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Water Budget Analysis for Stormwater Treatment Area 6, Section 1

(Water Years 98-99, 99-00, 00-01 and 01-02 – May 1, 1998 to April 30, 2002)

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by

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EXECUTIVE SUMMARY

This report presents a water budget for Stormwater Treatment Area (STA) 6, Section 1 from May 1, 1998 through April 30, 2002. It compliments and extends the first water budget for STA 6 (Huebner, 2001) that covered calendar years 1998 and 1999. STA 6, Section 1 was the first of six stormwater treatment areas to be built and was substantially completed on October 31, 1997 at a cost of $1.9 million. STA 6 became fully operational on December 9, 1997 for the purpose of reducing the phosphorous concentration in runoff from approximately 10,400 acres of agricultural land north of STA 6. Prior to the construction of STA 6, the area was a runoff detention area belonging to U.S. Sugar Corporation (USSC). This study covers the first four complete water years of STA operation. The water year used runs from May to April.

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, with a long-term design operating water depth of 2.0 feet. Water flows from west to east across the cells, then north to south in the discharge canal and eventually discharges to the L4 canal through G607.

In water years (WY) 98-99, 99-00, 00-01 and 01-02, STA 6 received 192,800 ac-ft of water from pumping operations at G600_P. Of this amount, 176,402 ac-ft entered treatment cells 3 and 5 at G601, G602, and G603. An additional 14,611 ac-ft were input to STA 6 from rainfall; 15,822 ac-ft were lost through evapotranspiration. Estimated seepage was 22.9 percent of the water budget during this period, losing 46,806 ac-ft to surrounding water bodies and the surficial aquifer. Outflow from STA 6 at G354 and G393 was 59.6 percent of the flow entering STA 6 at G601, G602, and G603, or 105,274 ac-ft. The amount of water stored in STA 6 was reduced by 3,217 ac-ft in four years. The error in the water budget was 3,607 ac-ft, or 1.8 percent of the budget. Cell 3 retained water an average of 5.9 days in WY 98-99, 99-00, 00-01 and 01-02. The average retention time in Cell 5 was 9.8 days.

An increase in the portion of the annual budget attributed to seepage for WY 99-00 and WY 00-01 was expected because inflow and outflow were significantly reduced due to drought conditions. Flow measurement discrepancies at the inflow and outflow weirs were apparent in preparing data for the analysis and were corrected. Mean hydraulic residence times continued to be lower than those observed at other STAs, yet the removal efficiencies remained high.

Additional years of data and improved information about seepage at the site are needed to improve the water budget for STA 6, Section 1.

ACKNOWLEDGEMENTS

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INTRODUCTION

Hydrologic analysis is vital to ongoing research and evaluation efforts to optimize performance of stormwater treatment areas (STAs). STAs are a cornerstone of Everglades restoration. The information provides a better understanding of the physical processes that are occurring and ultimately offers a perspective on where water in the system is coming from, where it is going, and in what quantities.

This report presents a water budget for Stormwater Treatment Area 6, Section 1 covering Water Years (WY) 98-99, 99-00, 00-01 and 01-02 from May 1, 1998, through April 30, 2002. At the beginning of this period, South and Central Florida experienced the end of a La Niña-influenced weather pattern. Hurricane Irene affected the area from October 14 through 17, 1999 (Abtew and Huebner, 2000), resulting in 6.84 inches of rain over the South Florida Water Management District. One of the most severe long-term droughts ever to impact the area began in November 1999. Rainfall during calendar years 1998, 1999, 2000, and 2001 was 55.94 in., 55.62 in., 39.46 in., and 53.25 in., respectively, compared with a historical average of 52.75 in.

This analysis is based upon a daily water budget for hydrologic units in STA 6. Daily results were aggregated to develop annual and period-of-study (four-year) water budgets. The daily water budget accounted for inflow, outflow, rainfall, evapotranspiration, seepage, storage and error. This section of the report presents background information about STA 6, water budget analyses, and monitoring at STA 6, followed by sections describing the operation of STA 6 and the sources of data used for the report. The actual water budget analysis is presented in the next section, followed by a summary, conclusions and recommendations.

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 (ENR) project begun in August 1994. Construction of STA 6 was substantially completed on October 31, 1997 at a cost of $1.9 million. It was funded as part of the Everglades Construction Project (ECP), an element of the Everglades Program established by the Everglades Forever Act (§373.4592, Florida Statute). STA 6 received a discharge permit from the Florida Department of Environmental Protection (DEP) and became fully operational on December 9, 1997. Its principal purpose is to reduce phosphorous concentrations in runoff from U.S. Sugar Corporation's (USSC's) Unit 2 development (approximately 10,400 acres) north of STA 6. Prior to construction of STA 6, the area was a runoff detention area belonging to USSC. Section 2 of STA 6 is in the planning stages.

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

- Inflow over weirs
- Outflow over weirs
- Rainfall
- Evapotranspiration
- Seepage
- Change in storage
- Water budget error

Each component makes up an important part of the water budget for STA 6. The budget is developed for varying time periods ranging from one day to three years using the following equation:

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

where	S	=	change in storage over the time period
	t	=	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
		=	water budget error over the time period

In equation 1, all terms have the same units: acre-feet per unit time (day, month, year). All the terms can be determined from observations or can be estimated, except the error term. To establish values for rainfall and evapotranspiration, units (in inches or millimeters) are converted to feet and multiplied by the effective surface area in acres (e.g., 245 acres for Cell 3) to get a volume of rainfall or evapotranspiration for a selected time period. Change in storage is also based on the effective surface area of each cell times the change in water surface elevation over time.

Four years of daily average stage, flow, rainfall and evapotranspiration data were used in this report. Using equation 1, the data were analyzed on a daily, monthly, annual and four-year (period of study) basis.

Site Description

STA 6 is in the southwestern corner of the Everglades Agricultural Area (EAA) adjacent to the Rotenberger Wildlife Management Area. STA 6 and its location relative to major canals and roadways are shown in **Figure** 1. The STA is comprised of two treatment cells, Cell 3 and Cell 5, with a total effective treatment area of 870 acres (245

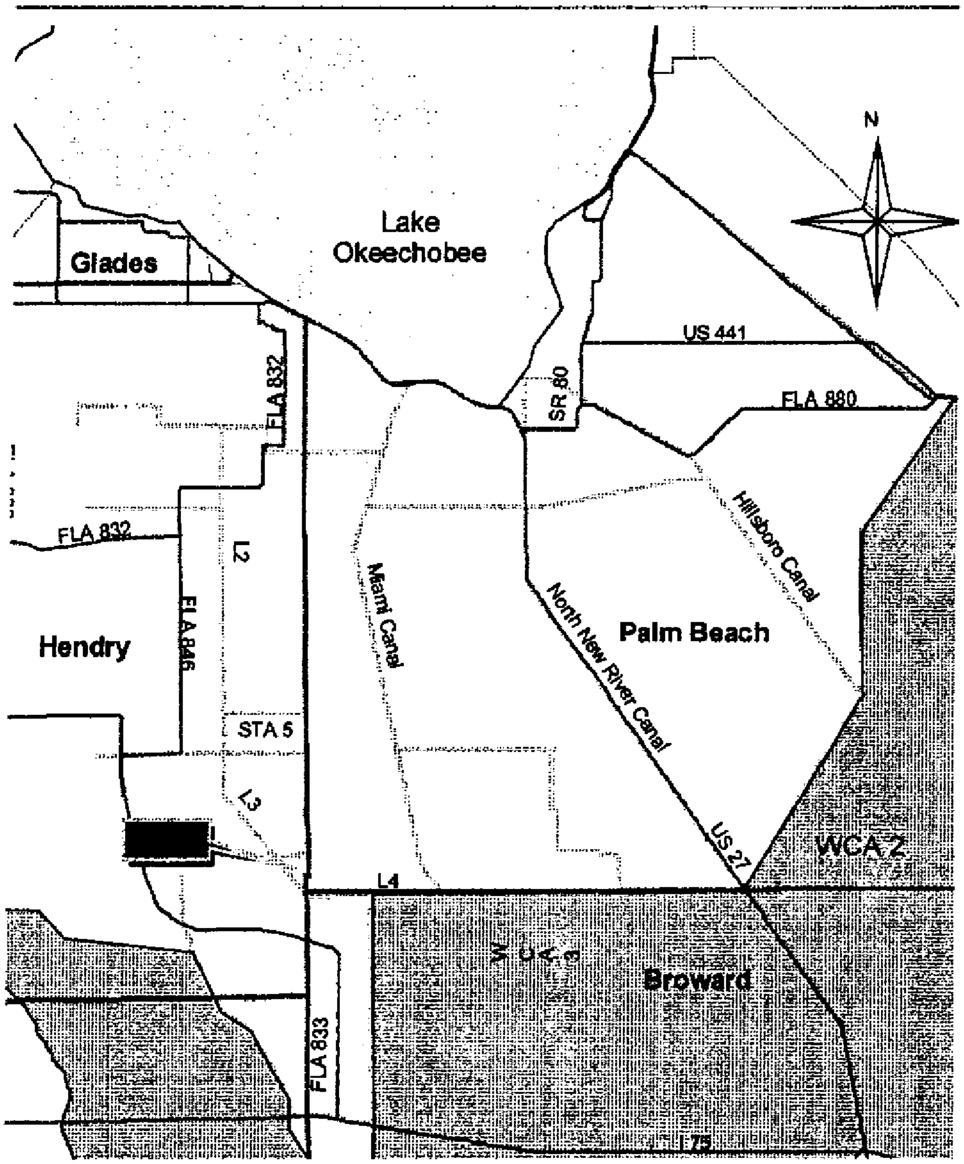

Figure 1. STA 6 site map

acres and 625 acres, respectively). The cells are bermed wetlands with structures that control inflow, outflow, and stage within the cells. Vegetation is described by Huebner (2001) based on a study by Geonex (1999). In general, vegetation is mixed wetland varieties for both cells. Cell 3 has only 3 percent open water, whereas Cell 5 has nearly 15 percent open water. **Table A-1** in Appendix A contains a summary of site properties used in the water budget calculations for STA 6.

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 canal through G604 at the southern end of the supply canal, consisting of a set of five culverts with upstream flap gates. Water entering the supply canal through G604 is used to irrigate USSC's unit 2 development to the north of STA 6 and rarely enters the treatment cells because the stage in the canal is typically below the crest of the inlet weirs under the conditions prevalent during the dry season when irrigation is occurring.

There is one inflow weir, G603, for Cell 3 and two inflow weirs, G601 and G602, for Cell 5. Water exits the treatment cells through a series of three outlet weir structures in each cell (G393A through C, and G354A through C). Under the current operation plan for STA 6, only one gate, G393B, is open for Cell 3 discharges, but all three gates, G354A, B, and C, are open in Cell 5. 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. The canal flows east during the wet season to the South Florida Water Management District's (SFWMD) S8 pump station and the Miami canal or through a breech in the L4 levee to the northwest corner of Water Conservation Area (WCA) 3A.

