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SFWMD-100**

**Water Budget Analysis for
Stormwater Treatment Area 6,
Section 1**

(Water Years 2006 and 2007; May 1, 2005 through April 30, 2007)

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By

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EXECUTIVE SUMMARY

This report presents a water budget for Stormwater Treatment Area 6 (STA-6), Section 1, for Water Years 2006 and 2007 (WY2006 and WY2007) (May 1, 2005–April 30, 2006 and May 1, 2006–April 30, 2007, respectively). Construction on Section 2 of STA-6 was started during this period. This work impacted the Section 1 water budget. Of the four hurricanes that affected Florida and the South Florida Water Management District in WY2006, Hurricane Wilma had the largest impact on STA-6, causing significant damage. A regional drought also became evident in WY2007 and resulted in lower water levels in the STA treatment cells.

STA-6, Section 1, was the first of six STAs to be built as part of the Everglades Construction Project (ECP). It became fully operational on December 9, 1997. It is used to reduce the phosphorous concentration in runoff from approximately 10,400 acres of agricultural land north of STA-6. During Section 2 construction, the pumps at structure G600 were used to drain the construction site and EAA Compartment C.

STA-6, Section 1, is comprised of two bermed wetland treatment cells, Cell 3 and Cell 5, with a total effective treatment area of 870 acres (245 acres and 625 acres, respectively). Under typical operating conditions, the cells are designed to have water depths of 0.5 to 4.5 feet (ft) with a long-term design operating water depth of 2.0 ft. Water flows from west to east across the cells, then south in the discharge canal through culverts at structure G607 to the L4 canal.

In WY2006, STA-6 received 28,307 acre-feet (ac-ft) of water. An additional 3,369 ac-ft of water entered STA-6 as rainfall and 3,836 ac-ft were lost through evapotranspiration (ET). Seepage was 9.8 percent of the water budget in WY2006, with an estimated net loss of 3,246 ac-ft to surrounding water bodies and the surficial aquifer. Outflow from STA-6 at the G354 and G393 structures was 86.5 percent of the inflow or, 24,735 ac-ft. The amount of water stored in STA-6 decreased by 7 ac-ft. The error in the water budget was 135 ac-ft, or 0.5 percent of the budget. Water entering Cell 3 was retained for an average of 8.1 days in WY2006, while the average retention time in Cell 5 was 20.9 days.

STA-6 received 28,601 acre-feet (ac-ft) of water during WY2007, a nominal increase over WY2006. Rainfall accounted for 2,114 ac-ft of water that entered the STA; 3,846 ac-ft of water was lost through ET. Seepage loss of 9,481 ac-ft to surrounding water bodies and the surficial aquifer was 30.3 percent of the water budget during this period. Outflow from STA-6 at the G354 and G393 structures was 58.6 percent of the flow entering STA-6, or 16,755 ac-ft. Overall, the amount of water stored in STA-6 decreased by 150 ac-ft; the error in the water budget was 2.4 percent, or 782 ac-ft. Cell 3 retained water for an average of 2.9 days in WY2007. The average retention time in Cell 5 was 6.5 days for the same period.

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INTRODUCTION

Hydrologic analysis of Stormwater Treatment Areas (STAs) is vital to ongoing efforts to optimize their performance and is a requirement of the Everglades Long-Term Plan for Achieving Water Quality Goals (Long-Term Plan) (Burns and McDonnell, 2003). Understanding the physical processes affecting water quality, and identifying and quantifying water sources and sinks in the water system, are critical factors in meeting the objectives of the Long-Term Plan. A water budget for STA-6, Section 1, covering Water Years 2006 and 2007 (WY2006 and WY2007) (May 1, 2005–April 30, 2006 and May 1, 2006–April 30, 2007, respectively) is presented here as part of this scientific effort. The reporting period covers the eighth and ninth water years of STA-6, Section 1 operation.

In 2005, the U.S. Sugar Corporation (USSC) abandoned sugarcane farming operations in their Unit 2 fields just north of the STA. Because farming operations ended, the pumps at structure G600 were not used, and the STA became a rain-driven system. The pumps at G600 were subsequently used to drain the adjacent site for STA-6, Section 2, when construction began in WY2006, and to provide flood protection for the remaining area of Compartment C of the Everglades Agricultural Area (EAA). Operation of Section 1 was modified to accommodate the construction of Section 2.

Four hurricanes affected Florida in WY2006: Dennis in July 2005; Katrina in August 2005; Rita in September 2005; and Wilma in October 2005. Hurricane Wilma's path took it directly over both the EAA and STAs, causing storm damage to ecosystem and hydrologic features and water management structures. In addition, a significant regional drought started in WY2007, that resulted in lower water levels in STA cells.

This analysis is based on a daily water budget for the three hydrologic units in STA-6: Cell 3, Cell 5, and the STA as a whole. Daily results were aggregated to develop monthly and annual water budgets. The daily water budget accounted for inflow, outflow, rainfall, evapotranspiration (ET), estimated seepage, storage, and error. The following section of the report presents background information about STA-6, water budget analyses, and monitoring at STA-6. Sections describing the operation of STA-6 and the sources of data used for the report follow. The actual water budget analysis is presented thereafter, followed by a summary, discussion, recommendations, and conclusions.

Background

STA-6, Section 1, was the first of six STAs to be built and operated following the success of the prototype Everglades Nutrient Removal Project. Construction of STA-6 was substantially completed by October 31, 1997. It was funded as part of the Everglades Construction Project (ECP), an element of the Everglades Program established by the Everglades Forever Act [Section 373.4592, Florida Statutes (F.S.)]. STA-6 received a discharge permit from the Florida Department of Environmental Protection and became fully operational on December 9, 1997. Its principal purpose was to reduce phosphorous

concentrations in runoff from USSC’s Unit 2 development (also known as EAA Compartment C), approximately 10,400 acres north of STA-6. Prior to construction of STA-6, the area was a runoff detention area that belonged to USSC. The Unit 2 development is now owned by the South Florida Water Management District (SFWMD or District). USSC continued to farm this area until the spring 2005 harvest. Construction of STA-6, Section 2, is substantially complete as of January 2008. Section 2 adds a treatment cell north of Cell 5 in STA-6.

The water budget at STA-6 involves the following hydrologic/hydraulic components:

- Inflow at pumps and uncontrolled weirs
- Outflow at gated combination weir-culverts
- Rainfall
- ET
- Estimated seepage
- Change in storage
- Water budget error

Each component makes up an important part of the water budget. The budget is developed for varying time periods ranging from one day to one year using the following equation:

$$\frac{\Delta S}{\Delta t} = I - O + R - ET - G + \varepsilon \quad \text{(Equation 1)}$$

where

ΔS	=	change in storage over the time period
Δt	=	time period
I	=	average inflow over the time period
O	=	average outflow over the time period
R	=	rainfall over the time period
ET	=	evapotranspiration over the time period
G	=	levee and deep seepage over the time period
ε	=	water budget error over the time period

In **Equation 1**, all terms have the same units, volume per unit time. In this report, units of acre-feet (ac-ft) per unit time (day, month, or year) are used. All of the terms can be either determined from direct observation or mathematically estimated. The error term (ε) is determined by solving **Equation 1** for that term. In order to establish values for rainfall and ET, units (in inches or millimeters) are converted to feet and multiplied by the effective surface area of the treatment cell in acres (e.g., 245 acres for Cell 3) to get a volume of rainfall or ET for a selected time period. Change in storage is calculated by multiplying the effective surface area of each cell by the change in water surface elevation over time.

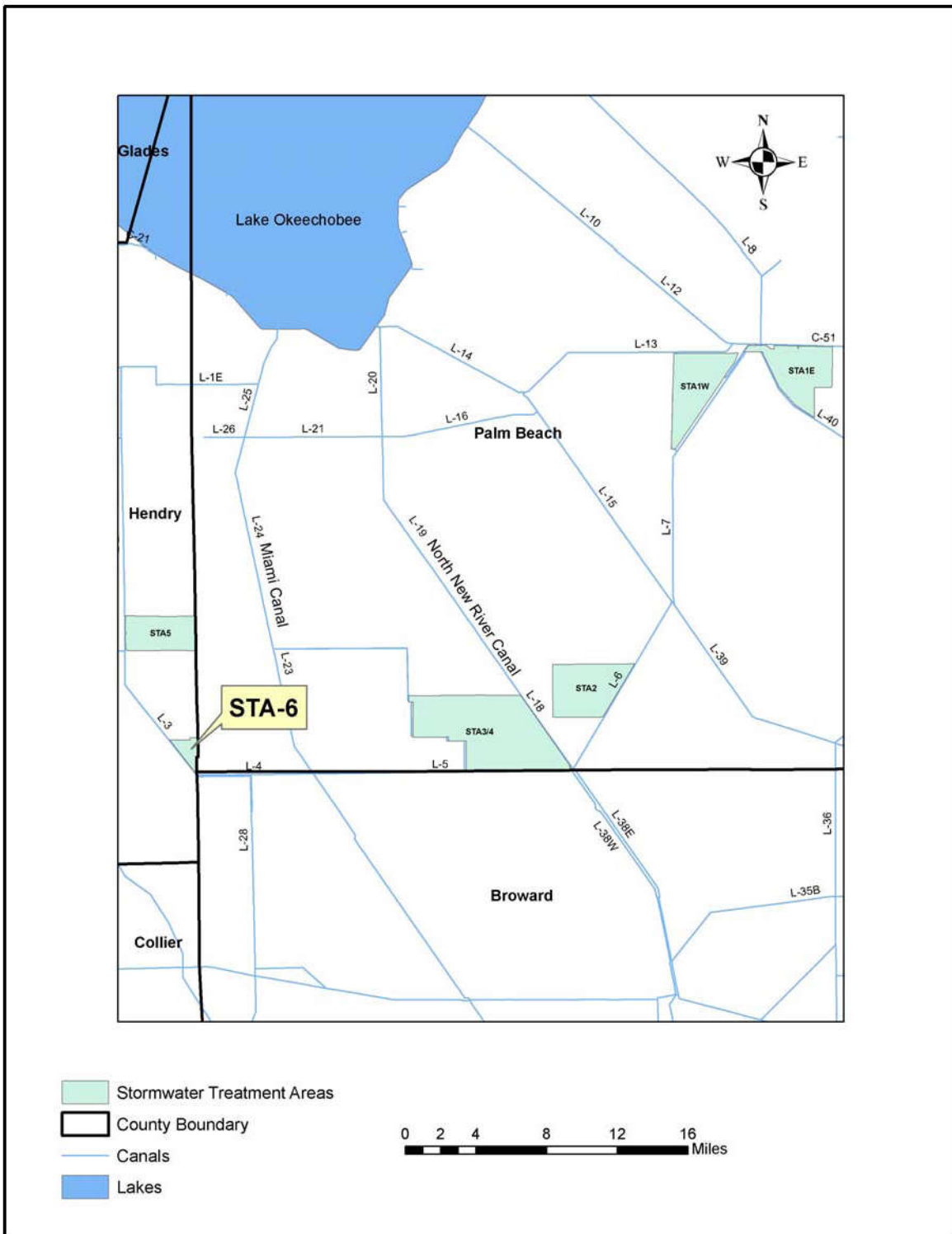


Figure 1. STA-6 site map.

Site Description

STA-6 is in the southwestern corner of the EAA, adjacent to the Rotenberger Wildlife Management Area (RWMA). STA-6 and its location relative to major canals and roadways are shown in **Figure 1**. It is comprised of two cells, Cell 3 and Cell 5, with a total effective treatment area of 870 acres (245 acres and 625 acres, respectively). The cells are bermed wetlands with structures that control inflow, outflow, and stage within the cells. Vegetation was mapped by Sheda Ecological Associates in December 2006. **Table 1** shows the types of vegetation and the percent of total area covered by each in STA-6 as a result of the 2006 survey. **Table A-1** in Appendix A of this report contains a summary of site properties used in the water budget calculations for STA-6.

Table 1. Vegetative areal coverage.

Vegetation Type	Coverage
Emergent	37%
Cattail (<i>Typha</i> spp.)	25%
Shrub	19%
Open water with or without vegetation	13%
Sawgrass (<i>Cladium jamaicense</i>)	5%
Spoil	0%

The treatment cells receive water via a supply canal west of the cells and east of the L-3 borrow canal (**Figure 2**). Under normal operating conditions, water enters the supply canal from the north through pump station G600_P. It can also enter the supply canal through structure G604 at the southern end of the supply canal, which consists of a set of five culverts with upstream flap gates. Water entering the supply canal through G604 was used to irrigate the Unit 2 development to the north of STA-6 when it was an active farm. This irrigation water rarely entered the treatment cells because the stage in the canal was typically below the crest of the inlet weirs under the conditions prevalent during the dry season when irrigation typically occurs.

There is one inflow weir (G603) for Cell 3, and two inflow weirs (G601 and G602) for Cell 5. Each treatment cell has a series of three outlet combination weir box/gated culvert structures (Cell 3: G393A, B, and C; Cell 5: G354A, B, and C) through which water exits the cell. Treated water from each cell then enters a discharge canal that connects to the L4 Canal. The L4 Canal runs east to west along the southern boundary of the EAA, then flows east during the wet season, either to the District's S8 pump station and the Miami Canal, or through a breach in the L-4 levee to the northwest corner of Water Conservation Area 3A.

A full description of STA-6, along with its design and operation are provided in the Integrated Operation Plan for STA-5 and STA-6 (SFWMD, 2006).

