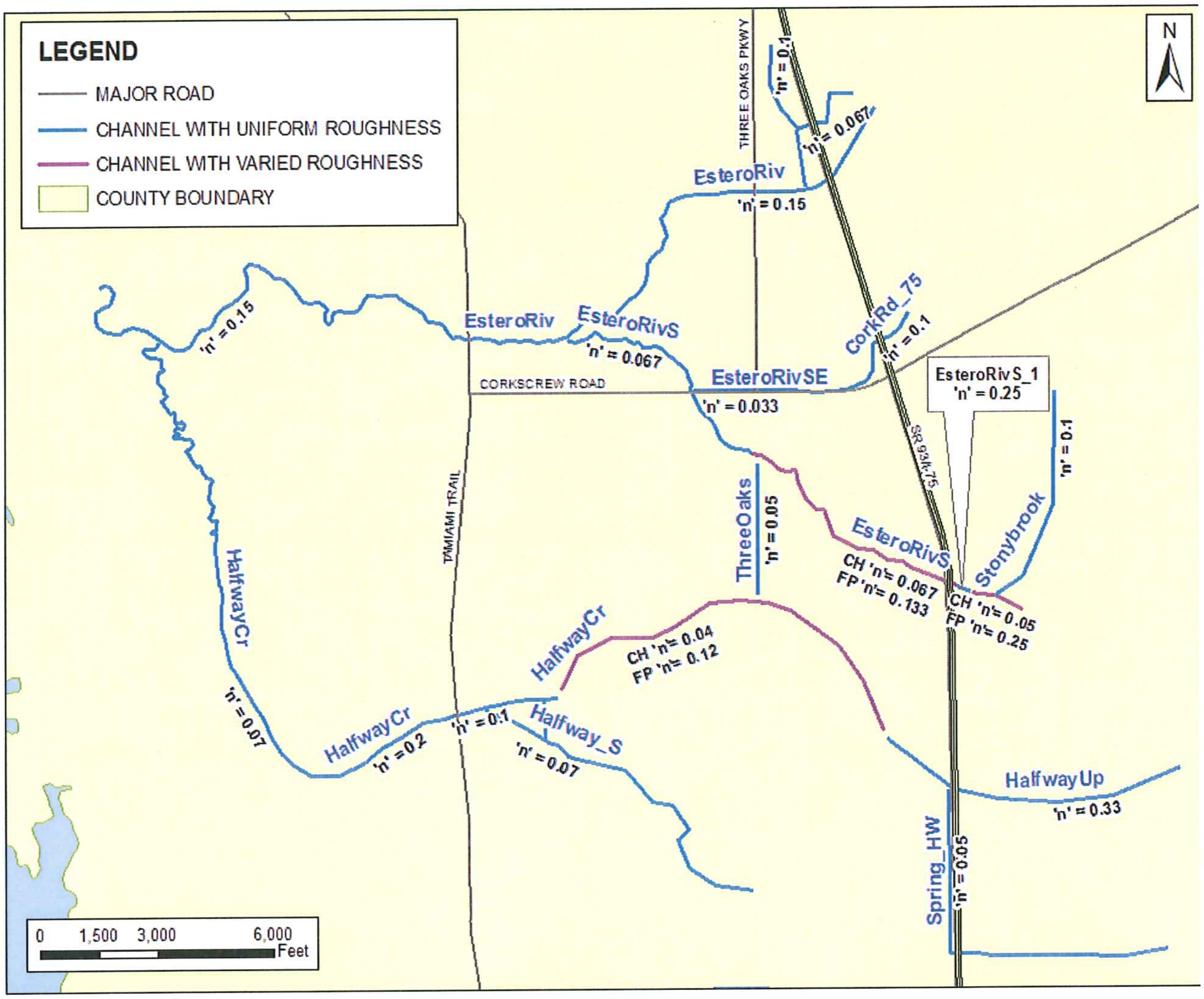


Figure 3-1 – Estero River and Halfway Creek Manning's n Values

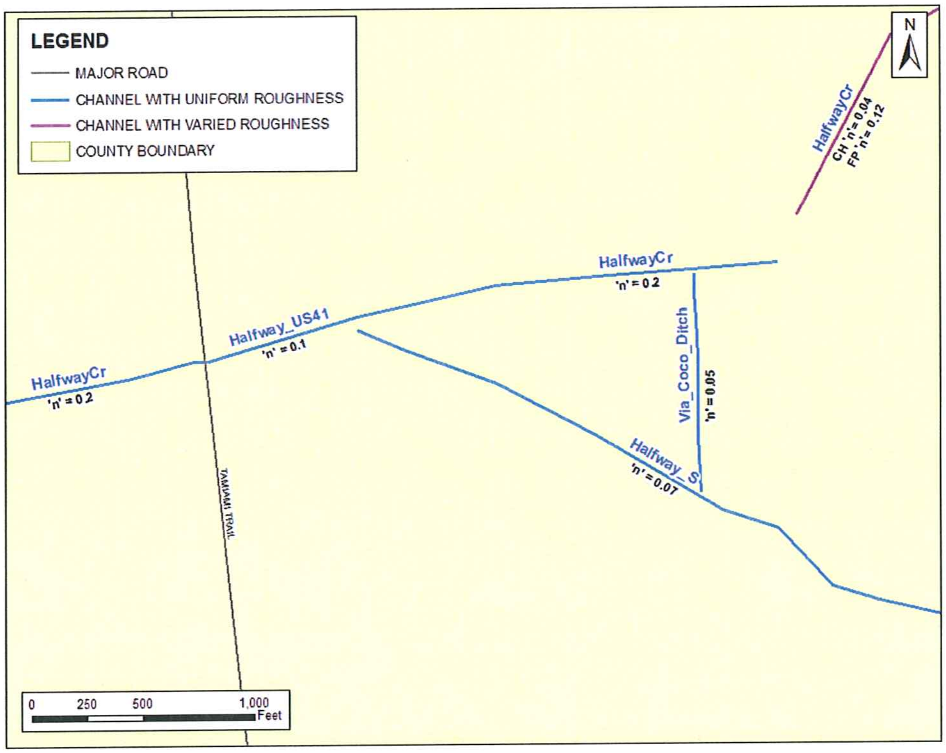


Figure 3-2 – Detailed View of Selected Halfway Creek Manning's n Values (Upstream of U.S. 41 and west of the Brooks Weirs)

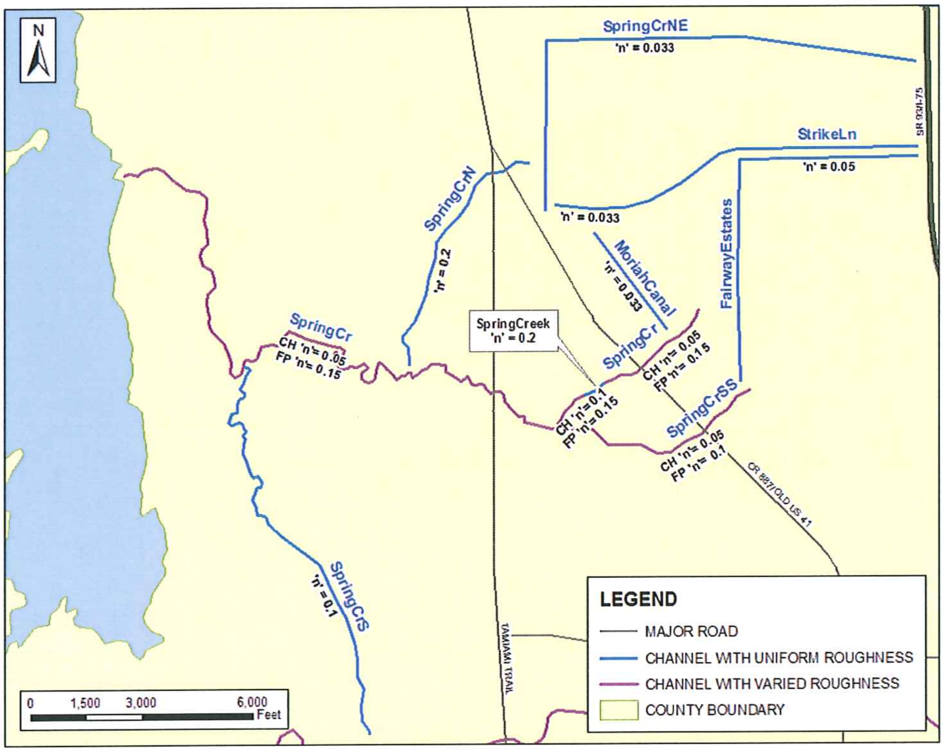


Figure 3-3 – Spring Creek Manning's n Values

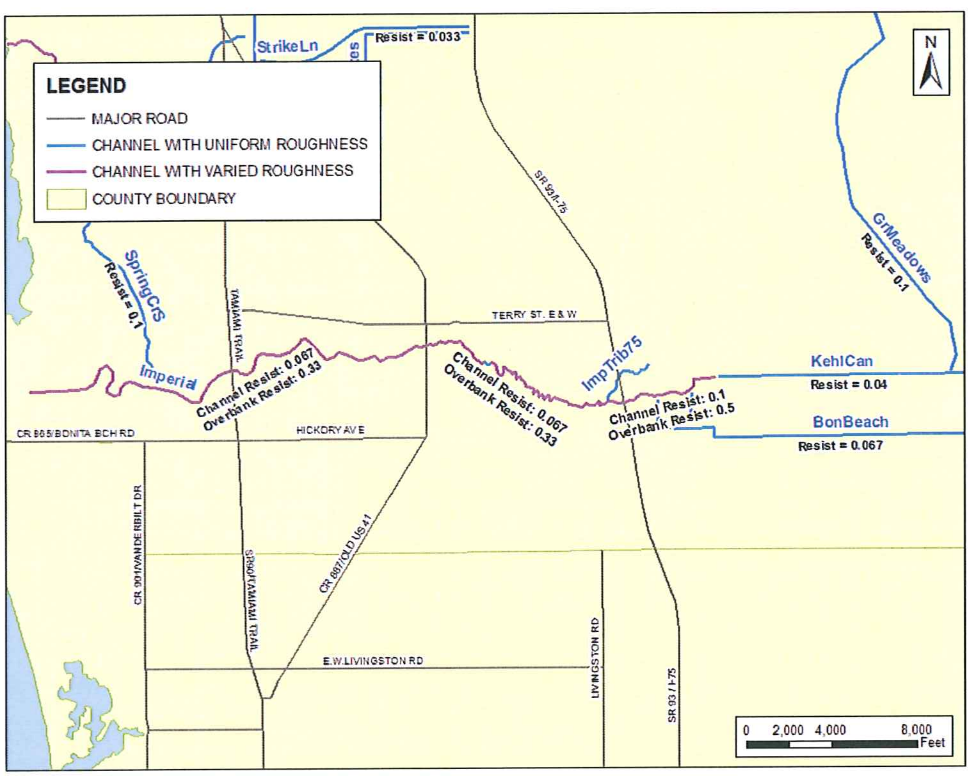


Figure 3-4 – Imperial River Manning's n Values

Figure 3-5 – Photograph of Dense Cypress in Halfway Creek Downstream of U.S. 41

Figure 3-6 – Photograph of Willow and Sedges in Halfway Creek Upstream of Via Villagio

A range of parameters were modified to decrease flows in the South Branch of the Estero River including overland flow and channel Manning's n values, and I-

75 bridge and culvert entrance loss coefficients, vegetation evaporation coefficients were increased, and hydraulic conductivity values were changed for the surficial and Sandstone aquifers. Detention storage coefficient, drainage level and time constants, and paved area coefficient were modified up and down to test the sensitivity of the calibration to those parameters.

Changes were made to the Paved Runoff coefficient for urban categories. Initial model runs indicate that the runoff rates for urban areas were too high. Consequently, the paved runoff coefficient was reduced from 70 to 35 percent. This reduction was justified because a large percentage of paved area runoff is routed to detention ponds that are not a part of the Mike 11 network. The assumption here is that 35 percent will runoff directly and only a portion of the remaining 65 percent will contribute to runoff depending on infiltration rates, etc.

On examining the evapotranspiration parameters in the DHI model, it was noted that the crop coefficients (kc) were all set at unity. The crop coefficient sets the maximum rate of evapotranspiration (potential evapotranspiration) for each crop or land use as a function of the Reference evapotranspiration (RET). Typically, open water bodies or wetlands may be equal to or approach RET which is the evapotranspiration rate for a wet prairie/marsh system, so that a value of unity may be appropriate. However, some other categories (e.g., pasture) normally have a lower value to account for the fact that evapotranspiration would be less than that of an open water body. Under the same climatological conditions, potential evapotranspiration from wetlands is larger than potential evapotranspiration from vegetated unsaturated soil areas primarily because of water availability with direct exposure to the atmosphere. The vegetated unsaturated soil areas are typically defined by adjusting the RET to a lower value by the application of a multiplier coefficient. The values of unity for all categories was then not considered to be appropriate and was modified to initially use lower values as used in the Camp Keias (HGL, DHI, 2006) and Kissimmee (Earth Tech, DHI, 2007) models. Final calibrated values used in this model are shown below in **Table 3-2**.

Land Use	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.754
Pasture	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Sugar Cane	0.73	0.73	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.76	0.91
Truck Crops	0.62	0.62	0.63	1.00	1.00	1.00	1.00	0.68	0.68	0.76	0.71	0.84
Golf Course	0.67	0.67	0.61	0.65	0.66	0.68	0.68	0.76	0.85	0.85	0.83	0.73
Bare Ground	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Mesic Flatwood	0.64	0.64	0.64	0.64	0.81	0.90	0.90	0.81	0.72	0.63	0.63	0.63
Mesic Hammock	0.64	0.64	0.64	0.64	0.81	0.90	0.90	0.81	0.72	0.63	0.63	0.63
Hydric Flatwood	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hydric Hammock	0.50	0.50	0.50	0.61	0.78	0.87	0.87	0.78	0.70	0.61	0.52	0.50
Wet Prairie	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Marsh	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cypress	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Swamp Forest	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mangrove	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Water	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Urban Low Density	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Urban Median Density	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Urban High Density	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

Table 3-2 – Crop Coefficients Used in the SLCWP MIKE SHE Model

The values for an urban category were relatively large compared to a value of 0.70 in the Camp Keias model. These relatively high values were determined during calibration and justified because of the numerous ponds as shown on **Figure 3-7** which are open water bodies with high rates of evapotranspiration.

Figure 3-7 – Urban Detention Ponds

Saturated flow components were modified during calibration. Specifically, the Holocene-Pliocene layer horizontal and vertical hydraulic conductivities were increased by a factor of 10, and the specific yield changed from 0.15 to 0.05 to conform to information provided by SFWMD. For the Lower Tamiami layer, the horizontal and vertical hydraulic conductivities were increased by a factor of 5, and the specific yield changed from 0.20 to 0.10. For the Sandstone layer, the horizontal and vertical hydraulic conductivities were decreased by a factor of 10.

Irrigation files were modified for lands west of I-75 to increase irrigation rates. DRGR irrigation rates were less than 5 inches/year for most urban lands west of I-75, and measured irrigation flow data obtained from Resource Conservation Systems, LLC were reviewed to determine if irrigation rates should be adjusted. Measured average irrigation from Brooks lakes and the surficial aquifer was 13 inches/year for 2006-2008. As a result, irrigation rates were increased for the Brooks and a number of other areas west of I-75. **Table 3-3** provides a summary of irrigation values used in the model for the Brooks area, and **Figures 3-8 and 3-9** show the DRGR and revised irrigation command areas, respectively.

Irrigation Command Area	Old Flow Rate, cfs	New Flow Rate, cfs
214 (golf course reuse water)	0.57	9.0
579	0.57	0.57
626	0.57	5.0
1180	N/A	4.0
1181	N/A	3.0

Table 3-3 – Old and New Flow Rates for Model Irrigation Command Areas

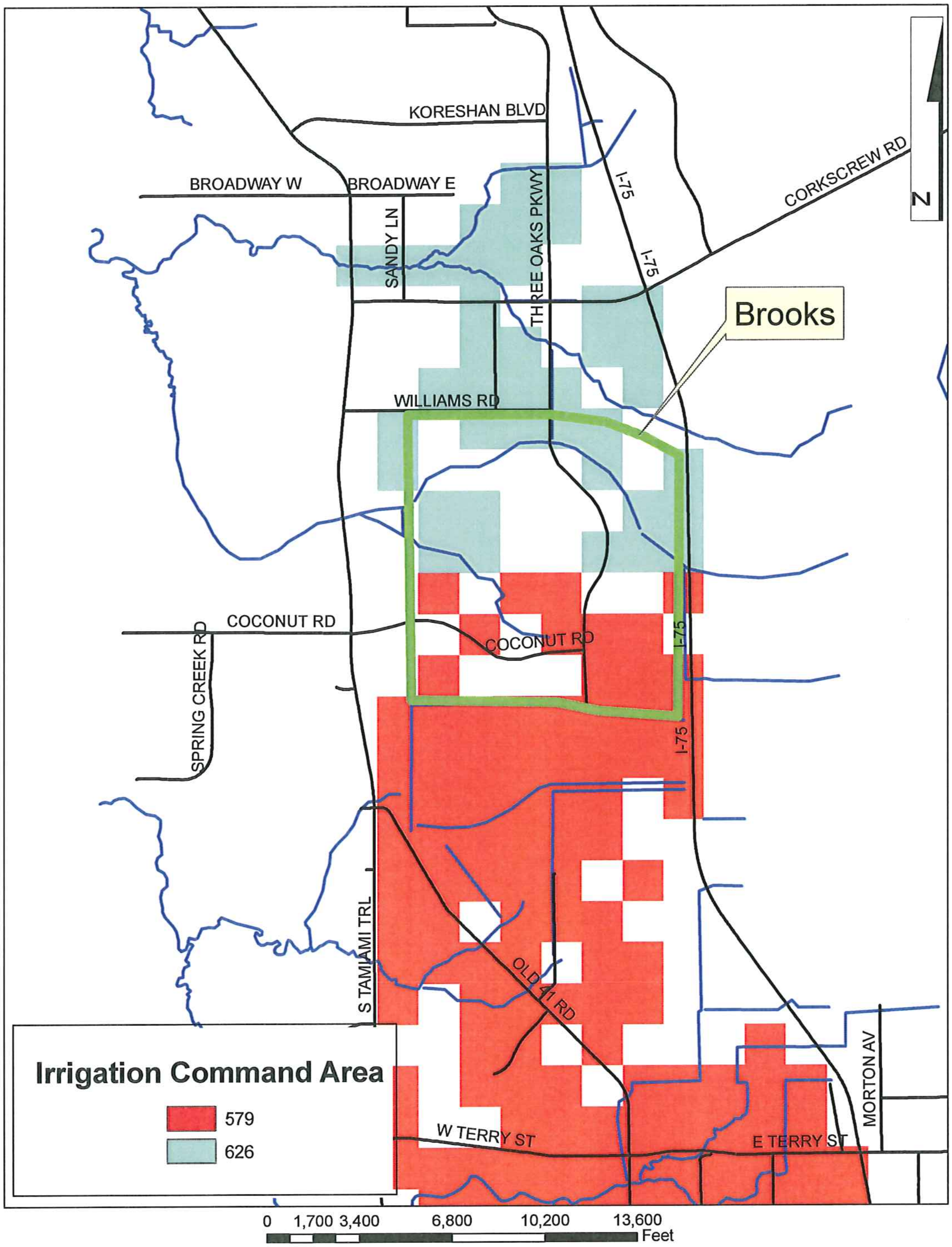


Figure 3-8 – Irrigation Command Areas used in the DRGR Model that were modified as part of this study (see next Figure)