A full description of STA 6, its design and operation are provided in the Operation Plan Stormwater Treatment Area No. 6, Section 1 (SFWMD, 1997) and the revised Operation Plan Stormwater Treatment Area No. 6 (SFWMD, 2002b).

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_P, and at a weather station (ROTNWX) located in the Rotenberger Wildlife Management Area. The rainfall data were compared to rainfall amounts at nearby rainfall recording locations to check for potential data errors. The station names, database (DB) keys and station descriptions are shown in **tables A-2** through **A-5** in Appendix A.

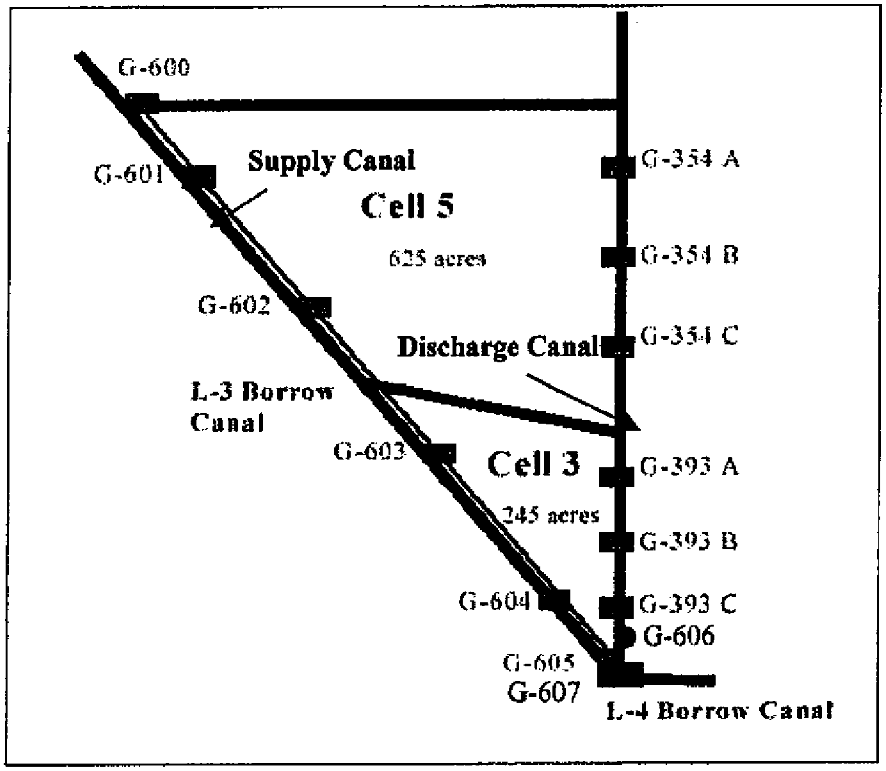

Figure 2. STA 6, Section 1 structure and monitoring locations

Evapotranspiration (ET) is the loss of water to the atmosphere by vaporization (evaporation) at a water or soil surface and/or by respiration of living organisms, including vegetation (transpiration). The evapotranspiration data used in this water budget analysis were derived from ET data for the ENR Project and STA 1 West and from total solar radiation (RADT) and air temperature (AIRT) data at weather station ROTNWX in the Rotenberger Wildlife Management Area. The station information for the ET database that was used in this study is listed in **Table A-5.**

STA OPERATION

The five pumps at station G600_P typically run during the wet season to drain agricultural fields to the north of STA 6. Each pump has a capacity of 100 cfs. The pumps are cycled on and off depending on the amount of water to be withdrawn from the fields. This water discharges into the supply canal and creates a hydraulic head on the inlet weirs G601, G602 and G603 to cells 3 and 5. There is no inflow control to the treatment cells other than controlling the stage in the supply canal 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 vs. 870 acres), it was designed to treat 28 percent of the total inflow. The design of the inlet weirs was based upon this division of flow (SFWMD, 1997). The inlet weir crests for G601 and G602 (Cell 5) are set at 14.1 ft

NGVD (National Geodetic Vertical Datum). The crest of the weir at G603 (Cell 3) is set at 14.2 ft NGVD. The maximum total design inflow for both cells is 500 cfs. This value has never been exceeded. The maximum inflow since the start-up of STA 6 was 456.7 cfs, recorded at G600_P on October 18, 1999 and attributed to runoff caused by Hurricane Irene.

Under typical operating conditions the cells are designed to have water depths of 0.5 to 4.5 ft. The average ground elevation of each cell is 12.4 ft NGVD. The long-term design operating depth is 2.0 ft (14.4 ft NGVD). 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 NGVD. During the first two years of operation it was observed that 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. The crests of the weir plates are now set at 14.0 ft NGVD in Cell 3 and 14.1 ft NGVD in Cell 5. Each of the six outlet weir boxes is connected to gated culverts that allow water to flow into the discharge canal. 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, 28 percent of the total design inflow of 500 cfs. Flow in the discharge canal goes to G607, a set of six culverts that connect the discharge canal to the L4 canal.

All STAs go through an initial start-up phase during which the four-week, flow-weighted, geometric mean concentration of various water quality constituents at the outlet structure(s) is compared to that at the inflow to the STA. When the mean at the outlet is less than that at the inlet, discharges are permitted from the STA. STA 6, Section 1 met this condition and began normal operation on December 9, 1997.

Two other flow conditions – extreme storm conditions and drought conditions – affect the operation of STA 6. 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 should, to the greatest extent practicable, be maintained at 12.4 ft NGVD. 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 that were used for the water budget computations and any special considerations for using the data. The source for the data was DBHYDRO, the South Florida Water Management District's corporate database (SFWMD, 2000a). The corresponding database (DB) keys and station names are presented in Appendix A.

Rainfall

Daily rainfall data for STA 6 is collected at G600_P (the inflow pumping station) and at ROTNWX. The data, stored in the DB key for G600_R, are compared to rainfall values at seven nearby rain gauge locations to check for data errors. Missing values are filled based on the best available information, usually from nearby rain gauges. The data for G600_R are loaded into a preferred DB key every month. A final QA/QC check of the data is completed quarterly. The preferred DB key provides a high-quality, continuous record of daily rainfall amounts.

G600_P is located at the northwest corner of the STA. The rain gauge at ROTNWX is located near the southeast corner of the STA in the Rotenberger Wildlife Management Area. Data from the Rotenberger rain gauge was averaged with values from the G600_R gauge and used for the mean daily rainfall at STA 6 for this report. **Tables B-1** and **B-2** in Appendix B list the daily rainfall amounts recorded at G600_R and ROTNWX.

Evapotranspiration

Daily evapotranspiration data was taken from preferred DB keys for the ENR Project and STA 1W for WY 98-99 through WY 00-01. The data for ET in these DB keys were considered to be of the highest quality available. The period of record for the DB key associated with the ENR Project ended September 30, 1999. For the remaining period through WY 00-01, ET was taken from the STA 1W DB key for ET. Weather station ROTNWX provided air temperature and total solar radiation data for ET values in WY 01-02. ET was calculated using equation 2 and air temperature and total solar radiation data. **Tables C-1, C-2** and **C-3** in Appendix C list the daily ET values used in this study.

$$ET = K_1 \frac{R_s}{\lambda} \qquad (2)$$

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

Stage

Stage data are collected instantaneously and are averaged and recorded as daily average stage in DBHYDRO. The instantaneous stage data are also used to compute flows at the inlet and outlet weir structures at STA 6. A headwater stage and a tailwater stage are needed to compute flow at each of the structures. As a result, more than one stage value was available to report average daily stage within each of the treatment cells. In this study, the daily average stage at each of the recording gauges within a cell was averaged to generate a daily average stage within the cell. **Tables D-1** and **D-2** show the average daily stage values for Cell 3 and Cell 5, respectively.

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 which was necessary to fill voids in the soils beneath the cells. Equations were developed for a falling and rising water table from cumulative water gain and water release equations presented by Abtew, et al. (1998) and are discussed in detail in Huebner (2000). They are shown in Appendix D, **Figures D-1** and **D-2**.

Flow

Daily average flow rates were determined using weir equations and pump performance curves. In this study the daily mean inflow at G601, G602, and G603 was used for the water budget. Daily average flows at G601, G602, G603 (inlet weirs), G354A through C, and G393A through C were computed using weir equations for each structure and were recorded in DBHYDRO. Because these flows were based primarily on changes in stage data and the fact that stage data records have relatively few missing values, the daily average flow records at these stations were complete for the period of the study.

At G600_P, average daily flow is computed instantaneously using motor speed and headwater and tailwater elevation data. The daily average flow at G600_P is recorded in DBHYDRO and reviewed monthly for accuracy and missing data. A complete record of daily average flow is loaded monthly to a preferred DB key in DBHYDRO. A final QA/QC check of the flow data in the preferred DB key is conducted quarterly.

In this study, the flows recorded for G601, G602 and G603 were considered not as accurate as flow calculated at a pump, especially since the calibration of the weir coefficient has not been completed for G601, G602, and G603. On certain days in water years 98-99, 99-00, and 00-01, the sum of the flows at these weirs was greater than the inflow at G600_P. On those days the flow at G601, G602 and G603 was corrected so that their sum was no greater than the inflow at G600_P for this study.

Outflow for Cells 3 and 5 in this report was computed at weirs G354A, B, and C, and G393A, B, and C. Again, calibration work at these weirs has not been completed. As noted above, the level of the weir box was corrected by adding plates to it at these stations in April 2000. Flow recorded prior to that date was corrected by using a relationship between flow at G606 and the flow at the G354 and G393 weirs shown in Equation 3. Flow at stations G605 and G606 was computed using data from ultrasonic velocity meters (UVM). Average daily flow data for both stations has been maintained in preferred DB keys. Flow at G605 was not used in this study since flow at the station has never affected the water budget in the treatment cells. Only the larger flows at G606, those reflecting flow through the STA, were represented in the relationship used to correct outflow weir data.

$$Q_{G354\_C + G393\_C} = 0.6733\ Q_{G606} \qquad (r^2 = 0.93) \qquad (3)$$

Outflow for the entire STA was taken from the preferred DB key, STA6OUT, which contains a combination of flows measured at G606 and at the outflow weirs, G354 and G393. For instance, for low flows at G606, data recorded were compared to outlet weir flow for cells 3 and 5. If there was no outflow from the treatment cells, flow at G606 was recorded as zero in the preferred DB key. Also, after the outlet weir crest elevations were corrected, G606 was abandoned because the flow recorded at the outlet weirs better represented the outflow from the STA 6 treatment cells.

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. They are discussed extensively in Huebner (2001). In general, seepage losses have been reported on the order of 2.0 to 5.6 cubic feet per second per mile of levee per foot of head difference (cfs/mi/ft). Huebner (2001) also shows the groundwater flow regimen 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 in the STA, the local gradients are out of the STA to the surrounding shallow aquifer and nearby canals.