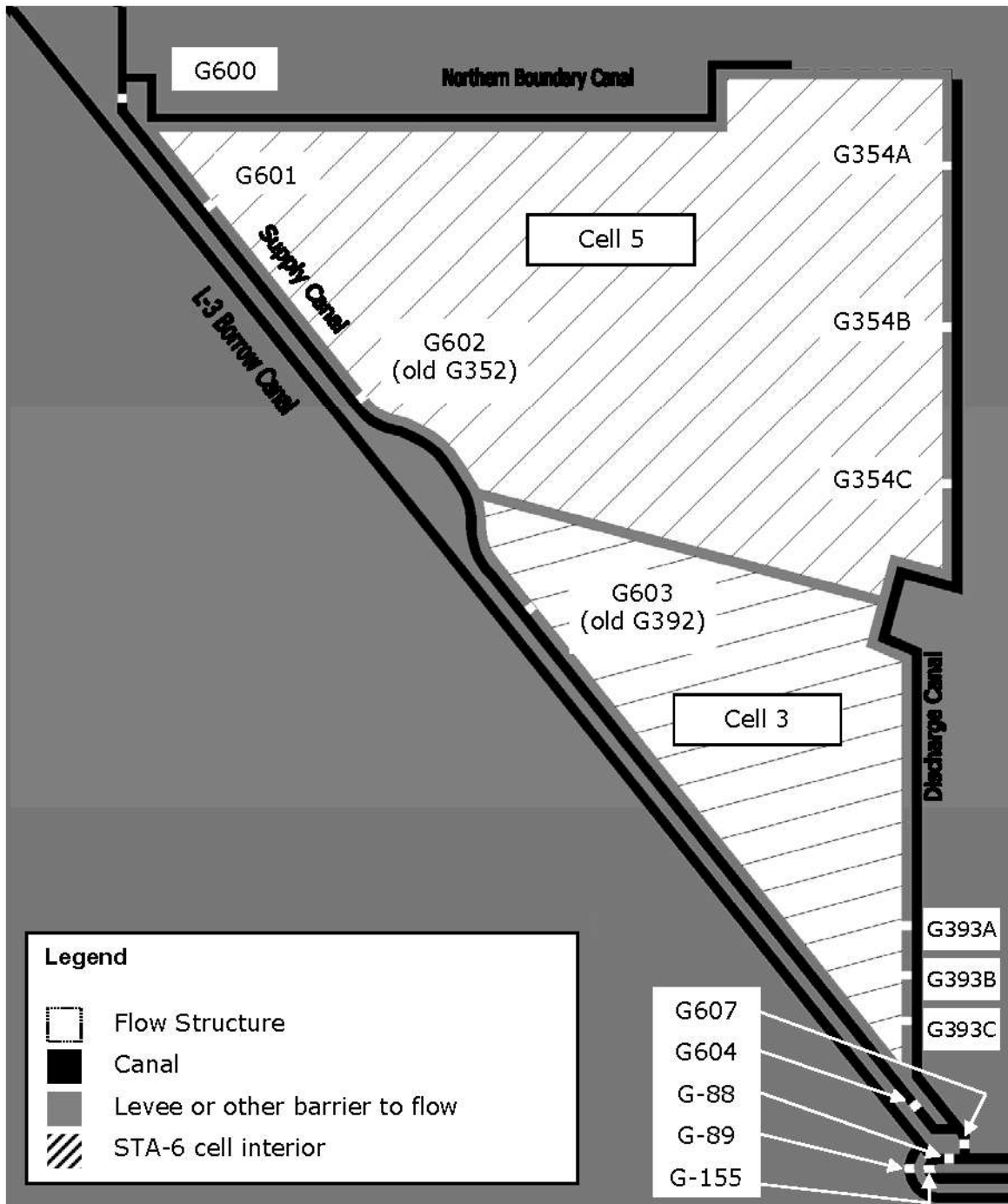


Figure 2. STA-6, Section 1, structure and monitoring locations (not to scale).

Monitoring

Two hydrologic parameters, stage and rainfall, were monitored at STA-6. Pump speed was also monitored. The depth of rainfall in inches was recorded at G600_R, located near pump station G600, and at a weather station (ROTNWX) located in the RWMA. The rainfall data at G600_R are stored in a preferred database (DB) key. Data at this station were compared to rainfall amounts at nearby rainfall recording locations and any potential data errors were corrected before they were uploaded to DBHYDRO, the District's corporate hydrologic and water quality database. The station names, DB keys, and station descriptions for STA-6 are shown in **Tables A-2** through **A-5** in Appendix A of this report.

Evapotranspiration is the loss of water to the atmosphere by vaporization (evaporation) at the surface of a water body and/or by respiration of living organisms, including vegetation (transpiration). The ET data used in this water budget analysis were derived from ET data for Stormwater Treatment Area 1 West (STA-1W). The station information for the ET data that was used in this study is listed in **Table A-5**.

STA OPERATION

Up to four pumps at station G600_P operated during the wet season in WY2006 and WY2007 in order to drain agricultural fields to the north of STA-6. The fifth pump at G600 and telemetry were damaged in a fire in 2004. Telemetry was restored on August 31, 2005. Each pump had a capacity of 100 cubic feet per second (cfs). The pumps were cycled on and off, depending upon the amount of water to be withdrawn from the fields. This water discharged into the STA-6 supply canal and created a hydraulic head on the inlet weirs, G601, G602, and G603, to Cells 3 and 5. The only means of inflow control for the treatment cells was accomplished by controlling the stage in the supply canal. This was done by varying the amount of water pumped at G600_P. Since Cell 3 has a surface area that is 28 percent of the total effective treatment area of STA-6 (245 acres of 870 acres), it was designed to treat 28 percent of the total inflow. The design of the inlet weirs was based upon this distribution of flow (SFWMD, 1997). The inlet weir crests for G601 and G602 (Cell 5) are set at 14.1 ft National Geodetic Vertical Datum 1929 (NGVD29). The crest of the inlet weir at G603 (Cell 3) is set at 14.2 ft NGVD29. The maximum total design inflow for Cells 3 and 5 is 500 cfs. This value has not been exceeded to date. The maximum inflow since the start-up of STA-6 was 456.7 cfs, recorded at G600_P on October 18, 1999, due to runoff caused by Hurricane Irene.

In February 2007, a plug was completed at the northern end of the supply canal. The plug isolated Section 1 (Cells 3 and 5) from the G600 pump station, effectively making Cells 3 and 5 rainfall-driven.

The cells are designed to have water depths of 0.5 to 4.5 ft under typical operating conditions. The average ground elevation of each cell is 12.4 ft NGVD29. The long-term design operating depth is 2.0 ft (14.4 ft NGVD29). The outlet weir boxes at G354A

through C and G393A through C control the water-surface elevations in each of the treatment cells. The outlet weir crest elevations were originally set at 13.6 ft NGVD29. During the first two years of operation, the outlet weir boxes at G354 (Cell 5) and G393 (Cell 3) were not level. In April 2000, weir plates were installed to correct this problem, leveling the weir crest. The crests of the weir plates are now set at 14.0 ft NGVD29 in Cell 3, and 14.1 ft NGVD29 in Cell 5. Each of the six outlet weir boxes is connected to gated culverts that allow water to flow into the STA-6 discharge canal. The gates are manually controlled. Normally, all three gates in Cell 5 (G354A through C) are open. In Cell 3, only one gate is usually open, G393B. Because of this, the maximum flow rate under normal operating conditions in Cell 3 is 140 cfs, which is 28 percent of the total design inflow of 500 cfs. In WY2006, the gates at G393A and C were opened to accommodate flow from flood control pumping at G600_P during Section 2 construction.

During extreme storm conditions, all the outlet structures for Cells 3 and 5 are opened and are operated at maximum capacity. Under drought conditions, minimum water levels in the cells are, to the greatest extent practicable, maintained at 12.4 ft NGVD29. This would maintain static water levels above the average ground surface elevation for approximately 50 percent of the treatment area.

HYDROLOGIC AND HYDRAULIC DATA

The following sections describe the data used for the water budget computations, and any special considerations for using the data. The source for the data was DBHYDRO (SFWMD, 2000), the District's corporate database.

Rainfall

Daily rainfall data for STA-6 were collected at G600_R and at the ROTNWX weather station. G600_R is located in the northwest corner of the STA near the G600 pump station. The weather station, ROTNWX, is located near the southeast corner of the STA in the RWMA. Missing values were filled based upon the best available information, usually from nearby rain gauges. Data from the ROTNWX rain gauge were averaged with values from the G600_R gauge and used for the mean daily rainfall at STA-6 for this report. **Table B-1** and **Table B-2** in Appendix B of this report show the average daily rainfall amounts recorded at G600_R and ROTNWX for WY2006 and WY2007. **Figure B-1** shows the daily average rainfall quantity for both water years, and **Figure B-2** shows the monthly rainfall quantity.

Evapotranspiration

Daily ET data were taken from a preferred DB key for STA-1W. The data for ET in this DB key were considered to be of the highest quality available. The DB key was populated with data using **Equation 2** (Abtew et al., 2003), daily air temperature, and total solar radiation. **Table C-1**, **C-2**, and **Figure C-1** in Appendix C of this report show the daily ET values used in this study. **Figure B-2** shows the monthly ET quantity.

$$ET = K_1 \frac{R_s}{\lambda} \quad \text{(Equation 2)}$$

where

ET	=	ET
K_1	=	empirical constant (= 0.53)
R_s	=	total solar radiation
λ	=	latent heat of vaporization (varies with air temperature)

Stage

Stage data were collected on an instantaneous basis, averaged, and recorded as daily mean stage in DBHYDRO. A headwater stage and a tailwater stage are needed in order to compute flow at each structure. As a result, more than one stage value was available for and used in computing average daily stage within each treatment cell. **Tables D-1 and D-2** and **Tables D-3 and D-4** show the mean daily stage values for Cell 3 and Cell 5, respectively for both water years.

Stage data were also used to estimate seepage to and from treatment cells and the STA. The equation used for seepage estimation is described below (**Equation 3**). Seepage was driven by stage differences between each treatment cell and surrounding water bodies. Details are provided in Appendix E of this report.

When the recorded stage in a treatment cell fell below the average ground elevation, a function was used to estimate the volume of water available for release or that was necessary to fill voids in the soils beneath the cells. An equation was developed representing storage below ground-surface elevation for a falling and a rising water table from cumulative water gain and water release equations (Abtew et al., 1998), and is discussed in detail by Huebner (2007).

Flow

Daily mean flow rates were obtained from DBHYDRO. In this study, the daily mean inflows at G601, G602, and G603 were used for the cell water budgets and for the STA water budget. In previous studies, STA-6 inflow was recorded at the G600 pumps. The G600_P flow data were not as reliable for STA inflow because of interrupted service during Section 2 construction. G601, G602, G603, and G354 A, B and C, and G393 A, B and C (outlet weir-culverts) are weir structures. Negative flow values at the weirs were retained in the analysis; however, daily mean flows that were negative had relatively small values.

The daily average flow at G354 and G393 was recorded in DBHYDRO and reviewed monthly for accuracy and missing data. A complete record of daily average flow was loaded monthly into a preferred DB key in DBHYDRO. Final quality assurance and quality control (QA/QC) checks of the flow data in the preferred DB key were conducted quarterly.

Outflow in this report was computed at weirs G354A, B, and C, and G393A, B, and C. Flow equation calibration work at these weirs was completed in WY2005. The

sum of the flow through the G354 and G393 structures was taken as the outflow of the entire STA.

Seepage

No direct measurement of seepage was made at the STA. A number of attempts to quantify seepage at wetland treatment sites like STA-6 have been made and are discussed extensively in Huebner (2001). In general, seepage losses have been reported on the order of 2.0 to 10.0 cfs per mile of levee per foot of head difference (cfs/mi/ft). Huebner (2001) also shows the estimated groundwater table gradient around STA-6 for dry and wet periods, with and without the STA. In general, the regional groundwater table gradient is from north to south. By impounding water within the STA, the local gradients tend to carry water away from the STA to the surrounding shallow aquifer and nearby canals.

In this analysis, seepage was computed as:

$$G = 1.983 * K_{sp} * L * \Delta H \quad \text{(Equation 3)}$$

where

G	=	levee (horizontal) and deep (vertical) seepage (ac-ft/d)
1.938	=	constant to convert from cubic ft per second (cfs) to ac-ft/d
K_{sp}	=	coefficient of seepage (cfs/mi/ft)
L	=	length along the seepage boundary (mi)
ΔH	=	elevation difference between the water level in the treatment cell or canal and the water level adjacent to the cell or canal (ft)

The value of K_{sp} was optimized by minimizing the error in the water budget for the six-year period from WY1999–WY2005. Details are provided in Appendix E of this report.

WATER BUDGET

Methodology

Three sets of water budgets were produced; one for each treatment cell and one for the entire STA. Each set of water budgets was computed on a daily, monthly, and annual basis using **Equation 1**. Terms in **Equation 1** were converted to ac-ft per unit time (day, month, or year, depending on the period being used for the water budget calculations). Each water year used in this report extends from May 1 to April 30, and was used as the annual period. Wet season months are June through October, and the dry season extends from November through May.

Results

Cell 3

Table 2 shows the annual water budget for Cell 3 for WY2006 and WY2007. Error in the annual water budget was 1 to 5 percent. Seepage loss was 32 percent of the

water budget for both years. Outflow through weir boxes G393 A, B and C was 67 percent of the inflow to Cell 3, measured at G603.

Table 3 contains the monthly water budget summary for Cell 3. The mean daily error in the monthly water budget analysis (**Table 3**) is the equivalent of less than 1.0 in. for 19 of the 24 months in the period. The seepage coefficient used for the water budget for Cell 3 was 10.0 cfs/mi/ft, which is within the values found in the literature.

Figure 3 shows the daily errors or residuals in the Cell 3 water budget for WY2006 and WY2007. Cell 3 displayed the lower amount of variation in the water budget residuals compared to Cell 5. **Figure 4** depicts the estimated seepage into and out of Cell 3. The variation in Cell 3 inflow, outflow, and stage is depicted in **Figure 5**.

Table 2. Cell 3 annual water budget summary (ac-ft), WY2006 and WY2007.

CELL 3	INFLOW	SEEPAGE IN	RAIN	TOTAL INFLOW	OUTFLOW	SEEPAGE OUT	ET	TOTAL OUTFLOW	CHANGE IN STORAGE	REMAINDER	ERROR %
WY 2006	16,643	1,304	927	18,874	12,911	4,040	1,056	18,007	-76	-944	-5.1
WY 2007	14,802	1,201	582	16,584	8,280	7,116	1,059	16,454	-111	-242	-1.4
TOTAL	31,445	2,504	1,509	35,459	21,190	11,156	2,115	34,461	-198	-1,185	-3.3
% Inflow	88.7	7.1	4.3	% Outflow	61.5	32.4	6.2				

Notes:

1. All values in ac-ft
2. Inflow measured at G603
3. Rain is the average value from G600_R and ROTNWX
4. Outflow measured at G393 A, B, and C
5. ET data from STA-1W
6. Seepage estimated based on differences between cell water level and surrounding water levels using a coefficient of seepage of: Cell 3 = 10.0 cfs/mi/ft; Cell 5 = 1.8 cfs/mi/ft
7. Change in storage for water levels below average ground level estimated using an equation developed by Huebner (2007) based on data available in Abteu et al. (1998)

Table 3. Cell 3 monthly water budget (ac-ft), WY2006 and WY2007.