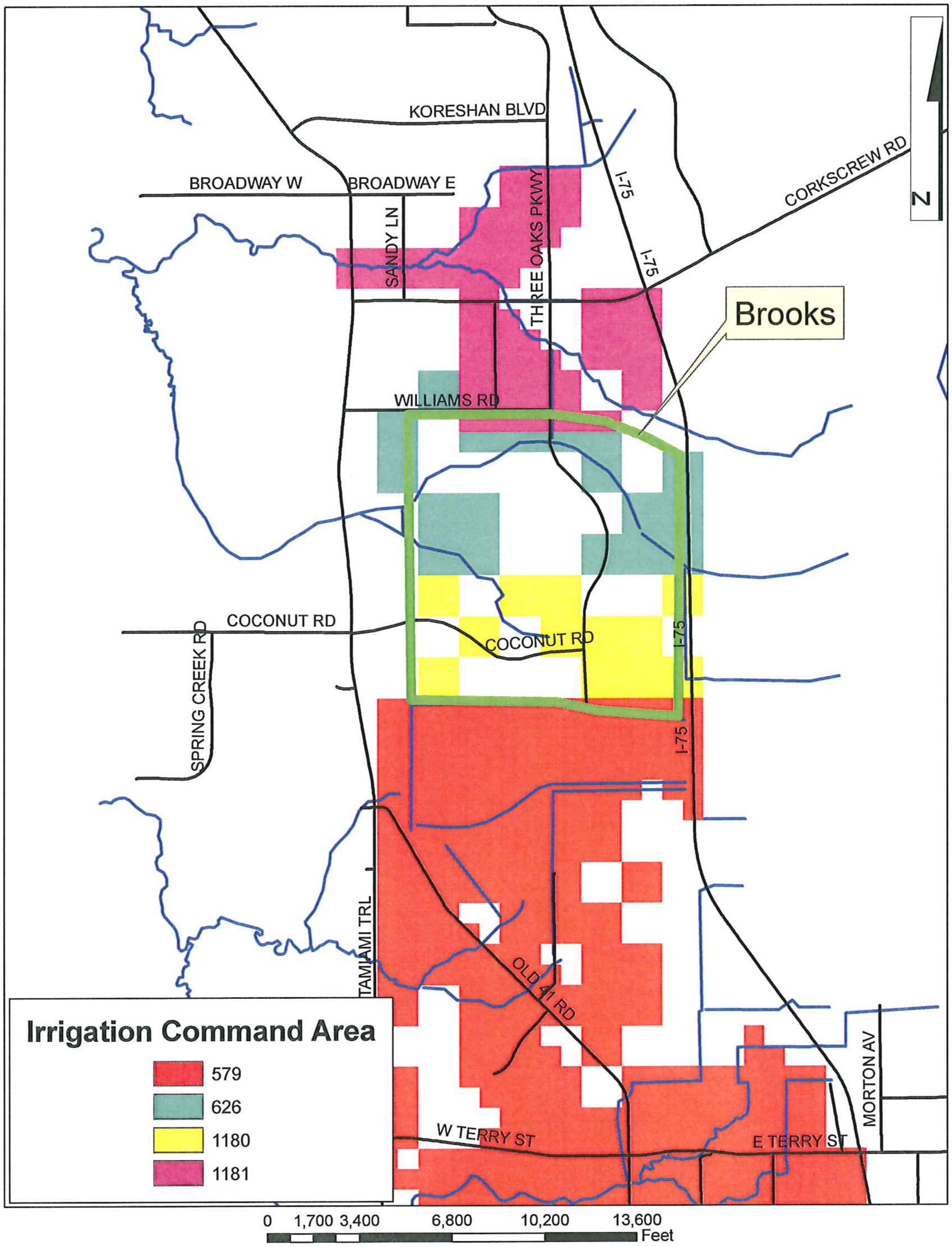


Figure 3-9 – Revised Irrigation Command Areas for the Estero River, Halfway Creek, Spring Creek, and Imperial River Watersheds

3.2.2 Calibration Statistics

MIKE SHE/MIKE 11 generates calibration statistics for stations where measured data is available. The statistics being used are mean error, mean absolute error, root mean square error, correlation coefficient, and the Nash-Sutcliffe coefficient. Mean error (ME) is the average of differences between measured and predicted values. Mean absolute error (MAE) is the average of the absolute differences between measured and simulated values. MAE is always greater than ME, and ME tends to under-report calibration accuracy as ME = 0 could mean half of the differences are -5 with the remainder of the differences equal to +5. Root Mean Square Error (RMSE) is similar to MAE, however it corrects for non-standard distributions. Stream flow has a non-standard distribution because flow is mostly low with infrequent periods of high flow. Accordingly, RMSE is a good metric for river calibration. The correlation coefficient measures the closeness of fit between the simulated and measured values, and 1.0 indicates perfect correlation. Nash Sutcliffe coefficient is a difficult statistical measure to describe, however it generally means the error divided by the variability. Stations with higher variability generally have higher error, and this statistic corrects for high variability. **Table 3-4** presents the model calibration targets and **Table 3-5** presents the equations used for each metric. Certain calibration targets for ME and MAE are narrower than for the DRGR model. The high model performance target for surface water has been reduced from 0.8 feet to 0.5 feet. The high model performance target for groundwater has been reduced from 1 foot to 0.5 feet. The medium and low targets were also revised. The groundwater correlation coefficient target for high performance has been increased from 0.7 to 0.8. The Nash-Sutcliffe coefficient targets were not used in the DRGR study, and the performance targets were taken from the Southwest Florida Feasibility Study MIKE SHE modeling study (SDI et. al., 2008).

<table>
<tr><td></td><td colspan="3">Level of Model Performance</td></tr>
<tr><td>Statistical parameter</td><td>High</td><td>Medium</td><td>Low</td></tr>
<tr><td colspan="4">Surface Water Flow Targets</td></tr>
<tr><td>R</td><td>0.8 <= R < 1.0</td><td>0.6 <= R < 0.8</td><td>R < 0.6</td></tr>
<tr><td colspan="4">Surface Water Stage</td></tr>
<tr><td>ME (ft)</td><td>|ME| <= 0.5</td><td>0.5 < |ME| <= 1.0</td><td>|ME| > 1.0</td></tr>
<tr><td>MAE (ft)</td><td>MAE <= 0.5</td><td>0.5 < MAE <= 1.0</td><td>MAE > 1.0</td></tr>
<tr><td>RMSE (ft)</td><td>RMSE <= 1.0</td><td>1.0< RMSE<= 2.0</td><td>RMSE > 2.0</td></tr>
<tr><td>R</td><td>0.8 <= R < 1.0</td><td>0.6 <= R < 0.8</td><td>R < 0.6</td></tr>
<tr><td>Nash Sutcliffe, R2</td><td>0.7 <=R2<=1.0</td><td>-1.0<=R2<=0.7</td><td>NS<= -1.0</td></tr>
<tr><td colspan="4">Groundwater Level Targets</td></tr>
<tr><td>ME (ft)</td><td>|ME| <= 0.5</td><td>0.5 < |ME| <= 1.0</td><td>|ME| > 1.0</td></tr>
<tr><td>MAE (ft)</td><td>MAE <= 0.5</td><td>0.5< MAE <= 1.0</td><td>MAE > 1.0</td></tr>
<tr><td>RMSE (ft)</td><td>RMSE <= 1.25</td><td>1.25 < RMSE<= 2.5</td><td>RMSE > 2.5</td></tr>
<tr><td>R</td><td>0.8 <= R < 1.0</td><td>0.5 <= R < 0.8</td><td>R < 0.5</td></tr>
<tr><td>Nash Sutcliffe, R2</td><td>0.7 <=R2<=1.0</td><td>-1.0<=R2<=0.7</td><td>NS<= -1.0</td></tr>
</table>

Table 3-4 - Performance Metrics

Symbol	Name	Formula
ME	Mean error	$\langle Obs_i - Calc_i \rangle = \frac{1}{n}\sum_{i=1}^{n}(Obs_i - Calc_i)$
MAE	Mean Absolute Error	$\frac{1}{n}\sum_{i=1}^{n}\lvert Obs_i - Calc_i \rvert$
RMSE	Root Mean Square Error	$\sqrt{\frac{1}{n}\sum_{i=1}^{n}(Obs_i - Calc_i)^2}$
R	Correlation Coefficient	$\sqrt{\frac{\sum_{i=1}^{n}(Obs_i - Calc_i)^2}{\sum_{i=1}^{n}(Obs_i - \langle Obs_i \rangle)^2}}$
R2	Nash Sutcliffe	$R2 = \frac{\sum_t (Obs_{i,t} - Calc_{i,t})}{\sum_t (Obs_{i,t} - \overline{Obs_i})}$

Table 3-5 - Equations used to define Performance Metrics

3.2.3 Calibration Results

Calibration statistics are presented in **Tables 3-6 and 3-7**. Cells highlighted in green meet the calibration criteria, yellow cells are just outside the calibration criteria, and orange cells indicate poor calibration.

Surface Water Stage Statistics					
Name	ME (ft)	MAE (ft)	RMSE (ft)	R_Correlat	R2_Nash_Su
Estero R NB 3943.57 (EsteroRiv, 1202.000	-0.53	0.62	0.73	0.83	0.31
Estero R SB 8628 (EsteroRivS, 2630.000)	-0.06	0.41	0.59	0.88	0.39
Copperleaf (Halfwayup, 2133.600)	-0.17	0.33	0.40	0.92	0.75
Halfway Creek S HW (Halfway_S, 2270.76	-0.76	0.83	0.99	0.75	-0.20
Halfway Creek S TW (Halfway_S, 2316.48	-0.23	0.45	0.58	0.81	-0.06
HalfwayCrDS HW (HalfwayCrDS, 3127.00	-0.18	0.32	0.39	0.93	0.82
HalfwayCrDS TW (HalfwayCrDS, 3200.40	0.10	0.36	0.50	0.81	0.29
Imperial_Orr (Imperial, 1230.000)	-0.99	1.16	1.55	0.89	0.63
KehlCan_9358 (KehlCan, 9358.000)	0.57	1.19	1.50	0.89	0.76
KehlCan_9479 (KehlCan, 9479.000)	-0.61	1.09	1.49	0.88	0.72
Spring Ck 1574.8 (SpringCRSS, 480.0000)	-0.14	0.36	0.48	0.77	0.38

Surface Water Flow Statistics		
Name	R_Correlat	R2_Nash_Su
Estero R NB Q 4443 (EsteroRiv, 1354.500)	0.84	0.70
Estero R SB 8697 (EsteroRivS, 2651.000)	0.85	0.61
Spring Ck 1637 (SpringCRSS, 499.0000)	0.80	0.56
Imperial_Orr (Imperial, 1245.000)	0.90	0.78

Table 3-6 – Surface Water Calibration Statistics

Name	Layer	ME (ft)	MAE (ft)	RMSE (ft)	R_Correlat	R2_Nash_Su
Corkscrew Swamp	1	-1.54	1.54	1.61	0.89	-1.90
FP10_G	1	-0.23	0.52	0.65	0.91	0.80
FP2_GW1	1	-1.37	1.46	1.63	0.82	-0.12
FP3_GW1	1	-0.31	0.51	0.61	0.92	0.77
FP5_GW1	1	-0.46	0.62	0.73	0.92	0.74
FP6_GW1	1	-0.43	0.68	0.78	0.91	0.72
FP7_GW1	1	-0.33	0.66	0.81	0.91	0.70
FP8_GW1	1	-0.45	0.67	0.78	0.92	0.75
FP9_G	1	-0.34	0.70	0.86	0.87	0.52
Imperial 49-GW10	1	-1.78	2.03	2.27	0.85	0.01
Imperial 49-GW11	1	-1.60	2.17	2.51	0.91	0.18
Imperial 49-GW12	1	-0.57	1.30	1.47	0.84	0.44
Imperial 49-GW14	1	0.11	0.51	0.63	0.96	0.86
Imperial 49-GW15	1	1.26	1.26	1.33	0.74	-4.01
Imperial 49-GW6	1	0.19	0.75	0.95	0.86	0.63
Imperial 49-GW7	1	0.01	0.64	0.69	0.87	0.75
Imperial 49-GW9	1	0.71	0.76	0.94	0.95	0.75
L-1138	1	-0.08	0.37	0.52	0.78	0.53
L-5667	1	0.69	0.78	1.09	0.89	0.47
L-5669R	1	-0.36	0.38	0.45	0.96	0.75
Leitner 49L-GW1	1	-0.99	1.32	1.50	0.76	0.00
USGS L-2195	1	-2.68	2.83	3.08	0.87	-0.76
USGS L-5730	1	1.70	1.70	1.79	0.91	-1.30
Average Values:		-0.38	1.05	1.20	0.88	0.10

Table 3-7 – Groundwater Calibration Statistics

The information presented in Table 2-1 was compared with Table 3-7 above. In general, if the elevation in the topography file in the model is higher than that surveyed and used in computing measured water level data used in the calibration, then the model may simulate a higher groundwater elevation than measured. Wells presented in Table 2-1, and Table 3-7 were compared. The wells FP2-GW1, FP3-GW1, FP5-GW1, FP6-GW1,FP7-GW1, FP8-GW1, FP9-GW1, and FP10-G all had negative differences in Table 2-1 meaning that the information in the model was higher than that surveyed. This is consistent with Table 3-7 which shows negative MEs for these wells indicating the model is simulating higher vales than that measured.

Figure 3-10 provides a map of calibration performance for river stations, and **Figure 3-11** provides a map of calibration performance for surficial aquifer stations. Green points represent stations that meet the calibration criteria, yellow points represent stations that are just outside of the calibration criteria, and red points indicate poor calibration. Plots of measured and simulated values are presented in **Figures 3-12** through **3-20.**