In this analysis, seepage was computed as:

$$G = 1.983 * K_{sp} * L * \Delta H \tag{4}$$

where G = levee (horizontal) and deep (vertical) seepage (ac-ft/d)
K_{sp} = coefficient of seepage (cfs/mi./ft)
L = length along the seepage boundary (mi.)
H = hydraulic head difference between the unit and the boundary (ft)
1.938 = constant to convert from cfs to ac-ft/d

The value of K_{sp} was optimized by minimizing the sum of the squared daily error in the water budget for the four-year period for the entire STA. The results from Guardo and Rohrer (2000) and Brown and Caldwell (1996) were used to compare the value of the optimized coefficient, 2.63 cfs/mi/ft. The optimized value compared favorably with the range of values presented in both studies and was used for the cell water budgets as well.

WATER BUDGET

Methodology

Three sets of water budgets were produced, one for each treatment cell and one for the entire STA. A water budget analysis was performed daily, monthly, annually, and quadrennially using Equation 1. Terms in Equation 1 were converted to acre-feet (ac-ft) per unit time (day, month, or year, depending on the period being used for the water budget calculations). The water year (WY) used in this report extends from May to April and was used for the annual and quadrennial periods.

Results

Cell 3

Table 1 and **Figure 3** show the quadrennial and annual water budgets for Cell 3 for WY 98-99, WY 99-00, WY 00-01 and WY 01-02. Cell 3 is south of Cell 5. Cell 3 is the smaller of the treatment cells at STA 6, covering 245 acres. Inflow was measured at G603; outflow was recorded at weir boxes G393A, B, and C. Missing flow data at G603 in DBHYDRO were supplied by running the FLOWCALC program (SFWMD, 1995) using archived stage data. Error in the quadrennial water budget was 6.3 percent. Seepage was 15.5 percent of the quadrennial water budget. Outflow through weir boxes G393A through C was 75.7 percent of the inflow to Cell 3, measured at G603.

Figure 3 presents the components of the water budget for each water year. **Figure 4** shows the errors or residuals in the Cell 3 water budget for WY 98-99 to WY 01-02. **Figure 5** depicts the estimated seepage into and out of Cell 3. **Figure 6** shows the stage in Cells 3 and 5 versus that in the supply and discharge canals and in Cell 5. The variation in Cell 3 inflow, outflow, and stage is depicted in **Figure 7**. In general, Cell 3 displayed the lower amount of variation in the water budget residuals because it is the smaller of the two treatment cells and received less flow.

Table 1. Cell 3 water budget summary, WY 98-99 to WY 01-02

	Inflows				Outflows						
Cell 3	I_s	I_g	P	Σ_{inflow}	O_s	O_g	ET	$\Sigma_{Outflow}$	ΔS	r	ε
WY 98-99	*14,519*	*186*	*934*	*15,639*	*9,071*	*2,827*	*1,243*	*13,141*	*-40*	*2,538*	*17.6%*
WY 99-00	*22,013*	*150*	*1,148*	*23,312*	*23,696*	*2,928*	*995*	*27,618*	*699*	*-5,006*	*-19.7%*
WY 00-01	*13,421*	*190*	*1,067*	*14,677*	*9,277*	*3,511*	*1,144*	*13,932*	*249*	*497*	*3.5%*
WY 01-02	*19,925*	*79*	*965*	*20,969*	*10,846*	*2,493*	*1,073*	*14,412*	*34*	*6,523*	*36.9%*
TOTAL	*69,877*	*605*	*4,115*	*74,597*	*52,889*	*11,759*	*4,456*	*69,103*	*942*	*4,552*	*6.3%*
$\%_{inflow}$	*93.7%*	*0.8%*	*5.5%*	$\%_{Outflow}$	*76.5%*	*17.0%*	*6.4%*				

Notes:

1. *All values in acre-feet (ac-ft).*
2. *I_s measured at G603.*
3. *P is average of values at G600_R and ROTNWX.*
4. *O_s measured at G393 (corrected for unlevel weirs prior to April 2000).*
5. *ET measured at ROTNWX from total radiation and air temperature for WY 01-02; ET data from STA 1W and ENRP used for WY98-99 through WY00-01.*
6. *I_g and O_g estimated based on head differences between cell water levels and surrounding water levels using a seepage coefficient of 2.63 cfs/mi/ft.*
7. *ΔS for water levels below average ground level (12.4 ft NGVD) estimated using equations developed by Huebner (2001) based on data available in Abtew, et al. (1998).*