Month-Year	INFLOW	OUTFLOW	CHANGE IN STORAGE	ET	RAIN	SEEPAGE	REMAINDER
May-05	0	0	-176	110	87	1,426	1,273
Jun-05	15	-35	469	81	207	-136	156
Jul-05	238	712	-38	108	55	-46	442
Aug-05	361	360	31	100	297	-92	-260
Sep-05	3,344	3,703	108	85	95	14	470
Oct-05	5,219	5,580	72	76	106	-212	190
Nov-05	2,699	2,170	-206	65	18	15	-673
Dec-05	1,722	45	-73	61	4	1	-1,692
Jan-06	316	0	-69	66	4	-108	-433
Feb-06	1,751	334	123	77	20	-37	-1,274
Mar-06	821	43	-77	111	19	665	-98
Apr-06	156	0	-239	118	15	1,245	954
May-06	1	0	-100	121	43	356	332
Jun-06	26	0	-3	101	40	-631	-599
Jul-06	2,535	1,191	472	104	80	135	-714
Aug-06	2,944	1,611	173	103	154	376	-835
Sep-06	3,789	2,890	-154	90	98	156	-905
Oct-06	2,935	1,316	1	88	16	528	-1,019
Nov-06	2,386	1,165	-37	63	23	550	-667
Dec-06	186	107	-193	53	33	1,831	1,579
Jan-07	0	0	-261	64	5	1,730	1,528
Feb-07	0	0	-4	64	32	580	609
Mar-07	0	0	-7	98	7	354	438
Apr-07	0	0	1	111	50	-50	12

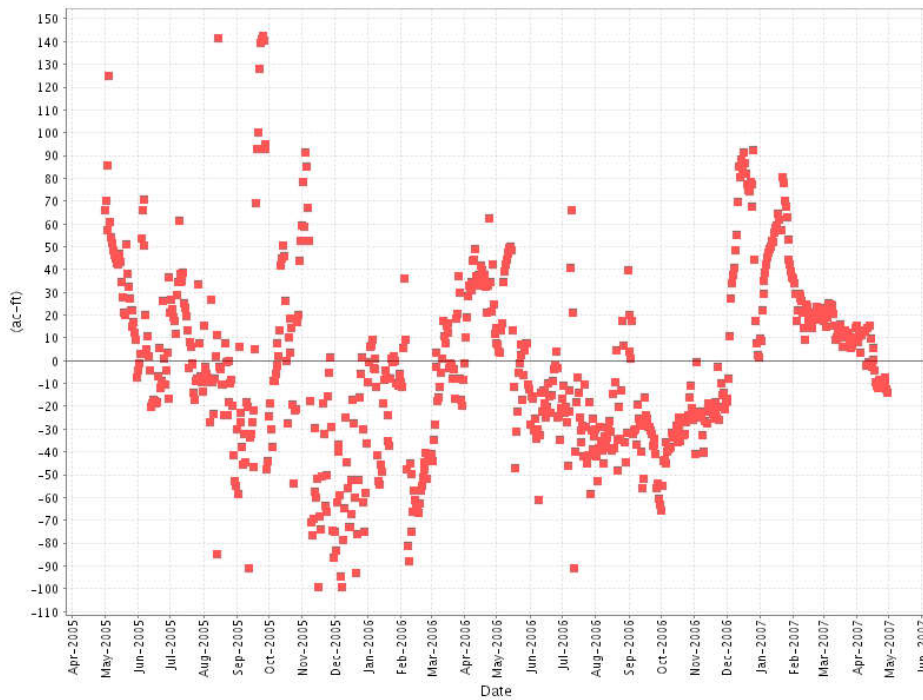


Figure 3. Cell 3 daily water budget residual, WY2006 and WY2007.

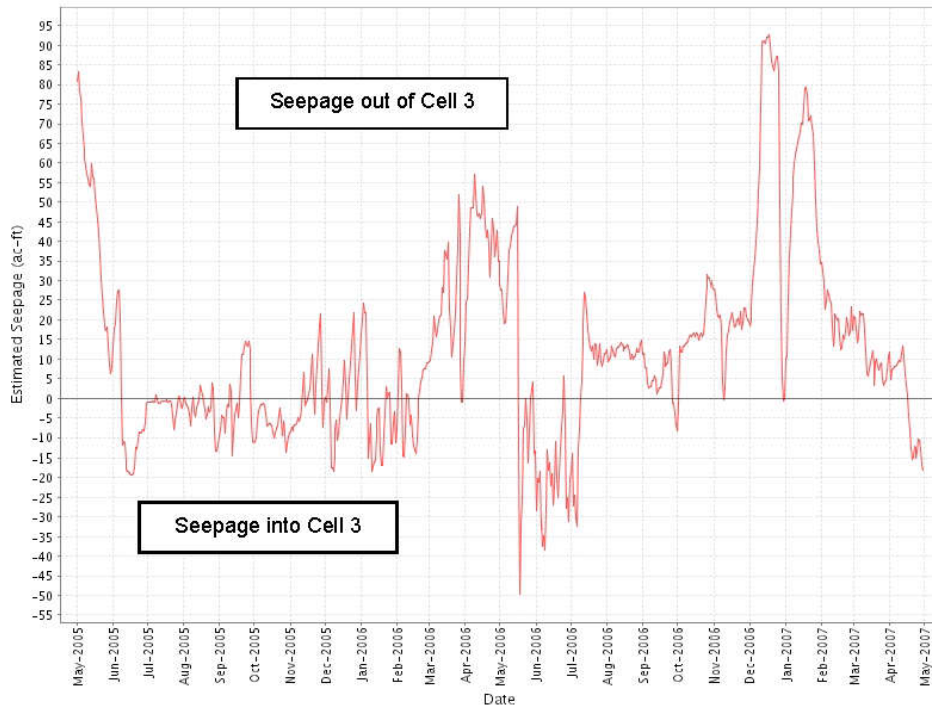


Figure 4. Cell 3 estimated daily seepage, WY2006 and WY2007.

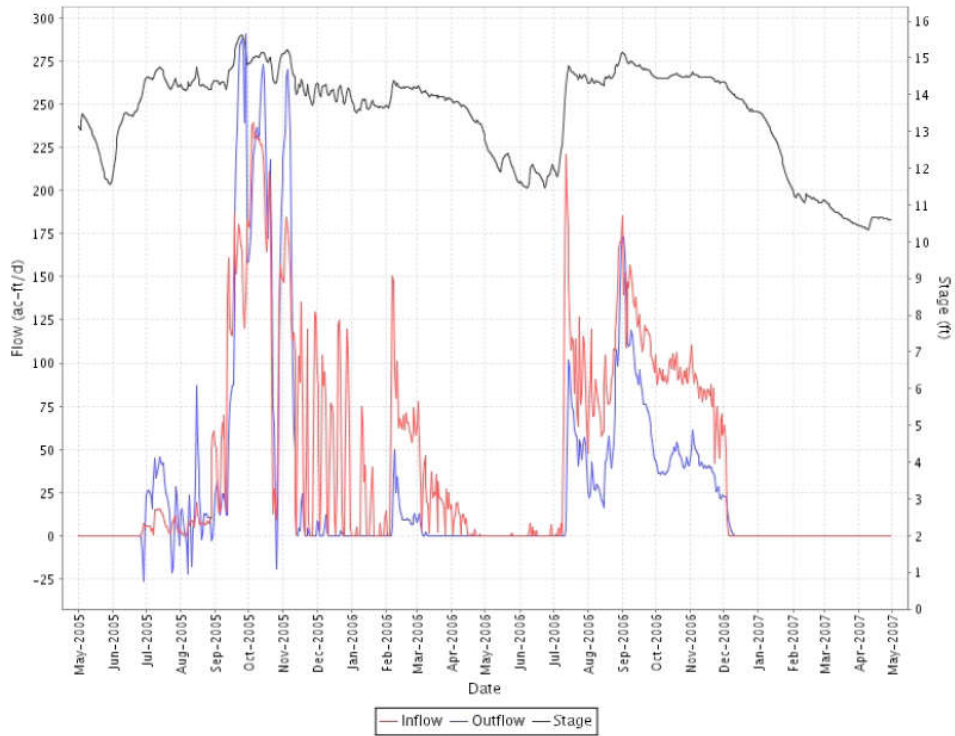


Figure 5. Cell 3 inflow, outflow, and stage, WY2006 and WY2007.

Cell 5

Table 4 shows the annual water budget for Cell 5. Cell 5 is the northern of the two treatment cells in STA-6, Section 1. As a percentage of the annual water budget, error for Cell 5 was 4 percent. **Figure 6** shows the residual error plot for the Cell 5 water budget. The seepage coefficient used for the Cell 5 water budget was 1.8 cfs/mi/ft, which agrees with values from the literature. Seepage loss constituted 18 percent of the water budget.

Seepage into and out of Cell 5 is depicted in **Figure 7**. In WY2006 and WY2007, 80 percent of the inflow to the cell at G601 and G602 left the cell at G354 A, B, and C. **Figure 8** shows the inflow, outflow, and stage in Cell 5 for WY2006 and WY2007.

Cell 5's monthly water budgets for WY2006 and WY2007 are shown in **Table 5**. The average daily error is less than 1.0 in. for 20 of 24 months. The sum of the mean daily error was lower for Cell 5 (1,094 ac-ft) than Cell 3 (1,185 ac-ft), partly because the budget is being applied to a unit that has a much larger surface area (625 acres versus 245 acres for Cell 3).

Table 4. Cell 5 annual water budget summary (ac-ft), WY2006 and WY2007.

CELL 5	INFLOW	SEEPAGE IN	RAIN	TOTAL INFLOW	OUTFLOW	SEEPAGE OUT	ET	TOTAL OUTFLOW	CHANGE IN STORAGE	REMAINDER	ERROR %
WY 2006	11,664	786	2,366	14,816	11,824	1,661	2,694	16,179	47	1,411	9.2
WY 2007	13,799	267	1,484	15,551	8,476	4,059	2,701	15,235	-1	-317	-2
TOTAL	25,463	1,054	3,850	30,367	20,300	5,720	5,395	31,415	46	1,094	3.6
% Inflow	83.9	3.5	12.7	% Outflow	64.7	18.3	17.2				

Notes:

1. All values in ac-ft
2. Inflow measured at G601 and G602
3. Rain is the average value from G600_R and ROTNWX
4. Outflow measured at G354 A, B, and C
5. ET data from STA-1W
6. Seepage estimated based on differences between cell water level and surrounding water levels using a coefficient of seepage of: Cell 3 = 10.0 cfs/mi/ft; Cell 5 = 1.8 cfs/mi/ft
7. Change in storage for water levels below average ground level estimated using an equation developed by Huebner (2007) based on data available in Abtew et al. (1998)

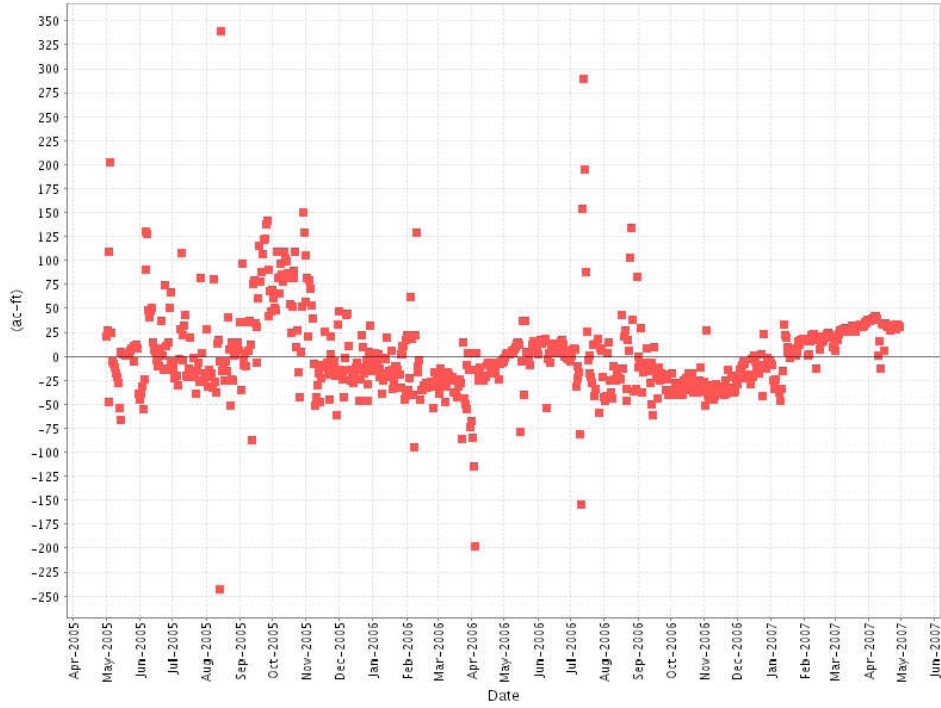


Figure 6. Cell 5 daily water budget residual, WY2006 and WY2007.

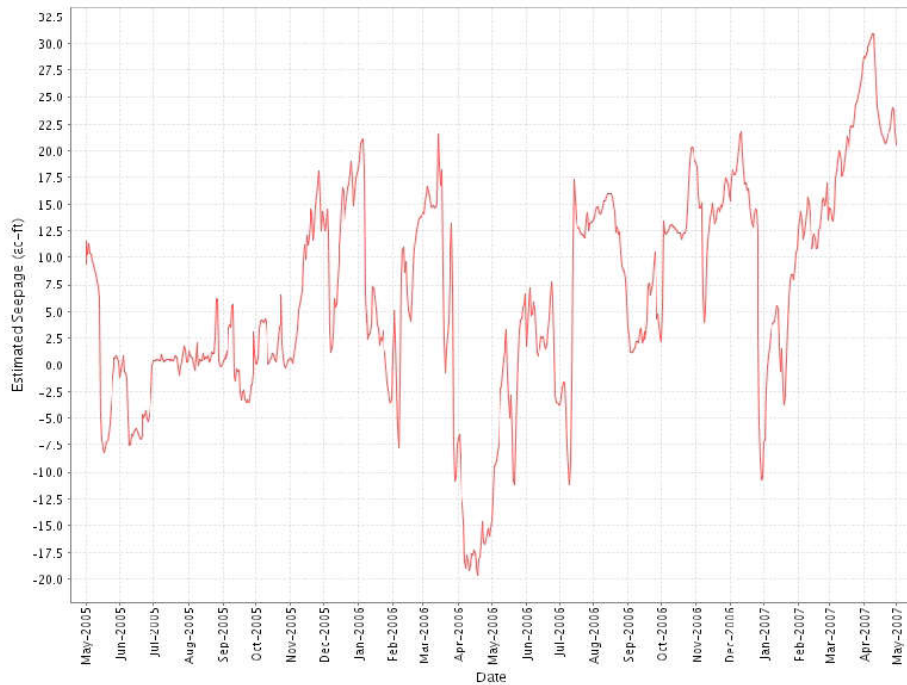


Figure 7. Cell 5 estimated daily seepage, WY2006 and WY2007.

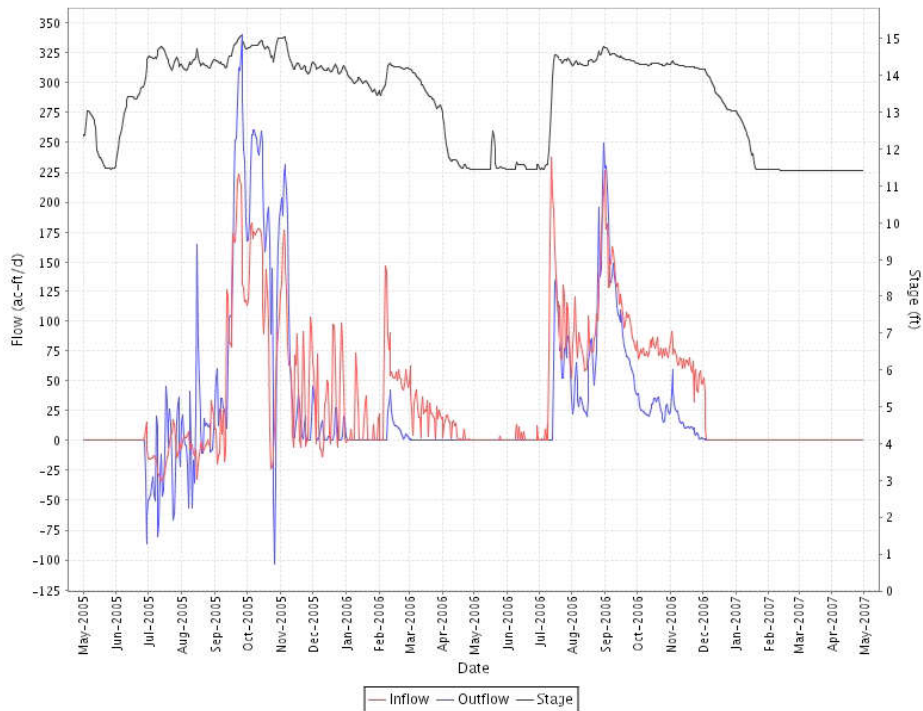


Figure 8. Cell 5 inflow, outflow, and stage, WY2006 and WY2007.