Surface Water Calibration

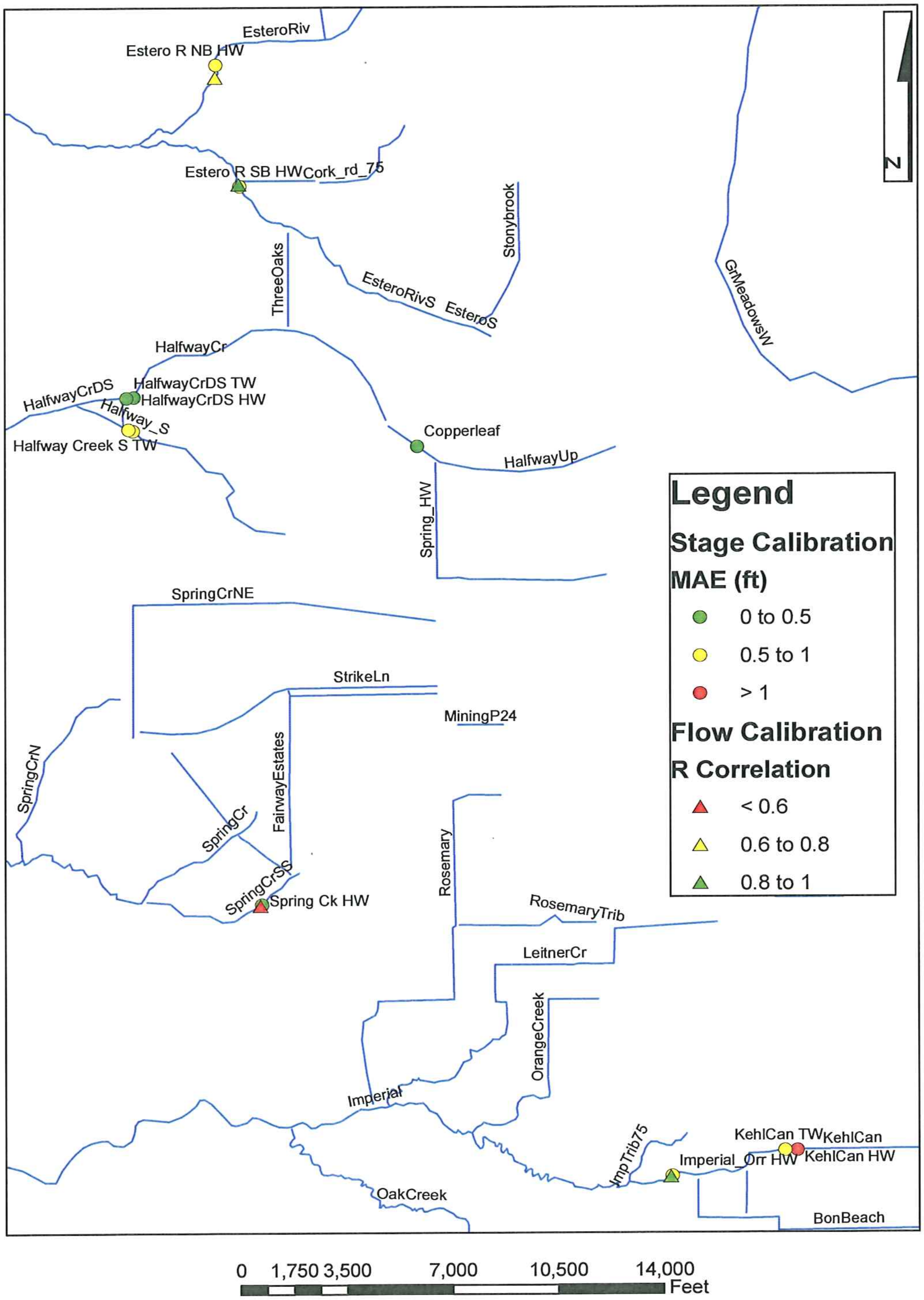


Figure 3-10 – Map of Surface Water Calibration Performance

Surficial Well Calibration

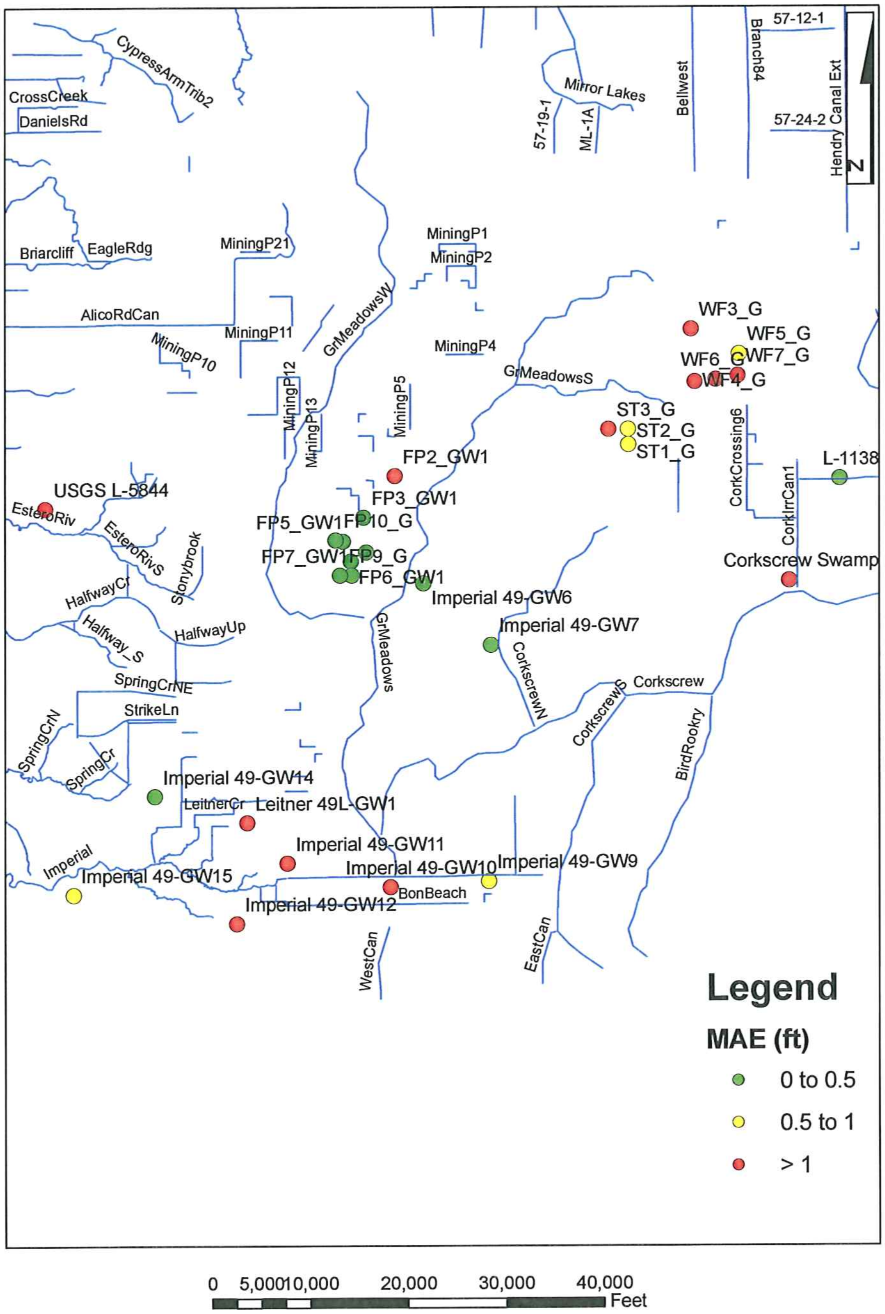


Figure 3-11 – Map of Surficial Aquifer Calibration Performance

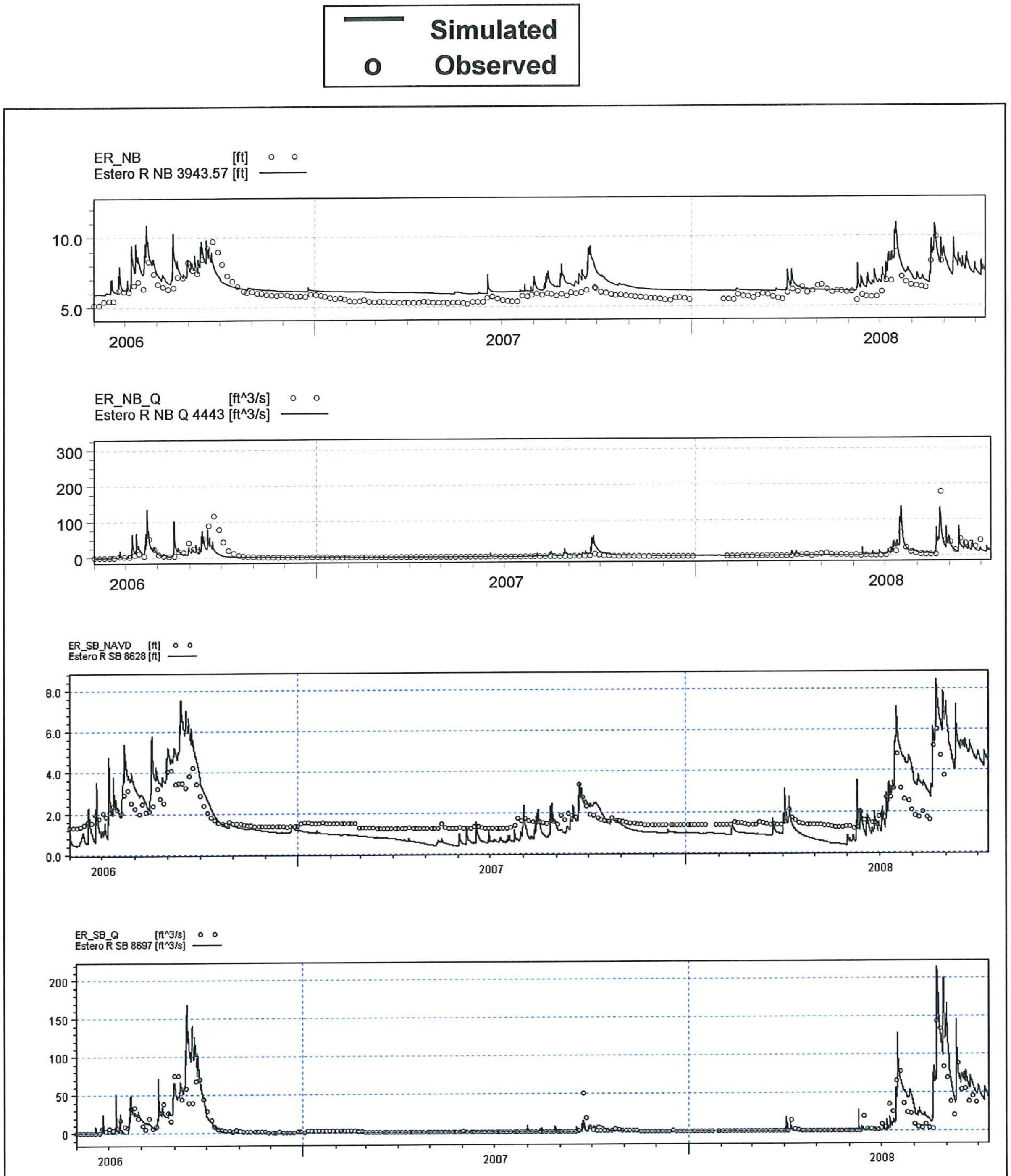


Figure 3-12 – Calibration Plots for the Estero River

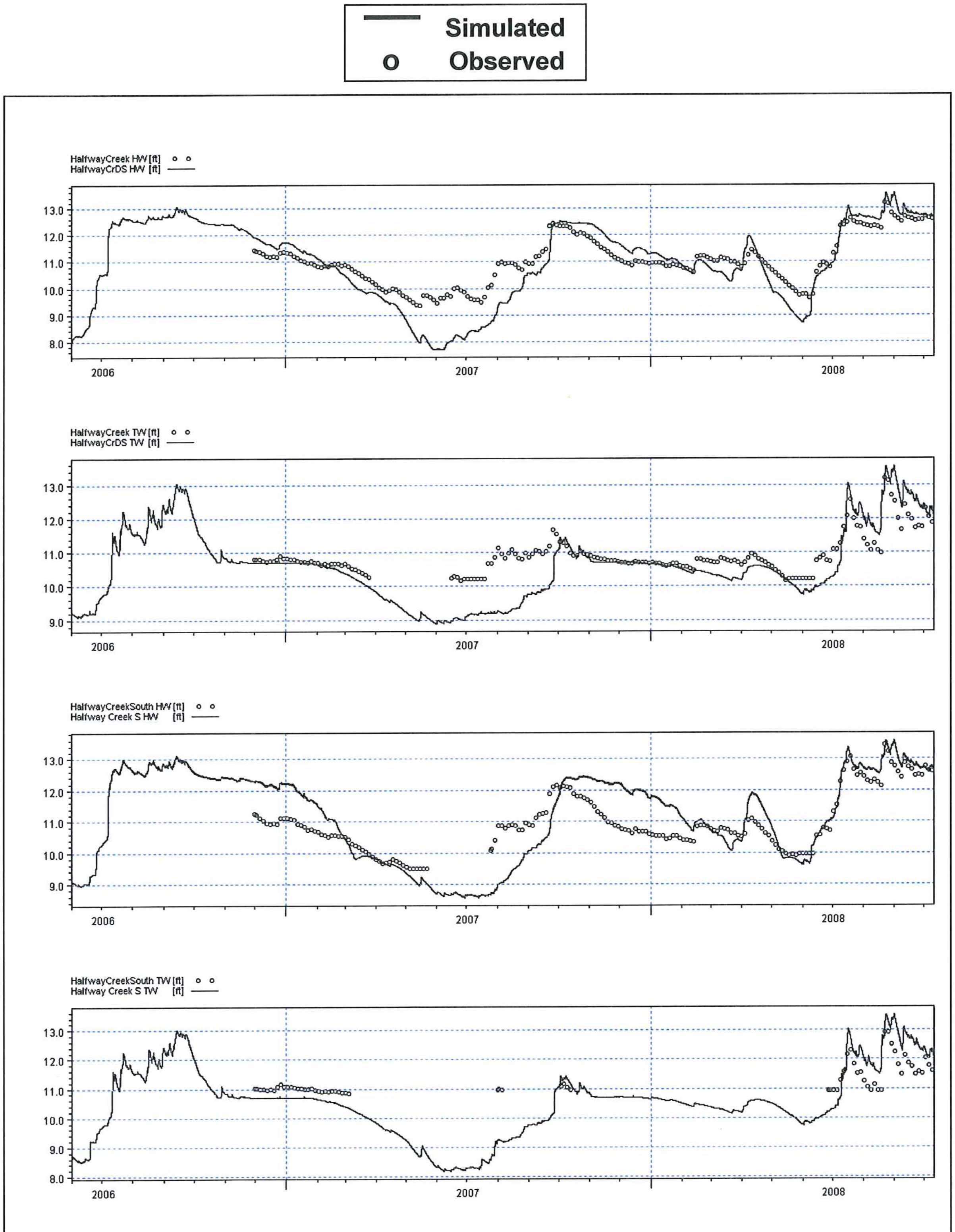


Figure 3-13 – Calibration Plots for Halfway Creek

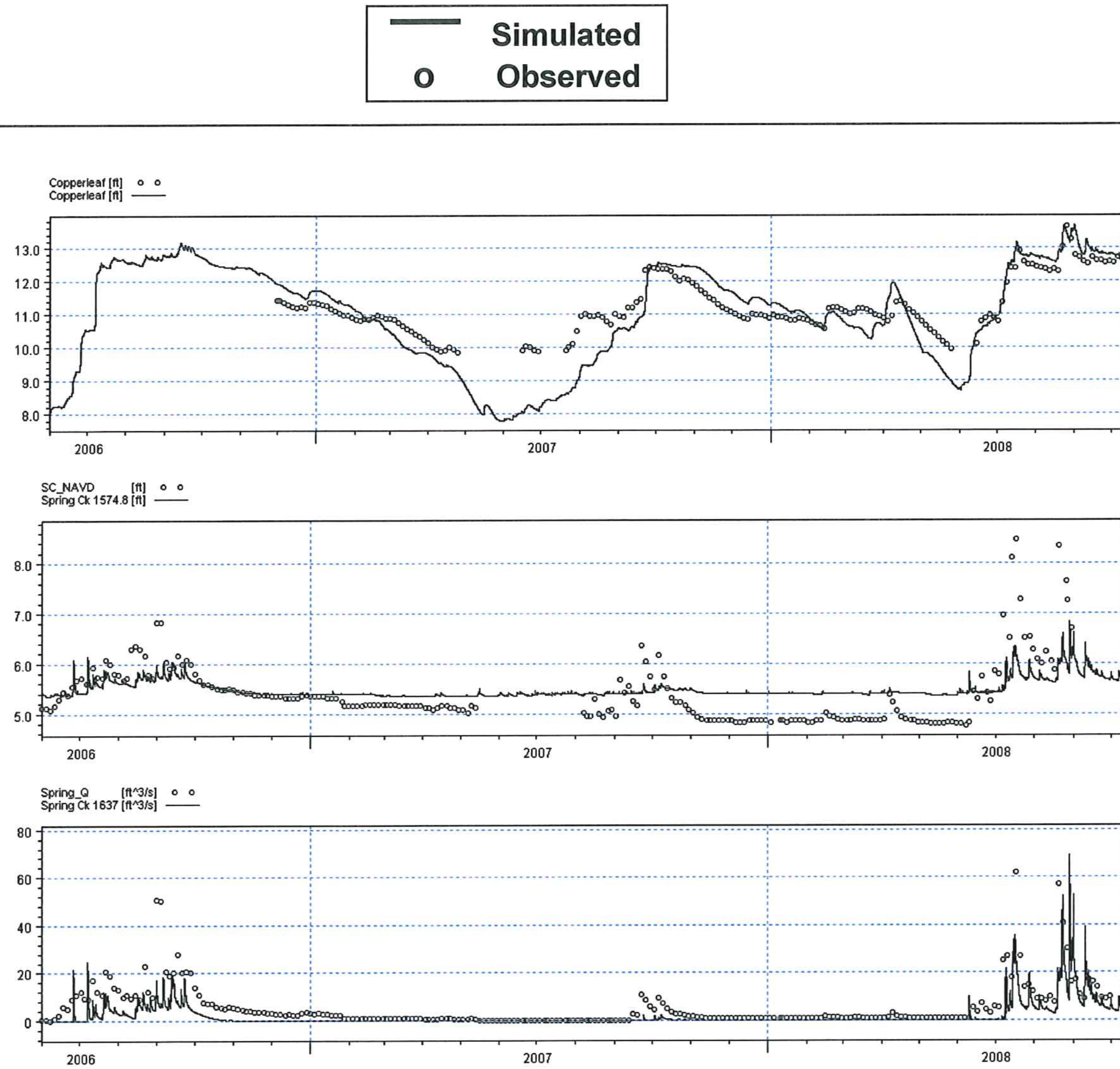


Figure 3-14 – Calibration Plots for Copperleaf (Brooks Lake) and Spring Creek Stage and Flow

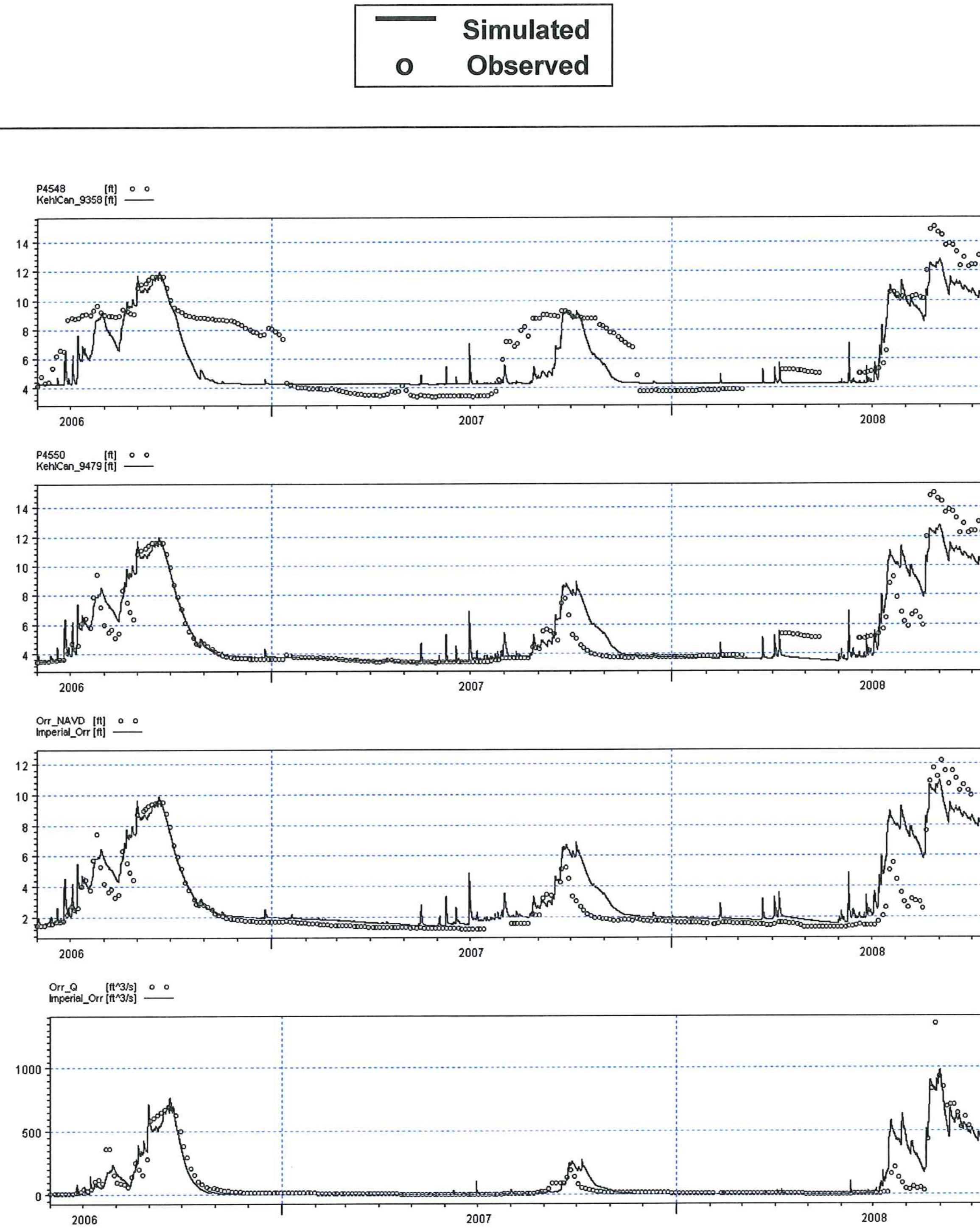
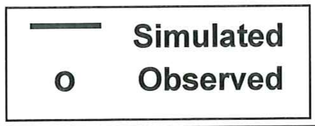