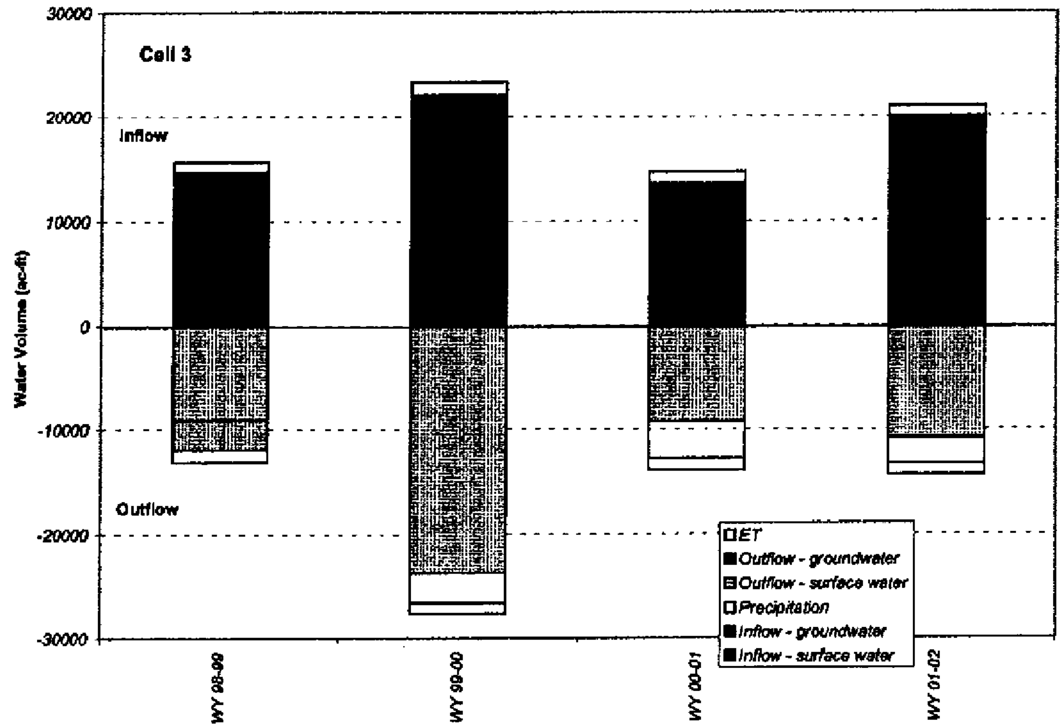

Figure 3. Cell 3 water budget, WY 98-99 to WY 01-02

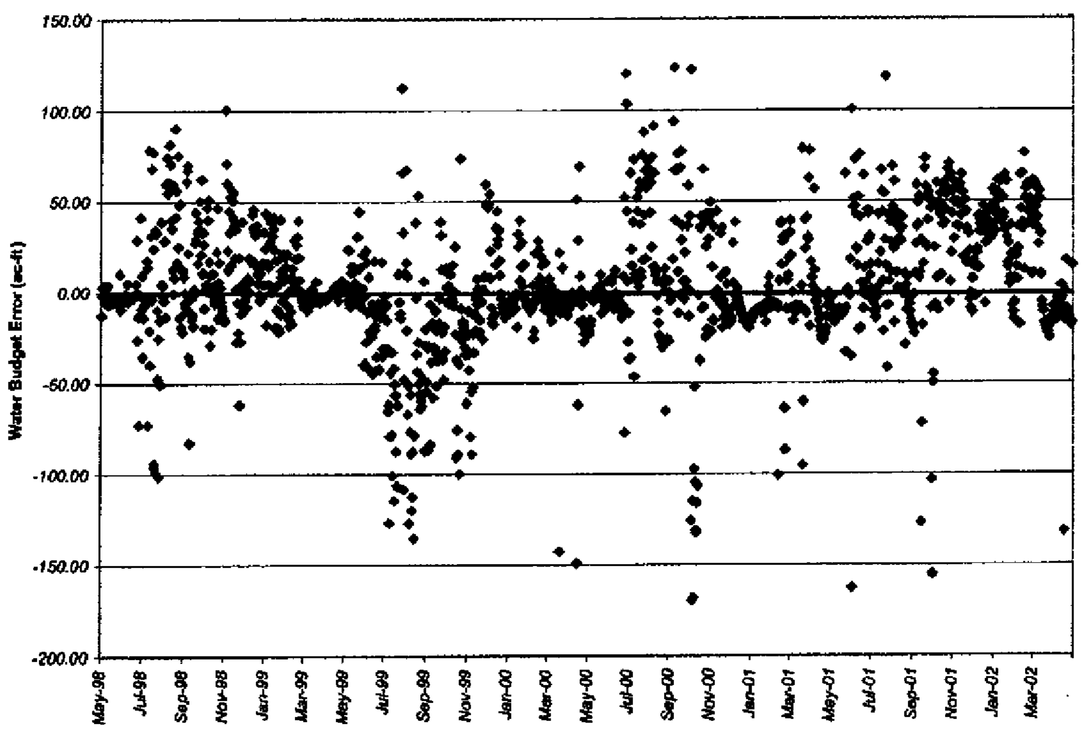

Figure 4. Daily water budget residuals for Cell 3, WY 98-99 to WY 01-02

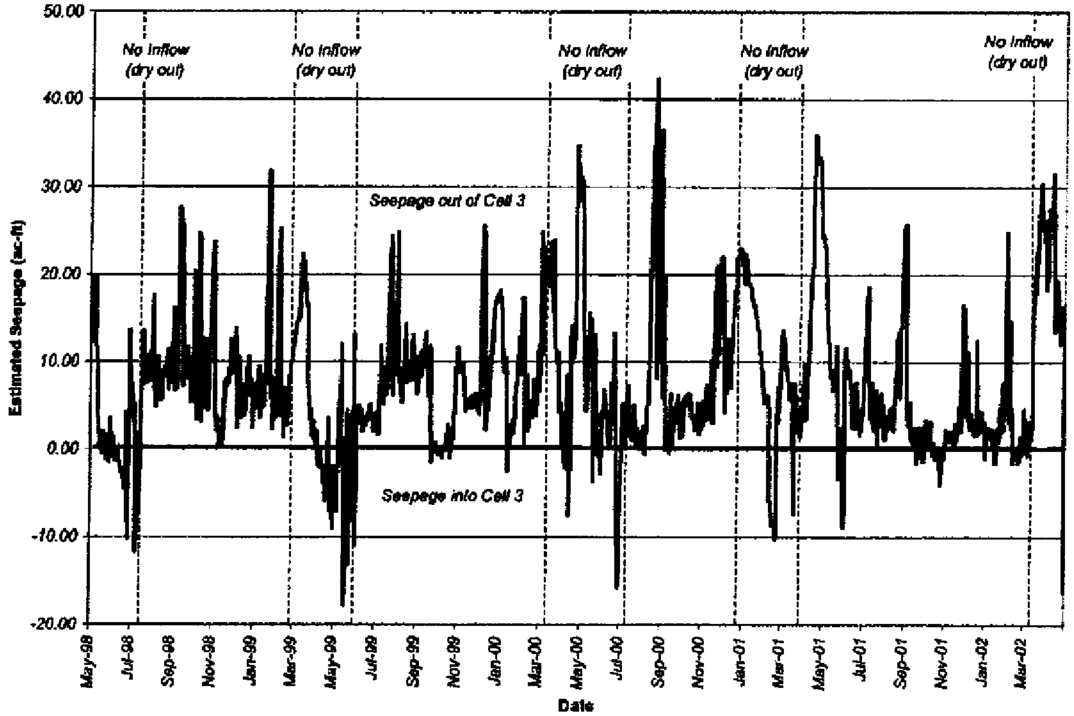

Figure 5. Cell 3 estimated seepage, WY 98-99 to WY 01-02

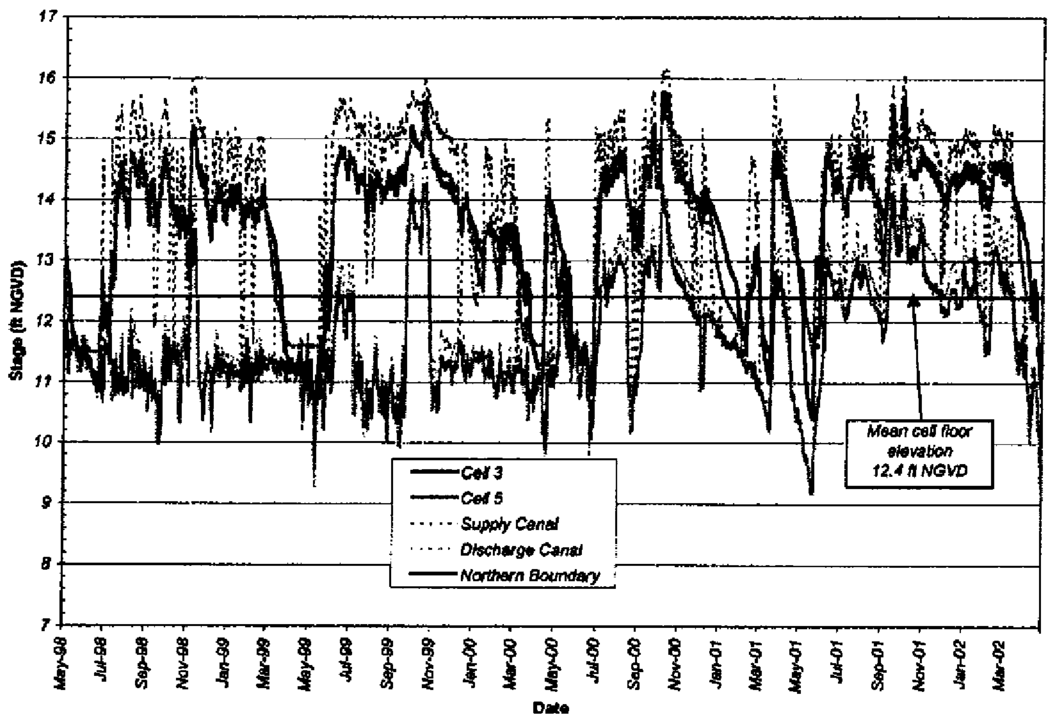

Figure 6. Stage in Cells 3 and 5 and surrounding water bodies, WY 98-99 to WY 01-02

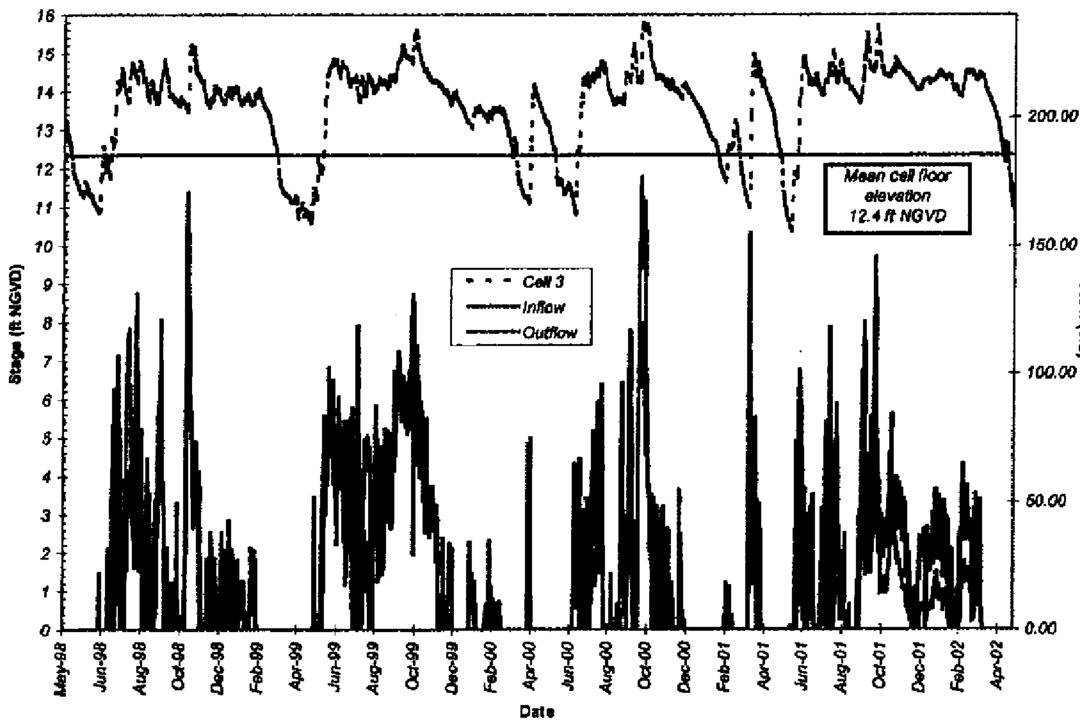

Figure 7. Cell 3 inflow, outflow and stage, WY 98-99 to WY 01-02

Cell 5

Table 2 and **Figure 8** show the quadrennial and annual water budgets for Cell 5. Cell 5 is the northern cell of the two treatment cells in STA 6. Inflow was measured at G601 and G602; outflow was recorded at G354A, B, and C.

As a percentage of the water budget, error for Cell 5 was 14.2 percent over four years. Error in WY 98-99 and WY 99-00 was offset by the error in WY 00-01 (apparently, outflow was overestimated in WY 00-01 and underestimated in WY 98-99 and WY 99-00). **Figure 9** shows the residual error plot for the Cell 5 water budget. Seepage constituted 32.9 percent of the quadrennial water budget. Seepage as a percentage of the water budget during this period should be relatively higher because of the extended drought from November 1999 through September 2001. Proportionally, the water budget residuals for Cell 5 were on the same order as those for Cell 3. Seepage into and out of Cell 5 is depicted in **Figure 10.** There was negligible seepage into Cell 5 during WY 98-99 to WY 01-02, even during periods when the cell dried out. Stage in Cells 3 and 5 and in surrounding water bodies is presented in **Figure 6.** 49.2 percent of the inflow to the cell at G601 and G602 left the cell at G354A, B, and C. **Figure 11** shows the inflow, outflow, and stage in Cell 5 for WY 98-99 to 01-02.

Table 2. Cell 5 water budget summary, WY 98-99 to WY 01-02

	Inflows				Outflows						
Cell 5	I_s	I_g	P	Σ_{Inflow}	O_s	O_g	ET	$\Sigma_{Outflow}$	ΔS	r	ε
WY 98-99	22,285	0	2,382	24,668	5,916	9,493	3,172	18,582	173	5,913	27.3%
WY 99-00	32,892	0	2,929	35,821	14,922	10,593	2,538	28,053	1,183	6,585	20.6%
WY 00-01	20,816	106	2,722	23,644	14,447	7,104	2,919	24,470	910	-1,736	-7.2%
WY 01-02	30,532	0	2,463	32,995	17,099	8,569	2,737	28,405	9	4,580	14.9%
TOTAL	106,525	107	10,497	117,128	52,385	35,759	11,366	99,510	2,275	15,342	14.2%
$\%_{Inflow}$	90.9%	0.1%	9.0%	$\%_{Outflow}$	52.6%	35.9%	11.4%				

Notes:

1. *All values in acre-feet (ac-ft).*
2. *I_s measured at G601 and G602.*
3. *P is average of values at G600_R and ROTNWX.*
4. *O_s measured at G354 (corrected for unlevel weirs prior to April 2000).*
5. *ET measured at ROTNWX from total radiation and air temperature for WY 01-02; ET data from STA 1W and ENRP used for WY98-99 through WY00-01.*
6. *I_g and O_g estimated based on head differences between cell water levels and surrounding water levels using a seepage coefficient of 2.63 cfs/mi/ft.*
7. *ΔS for water levels below average ground level (12.4 ft NGVD) estimated using equations developed by Huebner (2001) based on data available in Abtew, et al. (1998).*