Table 5. Cell 5 monthly water budget (ac-ft), WY2006 and WY2007.

Month-Year	INFLOW	OUTFLOW	CHANGE IN STORAGE	ET	RAIN	SEEPAGE	REMAINDER
May-05	0	0	49	279	221	54	162
Jun-05	20	-178	1,212	206	528	-129	562
Jul-05	-408	-557	-82	275	141	15	-81
Aug-05	-68	279	79	254	759	32	-46
Sep-05	2,859	4,209	194	217	242	-5	1,514
Oct-05	3,407	5,378	187	193	270	57	2,138
Nov-05	2,024	2,113	-460	165	46	284	33
Dec-05	999	291	-56	156	10	378	-239
Jan-06	319	3	-425	167	11	177	-408
Feb-06	1,521	281	419	196	52	197	-480
Mar-06	779	3	-684	283	49	294	-930
Apr-06	212	0	-386	302	38	-480	-814
May-06	4	0	0	307	110	-94	100
Jun-06	57	0	3	257	101	81	183
Jul-06	2,653	1,517	1,179	265	205	190	293
Aug-06	2,996	2,351	253	264	393	410	-112
Sep-06	3,699	3,291	-270	229	251	123	-576
Oct-06	2,338	830	-29	224	41	421	-933
Nov-06	1,903	482	-69	161	58	417	-971
Dec-06	150	4	-712	134	85	404	-405
Jan-07	0	0	-355	162	13	85	-121
Feb-07	0	0	0	165	82	372	454
Mar-07	0	0	0	251	18	631	864
Apr-07	0	0	0	282	127	751	907

STA-6

Table 6 contains the summary of the WY2006 and WY2007 water budgets for all of STA-6, which includes Cells 3 and 5, as discussed previously. Water budget error constituted 1 percent of the STA-6 budget and seepage loss was 24 percent.

Table 7 shows the monthly water budget summary. The daily average errors are less than 1.0 in. for 15 of the 24 months. **Figure 9** shows these residuals in the daily water budgets. The peaks in the residual plot occur during periods of high inflow, showing that the daily water budget under these conditions does not accurately quantify all of the hydrologic processes occurring in STA-6. Work completed for STA-5 indicates that this may be due to transient flow and stage conditions that take place in less than one day (Parrish and Huebner, 2004.). **Figure 10** presents the estimated daily seepage into and out of STA-6.

Figure 11 shows the daily inflow and outflow volumes for STA-6 for WY2006 and WY2007. Outflow from Cells 3 and 5 was 73 percent of the inflow recorded at G601, G602, and G603 during WY2006 and WY2007.

Table 6. STA-6 annual water budget summary (ac-ft), WY2006 and WY2007.

STA-6	INFLOW	SEEPAGE IN	RAIN	TOTAL INFLOW	OUTFLOW	SEEPAGE OUT	ET	TOTAL OUTFLOW	CHANGE IN STORAGE	REMAINDER	ERROR %
WY 2006	28,307	1,340	3,369	33,015	24,735	4,586	3,836	33,157	-7	135	0.5
WY 2007	28,601	1,235	2,114	31,950	16,755	10,716	3,846	31,317	-150	-782	-2.4
TOTAL	56,908	2,574	5,482	64,965	41,490	15,302	7,682	64,474	-157	-647	-1
% Inflow	87.6	4	8.5	% Outflow	64.4	23.8	12				

Notes:

1. All values in ac-ft
2. Inflow measured at G601, G602, and G603
3. Rain is the average value from G600_R and ROTNWX
4. Outflow measured at G354 A, B and C and G393 A, B and C
5. ET data from STA-1W
6. Seepage estimated based on differences between cell water level and surrounding water levels using a coefficient of seepage of: Cell 3 = 10.0 cfs/mi/ft; Cell 5 = 1.8 cfs/mi/ft
7. Change in storage for water levels below average ground level estimated using an equation developed by Huebner (2007) based on data available in Abteu et al. (1998)

Table 7. STA-6 monthly water budget, WY2006 and WY2007.

Month-Year	INFLOW	OUTFLOW	CHANGE IN STORAGE	ET	RAIN	SEEPAGE	REMAINDER
May-05	0	0	-137	398	314	1,497	1,444
Jun-05	35	-213	1,738	293	752	-281	750
Jul-05	-170	155	-123	392	200	-31	363
Aug-05	293	639	121	362	1,081	-67	-317
Sep-05	6,203	7,912	316	309	344	-27	1,962
Oct-05	8,627	10,958	259	275	385	-199	2,282
Nov-05	4,723	4,283	-672	235	66	271	-673
Dec-05	2,720	336	-148	222	14	352	-1,973
Jan-06	635	3	-496	238	16	60	-847
Feb-06	3,273	616	556	279	73	124	-1,772
Mar-06	1,600	46	-768	404	70	909	-1,079
Apr-06	368	0	-653	430	53	638	-6
May-06	5	0	-100	438	156	198	374
Jun-06	83	0	14	367	144	-660	-505
Jul-06	5,188	2,708	1,671	377	292	248	-476
Aug-06	5,941	3,962	440	376	559	747	-975
Sep-06	7,488	6,182	-434	326	357	235	-1,537
Oct-06	5,273	2,145	-28	319	59	904	-1,990
Nov-06	4,288	1,647	-111	229	83	925	-1,681
Dec-06	335	111	-929	191	122	2,271	1,187
Jan-07	0	0	-675	231	19	1,842	1,380
Feb-07	0	0	-2	234	117	987	1,102
Mar-07	0	0	-20	358	26	1,046	1,357
Apr-07	0	0	23	402	180	737	982

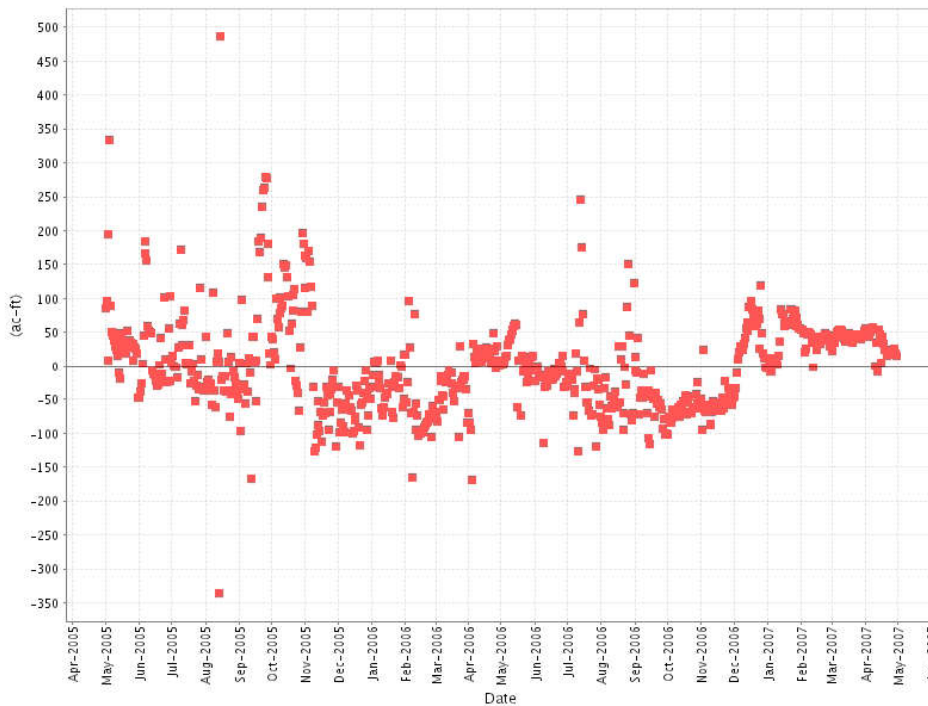


Figure 9. STA-6 daily water budget residual, WY2006 and WY2007.

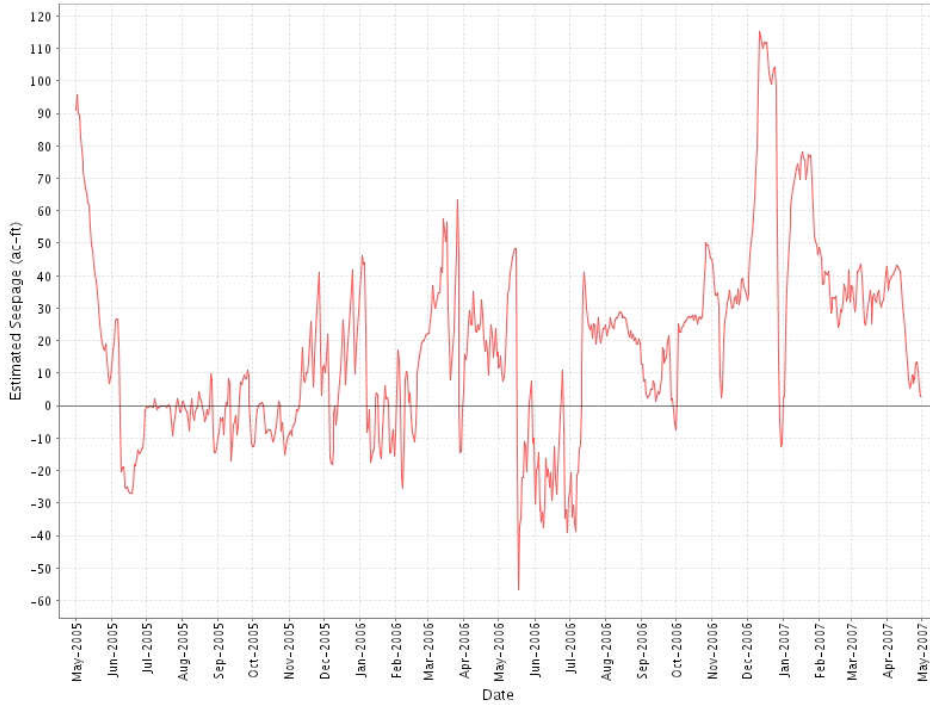


Figure 10. STA-6 estimated daily seepage, WY2006 and WY2007.

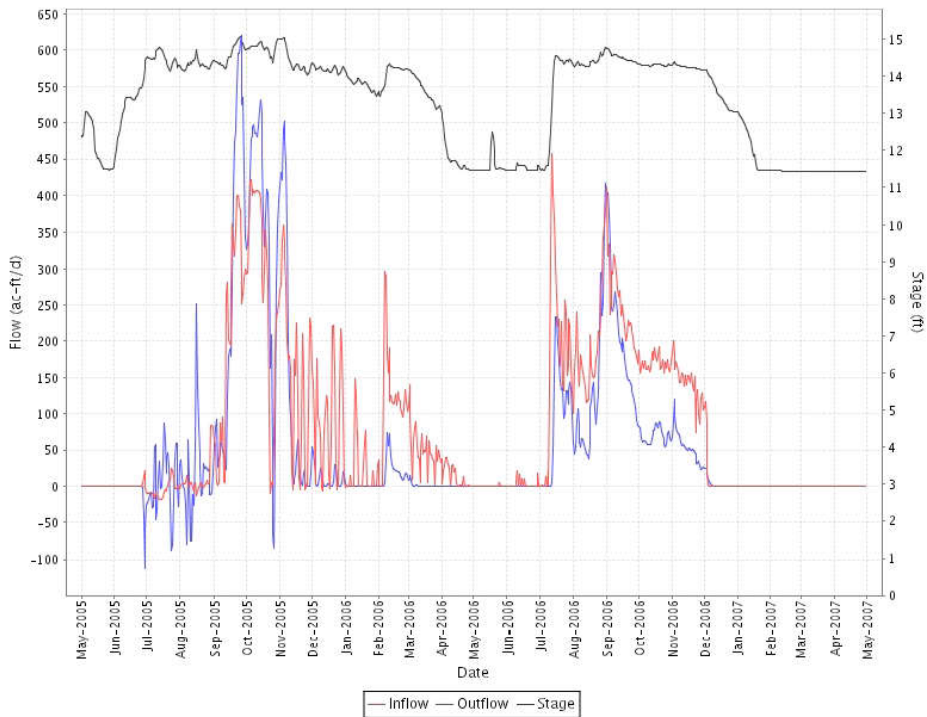


Figure 11. STA-6 inflow, outflow, and stage, WY2006 and WY2007.

Mean Hydraulic Retention Time

Mean hydraulic retention time (MHRT) is an estimate of how long water remains in each cell. During that time, physical, chemical, and biological processes remove particulate and soluble phosphorous and other contaminants. The MHRT, also referred to as mean cell residence time, was determined using **Equation 4**:

$$t = \frac{V}{Q} \quad \text{(Equation 4)}$$

where

t	=	mean hydraulic retention time (d)
V	=	cell volume (ac-ft, effective area times depth)
Q	=	flow rate (mean of inflow and outflow; ac-ft/d)

Table 8 shows the MHRT in days for Cells 3 and 5 and the STA. The annual mean was based on the average stage during the water years or seasons, and the average rate of inflow and outflow including rainfall, ET, and seepage. Wet-season MHRT is based on data spanning June to October, and dry-season MHRT is based on data spanning November through May.

Table 8. Mean hydraulic retention time, WY2006 and WY2007.

Cell 3	ANNUAL AVG DEPTH	ANNUAL MHRT	WET AVG DEPTH	WET MHRT	DRY AVG DEPTH	DRY MHRT
WY 2006	1.61	8.1	1.96	7.0	1.36	9.7
WY 2007	0.52	2.9	1.46	5.1	-0.16	---
2-yr. Mean	1.07	5.5	1.71	6.0	0.60	4.1

Cell 5	ANNUAL AVG DEPTH	ANNUAL MHRT	WET AVG DEPTH	WET MHRT	DRY AVG DEPTH	DRY MHRT
WY 2006	1.39	20.9	1.89	19.8	1.02	22.5
WY 2007	0.44	6.5	1.24	10.2	-0.15	---
2-yr. Mean	0.91	13.7	1.56	15.0	0.44	8.6

STA	ANNUAL AVG DEPTH	ANNUAL MHRT	WET AVG DEPTH	WET MHRT	DRY AVG DEPTH	DRY MHRT
WY 2006	1.39	13.9	1.89	13.1	1.02	15.0
WY 2007	0.44	4.6	1.24	7.6	-0.15	---
2-yr. Mean	0.91	9.2	1.56	10.3	0.44	5.9

According to the operation plan for the STA, Cell 5 inflow should be about twice as Cell 3 inflow values, since it has two inflow weirs, as opposed to one in Cell 3. This was not the case in WY2006 and WY2007, where the inflow to Cell 3 was greater than the inflow to Cell 5. This effectively shortened MHRT values for Cell 3.