Figure 3-15 – Calibration Plots for the Imperial River



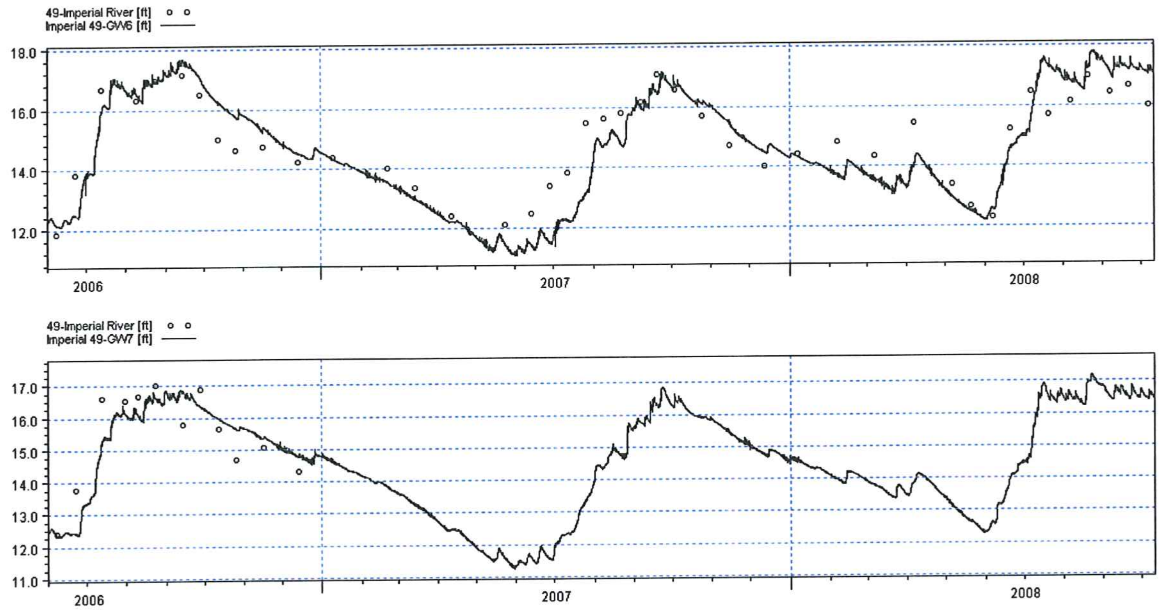


Figure 3-16 – Calibration Plots for GW-6 and GW-7

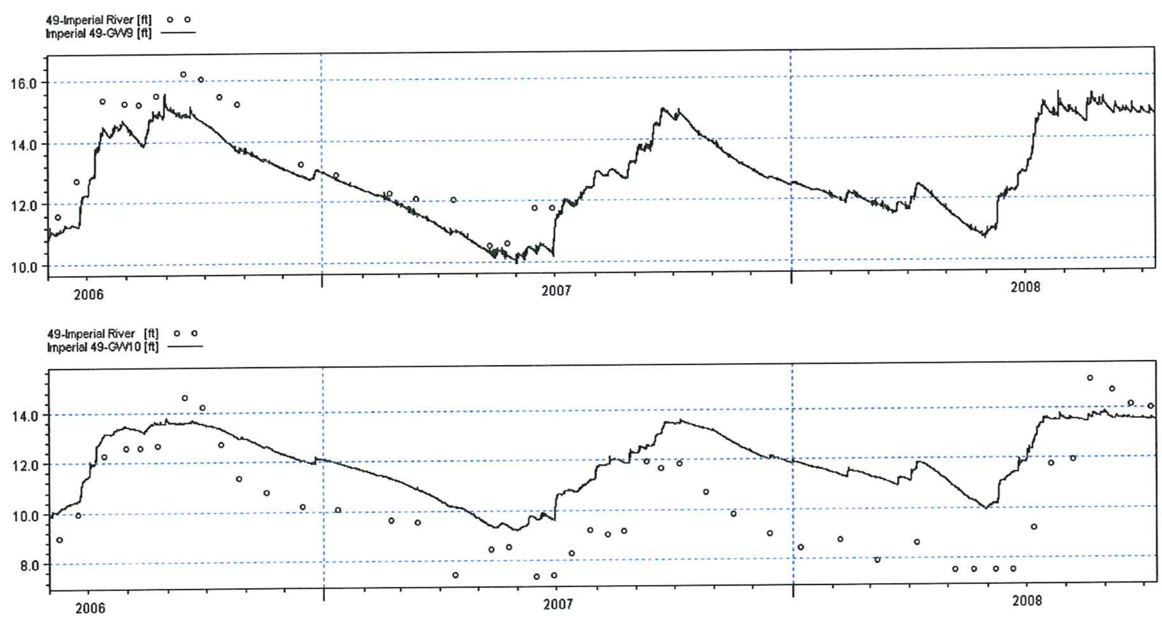


Figure 3-17 – Calibration Plots for GW-9 and GW-10

Simulated
o Observed

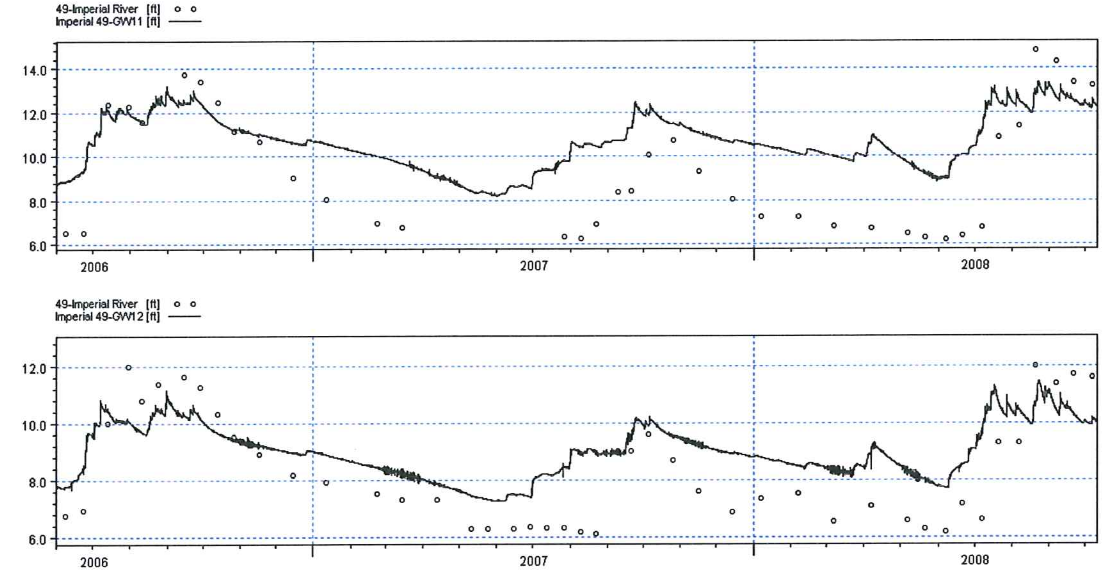


Figure 3-18 – Calibration Plots for GW-11 and GW-12

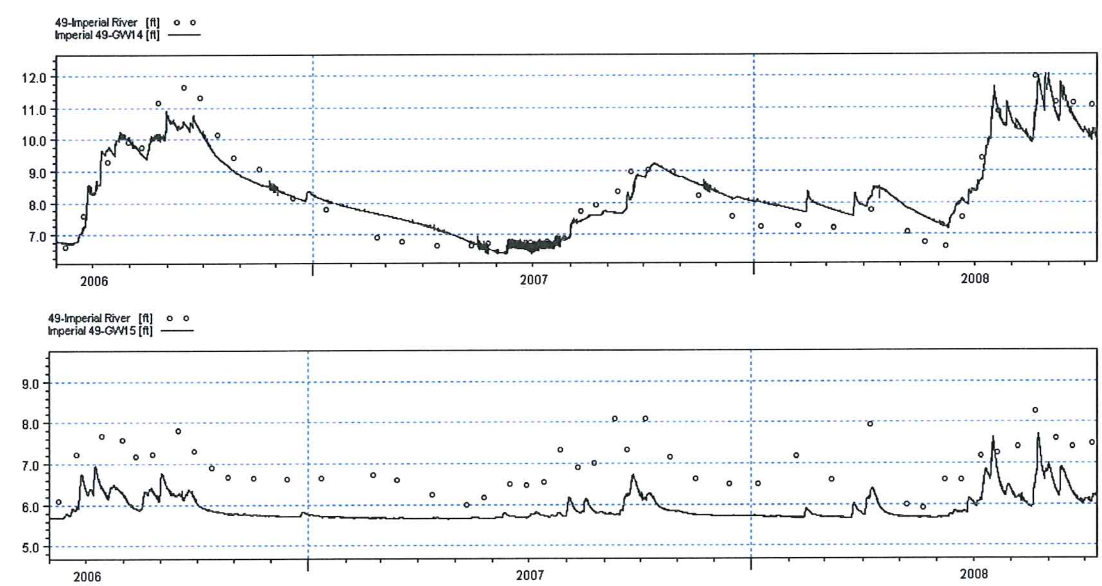


Figure 3-19 – Calibration Plots for GW-14 and GW-15

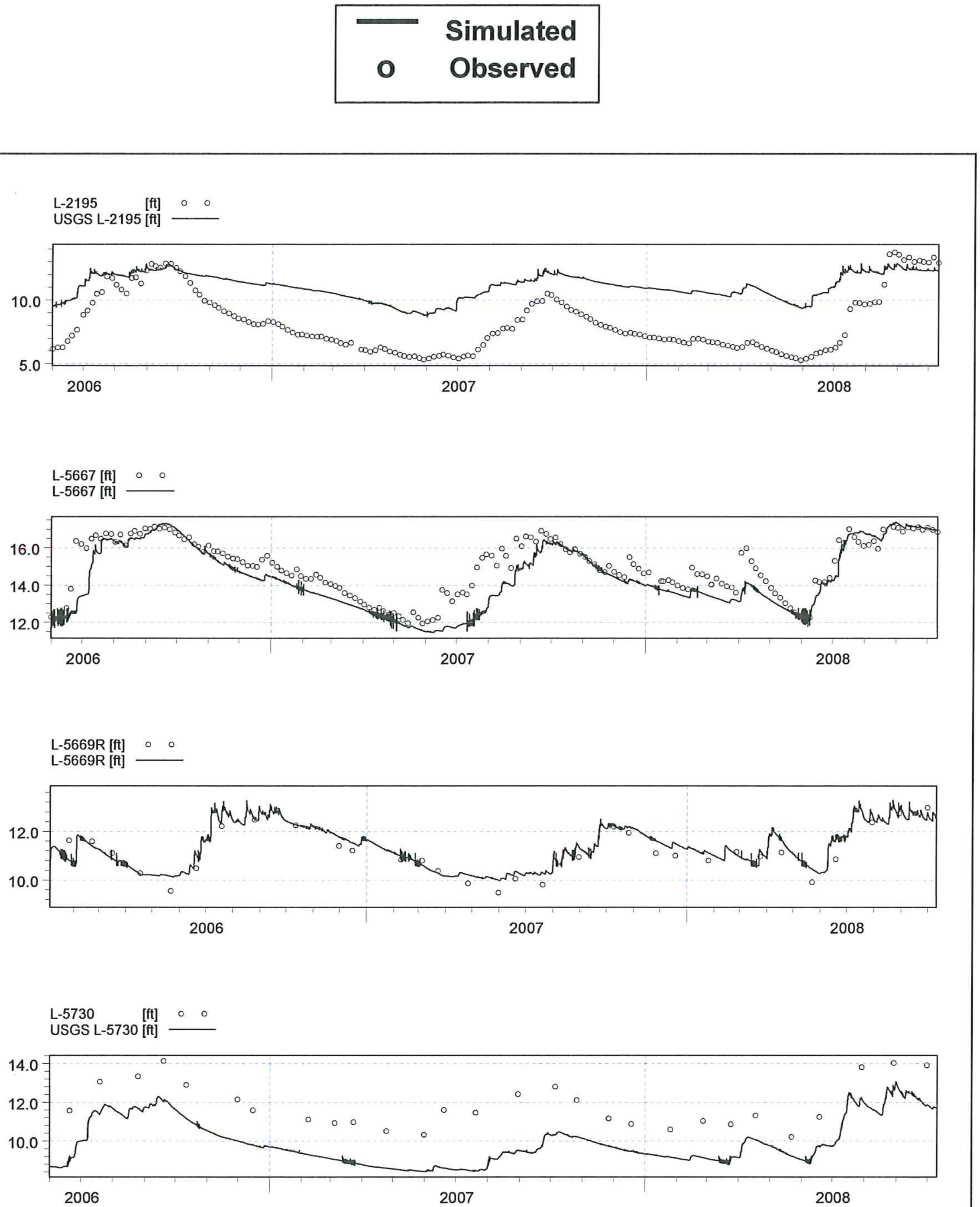


Figure 3-20 – Calibration Plots for USGS Wells L-2195, L-5667, L-5669R and L-5730

3.3 Mass Balance Information for the Calibrated MIKE SHE/MIKE 11 Model of the Estero River, Halfway Creek, and Imperial River

A mass balance plot for the entire model domain is presented in **Table 3-8** for June 1, 2006 through October 11, 2008. The annual average precipitation during that period was 48 inches, and the evapotranspiration was 31 inches/year, or 64% of rainfall.

Period of Record (Number of Months used in Water Balance)	Rain *(Rai)*	Actual ET *(AET)*	Canopy-OL Storage Change *ΔOL*	Runoff +Drainage to River *(Ro)*	OL Boundary Flows *(OL_{BC})*	Baseflow *(BF)*	Irrigation *(Irr)*	Pumpage *(GW_P)*	SZ Boundary Flow *(SZ_{BC})*	SubSurface Storage Change *(ΔSUB)*	Total Error *(Err)*
6/1/06 to 12/31/06	45.17	22.06	0.39	14.11	0.000	2.32	1.02	1.60	0.24	5.99	-0.040
1/1/07 to 12/31/07	40.91	35.37	-0.17	5.09	0.000	1.93	4.79	5.81	0.81	-1.35	-0.184
1/1/08 to 10/11/08	58.74	30.53	2.09	17.87	0.000	2.49	3.42	4.19	0.04	5.19	-0.166

Table 3-8 – Water Balance for Entire Model Domain (values in inches)

Irrigation in the Brooks for the DRGR model was less than 1 inch/year, which seemed low, therefore measured irrigation pumpage rates were obtained to assist in the calibration. Measured irrigation was equal to 11.3 inches/year from surface water and the surficial aquifer between June 1, 2006 and September, 2008. Measured irrigation from external sources was 6.3 inches/year during the same period.

3.4 Overland Flow Depths During the Wet Season

The model simulates flooding in areas without river channels and in areas where the water depth exceeds the maximum channel elevation within the river cross section. **Figure 3-21** presents the overland flow depth map for Tropical Storm Ernesto in the fall of 2006. The areas of red and orange are mining pits where water depths are greater than 5 feet deep. In general, overland flow depths are in the range of 0-1 foot deep with some areas in Flint Pen Strand that have water depths in the range of 2 feet. The overland flow vectors illustrate that a portion of the water in DRGR wetlands flows toward the Estero River and Halfway Creek during the wet season.

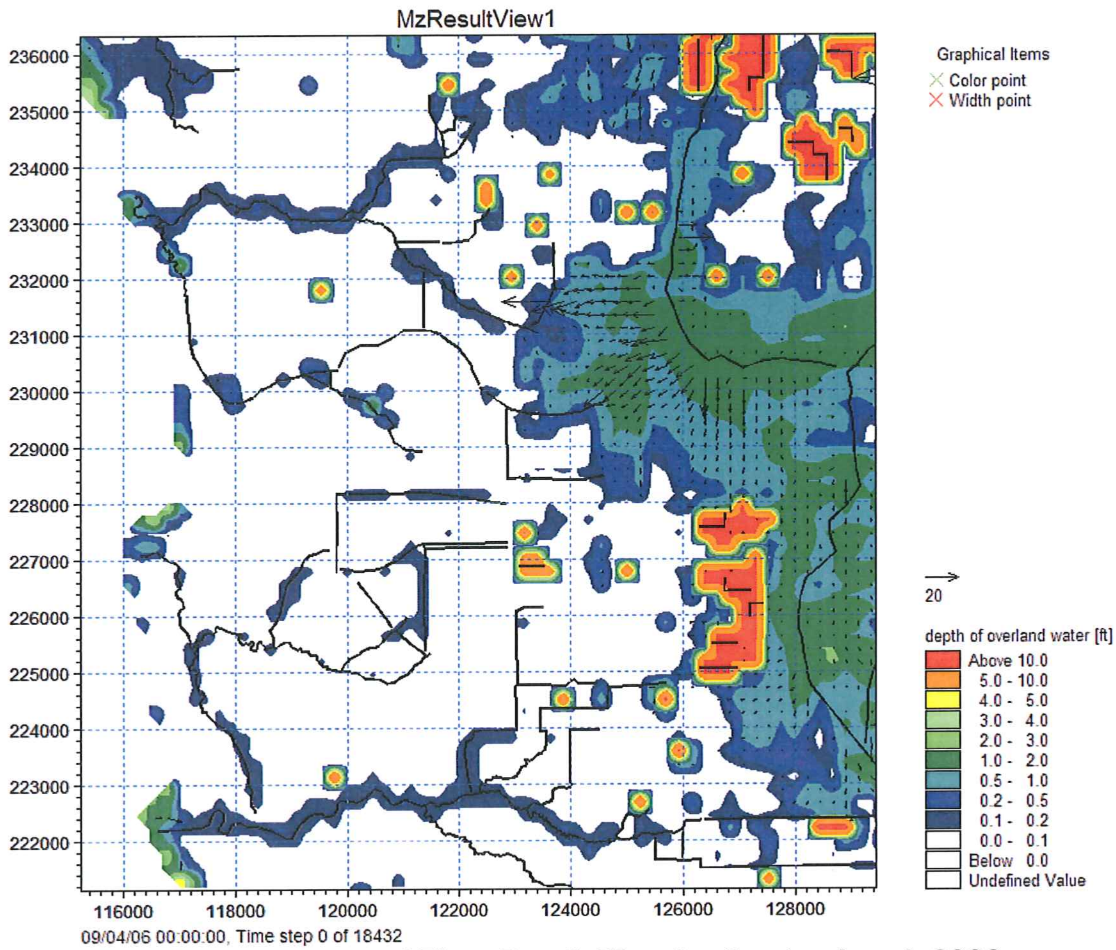


Figure 3-21 – Overland Flow Depth Map for September 4, 2006

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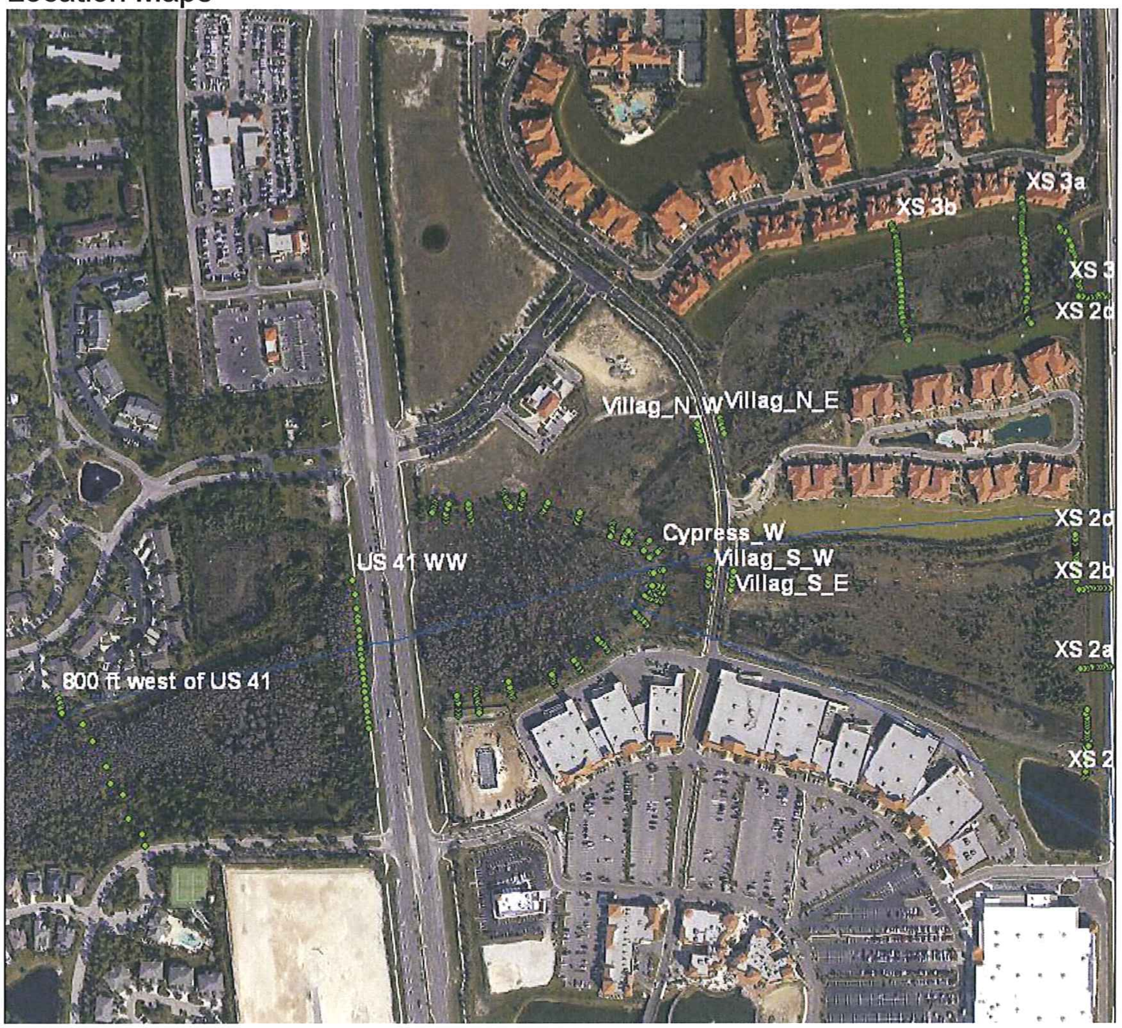
HGL, DHI, 2006, Hydrologic-Hydraulic and Environmental Assessment for the Camp Keais Strand Flowway. Prepared for South Florida Water Management District.