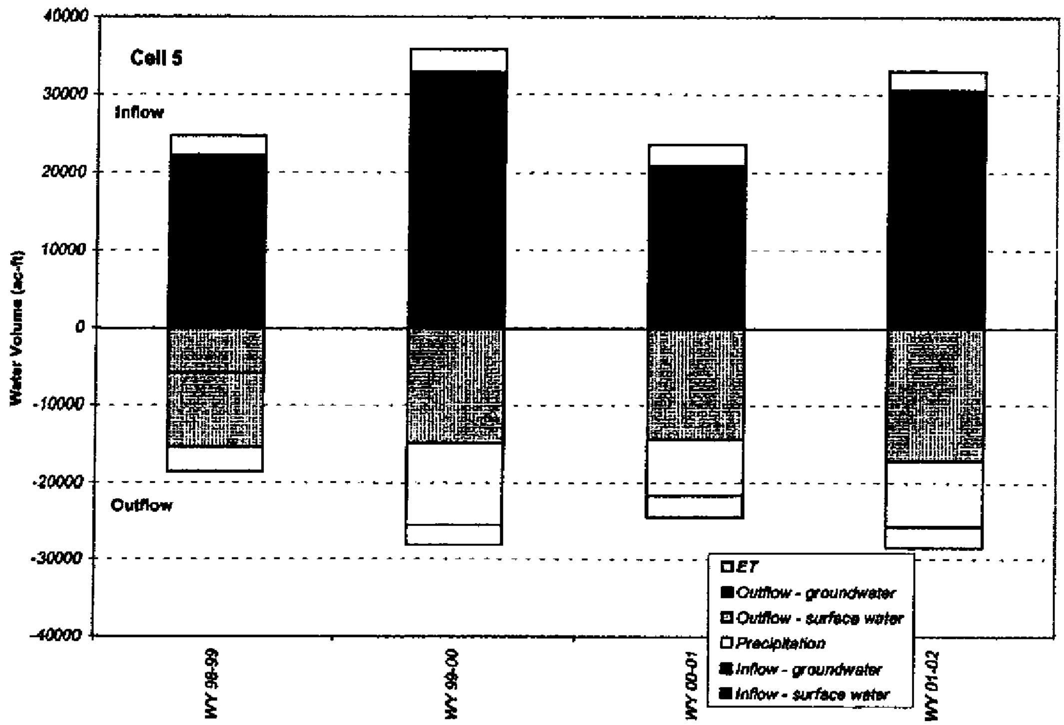

Figure 8. Cell 5 water budget, WY 98-99 to WY 01-02

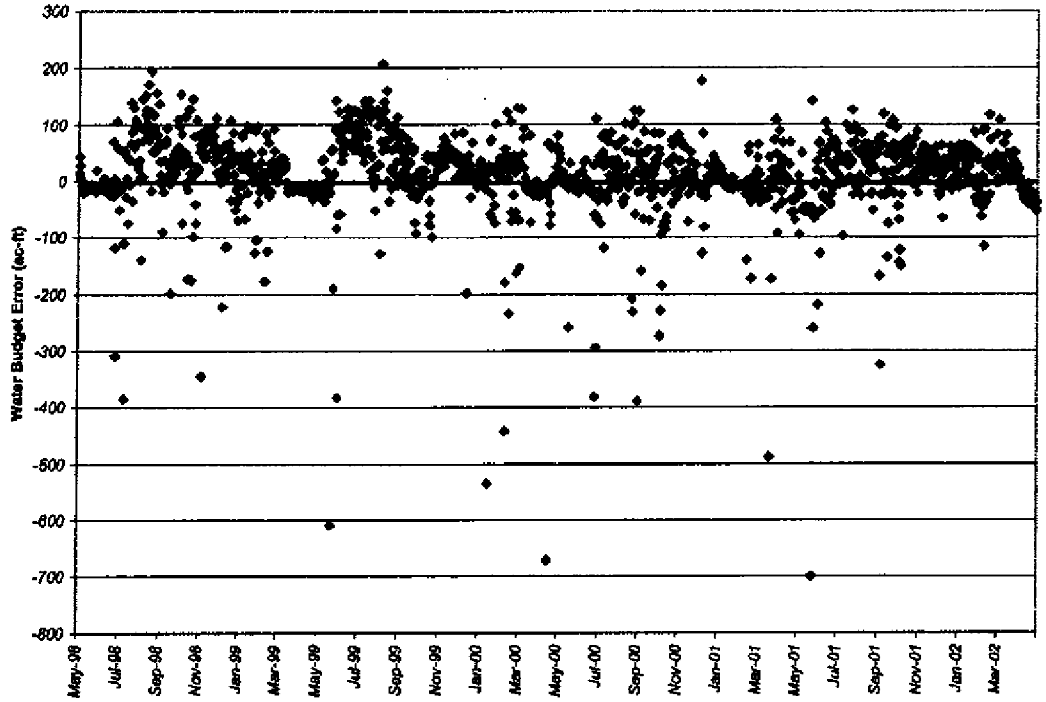

Figure 9. Daily water budget residuals for Cell 5, WY 98-99 to WY 01-02

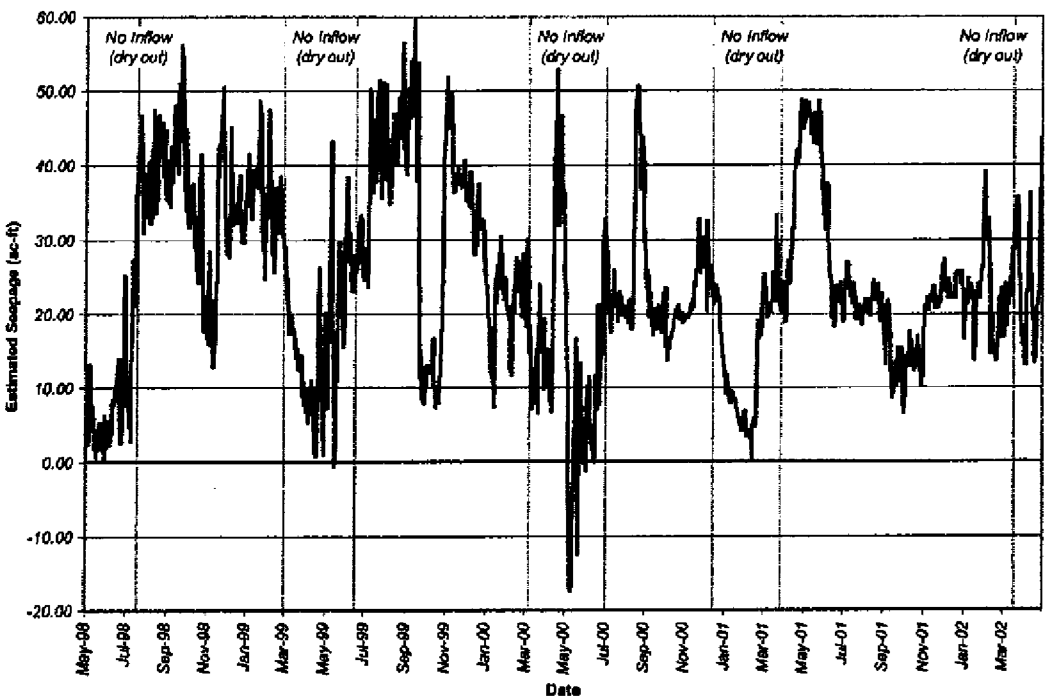

Figure 10. Cell 5 estimated seepage, WY 98-99 to WY 01-02

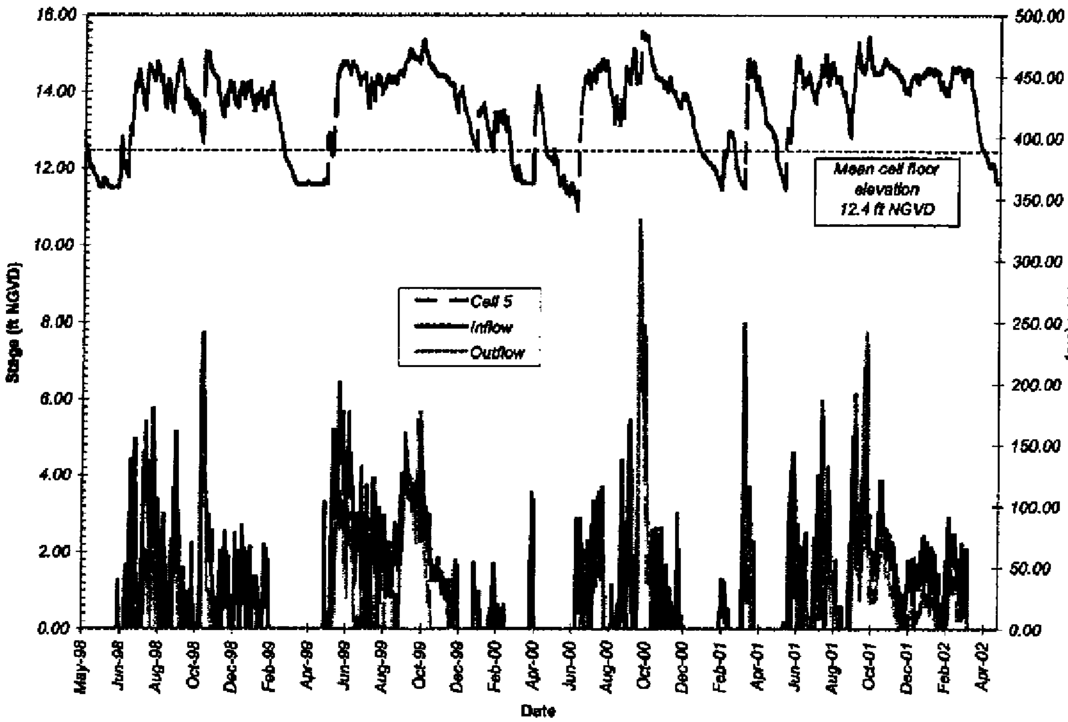

Figure 11. Cell 5 inflow, outflow and stage, WY 98-99 to WY 01-02

STA 6

Table 3 and **Figure 12** contain the summary of the quadrennial and annual water budgets for the entire STA, which includes Cells 3 and 5, discussed previously. The water budget for the entire STA was affected by the apparent problems with outflow measurement at G354A, B, and C, G393A, B, and C and G606. Seepage was estimated by summing the daily seepage estimated for cells 3 and 5. Errors for the four years were 1.7 percent of the budget. Seepage was 23.7 percent of the water budget.

The daily average errors are less than 1.0 in. except in August 1998. **Figure 13** shows the residual 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 the hydrologic processes occurring in STA 6. **Figure 14** presents the estimated seepage into and out of STA 6, indicating a net loss of water seeping from STA 6 into the surrounding area. This is consistent with groundwater gradients depicted in **Figure 6**.

Figure 15 shows the daily inflow and outflow volumes for STA 6 for WY 98-99 to WY 01-02. **Figures 16** through **20** summarize the quadrennial and annual water budgets. Outflow from the STA was 71.6 percent of the inflow recorded at G600_P during the four-year period.

Table 3. STA 6 water budget summary, WY 98-99 to WY 01-02

	Inflows				Outflows						
STA 6	I_s	I_g	P	Σ_{inflow}	O_s	O_g	ET	$\Sigma_{Outflow}$	ΔS	r	ε
WY 98-99	40,120	31	3,316	43,467	24,035	12,165	4,416	40,616	134	2,717	6.5%
WY 99-00	59,848	29	4,077	63,955	59,261	13,399	3,534	76,193	1,882	-14,120	-20.2%
WY 00-01	39,395	88	3,790	43,273	26,718	10,407	4,063	41,188	1,158	927	2.2%
WY 01-02	53,437	0	3,428	56,865	27,945	10,983	3,810	42,738	44	14,084	28.3%
TOTAL	192,800	148	14,611	207,580	137,959	46,954	15,822	200,735	3,217	3,607	1.8%
$\%_{inflow}$	92.9%	0.1%	7.0%	$\%_{Outflow}$	68.7%	23.4%	7.9%				

Notes:

1. *All values in acre-feet (ac-ft).*
2. *I_s measured at G600_P.*
3. *P is average of values at G600_R and ROTNWX.*
4. *O_s measured at G606 through 2/28/01 and at G354 and G393 thereafter.*
5. *ET measured at ROTNWX from total radiation and air temperature for WY 01-02; ET data from STA 1W and ENRP used for WY98-99 through WY00-01.*
6. *I_g and O_g estimated based on head differences between cell water levels and surrounding water levels using a seepage coefficient of 2.81 cfs/mi/ft.*
7. *ΔS for water levels below average ground level (12.4 ft NGVD) estimated using equations developed by Huebner (2001) based on data available in Abtew, et al. (1998).*