During the wet season, the MHRT for Cell 3 averaged 6 days, and 15 days for Cell 5. Dry-season MHRTs could not be computed for WY2007 since the mean water depth was below the mean ground surface due to the regional drought. In WY2006, the MHRT was 10 days for Cell 3 and 22 days for Cell 5. Annually, the MHRT for Cell 3 averaged 6 days, and 14 days for Cell 5. At maximum normal flow conditions in the STA, as described in the STA's Operation Plan (SFWMD, 1997), Cell 3 has a MHRT of 4.0 days, based on a flow of 140 cfs and a depth of 4.5 ft. Cell 5 has a MHRT of 3.9 days, based on a flow of 360 cfs and a depth of 4.5 ft.

Hydraulic Loading Rate

Hydraulic loading rate (HLR) is the rate at which water flows into a system. This was calculated by dividing the inflow (ac-ft/day) at the control structures by the treatment area. For this analysis, the entire STA-6 was considered and therefore inflow was divided by 870 acres (the area of STA-6). **Table 9** presents the average HLR for each month for WY2006 and WY2007. The highest HLR occurred in October 2005, which was 0.32 ac-ft/day/ac. The HLR was zero in 7 months, since inflow was zero or negative. **Figure 12** shows the average HLR based on the wet and dry seasons of the water year.

Table 9. Monthly hydraulic loading rate (ac-ft/d/ac), WY2006 and WY2007.

Month	WY2006	WY2007
May	0.00	0.00
June	0.00	0.00
July	0.00	0.19
August	0.01	0.22
September	0.24	0.29
October	0.32	0.20
November	0.18	0.16
December	0.10	0.01
January	0.02	0.00
February	0.13	0.00
March	0.06	0.00
April	0.01	0.00

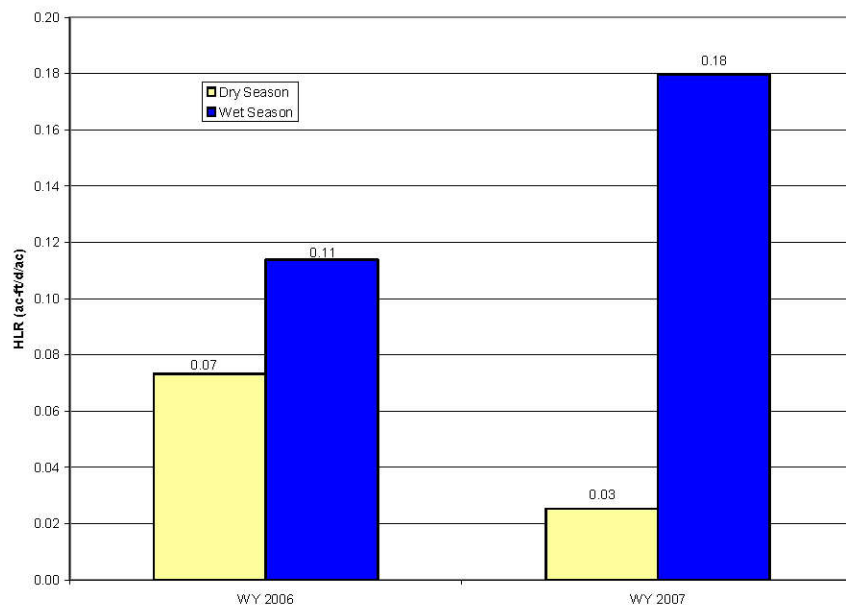


Figure 12. Average hydraulic loading rate (HLR) based on wet or dry season, WY2006 and WY2007

SUMMARY AND DISCUSSION

In WY2006, STA-6 received 28,307 ac-ft of water. An additional 3,369 ac-ft of water entered STA-6 as rainfall and 3,836 ac-ft were lost through ET. Seepage was 9.8 percent of the water budget in WY2006, with an estimated net loss of 3,246 ac-ft to surrounding water bodies and the surficial aquifer. Outflow from STA-6 at the G354 and G393 structures was 86.5 percent of the inflow or 24,735 ac-ft. The amount of water stored in STA-6 decreased by 7 ac-ft. The error in the water budget was 135 ac-ft, or 0.5 percent of the budget. Water entering Cell 3 was retained for an average of 8.1 days in WY2006, while the average retention time in Cell 5 was 20.9 days.

STA-6 received 28,601 ac-ft of water during WY2007, a nominal increase over WY2006. Rainfall accounted for 2,114 ac-ft of water that entered the STA; 3,846 ac-ft of water was lost through ET. Seepage loss of 9,481 ac-ft to surrounding water bodies and the surficial aquifer was 30.3 percent of the water budget during this period. Outflow from STA-6 at the G354 and G393 structures was 58.6 percent of the flow entering STA-6, or 16,755 ac-ft. Overall, the amount of water stored in STA-6 decreased by 150 ac-ft; the error in the water budget was 2.4 percent, or 782 ac-ft. Cell 3 retained water for an average of 2.9 days in WY2007. The average retention time in Cell 5 was 6.5 days for the same period.

The seepage coefficient used for the water budget for Cell 3 was 10.0 cfs/mi/ft based on calibration using data from WY1999 to WY2005. The seepage coefficient for Cell 5 was 1.8 cfs/mi/ft. Both are within the values found in the literature.

In WY2006 and WY2007, Cell 5 inflow was less than Cell 3 inflow, which is the inverse of the design-intended inflow volume to the cells. This can be attributed to the fact that the weir at G603 (Cell 3) is larger than either of the weirs at G601 and G602 (Cell 5). However, the elevation of the weir crest at G603 is 14.2 ft. NGVD29; the crest elevation of weirs at G601 and G602 is 14.1 ft. NGVD29. This higher loading rate was also reflected in MHRT values for both cells.

There are two other structures, an irrigation pump at station G600I_P, and a gated culvert at station G600_C at STA-6, that were instrumented in 2004, but not used for data collection in WY2006 and WY2007.

The water budget residuals for STA-6 shown in **Figures 3, 6, and 9** (residuals for Cell 3, Cell 5, and STA-6 as a whole) are not random. In general, the residuals increase when flow increases, as shown in **Figures 13 and 14**. Although seepage also increases during these periods (in response to increased stage in STA-6), the volume of outflow from STA-6, plus the increased seepage and the increase in storage, do not equal the daily volume of water entering STA-6. Flow measurement error may account for this. The algorithm for inflow is based on a uniform trapezoidal shape. The construction drawings show that inflow weirs have sloped sides approximating a trapezoid, but the crest elevation (bottom of the trapezoid) is irregular. Likewise, the outflow structures are a combination of gated culvert and weir. Flow equations for these structures are being revised to account for the complex nature of flow through these structures, and flow values used for this study represent best estimates at the time flow values were entered into DBHYDRO. Error in the budget may also indicate a response to flow that is not adequately represented by daily mean values of stage and storage used in water budget calculations.

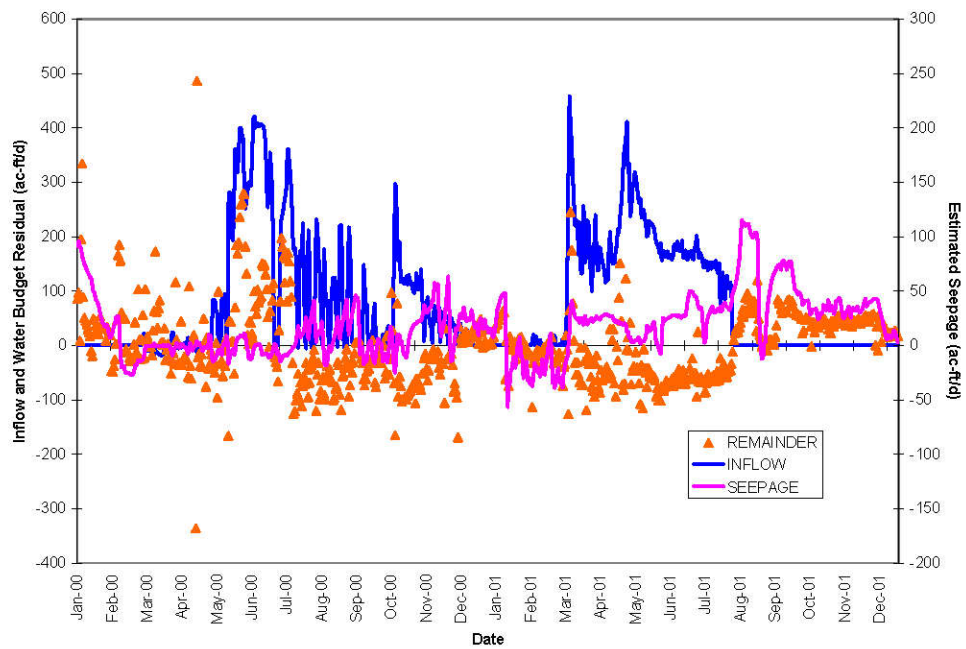


Figure 13. STA-6 daily inflow, estimated seepage and water budget residuals, WY2006 and WY2007.

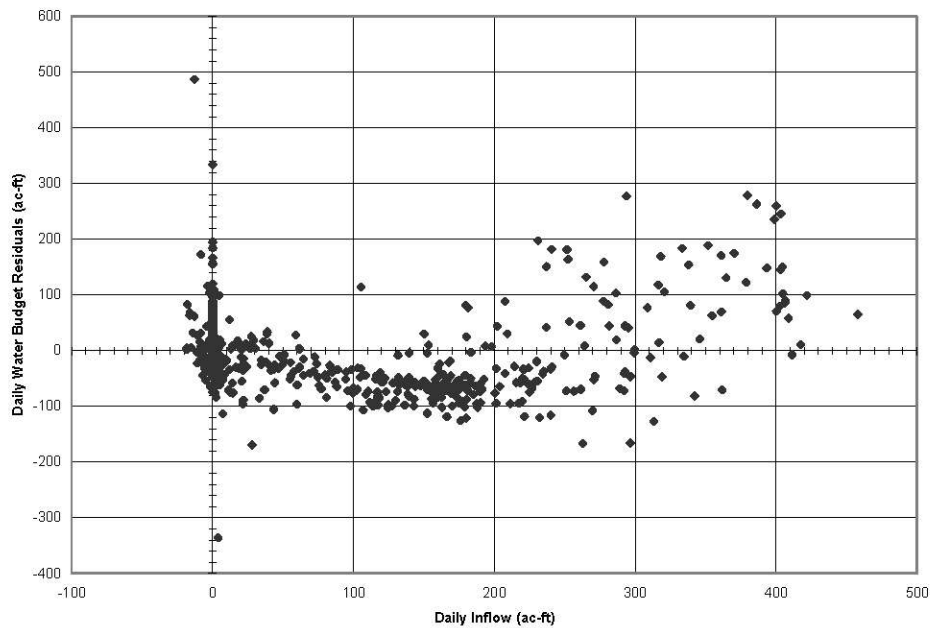


Figure 14. Daily Water Budget Residuals vs. Inflow

RECOMMENDATIONS AND CONCLUSIONS

Seepage constituted the largest single quantifiable unknown at the site, especially in Cell 3. The geology and the seepage characteristics of the area have received additional study with the installation and operation of test cells for the EAA Reservoir project. These test cells have shown that the limestone shell rock area lying beneath the peat layer in the EAA can be highly transmissive. The quantity and quality of water lost through seepage has implications for STA design and water quality management in the basin. Further investigation of this aspect of treatment cell dynamics, especially with respect to long-term aquifer and downstream impacts, remains a research need. Data from groundwater observation wells with stage recorders located inside and outside of the boundary of STA-6 would aid in the analysis and quantification of seepage, especially along the northern and eastern boundaries. As recommended in previous water budget reports, siting and installation of observation wells for this purpose should be a design/construction requirement for all STAs.

Also, since the retention time of Cell 3 was significantly lower than that reported for Cell 5, it is likely that short-circuiting would be an issue and may impact the removal efficiency of the cell. There may be an issue of significant flow measurement error at the inflow weirs to Cells 3 and 5 (G601, G602 and G603). However, these structures have been replaced by gated culverts as part of the work for STA-6, Section 2.

REFERENCES

- Abtew, W., D.L. Anderson, L.J. Lindstrom and A. Cadogan. 1998. *Soil Moisture and Shallow Water Table Monitoring for Irrigation and Drainage Decision-making*. Drainage in the 21st Century: Food Production and the Environment, Proceedings of the 7th Annual Drainage Symposium. Orlando, FL, March 9–10, 1998. ASAE. St. Joseph, MI.
- Abtew W., J. Obeysekera, M. Irizarry-Ortiz, D. Lyons and A. Reardon. 2003. Evapotranspiration Estimation for South Florida, Technical Publication EMA #407. South Florida Water Management District, West Palm Beach, FL. January 2003.
- Burns and McDonnell. 2003. Everglades Protection Area Tributary Basins Long-Term Plan for Achieving Water Quality Goals. October 2003. Report prepared for the South Florida Water Management District, West Palm Beach, FL.
- Huebner, R.S. 2001. Water Budget Analysis for Stormwater Treatment Area 6, Section 1. Technical Memorandum EMA #391. South Florida Water Management District, West Palm Beach, FL. February 2001.
- Huebner, R.S. 2007. Water Budget Analysis for Stormwater Treatment Area 5, (WY2006; May 1, 2005 through April 30, 2006). Technical Publication ERA #447. South Florida Water Management District, West Palm Beach, FL. May 2007.
- Parrish, D.M. and R.S. Huebner. 2004. Water Budget Analysis for Stormwater Treatment Area 5, Technical Publication EMA #418. South Florida Water Management District, West Palm Beach, FL. May 2004.
- SFWMD. 1997. Operation Plan Stormwater Treatment Area No. 6, Section 1. South Florida Water Management District, West Palm Beach, FL. July 1997.
- SFWMD. 2000. User's Guide to Accessing the South Florida Water Management District Hydrometeorologic and Water Quality Database "DBHYDRO." South Florida Water Management District, West Palm Beach, FL. July 2000.
- SFWMD. 2006. Integrated Operation Plan Stormwater Treatment Areas 5 & 6 (UPDATED). South Florida Water Management District, West Palm Beach, FL. February 2006.

APPENDICES

Appendix A – Site Properties and Monitoring Stations

Table A-1. STA-6 site properties.

Surface Area	
Cell 5	625 ac
Cell 3	245 ac
Cell 5 Ground Elevation (NGVD29)	~ 12.4 ft
Cell 3 Ground Elevation (NGVD29)	~ 12.4 ft
Levee Length	
Along Northern Boundary	7,785 ft
Supply Canal Along Cell 5	4,412 ft
Supply Canal Along Cell 3	7,136 ft
Discharge Canal Along Cell 5	6,012 ft
Discharge Canal Along Cell 3	4,584 ft
Between Cells 3 and 5	4,195 ft

Table A-2. STA-6 stage monitoring stations.