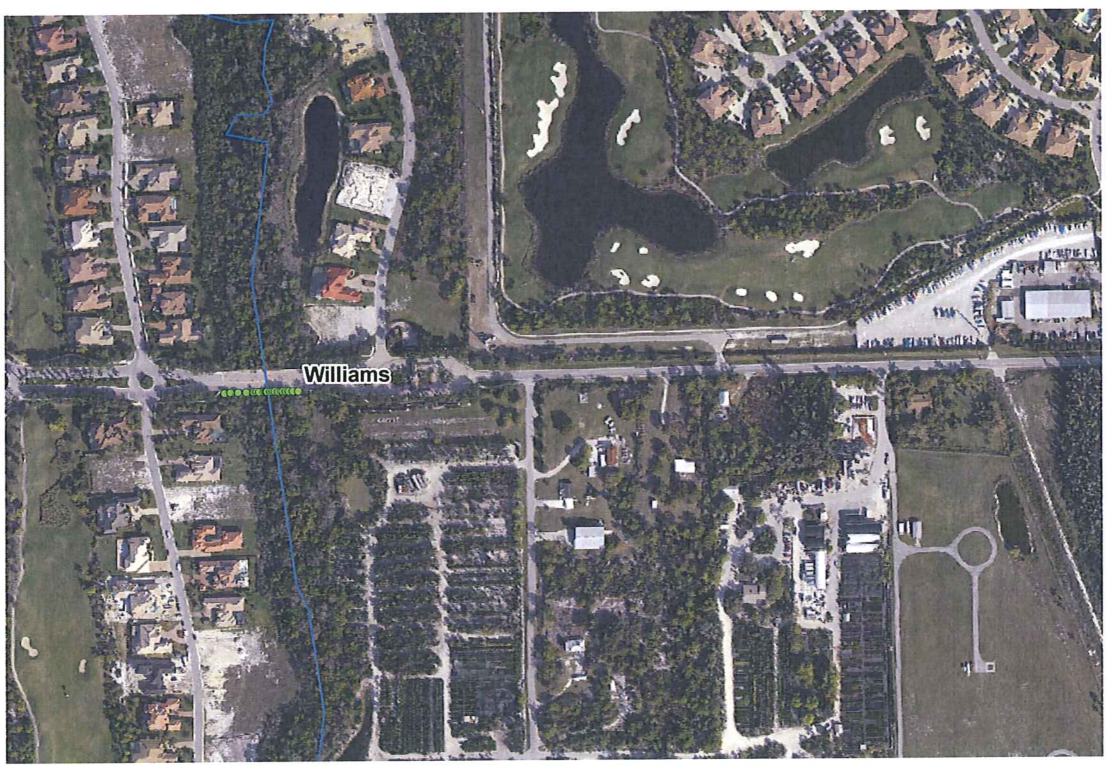
Appendix 1

Survey Cross Section Location Maps and Drawings

Location Maps




XS_ER_SB_N
XS_ER_SB_S
XS 3_Oaks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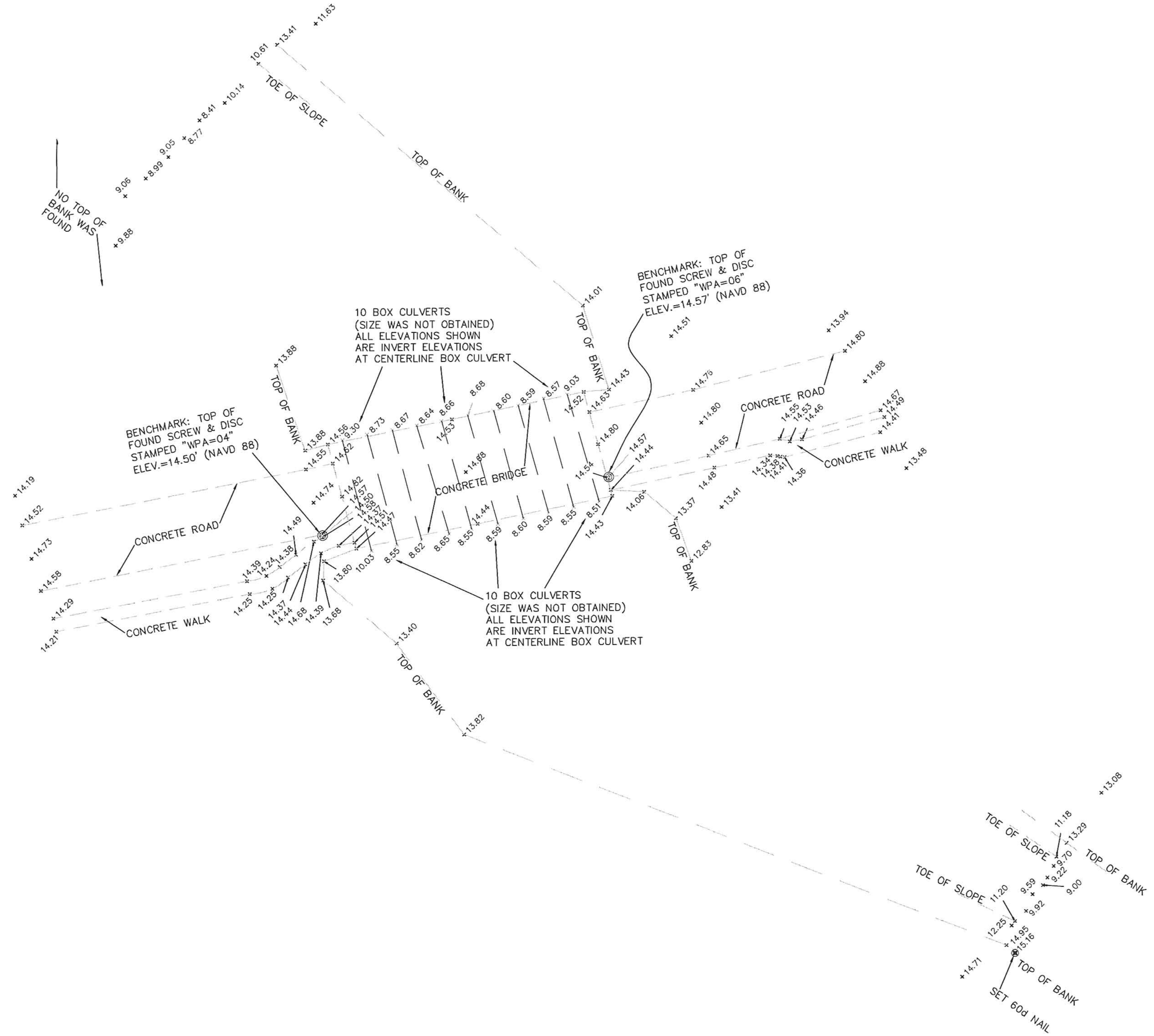

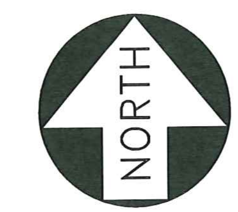

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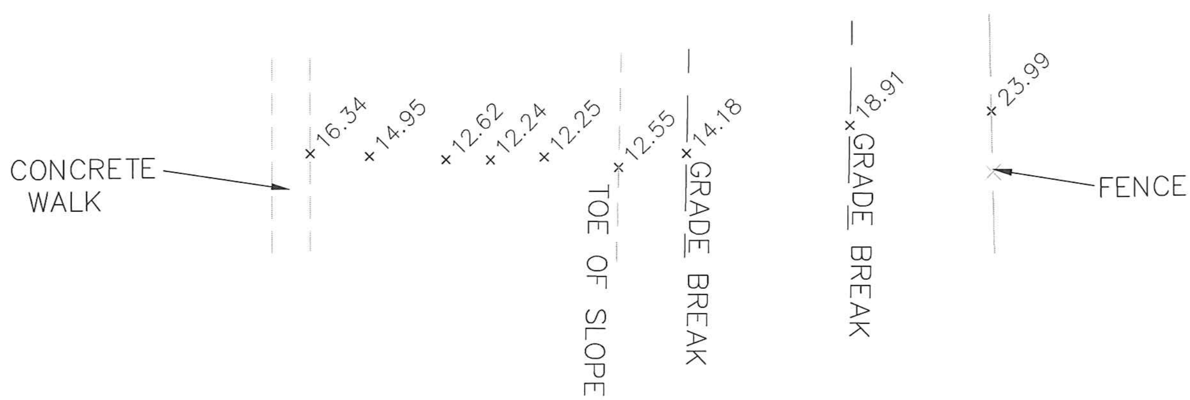

SECTION BOYLE 4

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DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 2 (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:12 PM
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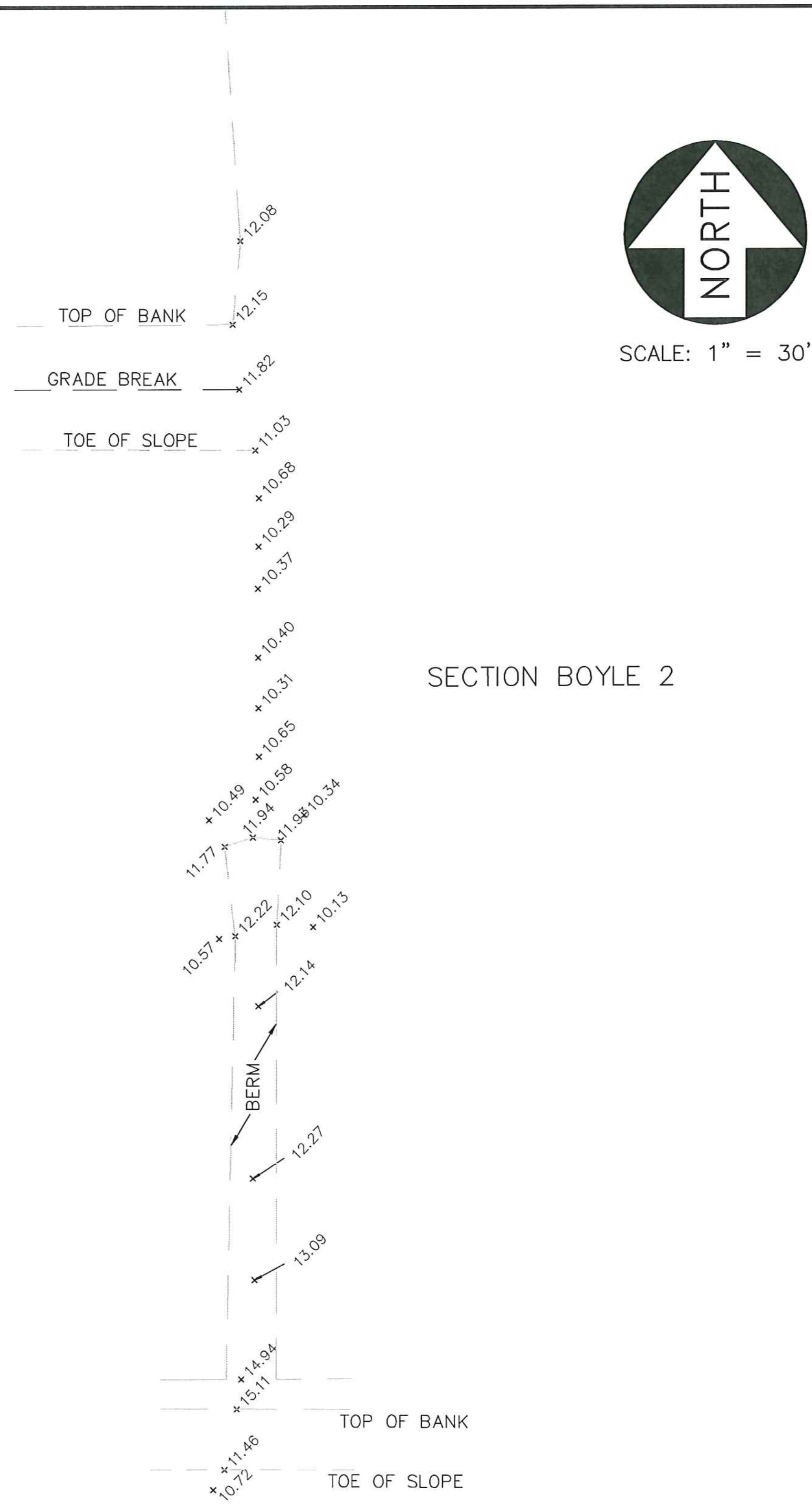

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SOUTH LEE COUNTY WATERSHED PLAN UPDATE

XS-2 VIA COCONUT POINT S

BEC PROJECT NO. 17312.02

FIGURE 3

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 3 (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:12 PM
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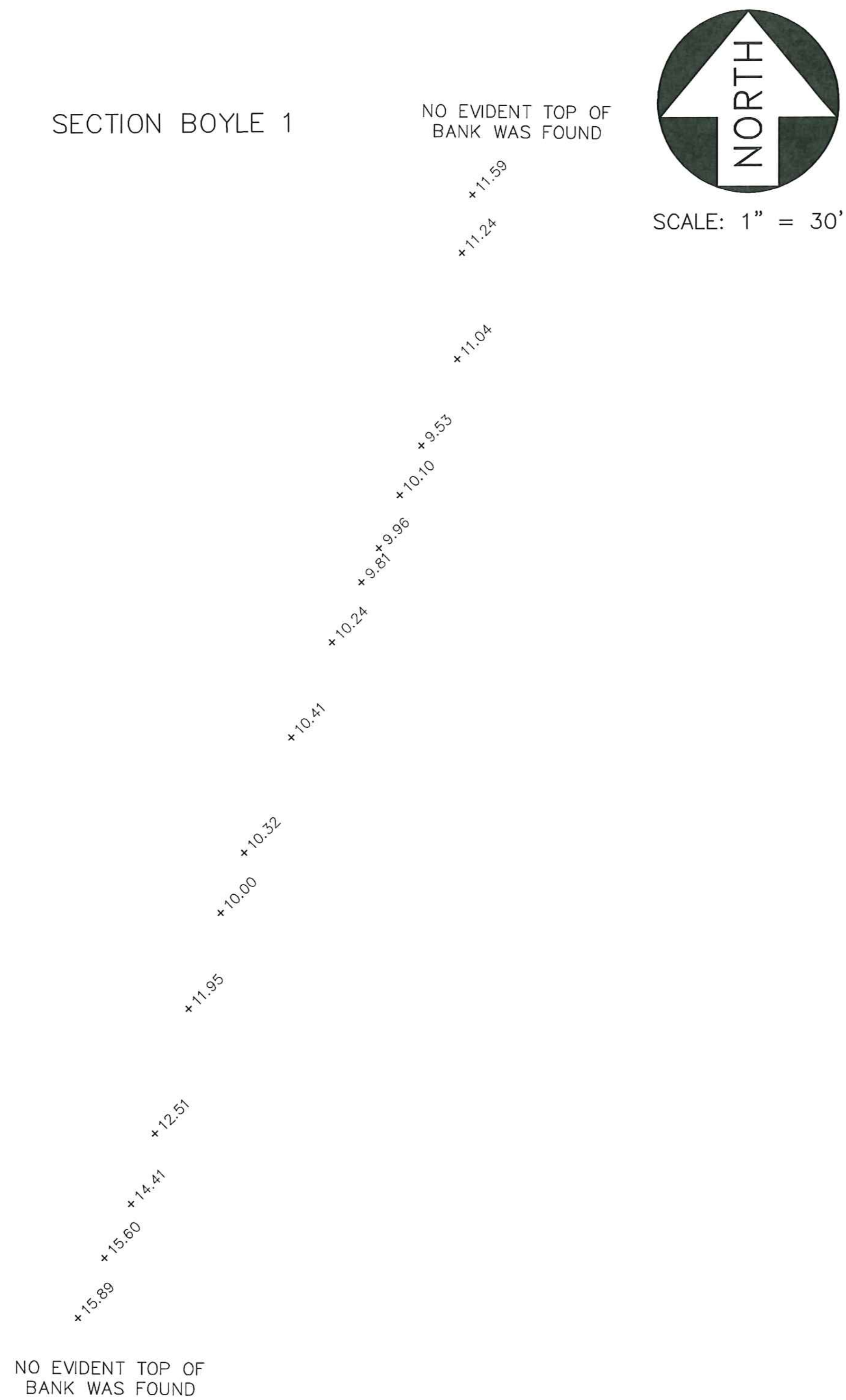

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SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SOUTH LEE COUNTY WATERSHED PLAN UPDATE
S BRANCH HALFWAY CREEK FLOWWAY

BEC PROJECT NO. 17312.02

FIGURE 4

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 4 (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:12 PM
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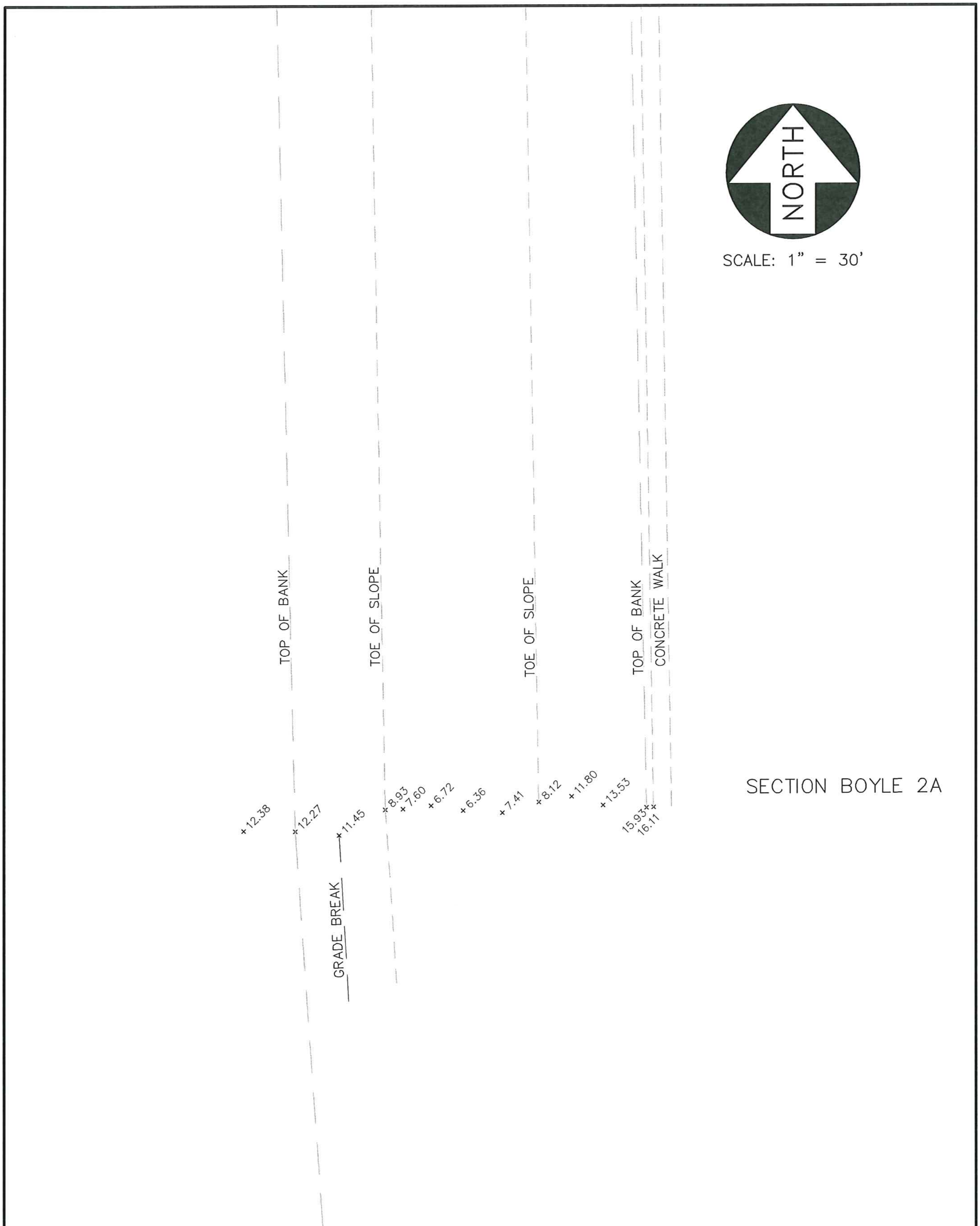