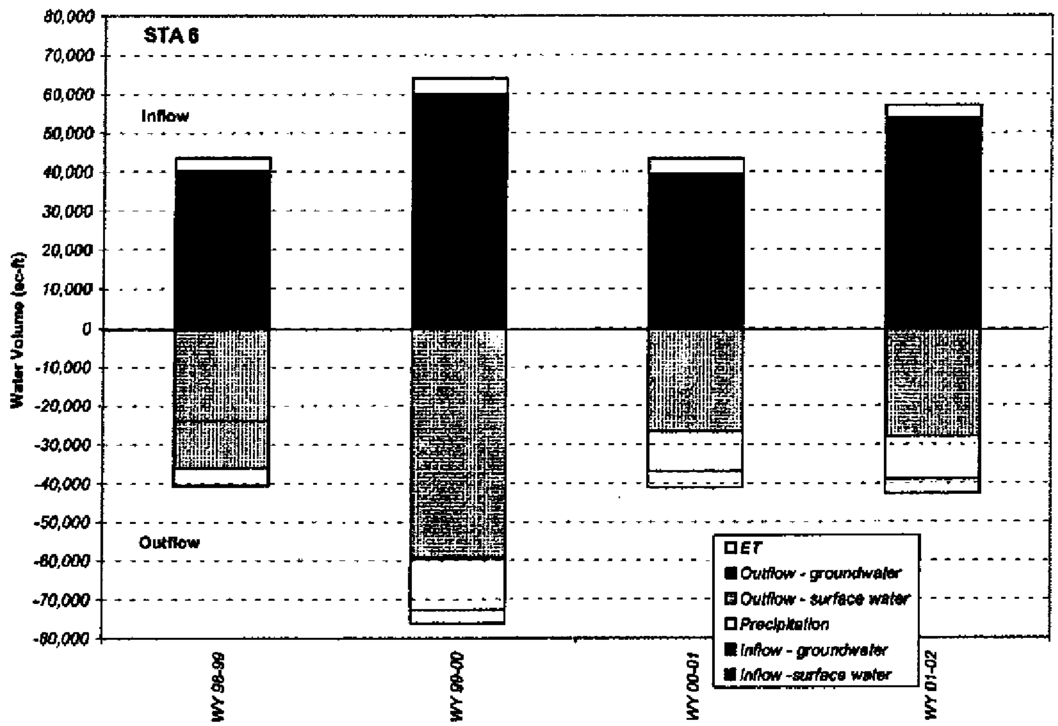

Figure 12. STA 6 water budget, WY 98-99 to WY 01-02

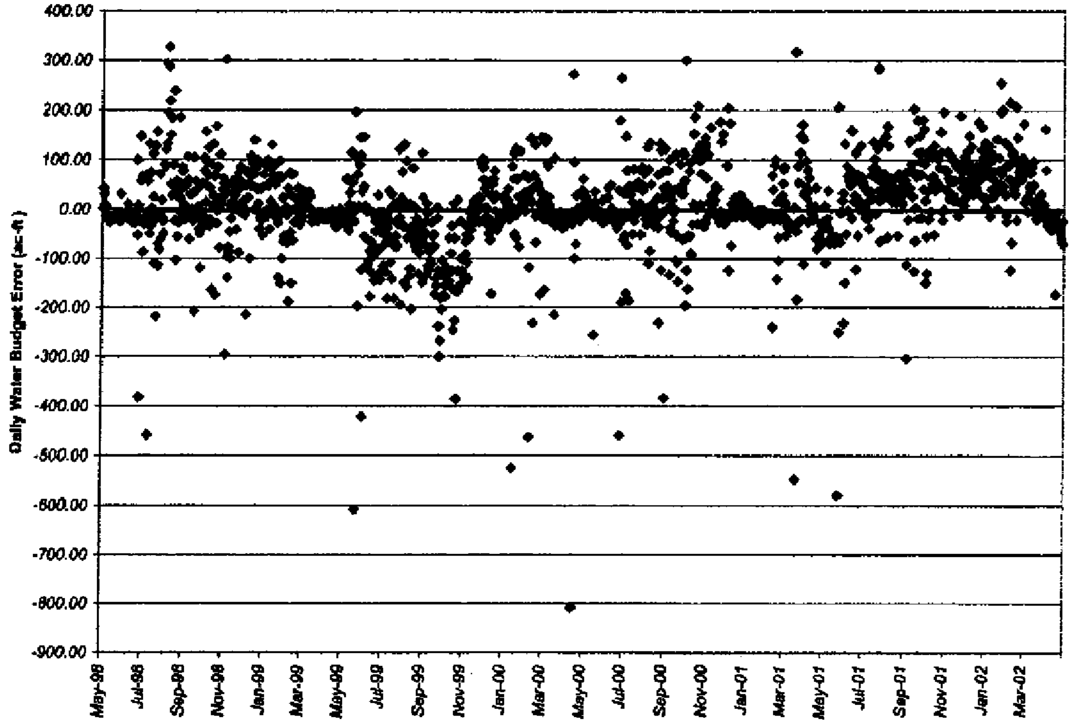

Figure 13. Water budget residual for STA 6, WY 98-99 to WY 01-02

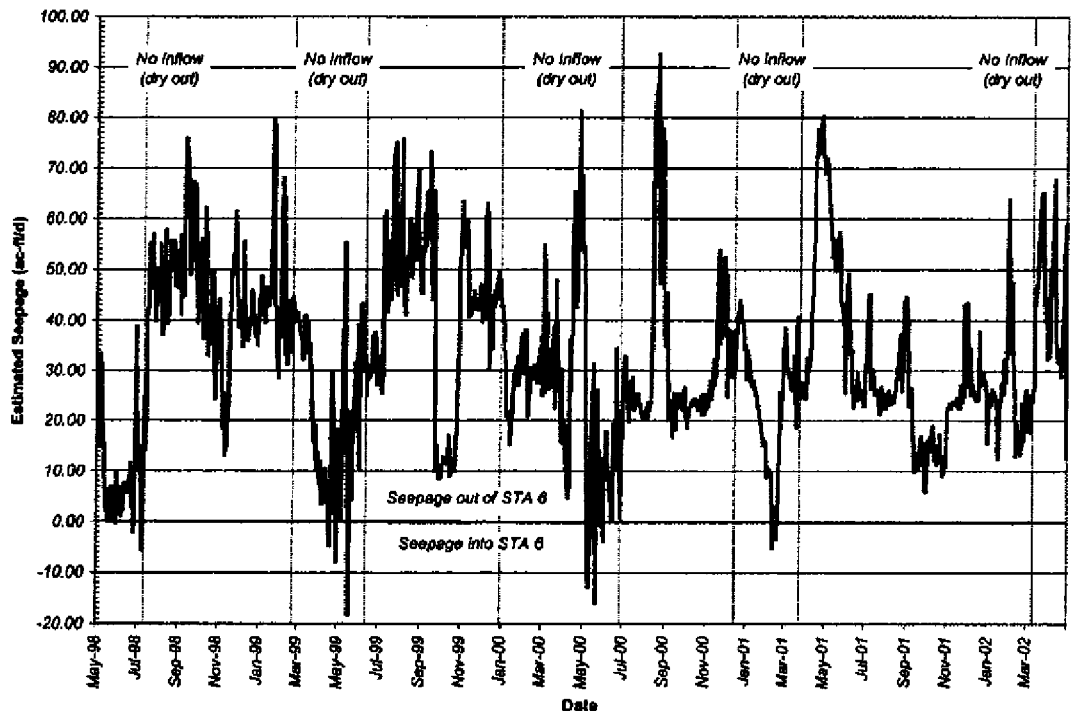

Figure 14. STA 6 estimated seepage, WY 98-99 to WY 01-02

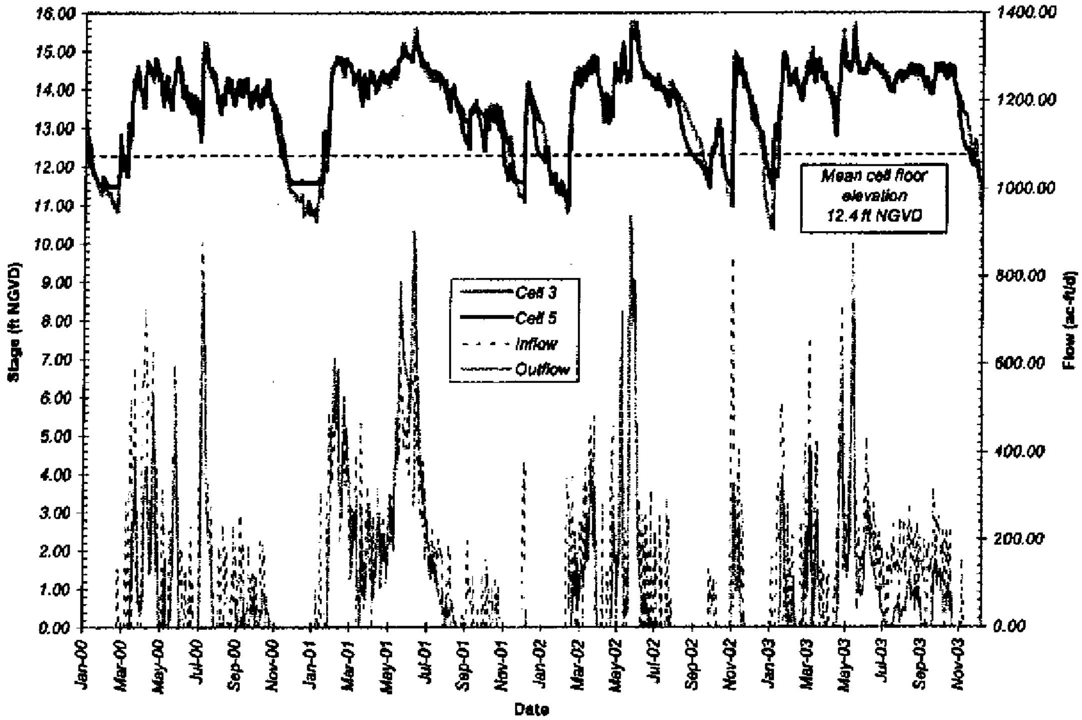

Figure 15. Inflow, outflow and stage for STA 6, WY 98-99 to WY 01-02

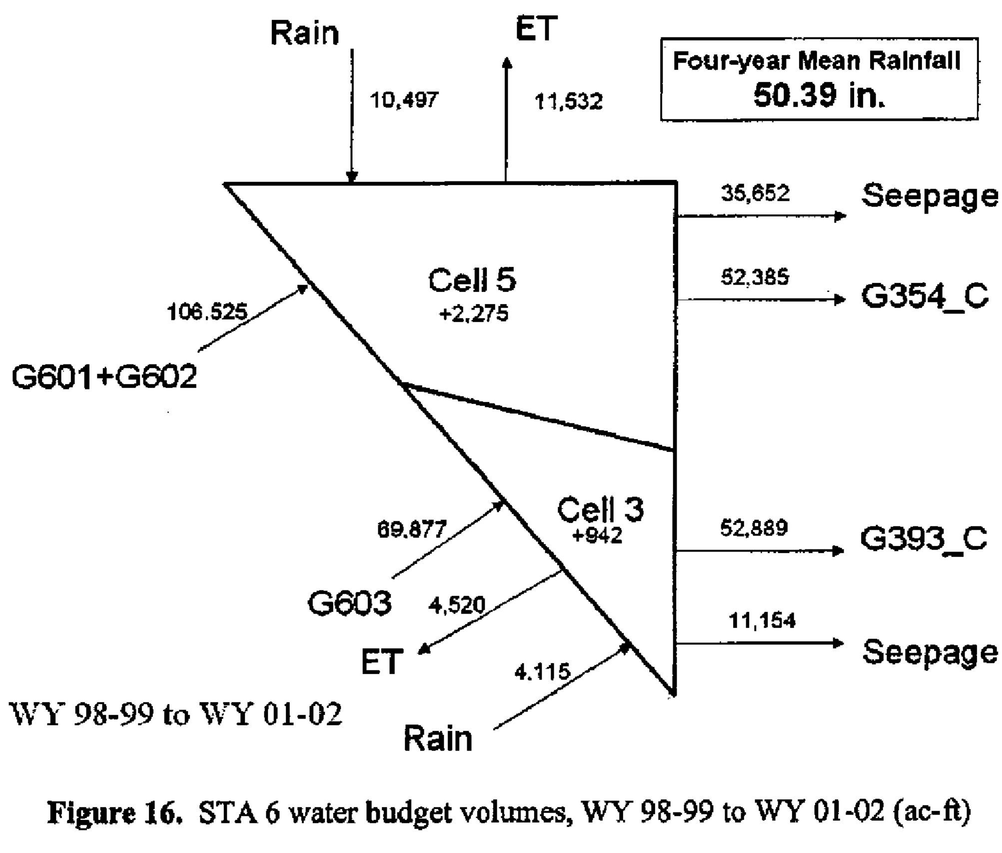

Figure 16. STA 6 water budget volumes, WY 98-99 to WY 01-02 (ac-ft)

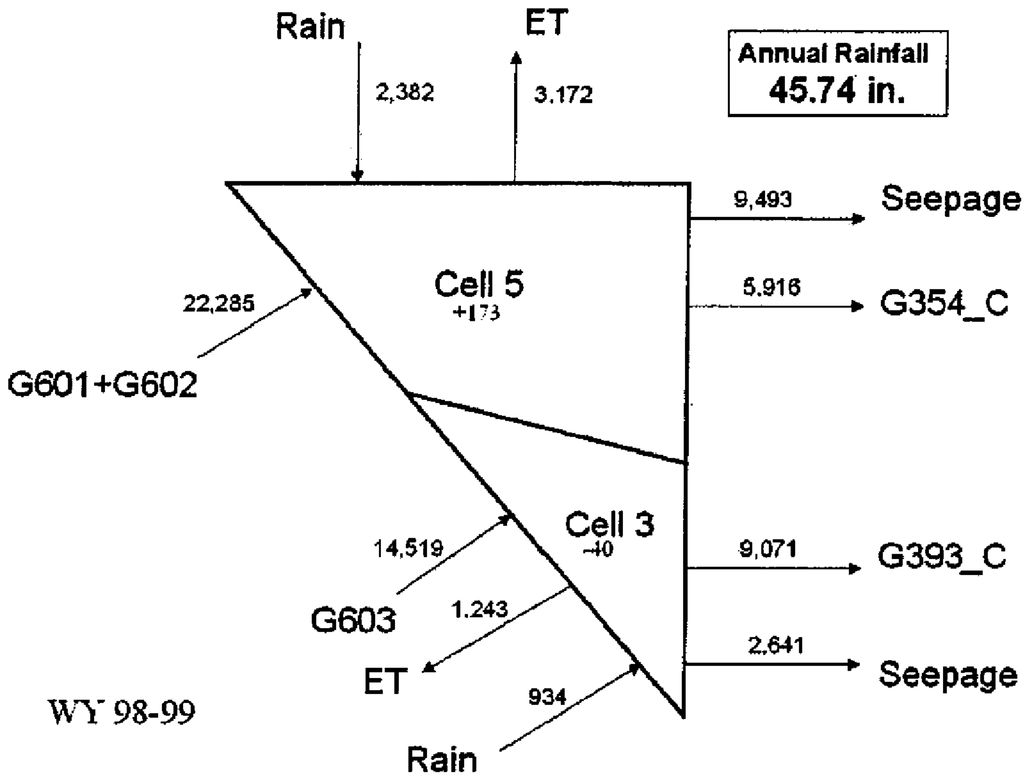

Figure 17. STA 6 water budget volumes, WY 98-99 (ac-ft)

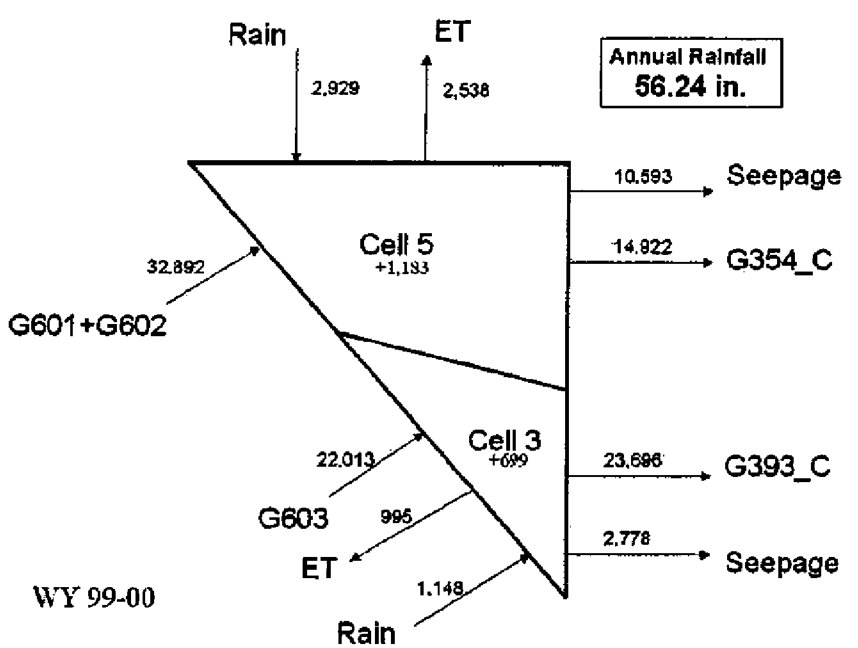

Figure 18. STA 6 water budget volumes, WY 99-00 (ac-ft)

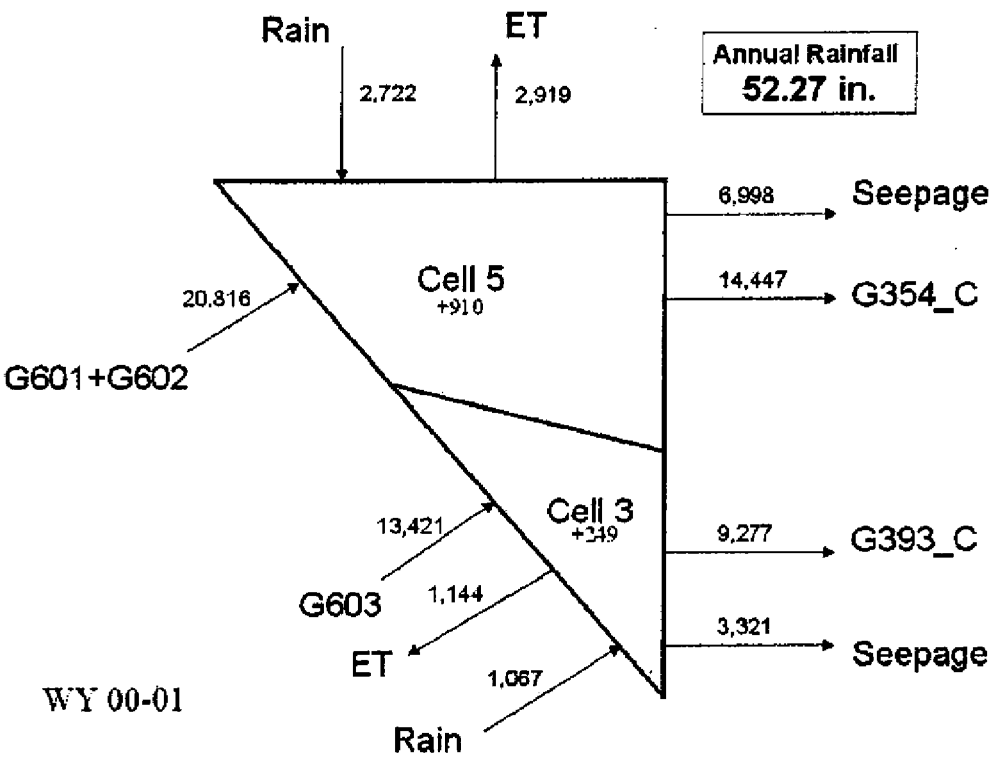

Figure 19. STA 6 water budget volumes, WY 00-01 (ac-ft)

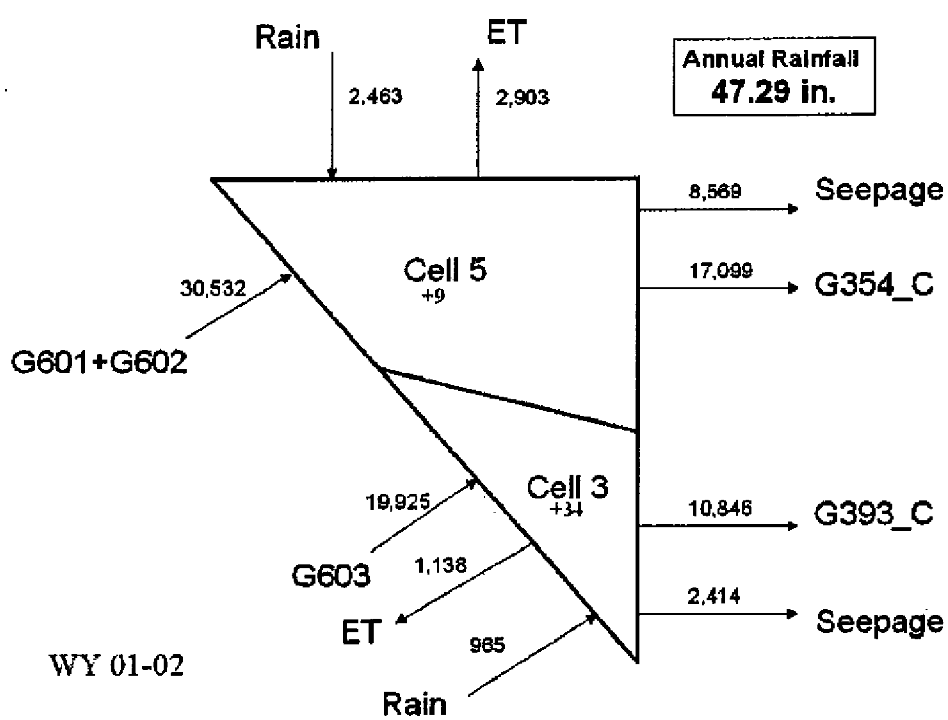

Figure 20. STA 6 water budget volumes, WY 01-02 (ac-ft)

Mean Hydraulic Retention Time

Hydraulic retention time is a measure of how long water remains in each cell. It estimates the period of time that water will be treated. Over this period, physical, chemical, and biological processes remove particulate and soluble phosphorous and other contaminants. The mean hydraulic retention time (MHRT, also referred to as mean cell residence time) was determined using equation 5:

$$t = \frac{V}{Q} \quad (5)$$

where t = mean hydraulic retention time (d)
V = cell volume (ac-ft)
Q = flow rate (ac-ft/d)

Table 4 shows the mean hydraulic retention time, in days, for Cells 3 and 5. The four-year mean was based on the average stage during the quadrennial period (WY 98-99 to WY01-02) and the average rate of inflow and outflow, including rainfall, evapotranspiration, and seepage. Wet-season values were based on data from June through October, and dry-season values were based on values from November to May. Since WY 01-02 ends in April 2002, data for May 2002 is not represented in the dry-season values for that water year or the four-year mean.