DBKEY	Structure	STA	COUNTY
G6559	G352S_H	STA-6 Section 1 (in supply canal across from Cell 5)	HENDRY
G6560	G352S_T	STA-6 Section 1 (in Cell 5 across from supply canal)	HENDRY
G6563	G354C_H	STA-6 Section 1 (in Cell 5 near Outflow C)	HENDRY
G6564	G354C_T	STA-6 Section 1 (in discharge canal near Outflow C)	HENDRY
G6561	G392S_H	STA-6 Section 1 (in supply canal across from Cell 3)	HENDRY
G6562	G392S_T	STA-6 Section 1 (in Cell 3 across from supply canal)	HENDRY
G6565	G393B_H	STA-6 Section 1 (in Cell 3 at Weir-culvert B)	HENDRY
G6566	G393B_T	STA-6 Section 1 (in discharge canal at Weir-culvert B)	HENDRY
G6528	G600_H	STA-6 Section 1, Inflow pump station (headwater)	HENDRY
G6529	G600_T	STA-6 Section 1, Inflow pump station (tailwater)	HENDRY

Table A-3. STA-6 flow monitoring stations.

DBKEY	Structure	STA	COUNTY
MC958	G354_C	STA-6 Section 1 discharge canal, combined flow for G354A, B, C	HENDRY
MC959	G393_C	STA-6 Section 1 Cell 3 combined Outflow for G393A, B, C	HENDRY
GG955	G600_P	STA-6 Section 1 Inflow pump station	HENDRY
J5566	G601	STA-6 Section 1 Cell 5 Inflow Weir 1	HENDRY
J5567	G602	STA-6 Section 1 Cell 5 Inflow Weir 2	HENDRY
J5568	G603	STA-6 Section 1 Cell 3 Inflow Weir 3	HENDRY

Table A-4. STA-6 rainfall monitoring stations.

DBKEY	Structure	STA	COUNTY
JJ025	G600_R	STA-6 Section 1 Inflow pump station at rain gauge	HENDRY
GE354	ROTNWX	STA-6 Rotenberger tract weather station, located by G606 at STA-6	BROWARD

Table A-5. STA-1W evapotranspiration monitoring stations.

DBKEY	Structure	STA	COUNTY
KN810	STA-1W	Areal computed parameter for STA-1W project	PALM BEACH

Appendix B – Rainfall Data

Table B-1. Daily average rainfall at G600_R and ROTNWX (inches), WY2006.

Day	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06
1	0.00	0.93	0.66	0.38	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00
2	0.01	0.80	0.00	0.18	1.33	0.14	0.00	0.00	0.00	0.00	0.00	0.00
3	0.90	0.56	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.05	0.00	0.00
4	2.14	0.60	0.00	0.19	0.01	0.46	0.00	0.00	0.00	0.34	0.00	0.00
5	0.00	0.35	0.00	0.30	0.84	0.07	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.04	0.00	0.20	0.08	0.25	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.39	0.00	0.83	0.25	0.62	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.61	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.42	0.00	0.92	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.11
11	0.00	0.84	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.24	0.00	0.25	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
14	0.00	0.00	0.00	6.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.23	0.16	0.11	0.00	0.01	0.11	0.06	0.00	0.00	0.00
19	0.00	0.00	0.02	0.18	0.07	0.00	0.04	0.02	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.68	0.79	0.00	0.02	0.01	0.03	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.03	0.01	0.03	0.00	0.00	0.00	0.00	0.01
22	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.07
23	0.00	1.25	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.25
24	0.00	0.37	0.00	0.23	0.00	3.44	0.00	0.00	0.00	0.00	0.01	0.00
25	0.00	0.16	0.04	0.56	0.04	0.00	0.00	0.00	0.00	0.56	0.00	0.00
26	0.24	0.47	1.10	0.45	0.56	0.00	0.00	0.00	0.00	0.03	0.00	0.28
27	0.01	0.73	0.01	0.76	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.39	0.00	0.01	0.51	0.00	0.01	0.00	0.00	0.00	0.00	0.00
29	0.00	1.47	0.01	0.01	0.00	0.00	0.40	0.03	0.00		0.00	0.00
30	0.01	0.13	0.02	0.02	0.00	0.00	0.02	0.00	0.03		0.00	0.00
31	0.90		0.59	0.54		0.00		0.00	0.00		0.00	
MAX	2.14	1.47	1.10	6.09	1.33	3.44	0.40	0.11	0.06	0.56	0.93	0.28
MEAN	0.14	0.34	0.09	0.47	0.16	0.17	0.03	0.01	0.01	0.04	0.03	0.02
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM	4.24	10.14	2.70	14.57	4.64	5.19	0.89	0.19	0.21	0.99	0.94	0.72

Table B-2. Daily average rainfall at G600_R and ROTNWX (inches), WY2007.

Day	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr-07
1	0.00	0.13	0.17	0.00	0.13	0.05	0.00	0.00	0.00	0.00	0.30	0.00
2	0.00	0.00	0.01	0.00	1.09	0.00	0.95	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.30	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.15	0.00	0.01	0.00	0.00	0.27	0.00	0.00
5	0.00	0.00	0.00	0.04	0.20	0.00	0.00	0.01	0.00	0.21	0.00	0.00
6	0.00	0.00	0.54	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02
7	0.00	0.00	0.30	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.13	0.08	0.11	0.00	0.00	0.01	0.00	0.00	0.00	0.00
9	0.06	1.23	0.32	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.09	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
11	0.00	0.02	0.41	0.00	0.09	0.00	0.00	0.00	0.00	0.06	0.00	0.43
12	0.06	0.02	0.12	0.00	0.00	0.15	0.00	0.00	0.00	0.50	0.00	0.85
13	0.00	0.00	0.08	0.06	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.36	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.01	0.00	0.12	0.00	0.37
16	1.55	0.00	0.00	0.41	0.01	0.00	0.00	0.35	0.00	0.01	0.04	0.00
17	0.00	0.06	0.00	0.07	0.00	0.00	0.01	0.06	0.00	0.00	0.00	0.00
18	0.00	0.00	0.21	0.59	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
19	0.00	0.00	0.05	0.34	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.24	0.14	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00
21	0.00	0.00	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.17	0.15	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
24	0.01	0.02	0.00	0.15	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00
25	0.24	0.22	0.00	0.50	0.00	0.00	0.00	0.69	0.08	0.00	0.00	0.00
26	0.08	0.05	0.00	0.64	0.00	0.00	0.09	0.03	0.00	0.00	0.00	0.09
27	0.00	0.00	0.93	0.26	0.26	0.00	0.00	0.00	0.00	0.26	0.00	0.00
28	0.00	0.13	0.05	0.00	0.00	0.55	0.00	0.00	0.02	0.09	0.00	0.00
29	0.00	0.00	0.05	0.68	0.00	0.00	0.06	0.00	0.00		0.00	0.00
30	0.01	0.06	0.00	2.81	0.00	0.00	0.00	0.00	0.00		0.00	0.00
31	0.10		0.00	0.15		0.03		0.00	0.00		0.00	
MAX	1.55	1.23	0.93	2.81	1.09	0.55	0.95	0.69	0.15	0.50	0.30	0.85
MEAN	0.07	0.07	0.13	0.24	0.16	0.03	0.04	0.05	0.01	0.06	0.01	0.08
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM	2.11	1.94	3.94	7.54	4.81	0.79	1.12	1.64	0.25	1.58	0.35	2.43

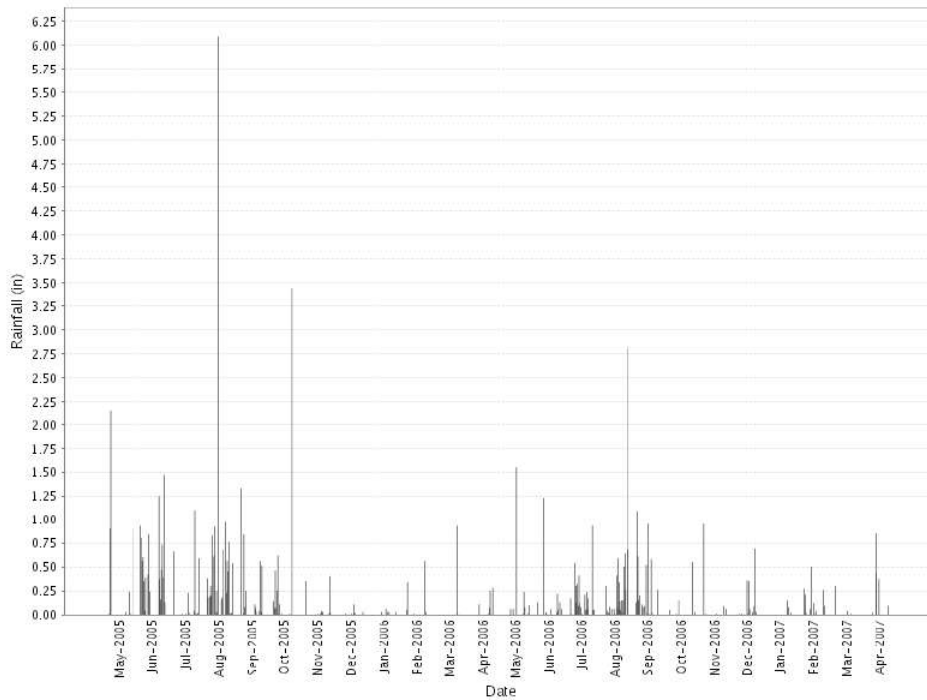


Figure B-1. Daily rainfall at G600_R and ROTNWX, WY2006 and WY2007.

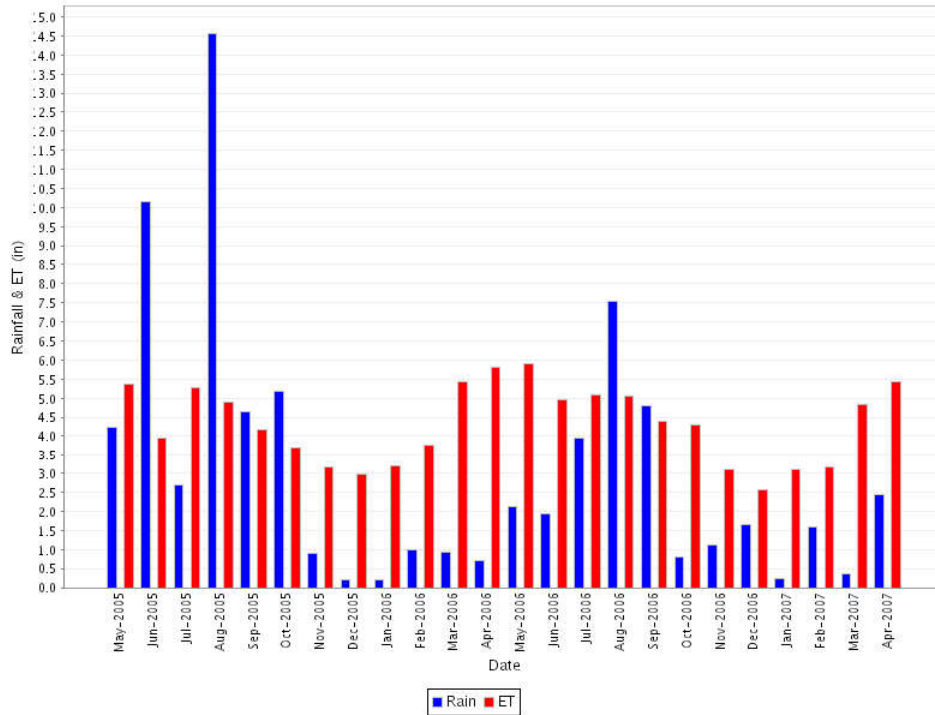


Figure B-2. Monthly rainfall and ET, WY2006 and WY2007.

Appendix C – Evapotranspiration Data

Table C-1. STA-1W ET (inches), WY2006.

Day	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06
1	0.10	0.07	0.18	0.20	0.14	0.16	0.05	0.14	0.09	0.13	0.18	0.17
2	0.15	0.04	0.20	0.17	0.15	0.14	0.14	0.13	0.11	0.08	0.19	0.20
3	0.09	0.07	0.17	0.16	0.11	0.13	0.11	0.11	0.10	0.07	0.17	0.21
4	0.08	0.07	0.19	0.18	0.06	0.06	0.12	0.12	0.12	0.02	0.16	0.20
5	0.08	0.11	0.23	0.11	0.09	0.14	0.13	0.08	0.12	0.16	0.19	0.22
6	0.19	0.17	0.22	0.20	0.08	0.08	0.11	0.07	0.11	0.17	0.17	0.20
7	0.19	0.15	0.19	0.17	0.13	0.09	0.14	0.06	0.13	0.16	0.19	0.21
8	0.23	0.11	0.19	0.21	0.12	0.15	0.11	0.08	0.13	0.16	0.20	0.17
9	0.23	0.07	0.06	0.17	0.19	0.12	0.14	0.11	0.11	0.17	0.17	0.13
10	0.21	0.05	0.08	0.14	0.16	0.12	0.15	0.11	0.07	0.16	0.15	0.19
11	0.20	0.09	0.18	0.18	0.16	0.12	0.11	0.08	0.10	0.14	0.18	0.21
12	0.17	0.22	0.17	0.11	0.19	0.15	0.13	0.13	0.10	0.07	0.15	0.18
13	0.20	0.22	0.14	0.18	0.18	0.15	0.12	0.12	0.08	0.16	0.17	0.18
14	0.15	0.21	0.14	0.17	0.18	0.12	0.09	0.12	0.12	0.17	0.14	0.20
15	0.18	0.22	0.22	0.18	0.19	0.09	0.11	0.06	0.14	0.12	0.15	0.24
16	0.19	0.21	0.14	0.18	0.17	0.15	0.10	0.09	0.13	0.15	0.19	0.23
17	0.19	0.18	0.19	0.16	0.17	0.16	0.10	0.09	0.11	0.16	0.18	0.22
18	0.20	0.16	0.18	0.19	0.16	0.12	0.05	0.08	0.07	0.18	0.19	0.19
19	0.18	0.14	0.22	0.20	0.12	0.10	0.07	0.02	0.08	0.16	0.15	0.11
20	0.18	0.02	0.21	0.17	0.06	0.12	0.10	0.04	0.08	0.14	0.19	0.23
21	0.20	0.09	0.20	0.14	0.14	0.06	0.08	0.07	0.09	0.14	0.18	0.20
22	0.17	0.09	0.20	0.16	0.07	0.07	0.14	0.11	0.08	0.12	0.19	0.20
23	0.20	0.14	0.20	0.18	0.11	0.11	0.14	0.11	0.11	0.16	0.08	0.22
24	0.21	0.19	0.13	0.17	0.18	0.05	0.12	0.09	0.10	0.13	0.17	0.20
25	0.19	0.22	0.15	0.02	0.17	0.16	0.13	0.10	0.14	0.08	0.23	0.20
26	0.14	0.13	0.19	0.11	0.15	0.17	0.13	0.12	0.13	0.07	0.21	0.17
27	0.22	0.10	0.17	0.12	0.12	0.15	0.09	0.13	0.08	0.17	0.23	0.16
28	0.20	0.12	0.17	0.11	0.13	0.14	0.08	0.12	0.09	0.19	0.21	0.20
29	0.21	0.11	0.13	0.15	0.15	0.13	0.02	0.08	0.09		0.15	0.17
30	0.16	0.21	0.16	0.15	0.15	0.13	0.09	0.12	0.07		0.19	0.20
31	0.11		0.11	0.15		0.09		0.12	0.14		0.18	
MAX	0.23	0.22	0.23	0.21	0.19	0.17	0.15	0.14	0.14	0.19	0.23	0.24
MEAN	0.17	0.13	0.17	0.16	0.14	0.12	0.11	0.10	0.10	0.13	0.18	0.19
MIN	0.08	0.02	0.06	0.02	0.06	0.05	0.02	0.02	0.07	0.02	0.08	0.11
SUM	5.37	3.95	5.29	4.88	4.16	3.71	3.17	2.99	3.21	3.76	5.44	5.80

Table C-2. STA-1W ET (inches), WY2007.