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 5 (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:13 PM
XREFS: IMAGES:

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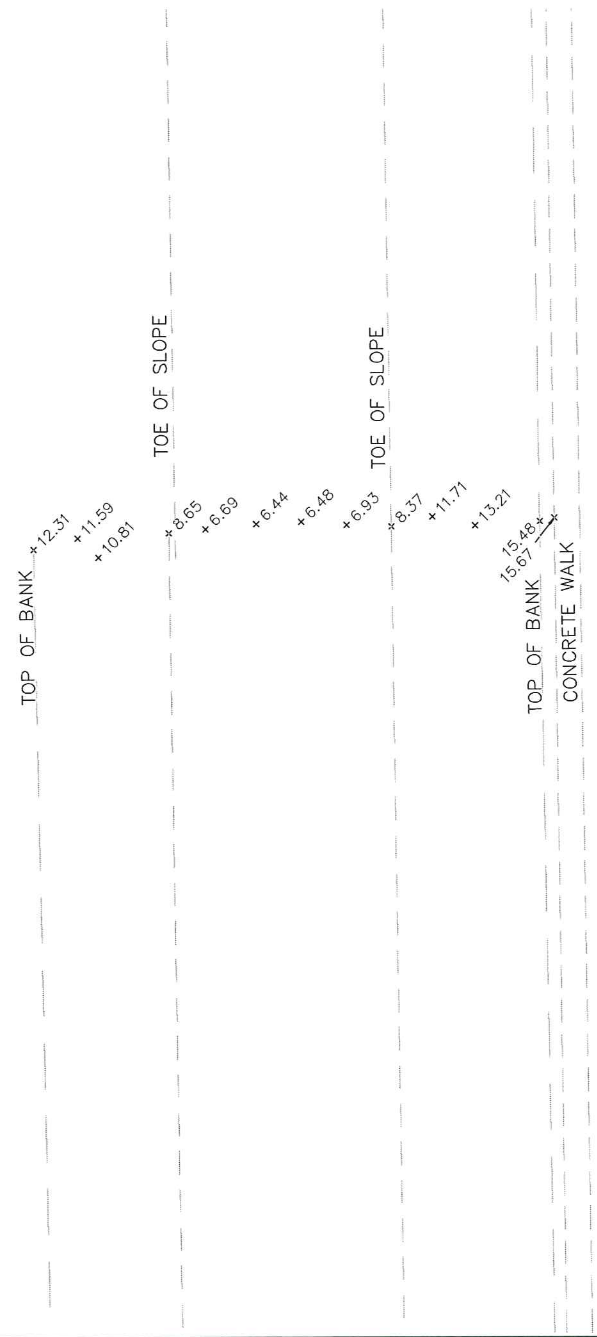
SOUTH FLORIDA WATER MANAGEMENT DISTRICT	BEC PROJECT NO.	FIGURE
SOUTH LEE COUNTY WATERSHED PLAN UPDATE XS-2A W SIDE OF 3 OAKS DITCH	17312.02	5

SCALE: 1" = 30'

SECTION BOYLE 2B



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	SOUTH LEE COUNTY WATERSHED PLAN UPDATE XS-2B W SIDE OF 3 OAKS DITCH	17312.02	6

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 6 (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:13 PM
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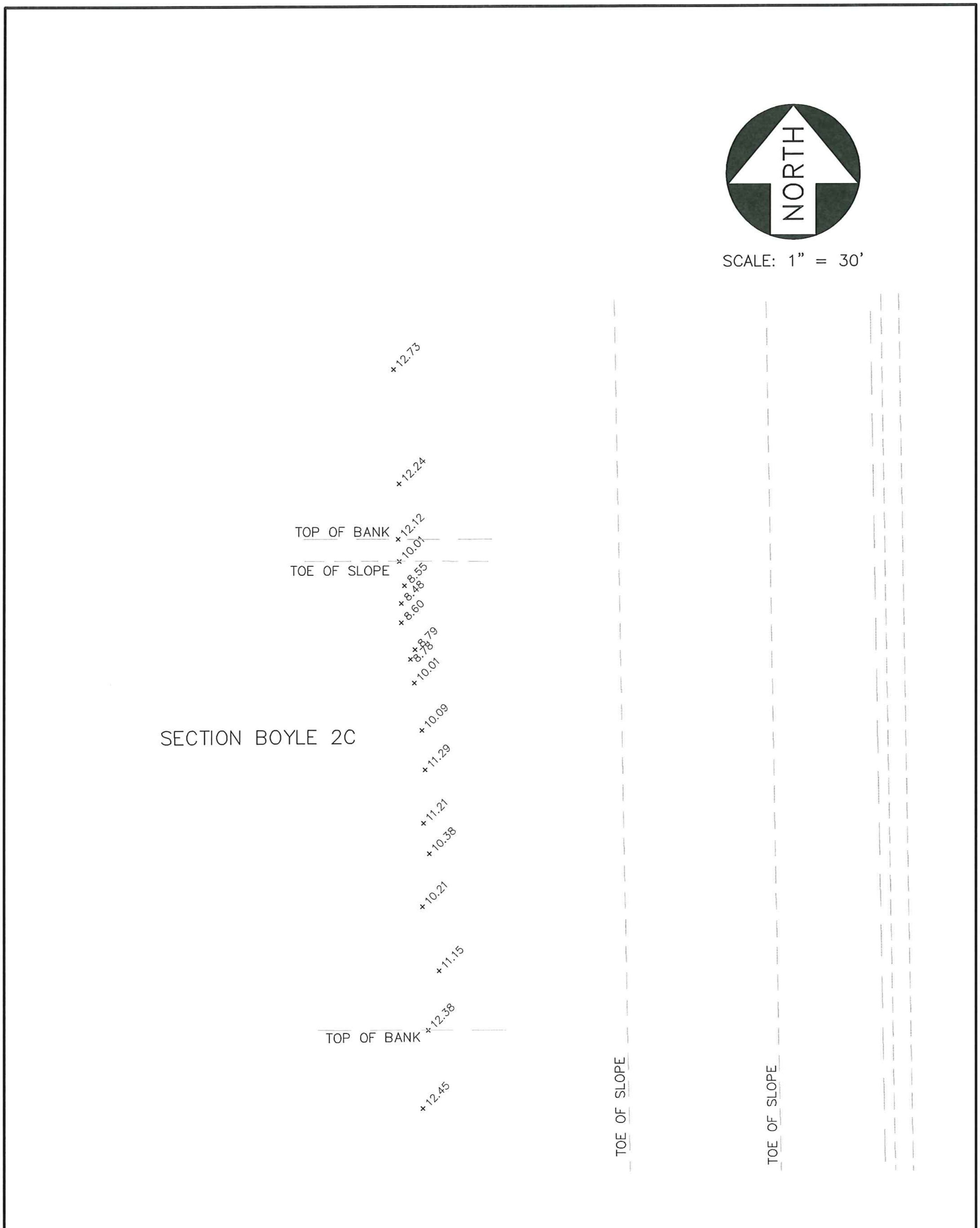

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	SOUTH LEE COUNTY WATERSHED PLAN UPDATE XS-2C S BRANCH HALFWAY CREEK N FLOWWAY	17312.02	7

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 7 (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:13 PM
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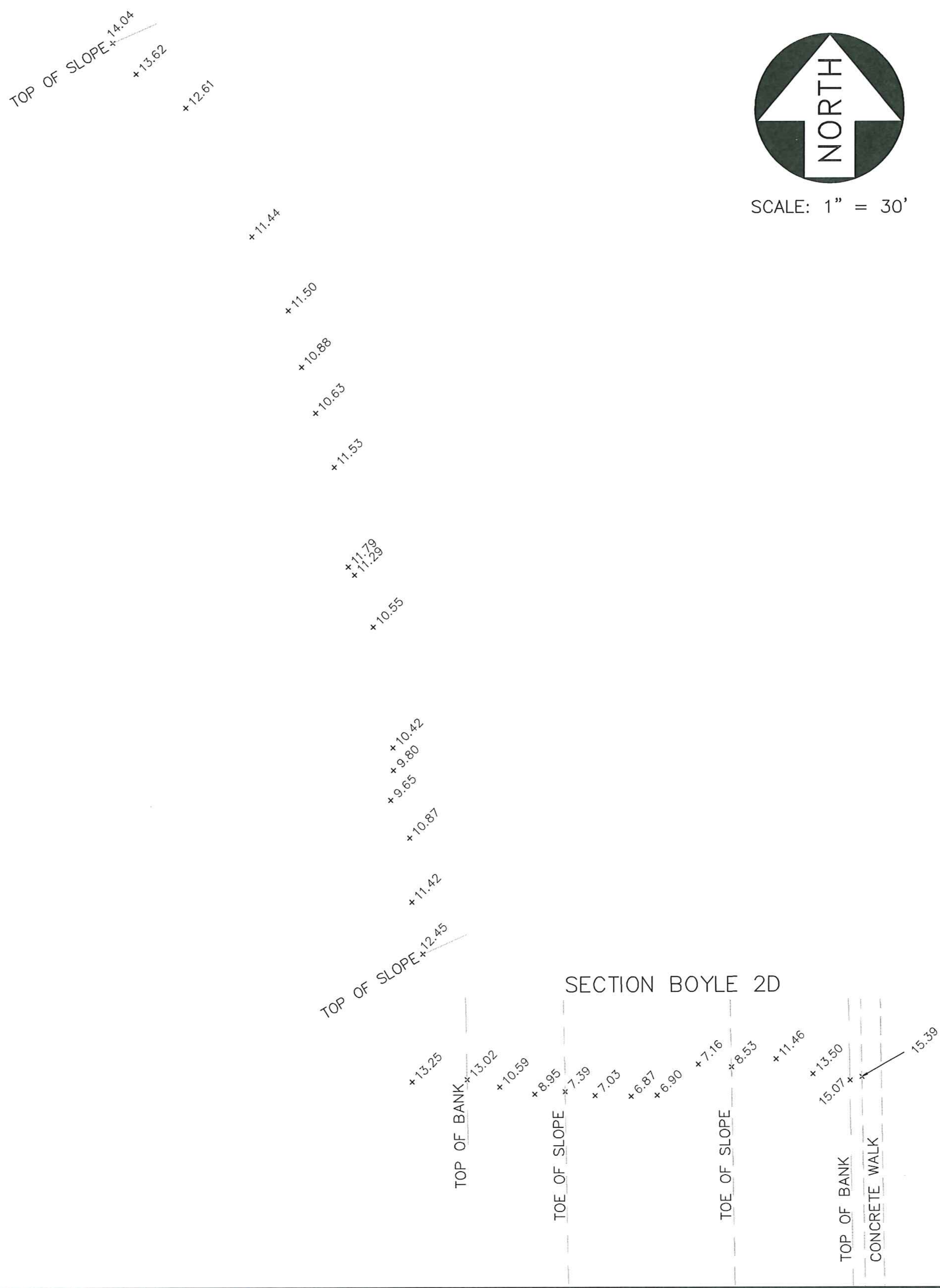

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SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SOUTH LEE COUNTY WATERSHED PLAN UPDATE

XS-2D VIA COCONUT POINT N

BEC PROJECT NO. 17312.02

FIGURE 8

DWG: P:\17312\17312.02\Design\17312cago.dwg Layout Name: EXHIBIT 8 (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:13 PM
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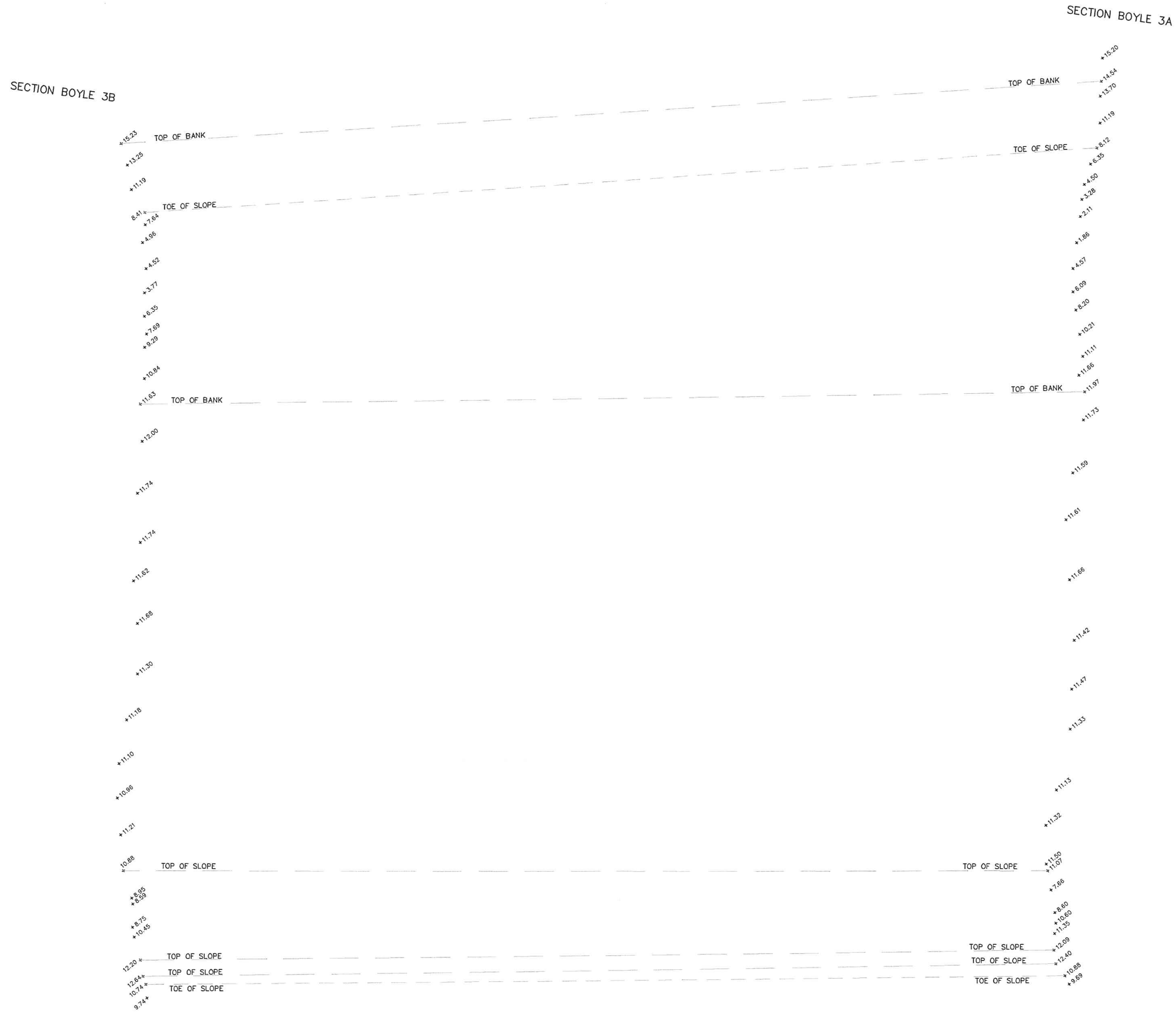

SCALE: 1" = 50'

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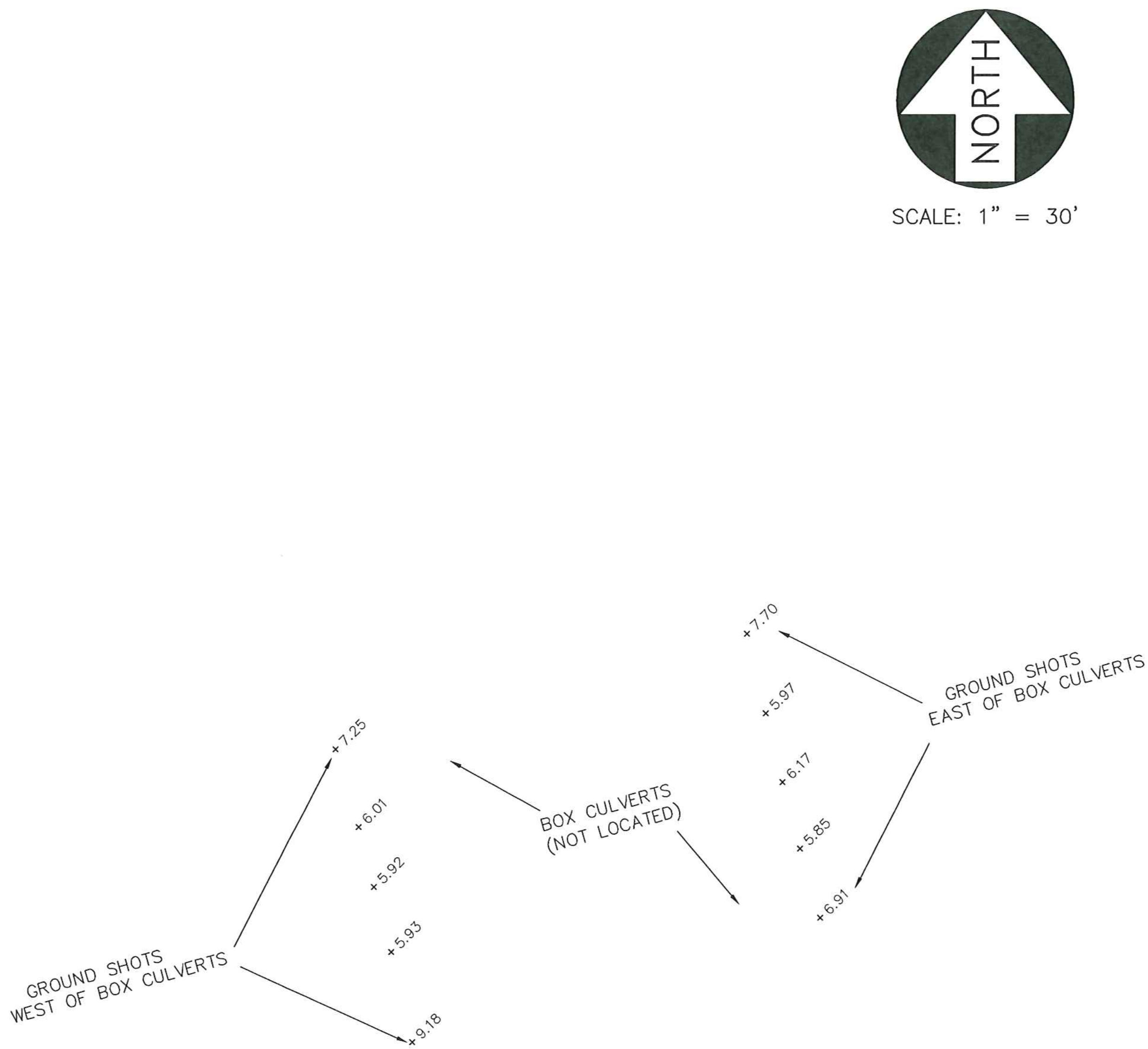
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SOUTH LEE COUNTY WATERSHED PLAN UPDATE
XS-3A AND 3B
N BRANCH HALFWAY CREEK W OF 3 OAKS