Day	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr-07
1	0.22	0.14	0.17	0.21	0.12	0.15	0.11	0.09	0.10	0.09	0.12	0.19
2	0.21	0.21	0.11	0.20	0.08	0.16	0.02	0.10	0.08	0.10	0.13	0.15
3	0.23	0.22	0.20	0.15	0.14	0.13	0.08	0.11	0.09	0.05	0.11	0.19
4	0.23	0.16	0.20	0.17	0.11	0.12	0.08	0.09	0.09	0.04	0.06	0.20
5	0.22	0.16	0.17	0.18	0.06	0.15	0.13	0.05	0.08	0.03	0.17	0.16
6	0.21	0.24	0.10	0.19	0.16	0.17	0.12	0.11	0.13	0.09	0.19	0.17
7	0.22	0.19	0.18	0.20	0.18	0.18	0.04	0.11	0.11	0.15	0.15	0.22
8	0.21	0.24	0.11	0.21	0.16	0.15	0.11	0.02	0.09	0.15	0.18	0.22
9	0.17	0.17	0.19	0.19	0.15	0.13	0.15	0.09	0.12	0.13	0.16	0.16
10	0.18	0.12	0.17	0.20	0.14	0.16	0.14	0.10	0.11	0.16	0.18	0.09
11	0.19	0.08	0.17	0.20	0.14	0.15	0.11	0.08	0.09	0.13	0.17	0.19
12	0.23	0.08	0.08	0.22	0.12	0.14	0.13	0.09	0.11	0.03	0.16	0.11
13	0.22	0.16	0.11	0.20	0.16	0.17	0.11	0.07	0.11	0.12	0.19	0.20
14	0.24	0.22	0.22	0.14	0.13	0.14	0.11	0.03	0.10	0.14	0.14	0.18
15	0.18	0.21	0.21	0.17	0.16	0.16	0.11	0.04	0.06	0.02	0.15	0.06
16	0.06	0.22	0.21	0.11	0.12	0.16	0.05	0.02	0.12	0.05	0.16	0.24
17	0.20	0.16	0.22	0.15	0.15	0.11	0.09	0.12	0.07	0.17	0.21	0.23
18	0.23	0.06	0.18	0.17	0.18	0.13	0.14	0.11	0.11	0.14	0.20	0.22
19	0.24	0.20	0.12	0.10	0.14	0.12	0.14	0.10	0.11	0.17	0.15	0.18
20	0.22	0.13	0.16	0.13	0.16	0.12	0.09	0.10	0.13	0.14	0.07	0.22
21	0.22	0.19	0.12	0.12	0.17	0.16	0.14	0.08	0.12	0.15	0.17	0.12
22	0.18	0.22	0.13	0.14	0.17	0.13	0.12	0.09	0.08	0.17	0.17	0.20
23	0.08	0.21	0.15	0.17	0.18	0.14	0.14	0.07	0.08	0.18	0.17	0.19
24	0.14	0.10	0.20	0.15	0.14	0.16	0.10	0.09	0.05	0.16	0.16	0.18
25	0.11	0.09	0.18	0.13	0.19	0.15	0.07	0.08	0.02	0.11	0.16	0.22
26	0.11	0.12	0.19	0.17	0.17	0.14	0.09	0.03	0.14	0.09	0.17	0.17
27	0.17	0.15	0.11	0.15	0.12	0.13	0.11	0.13	0.13	0.12	0.12	0.17
28	0.22	0.17	0.19	0.19	0.16	0.05	0.11	0.12	0.11	0.10	0.12	0.19
29	0.18	0.19	0.15	0.14	0.19	0.15	0.09	0.09	0.15		0.18	0.20
30	0.22	0.17	0.20	0.06	0.16	0.14	0.08	0.09	0.10		0.15	0.21
31	0.17		0.19	0.15		0.07		0.08	0.14		0.20	
MAX	0.24	0.24	0.22	0.22	0.19	0.18	0.15	0.13	0.15	0.18	0.21	0.24
MEAN	0.19	0.17	0.16	0.16	0.15	0.14	0.10	0.08	0.10	0.11	0.16	0.18
MIN	0.06	0.06	0.08	0.06	0.06	0.05	0.02	0.02	0.02	0.02	0.06	0.06
SUM	5.90	4.94	5.09	5.06	4.39	4.30	3.09	2.58	3.11	3.16	4.82	5.42

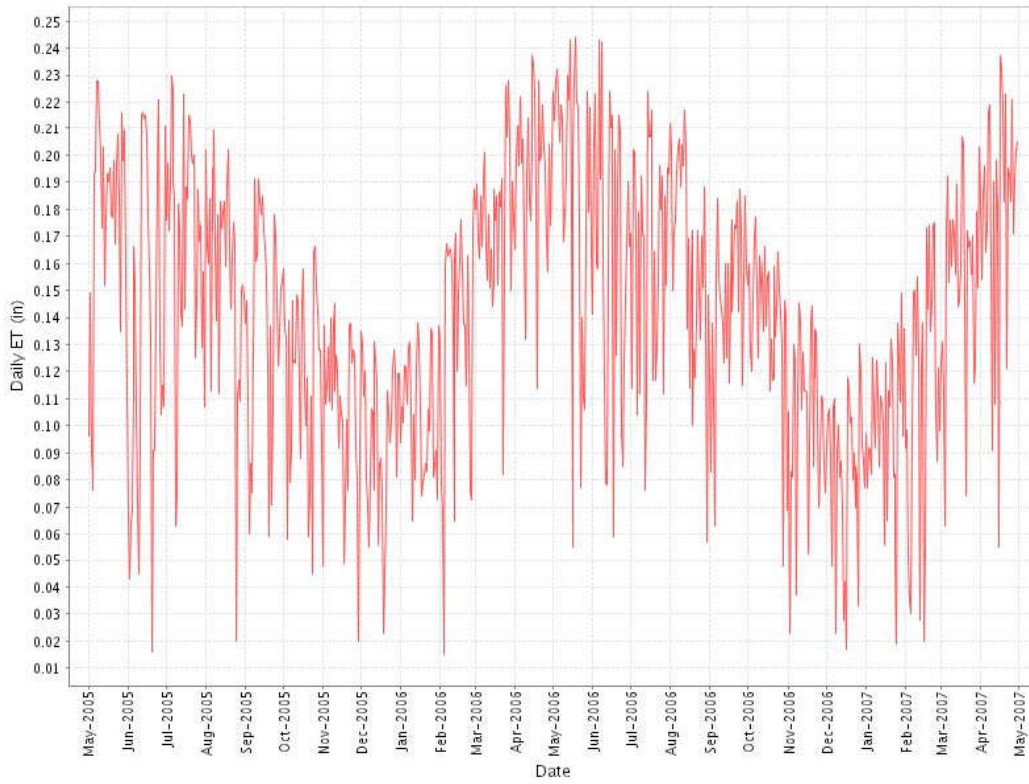


Figure C-1. Daily ET, WY2006 and WY2007.

Appendix D – Stage Data

Table D-1. Cell 3 daily average stage (ft NGVD29), WY2006.

Day	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06
1	13.14	11.83	14.46	14.28	14.39	14.83	15.12	14.30	13.85	13.72	14.19	13.87
2	13.07	12.08	14.48	14.20	14.38	14.86	15.13	14.27	13.76	13.66	14.23	13.80
3	13.05	12.26	14.47	14.15	14.38	14.88	15.16	14.18	13.68	13.63	14.19	13.79
4	13.26	12.61	14.46	14.13	14.30	14.95	15.22	13.99	13.61	13.76	14.11	13.80
5	13.48	12.79	14.43	14.12	14.29	15.00	15.21	13.94	13.55	13.77	14.03	13.82
6	13.44	12.96	14.42	14.13	14.33	15.01	15.16	14.20	13.52	13.95	14.06	13.81
7	13.38	13.10	14.45	14.22	14.34	15.03	15.06	14.23	13.56	14.26	14.08	13.78
8	13.32	13.17	14.44	14.33	14.33	15.03	14.79	14.26	13.60	14.38	14.11	13.75
9	13.26	13.24	14.56	14.26	14.34	15.02	14.59	14.26	13.56	14.36	14.07	13.69
10	13.20	13.36	14.64	14.25	14.25	15.02	14.52	14.06	13.77	14.26	14.03	13.67
11	13.14	13.47	14.68	14.33	14.16	15.05	14.47	13.98	13.89	14.32	14.01	13.71
12	13.08	13.52	14.72	14.38	14.34	15.12	14.19	14.01	13.85	14.22	13.96	13.71
13	13.01	13.50	14.74	14.40	14.64	15.15	14.02	14.09	13.89	14.21	13.98	13.67
14	12.95	13.48	14.72	14.48	14.69	15.15	14.09	14.11	13.72	14.19	14.00	13.66
15	12.88	13.46	14.69	14.75	14.72	15.12	14.28	14.12	13.66	14.18	13.99	13.59
16	12.81	13.45	14.63	14.54	14.74	15.01	14.22	14.13	13.62	14.18	13.98	13.52
17	12.73	13.44	14.55	14.40	14.80	14.91	14.40	13.93	13.60	14.19	13.96	13.46
18	12.63	13.43	14.45	14.29	15.05	14.89	14.32	13.82	13.67	14.18	13.99	13.42
19	12.51	13.42	14.39	14.23	15.22	14.99	14.10	13.82	13.76	14.20	13.90	13.38
20	12.39	13.46	14.33	14.23	15.33	15.00	13.97	14.09	13.84	14.19	13.96	13.34
21	12.25	13.53	14.24	14.29	15.40	14.94	13.97	14.22	13.72	14.19	13.95	13.30
22	12.10	13.52	14.17	14.26	15.52	14.74	14.20	14.26	13.70	14.18	13.94	13.27
23	11.97	13.62	14.13	14.21	15.58	14.41	14.27	14.05	13.68	14.17	13.94	13.25
24	11.87	13.78	14.20	14.21	15.60	14.35	14.05	13.92	13.67	14.16	13.95	13.30
25	11.76	13.82	14.29	14.18	15.62	14.29	13.92	13.82	13.66	14.18	13.93	13.25
26	11.71	13.84	14.38	14.14	15.56	14.34	13.81	13.73	13.64	14.22	13.85	13.20
27	11.68	13.91	14.46	14.14	15.40	14.55	13.72	13.83	13.67	14.21	13.90	13.20
28	11.62	14.04	14.39	14.14	15.17	14.79	13.81	14.06	13.67	14.19	13.88	13.10
29	11.56	14.25	14.28	14.23	14.86	14.99	14.10	14.18	13.64		13.90	13.00
30	11.56	14.40	14.22	14.31	14.81	15.07	14.26	14.15	13.63		13.89	12.89
31	11.64		14.24	14.37		15.10		13.96	13.68		13.87	
MAX	13.48	14.40	14.74	14.75	15.62	15.15	15.22	14.30	13.89	14.38	14.23	13.87
MEAN	12.60	13.36	14.44	14.28	14.82	14.89	14.40	14.06	13.69	14.12	13.99	13.50
MIN	11.56	11.83	14.13	14.12	14.16	14.29	13.72	13.73	13.52	13.63	13.85	12.89

Table D- 2. Cell 3 daily average stage (ft NGVD29), WY2007.

Day	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr-07
1	12.79	11.61	12.01	14.30	15.13	14.49	14.50	14.33	13.53	11.37	11.13	10.44
2	12.68	11.63	11.94	14.30	15.12	14.45	14.55	14.34	13.52	11.31	11.11	10.42
3	12.57	11.59	11.87	14.34	15.09	14.43	14.60	14.32	13.50	11.25	11.08	10.42
4	12.48	11.54	11.82	14.45	14.99	14.44	14.55	14.21	13.46	11.21	11.05	10.41
5	12.43	11.51	11.76	14.44	14.87	14.44	14.54	14.15	13.42	11.30	11.02	10.39
6	12.40	11.51	11.91	14.37	14.87	14.44	14.53	14.10	13.38	11.31	10.98	10.38
7	12.35	11.46	12.21	14.32	14.86	14.45	14.52	14.07	13.33	11.26	10.93	10.37
8	12.29	11.45	12.47	14.35	14.88	14.44	14.50	14.04	13.28	11.20	10.90	10.35
9	12.23	11.56	12.64	14.37	14.91	14.43	14.48	14.02	13.22	11.14	10.85	10.34
10	12.17	11.96	13.13	14.35	14.90	14.44	14.48	13.99	13.15	11.10	10.82	10.34
11	12.12	12.07	13.79	14.34	14.86	14.44	14.49	13.97	13.09	11.08	10.79	10.46
12	12.06	12.08	14.23	14.31	14.80	14.46	14.47	13.94	13.03	11.21	10.78	10.60
13	12.00	12.08	14.55	14.27	14.78	14.49	14.47	13.91	12.96	11.30	10.78	10.66
14	11.94	12.01	14.72	14.26	14.77	14.51	14.48	13.89	12.90	11.27	10.77	10.65
15	11.89	11.94	14.77	14.25	14.76	14.52	14.46	13.88	12.85	11.24	10.75	10.65
16	12.15	11.88	14.74	14.33	14.81	14.53	14.47	13.87	12.79	11.22	10.72	10.66
17	12.27	11.87	14.66	14.46	14.79	14.54	14.48	13.87	12.72	11.19	10.69	10.65
18	12.32	11.85	14.63	14.45	14.75	14.53	14.47	13.83	12.65	11.18	10.67	10.65
19	12.36	11.78	14.61	14.49	14.72	14.53	14.47	13.79	12.58	11.18	10.64	10.64
20	12.38	11.72	14.54	14.52	14.68	14.57	14.47	13.74	12.48	11.16	10.64	10.65
21	12.39	11.67	14.55	14.46	14.70	14.54	14.44	13.70	12.38	11.14	10.62	10.65
22	12.38	11.60	14.51	14.43	14.69	14.51	14.46	13.65	12.27	11.12	10.60	10.65
23	12.31	11.52	14.41	14.49	14.68	14.51	14.38	13.63	12.14	11.10	10.59	10.64
24	12.17	11.45	14.50	14.53	14.66	14.49	14.35	13.58	12.02	11.08	10.56	10.64
25	12.06	11.58	14.54	14.60	14.64	14.47	14.38	13.55	11.92	11.07	10.54	10.63
26	12.00	11.77	14.49	14.75	14.61	14.47	14.36	13.59	11.81	11.06	10.52	10.62
27	11.91	11.81	14.44	14.81	14.58	14.48	14.29	13.56	11.70	11.07	10.51	10.61
28	11.82	11.82	14.52	14.79	14.55	14.50	14.33	13.54	11.62	11.13	10.50	10.60
29	11.71	11.98	14.54	14.84	14.51	14.50	14.35	13.54	11.55		10.49	10.60
30	11.63	12.10	14.50	14.99	14.48	14.48	14.33	13.54	11.48		10.48	10.58
31	11.61		14.40	15.11		14.48		13.54	11.43		10.46	
MAX	12.79	12.10	14.77	15.11	15.13	14.57	14.60	14.34	13.53	11.37	11.13	10.66
MEAN	12.19	11.75	13.75	14.49	14.78	14.48	14.46	13.86	12.65	11.19	10.74	10.54
MIN	11.61	11.45	11.76	14.25	14.48	14.43	14.29	13.54	11.43	11.06	10.46	10.34

Table D-3. Cell 5 daily average stage (ft NGVD29), WY2006.