BEC PROJECT NO. 17312.02

FIGURE 9

DWG: P:\17312\17312.02\Design\17312copo.dwg Layout Name: EXHIBIT 9 (11X17) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:15 PM
XREFS: IMAGES:



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	SOUTH LEE COUNTY WATERSHED PLAN UPDATE VIA VILLAGIO N (W AND E)	17312.02	10

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 10 (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:13 PM
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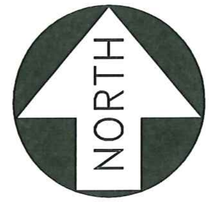
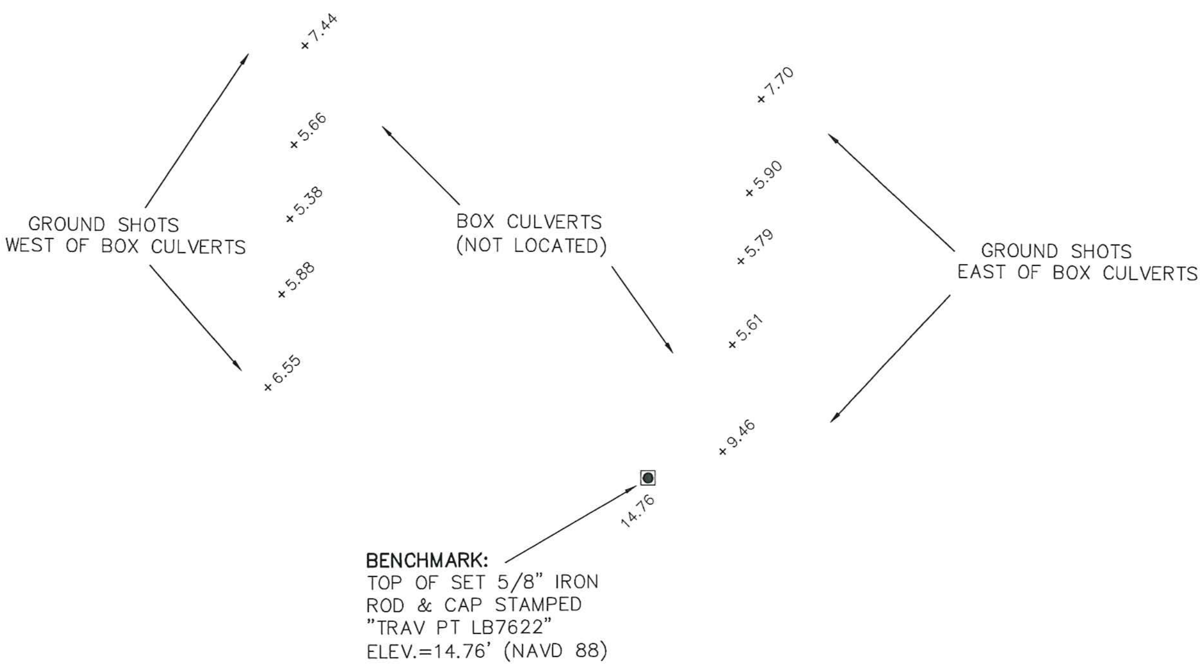


SCALE: 1" = 30'



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XREFS: IMAGES:

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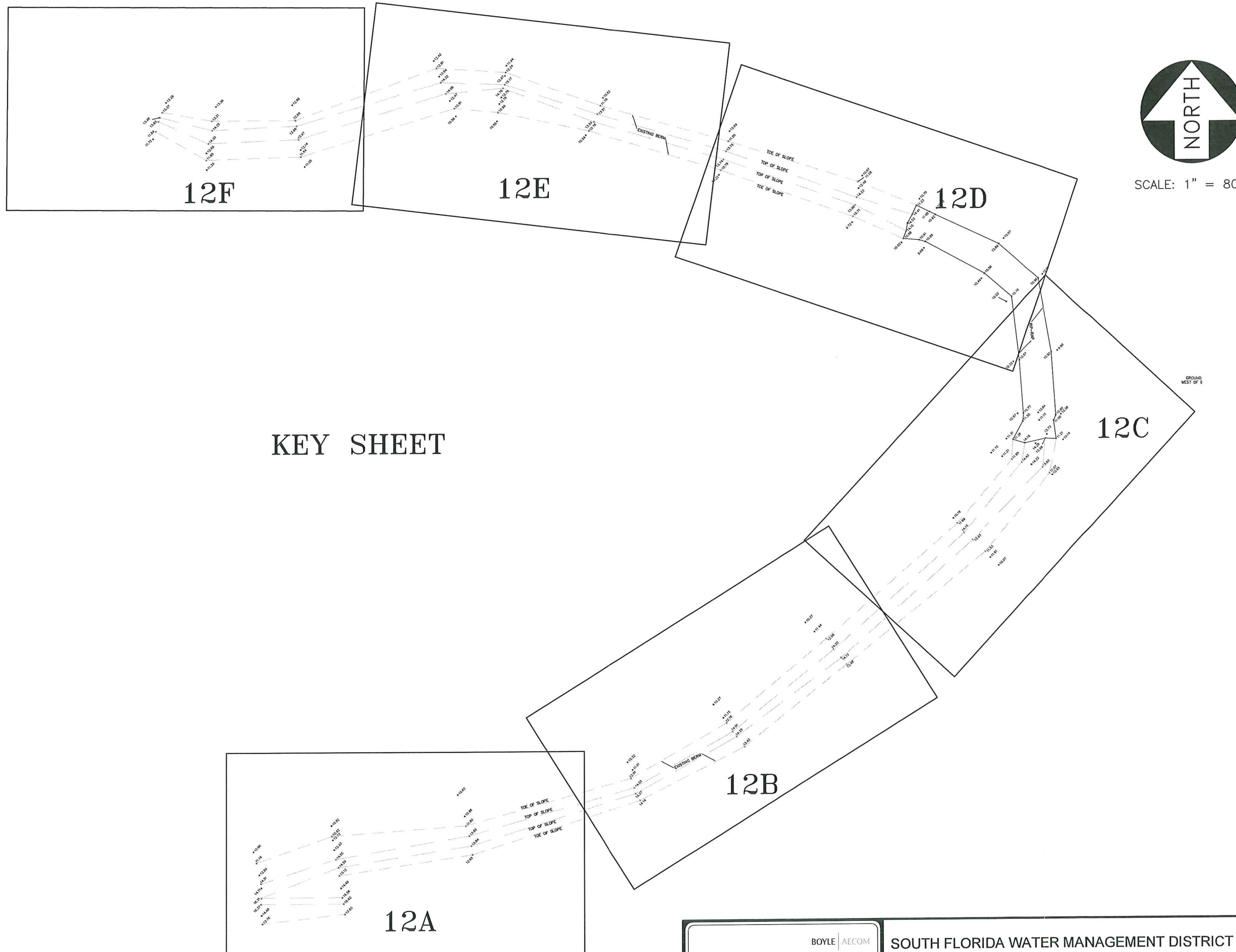
SOUTH FLORIDA WATER MANAGEMENT DISTRICT	BEC PROJECT NO.	FIGURE
SOUTH LEE COUNTY WATERSHED PLAN UPDATE VIA VILLAGIO S (W AND E)	17312.02	11



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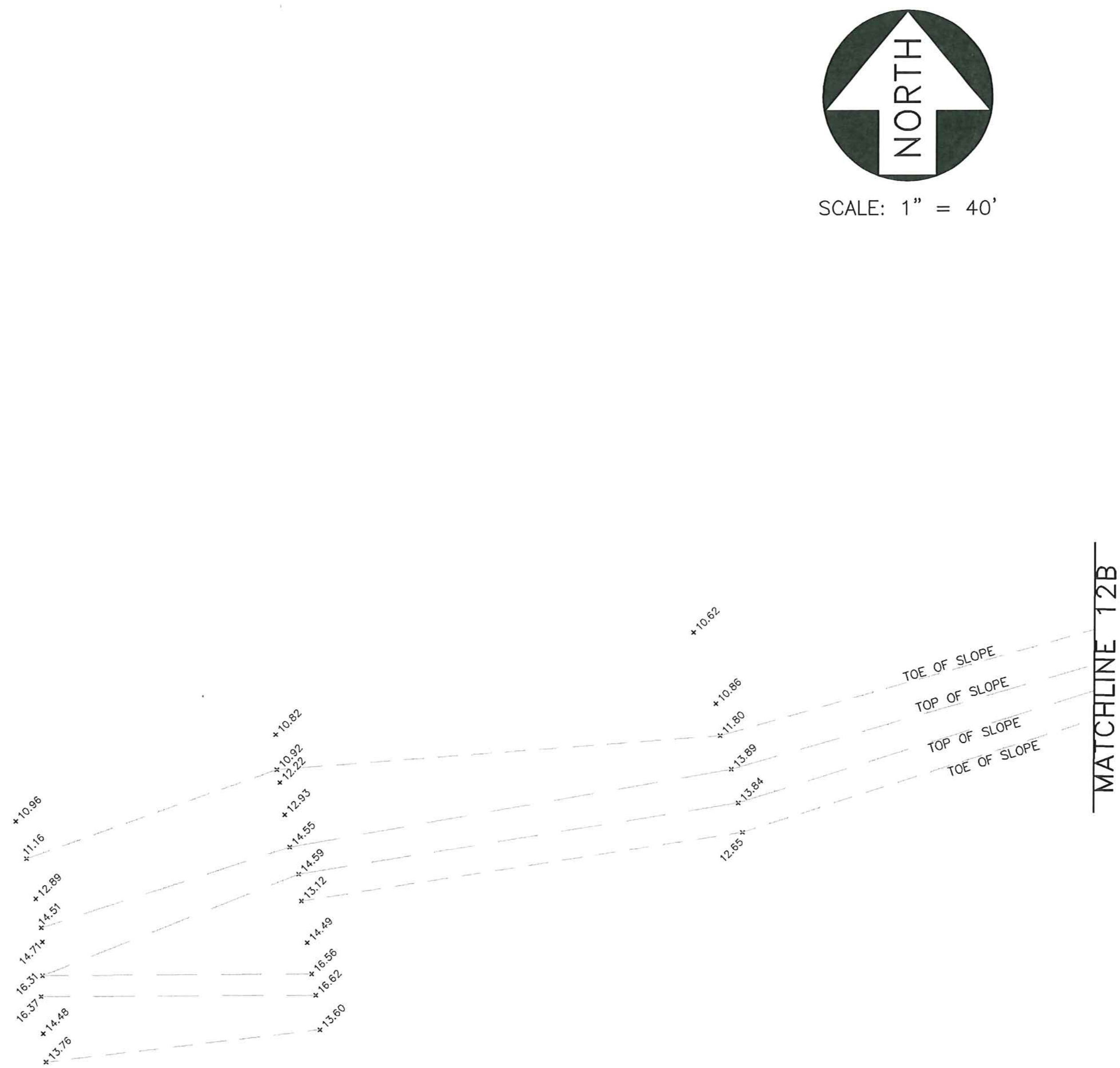
SOUTH FLORIDA WATER MANAGEMENT DISTRICT		BEC PROJECT NO.	FIGURE
SOUTH LEE COUNTY WATERSHED PLAN UPDATE HALFWAY CREEK WEIR CROSS SECTION		17312.02	12

DWG: P:\17312\17312.02\Design\17312oogo.dwg Layout Name: EXHIBIT 12 (11X17) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:15 PM
XREFS: IMAGES:



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SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SOUTH LEE COUNTY WATERSHED PLAN UPDATE
HALFWAY CREEK WEIR
CROSS SECTION

BEC PROJECT NO.
17312.02

FIGURE
12A
1 OF 6

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 12A (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:16 PM
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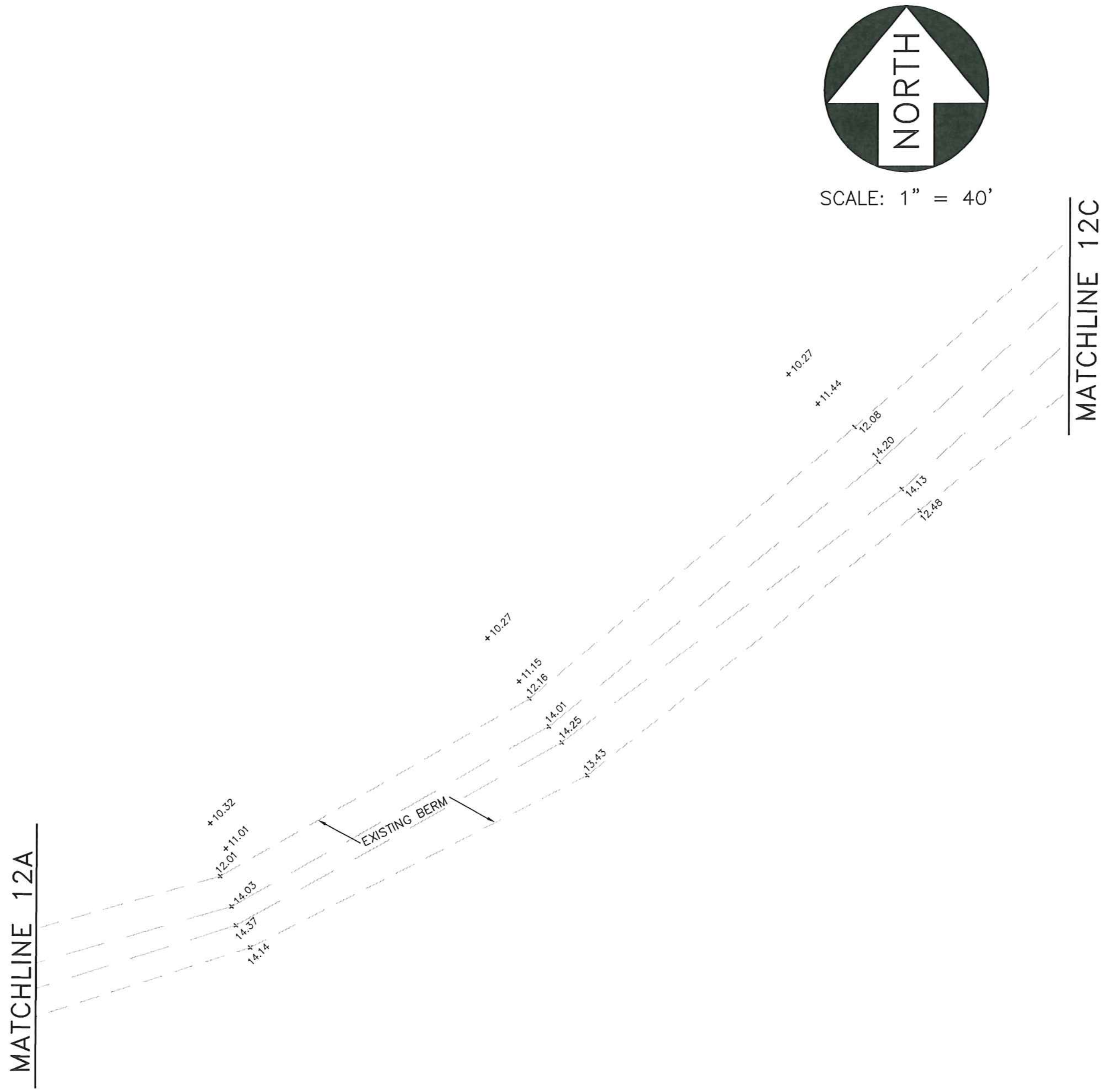

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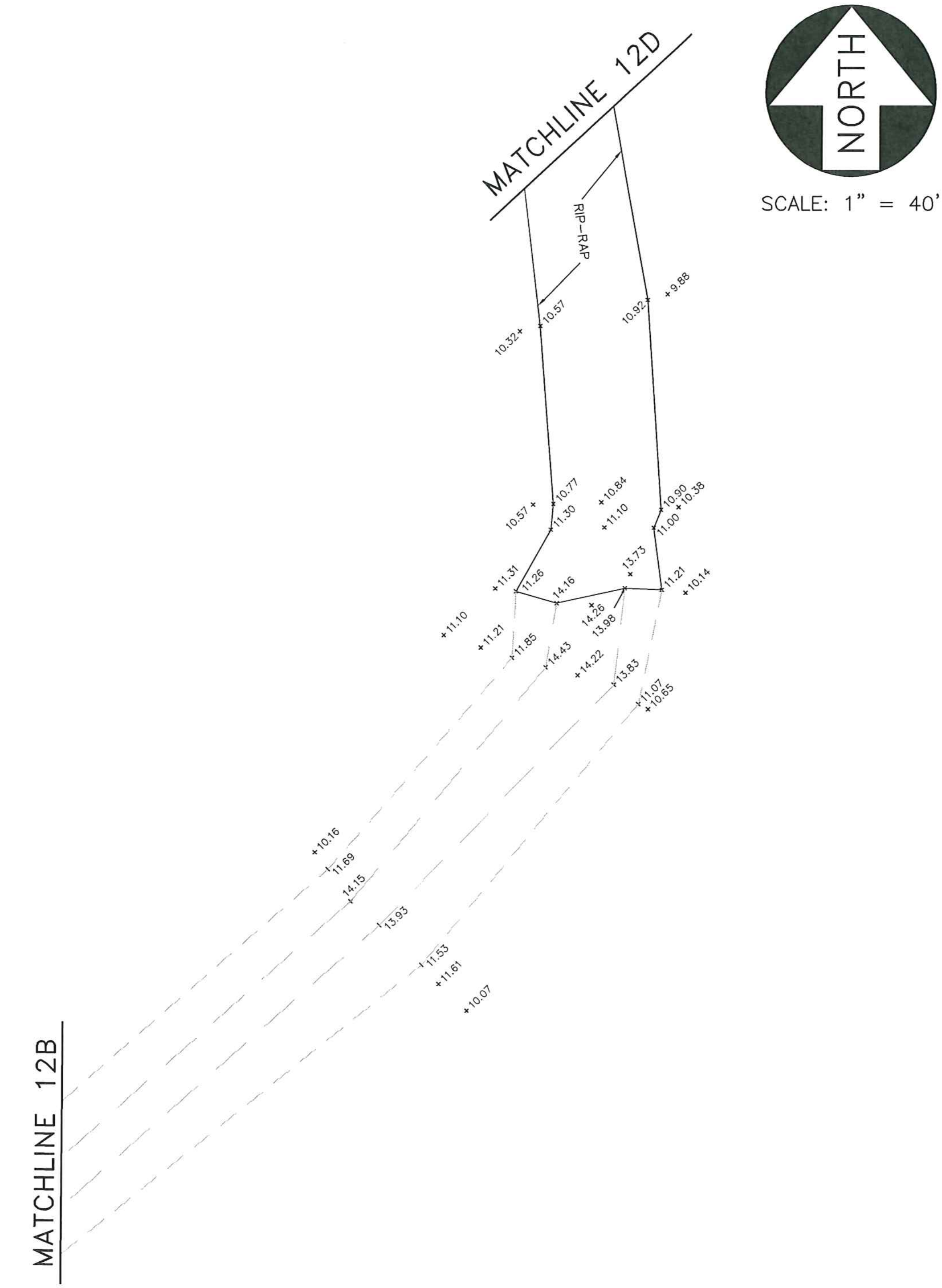
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SOUTH LEE COUNTY WATERSHED PLAN UPDATE
HALFWAY CREEK WEIR
CROSS SECTION

BEC PROJECT NO.	FIGURE
17312.02	12B

2 OF 6



DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 12C (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:16 PM
XREFS: IMAGES:

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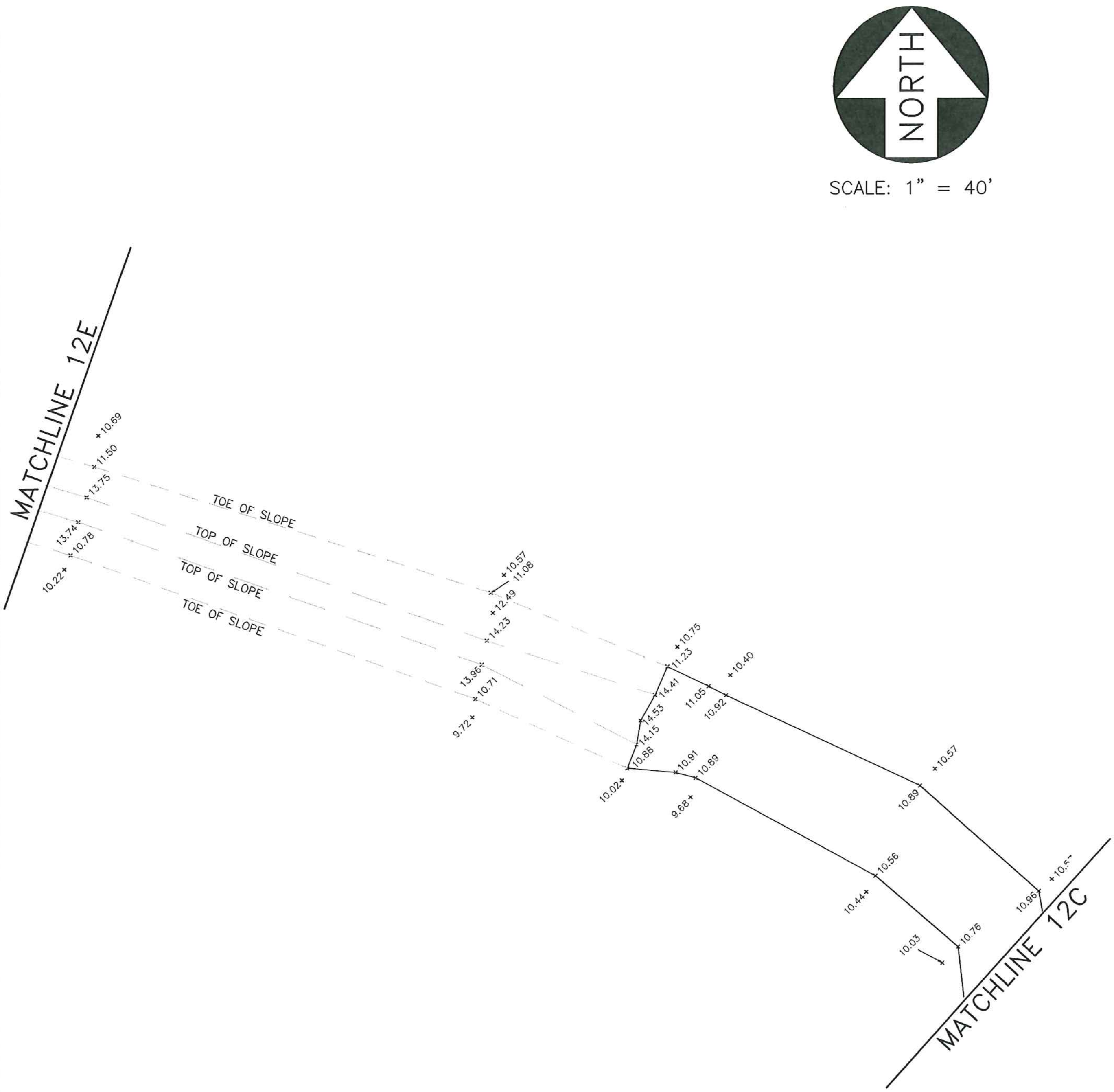
SOUTH FLORIDA WATER MANAGEMENT DISTRICT	BEC PROJECT NO.	FIGURE
SOUTH LEE COUNTY WATERSHED PLAN UPDATE HALFWAY CREEK WEIR CROSS SECTION	17312.02	12C 3 OF 6



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SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SOUTH LEE COUNTY WATERSHED PLAN UPDATE
HALFWAY CREEK WEIR
CROSS SECTION

BEC PROJECT NO. 17312.02

FIGURE 12D

4 OF 6

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 12D (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:16 PM
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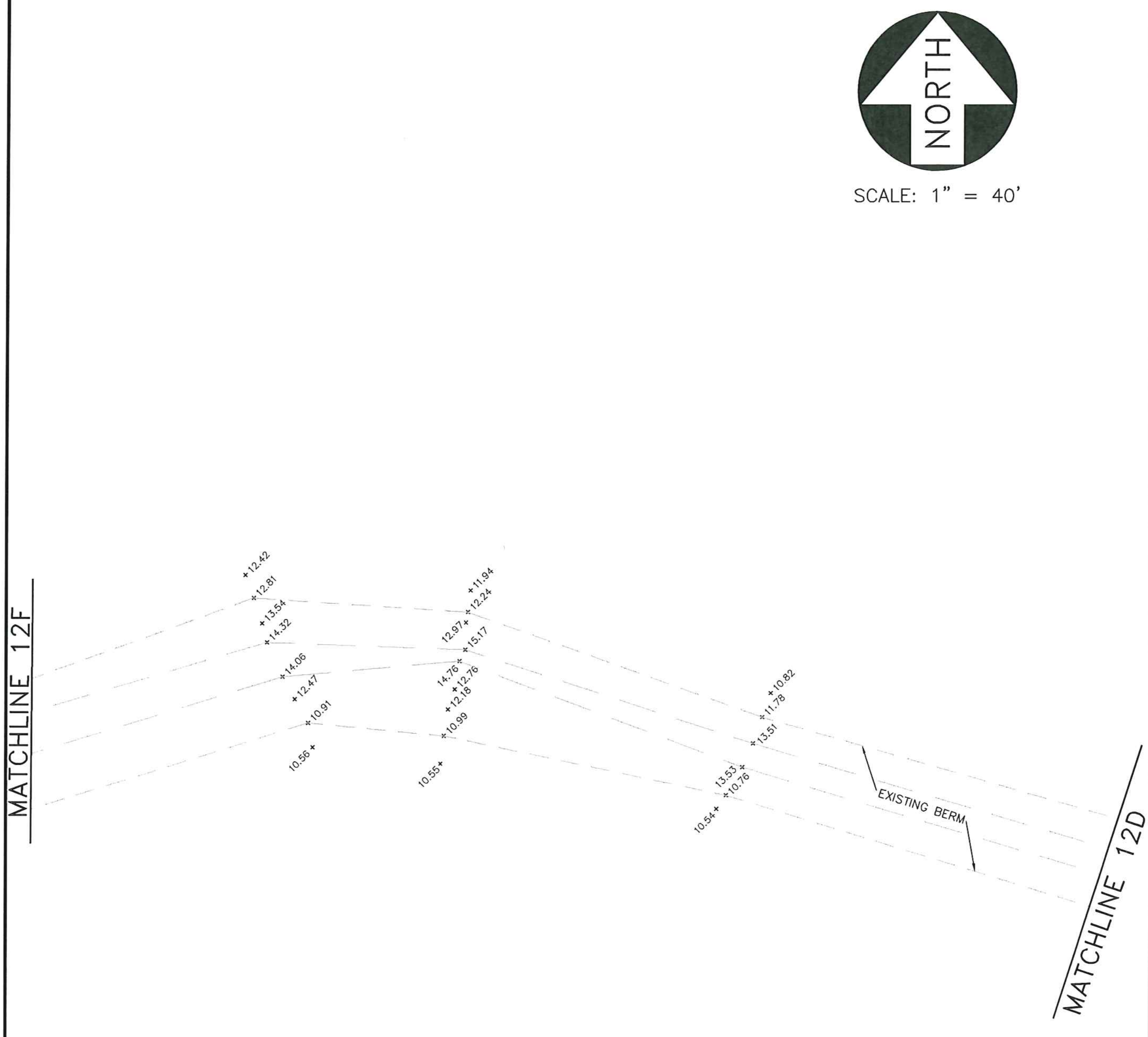

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	SOUTH LEE COUNTY WATERSHED PLAN UPDATE HALFWAY CREEK WEIR CROSS SECTION	17312.02	12E 5 OF 6

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 12E (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:17 PM
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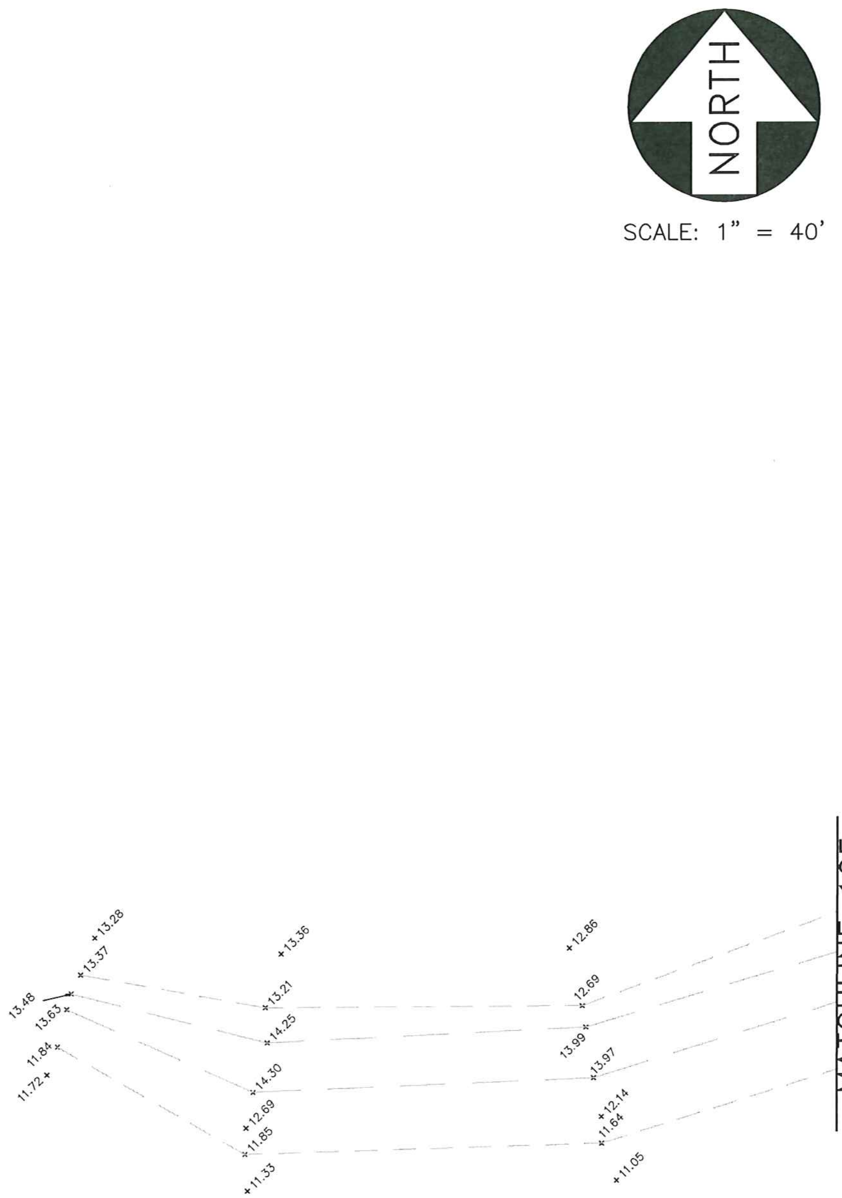

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SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SOUTH LEE COUNTY WATERSHED PLAN UPDATE
HALFWAY CREEK WEIR
CROSS SECTION

BEC PROJECT NO.
17312.02

FIGURE
12F
6 OF 6

DWG: P:\17312\17312.02\Design\17312cogo.dwg Layout Name: EXHIBIT 12F (8X11) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:17 PM
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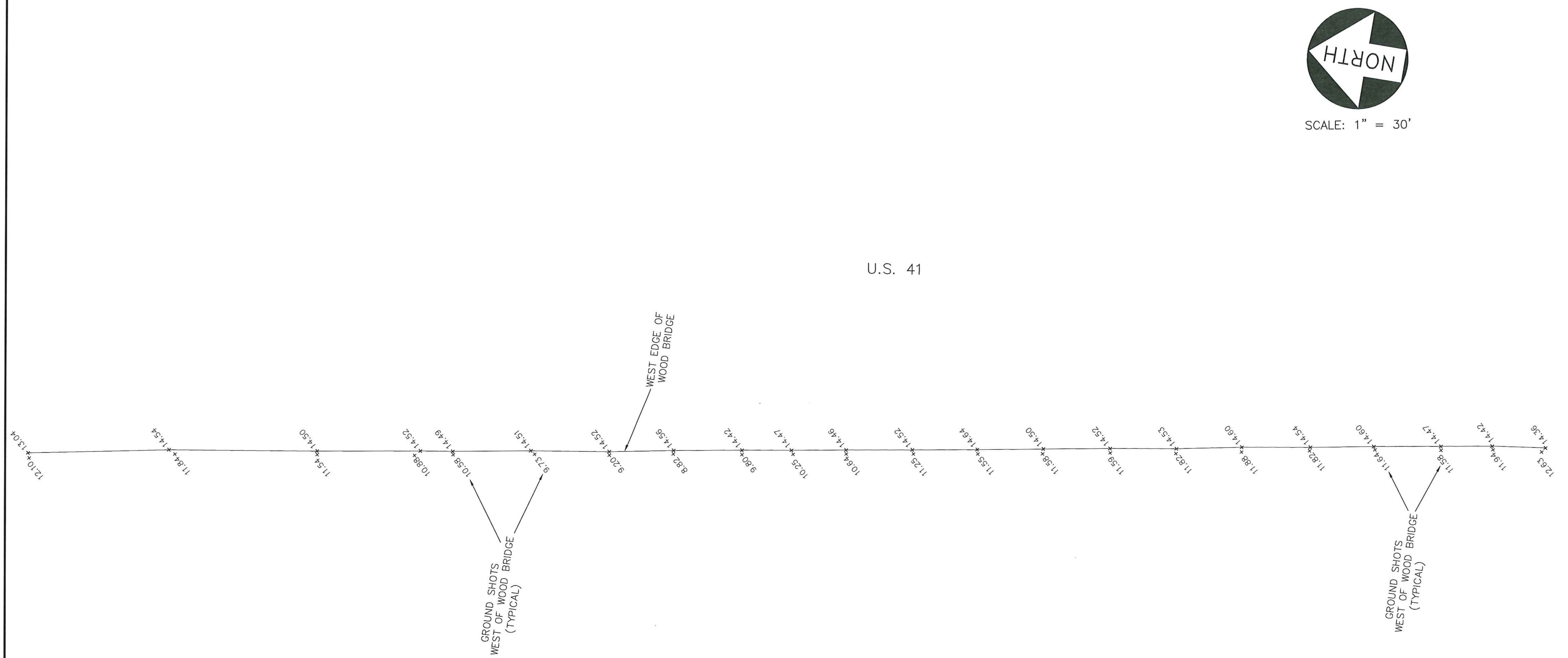

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SOUTH FLORIDA WATER MANAGEMENT DISTRICT	BEC PROJECT NO.	FIGURE
SOUTH LEE COUNTY WATERSHED PLAN UPDATE US 41 WOODEN WALKWAY	17312.02	13

DWG: P:\17312\17312.02\Design\17312oogo.dwg Layout Name: EXHIBIT 13 (11X17) - Plotted by: Boivin, Margot Date: 4/2/2009 - 1:15 PM
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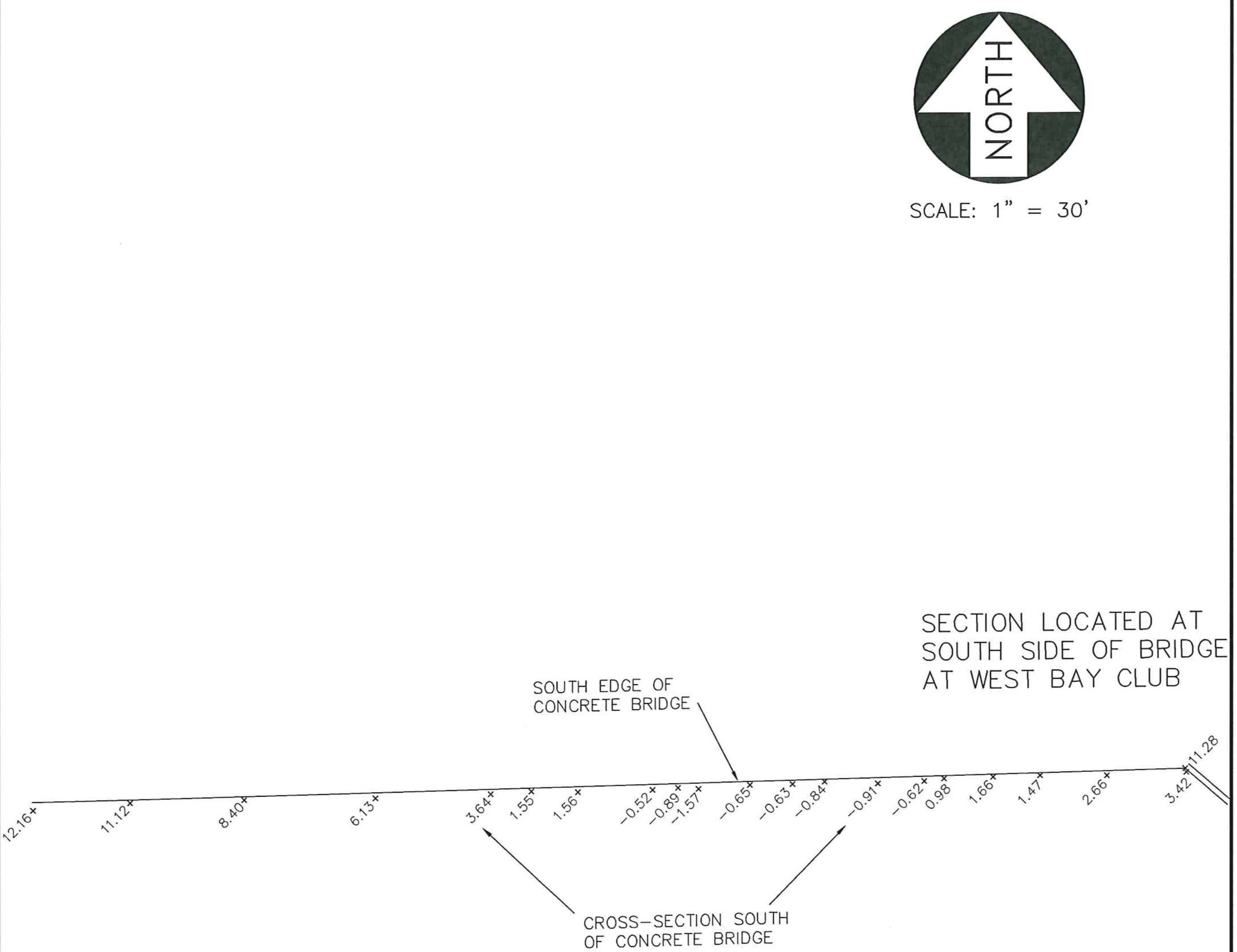

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SOUTH FLORIDA WATER MANAGEMENT DISTRICT	BEC PROJECT NO.	FIGURE
SOUTH LEE COUNTY WATERSHED PLAN UPDATE WILLIAMS RD BRIDGE AT HALFWAY CREEK	17312.02	14