Day	2005-05	2005-06	2005-07	2005-08	2005-09	2005-10	2005-11	2005-12	2006-01	2006-02	2006-03	2006-04
1	12.38	11.61	14.50	14.32	14.43	14.74	15.03	14.37	14.13	13.58	14.18	13.02
2	12.36	11.84	14.52	14.23	14.40	14.75	15.03	14.34	14.08	13.52	14.18	12.88
3	12.40	12.03	14.51	14.18	14.42	14.76	15.01	14.29	14.04	13.47	14.18	12.71
4	12.73	12.34	14.50	14.16	14.36	14.78	15.05	14.20	13.99	13.59	14.15	12.36
5	13.03	12.42	14.47	14.16	14.35	14.83	15.04	14.17	13.94	13.61	14.08	12.15
6	13.04	12.55	14.46	14.17	14.36	14.83	14.99	14.20	13.92	13.68	14.06	11.96
7	13.00	12.78	14.49	14.27	14.32	14.83	14.90	14.21	13.88	13.76	14.04	11.79
8	12.95	12.99	14.46	14.38	14.32	14.83	14.69	14.25	13.83	14.01	13.99	11.74
9	12.90	13.07	14.57	14.29	14.30	14.82	14.52	14.27	13.78	14.29	13.94	11.70
10	12.84	13.18	14.68	14.29	14.27	14.82	14.43	14.22	13.83	14.30	13.91	11.69
11	12.78	13.32	14.73	14.38	14.22	14.83	14.38	14.16	13.87	14.34	13.87	11.72
12	12.71	13.42	14.76	14.43	14.25	14.89	14.28	14.15	13.90	14.33	13.80	11.73
13	12.59	13.43	14.78	14.44	14.45	14.93	14.19	14.15	13.94	14.28	13.77	11.72
14	11.99	13.44	14.76	14.50	14.53	14.94	14.18	14.16	13.95	14.26	13.75	11.72
15	11.90	13.43	14.73	14.71	14.53	14.92	14.23	14.18	13.90	14.25	13.68	11.70
16	11.80	13.42	14.66	14.51	14.52	14.86	14.26	14.20	13.85	14.24	13.62	11.63
17	11.78	13.40	14.58	14.38	14.55	14.79	14.32	14.15	13.80	14.24	13.57	11.55
18	11.71	13.38	14.47	14.29	14.70	14.74	14.34	14.11	13.83	14.24	13.54	11.52
19	11.65	13.37	14.42	14.26	14.81	14.77	14.26	14.11	13.84	14.23	13.46	11.50
20	11.57	13.39	14.36	14.29	14.86	14.80	14.19	14.17	13.84	14.23	13.44	11.49
21	11.53	13.45	14.26	14.35	14.89	14.77	14.17	14.24	13.78	14.22	13.42	11.49
22	11.49	13.45	14.20	14.30	14.96	14.67	14.21	14.31	13.76	14.21	13.39	11.57
23	11.49	13.53	14.16	14.26	15.01	14.49	14.26	14.26	13.72	14.20	13.36	11.59
24	11.48	13.67	14.26	14.26	15.05	14.54	14.23	14.17	13.68	14.18	13.38	11.50
25	11.48	13.69	14.36	14.24	15.09	14.40	14.16	14.11	13.64	14.18	13.31	11.48
26	11.48	13.70	14.44	14.20	15.07	14.38	14.10	14.06	13.58	14.22	13.19	11.48
27	11.47	13.79	14.50	14.21	14.96	14.56	14.05	14.07	13.60	14.21	13.12	11.47
28	11.48	13.97	14.43	14.22	14.87	14.76	14.07	14.11	13.61	14.19	13.13	11.47
29	11.49	14.24	14.30	14.29	14.77	14.92	14.14	14.22	13.54		13.18	11.47
30	11.49	14.42	14.25	14.36	14.73	15.00	14.29	14.27	13.47		13.19	11.47
31	11.54		14.29	14.42		15.03		14.20	13.52		13.10	
MAX	13.04	14.42	14.78	14.71	15.09	15.03	15.05	14.37	14.13	14.34	14.18	13.02
MEAN	12.08	13.22	14.48	14.31	14.61	14.77	14.43	14.20	13.81	14.07	13.64	11.78
MIN	11.47	11.61	14.16	14.16	14.22	14.38	14.05	14.06	13.47	13.47	13.10	11.47

Table D- 4. Cell 5 daily average stage (ft NGVD29), WY2007.

Day	2006-05	2006-06	2006-07	2006-08	2006-09	2006-10	2006-11	2006-12	2007-01	2007-02	2007-03	2007-04
1	11.47	11.47	11.51	14.29	14.75	14.35	14.31	14.19	13.04	11.45	11.44	11.43
2	11.47	11.47	11.47	14.27	14.74	14.34	14.35	14.19	13.03	11.45	11.44	11.43
3	11.47	11.47	11.49	14.30	14.72	14.31	14.40	14.17	12.99	11.45	11.44	11.43
4	11.47	11.47	11.47	14.38	14.67	14.30	14.36	14.13	12.92	11.45	11.44	11.43
5	11.47	11.47	11.47	14.40	14.59	14.30	14.32	14.08	12.87	11.45	11.44	11.43
6	11.47	11.47	11.56	14.35	14.57	14.30	14.31	14.03	12.82	11.45	11.44	11.43
7	11.47	11.47	11.58	14.31	14.57	14.30	14.30	13.98	12.75	11.45	11.44	11.43
8	11.47	11.47	11.60	14.30	14.59	14.30	14.30	13.94	12.68	11.45	11.44	11.43
9	11.47	11.54	11.66	14.32	14.61	14.29	14.28	13.87	12.60	11.45	11.43	11.43
10	11.47	11.64	11.97	14.32	14.59	14.29	14.27	13.79	12.51	11.45	11.43	11.43
11	11.47	11.58	12.53	14.31	14.56	14.29	14.27	13.72	12.45	11.44	11.43	11.43
12	11.47	11.60	13.17	14.29	14.53	14.29	14.27	13.65	12.40	11.44	11.43	11.43
13	11.47	11.60	13.94	14.27	14.52	14.31	14.26	13.58	12.33	11.44	11.43	11.43
14	11.47	11.60	14.42	14.27	14.51	14.32	14.26	13.53	12.23	11.44	11.43	11.43
15	11.47	11.58	14.56	14.26	14.50	14.32	14.25	13.50	12.00	11.44	11.43	11.43
16	11.48	11.58	14.56	14.31	14.52	14.33	14.25	13.46	11.86	11.44	11.43	11.43
17	12.20	11.57	14.52	14.41	14.50	14.34	14.26	13.43	11.87	11.44	11.43	11.43
18	12.51	11.48	14.49	14.42	14.48	14.34	14.25	13.39	11.65	11.44	11.43	11.43
19	12.36	11.47	14.49	14.43	14.45	14.33	14.25	13.34	11.49	11.44	11.43	11.43
20	12.01	11.47	14.44	14.44	14.45	14.34	14.25	13.28	11.46	11.44	11.43	11.43
21	11.63	11.47	14.43	14.38	14.44	14.34	14.25	13.22	11.46	11.44	11.43	11.43
22	11.48	11.47	14.42	14.35	14.44	14.32	14.25	13.18	11.46	11.44	11.43	11.43
23	11.48	11.47	14.35	14.39	14.43	14.31	14.22	13.16	11.46	11.44	11.43	11.43
24	11.48	11.47	14.38	14.43	14.43	14.29	14.22	13.11	11.46	11.44	11.43	11.43
25	11.53	11.47	14.44	14.55	14.42	14.28	14.21	13.07	11.46	11.44	11.43	11.43
26	11.52	11.47	14.42	14.66	14.41	14.27	14.21	13.09	11.46	11.44	11.43	11.43
27	11.48	11.47	14.40	14.64	14.40	14.28	14.20	13.06	11.46	11.44	11.43	11.43
28	11.48	11.47	14.44	14.57	14.39	14.32	14.19	13.04	11.45	11.44	11.43	11.43
29	11.48	11.58	14.46	14.60	14.36	14.32	14.19	13.04	11.45		11.43	11.43
30	11.48	11.59	14.44	14.72	14.34	14.30	14.19	13.04	11.45		11.43	11.43
31	11.47		14.37	14.78		14.30		13.05	11.45		11.43	
MAX	12.51	11.64	14.56	14.78	14.75	14.35	14.40	14.19	13.04	11.45	11.44	11.43
MEAN	11.58	11.51	13.40	14.41	14.52	14.31	14.26	13.53	12.06	11.45	11.43	11.43
MIN	11.47	11.47	11.47	14.26	14.34	14.27	14.19	13.04	11.45	11.44	11.43	11.43

Appendix E – Seepage Calculation

There are three boundary segments around STA-6; the northern boundary, the western boundary, and the eastern boundary. Lengths along these seepage boundaries (L) are included in **Figure E-1**.

In this analysis, seepage was computed using **Equation 3** (please see the *Seepage* section of this report.)

To calculate hydraulic head difference between the unit and the boundary (ΔH), it is necessary to know the average stage values at each location. Units are Cell 3, Cell 5, or the entire STA-6.

Average stage east of STA-6 (stage discharge canal)
= Avg. (G354C_T, G393B_T, G607_H)

Average stage west of STA-6 (stage supply canal)
= Avg. (G352S_H, G392S_H, G600_T, G604_H)

Average stage north boundary = Avg. (G393B_T, G600_H)

Average stage Cell 3 = Avg. (G392S_T, G393B_H)

Average stage Cell 5 = Avg. (G352S_T, G354C_H)

Example of a seepage calculation equation:

$$\text{STA-6 Seepage (ac-ft)} = [(2*3600/43560/5280) * (K_{C5} * L_{N_{C5}} * (S_{C5} - S_N) + K_{C5} * L_{E_{C5}} * (S_{C5} - S_E) + K_{C3} * L_{E_{C3}} * (S_{C3} - S_E) + K_{C3} * L_{W_{C3}} * (S_{C3} - S_E) + K_{C5} * L_{W_{C5}} * (S_{C5} - S_W))]$$

K_{C5} = seepage coefficient of Cell 5

K_{C3} = seepage coefficient of Cell 3

S_N = average stage north of STA6

S_E = average stage east of STA-6

S_W = average stage west of STA-6

S_{C5} = average stage of Cell 5

S_{C3} = average stage of Cell 3

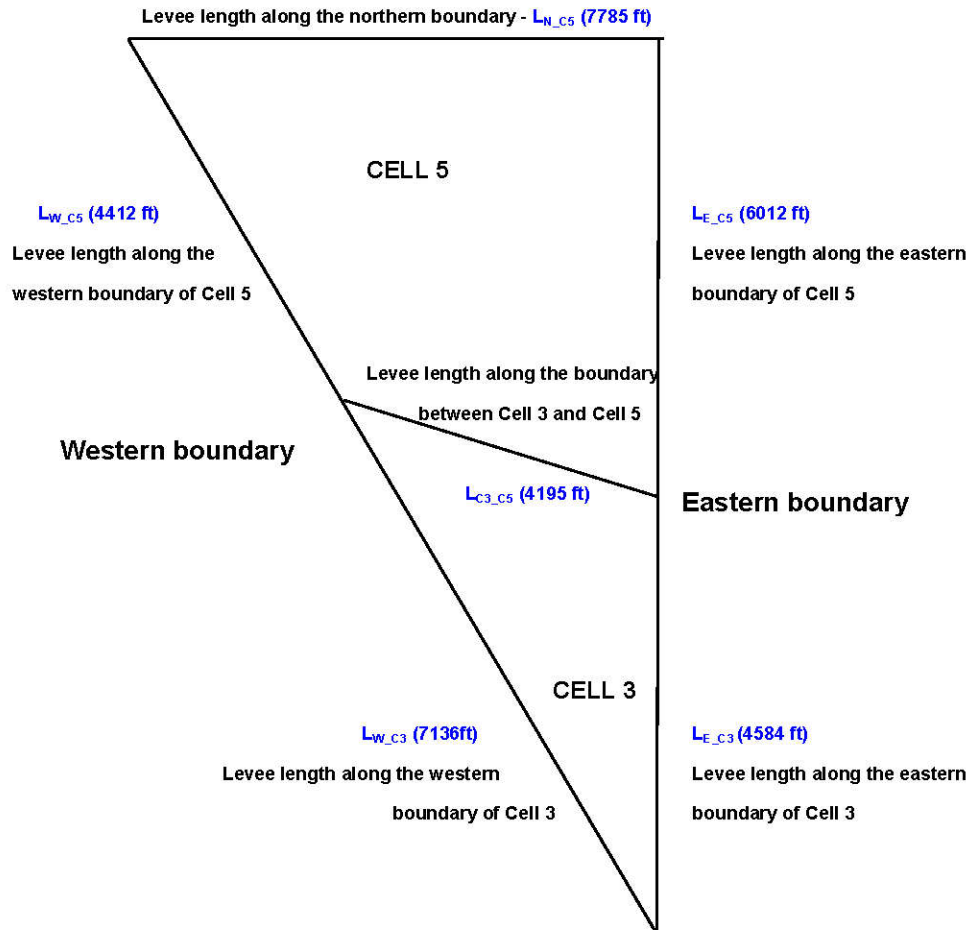


Figure E-1. Length of STA-6 seepage boundaries.

To calculate the seepage of Cell 5, there are four boundaries that should be taken into account: the northern boundary, the western boundary of Cell 5, the eastern boundary of Cell 5, and the boundary between Cell 3 and Cell 5. Cell 3 has three boundaries: the western boundary of Cell 3, the eastern boundary of Cell 3, and the boundary between Cell 3 and Cell 5.