Table 4. Mean hydraulic retention time (days)

	Annual		Wet Season		Dry Season	
Cell 3	Average Depth (ft)	MHRT (days)	Average Depth (ft)	MHRT (days)	Average Depth (ft)	MHRT (days)
WY98-99	0.83	5.2	1.03	4.6	0.69	7.1
WY99-00	1.26	4.4	2.09	3.9	0.66	6.6
WY00-01	1.10	6.9	1.48	5.4	0.83	10.9
WY01-02*	1.53	7.7	2.01	7.0	1.18	8.9
4-yr Mean*	1.18	5.9	1.65	5.2	0.84	8.4
Cell 5						
WY98-99	0.86	9.1	1.06	8.7	0.71	12.5
WY99-00	1.25	9.0	2.12	8.1	0.63	12.0
WY00-01	0.97	9.2	1.50	8.1	0.59	12.5
WY01-02*	1.59	11.8	1.98	10.1	1.30	14.3
4-yr Mean*	1.17	9.8	1.67	8.8	0.81	12.8

** - May 2002 is not included in the dry season data*

In April 2000, the outlet weir box crest elevations at STA 6 were increased to 14.1 ft NGVD in Cell 5 (stations G354A, B, and C) and to 14.0 ft NGVD in Cell 3 (stations G393A, B, and C). This increased the MHRT starting in WY 00-01.

During the wet season, MHRTs ranged from 3.9 to 7.0 days for Cell 3 and from 8.1 to 10.1 days for Cell 5. Dry-season MHRTs ranged from 6.6 to 10.9 days for Cell 3 and from 12.0 to 14.3 days for Cell 5. At maximum normal flow conditions in the STA 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.

SUMMARY AND DISCUSSION

Over the four-year period of water years 98-99, 99-00, 00-01 and 01-02, STA 6 received 192,800 ac-ft of water from pumping operations at G600_P. Of this amount, 176,402 ac-ft entered treatment Cells 3 and 5 at G601, G602, and G603. An additional 14,611 ac-ft were input into STA 6 via rainfall; 15,822 ac-ft were lost through evapotranspiration. Estimated seepage was 22.9 percent of the water budget during this period, losing 46,806 ac-ft to surrounding water bodies and the surficial aquifer. Outflow from STA 6 at G354 and G393 was 59.7 percent of the flow entering STA 6 at G601, G602, and G603, or 105,274 ac-ft. This volume was released into the discharge canal at STA 6 and was eventually discharged at G607 to the L-4 canal. The amount of water stored in STA 6 increased by 3,217 ac-ft in four years. The error in the water budget was 3,607 ac-ft or 1.8 percent of the budget. Cell 3 retained water for an average of 5.9 days in WY 98-99 to WY 01-02. The average retention time in Cell 5 was 9.8 days.

There were a number of problems associated with calculating the water budget for STA 6. The largest source of error may be the values computed for seepage. The seepage and budget residual combined constitute 24.7 percent of the water budget. It should be noted that the seepage coefficients used in this study were calibrated based on minimizing the four-year sum of the squared daily water budget error (SSE) for the entire STA. The coefficient values may also reflect other errors. When examining the estimated seepage by water year for the STA, it appears that the percent of the water budget attributed to seepage was highest during WY 98-99, the year the STA received the least rainfall.

In addition, there appeared to be an inconsistency between the values of inflow to and outflow from the STA and the treatment cells. These errors were also encountered in the previous water budget study at STA 6 (Huebner, 2001). Plates were installed at the G354 and G393 weirs in April 2000, and STA outflow monitoring was moved to these locations. It appears that this change is providing more consistent flow values than those calculated previously at these stations and at the former UVM site at G606. Calibration of inflow and outflow weirs at STA 6 is underway.

The water budget residuals for STA 6 shown in **Figures 4, 9,** and **13** (residuals for Cell 3, Cell 5, and the STA as a whole) are not random. In general, the residuals increase when flow increases, as shown in **Figure 21**, which shows daily inflow, seepage, and budget error for the four-year period. Although seepage also increases during these periods (in response to increased stages 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, but it may also indicate a response to inflow that is not adequately represented by the traditional equations for levee seepage and storage used in this and other studies.

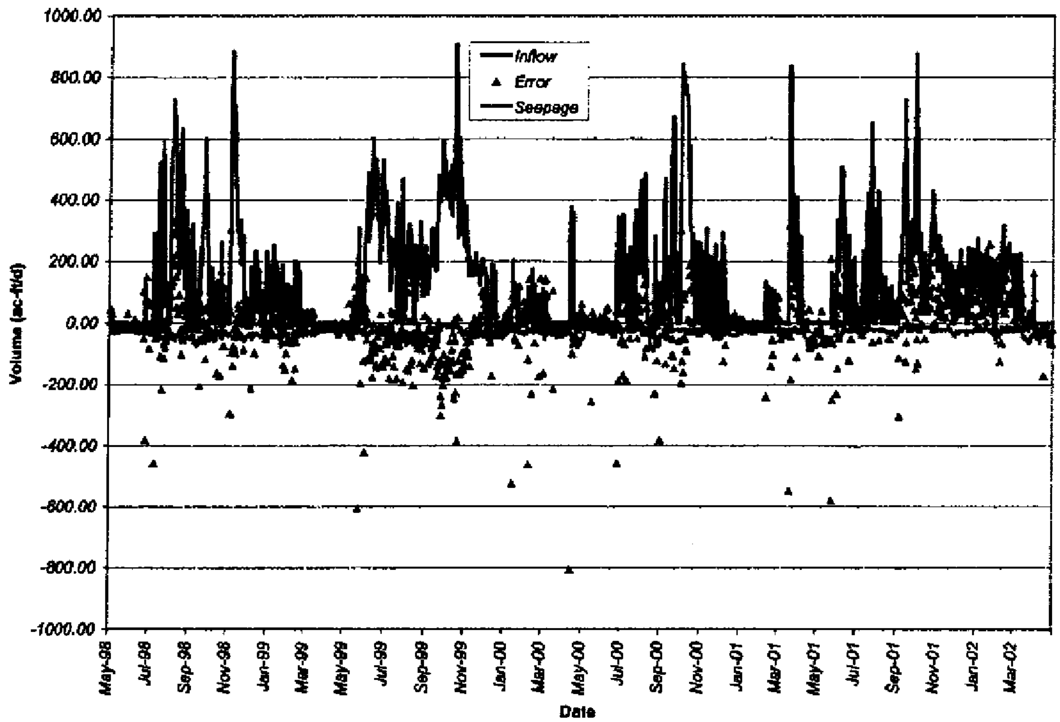

Figure 21. STA 6 inflow, estimated seepage, and water budget residuals, WY 98-99 to WY01-02

Other possible sources of error in the budget include use of ET values from the ENR Project, located approximately 35 miles northeast of STA 6, and use of a ground elevation of 12.4 ft NGVD for the bottom of the treatment cells. Both of these should have had a minor impact on the quadrennial water budget. Appendix E presents the results of an error analysis using daily values from the quadrennial water budget.

RECOMMENDATIONS

The geology and the seepage characteristics of the STA-6 area warrant additional study. Seepage constituted the largest single quantifiable unknown at the site. The quantity of water lost through seepage has implications for STA design and water quality management in the basin. A previous study (SFWMD, 2000b) found that approximately 50 percent of the total phosphorous load consisted of dissolved phosphorous in the Northern Everglades. Since 22.9 percent of the water entering STA 6 left via seepage during WY 98-99, WY 99-00, WY 00-01 and WY 01-02 and 50 percent of the phosphorous load is dissolved, a significant portion of the treatment efficiency of the STA, estimated to be 77 percent on a concentration basis in WY 00-01 (SFWMD, 2002), can be attributed to losses through seepage. Seepage also enhances the removal of particulate phosphorous through filtration. Soluble phosphorous in the form of orthophosphate might also be removed by precipitation as it comes in contact with limestone and reacts with calcium and hydroxyl ions (Kadlec and Knight, 1996). Further investigation of this aspect of treatment cell dynamics, especially with respect to long-term aquifer and downstream impacts, remains a research need.

Installation of observation wells with stage recorders located outside the boundary of STA 6 would aid the analysis of seepage, especially along the northern and eastern boundaries. Location and installation of observation wells for this purpose should be a design/construction requirement for all STAs.

Since the retention time of the cells is significantly lower than that reported for STA 1W, short-circuiting is likely to have a more pronounced impact on the removal efficiency of the treatment cells. A dye study test should be conducted to assess the extent of flow short-circuiting in cells 3 and 5 and its impact on treatment processes.

CONCLUSIONS

Seepage continued to constitute an unexpectedly large portion of the water budget. An increase in the portion of the annual budgets for WY 99-00 and WY 00-01 and the quadrennial budget attributed to seepage was expected, because inflow and outflow were significantly reduced due to drought conditions. Flow measurement errors at the inflow and outflow weirs were apparent in preparing data for the analysis and were corrected. Mean hydraulic residence times continued to be lower than those observed at other STAs, yet the removal efficiencies remained high.

Additional years of data and improved information about seepage at the site are needed to improve the water budget for STA 6, Section 1 in the future.

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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	**~12.4 ft**
Cell 3 Ground Elevation	**~12.4 ft**
Levee Length	
Along Northern Boundary	**7785 ft**
Supply Canal	
Along Cell 5	**4412 ft**
Along Cell 3	**7136 ft**
Discharge Canal	
Along Cell 5	**6012 ft**
Along Cell 3	**4584 ft**
Between Cells 3 and 5	**4195 ft**

Table A-2. Stage monitoring stations

DBKEY	STATION	STATION_DESC	COUNTY
G6559	G352S_H	STA 6 SECTION 1 (ON 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 (ON SUPPLY CANAL ACROSS FROM CELL 3)	HENDRY
G6562	G392S_T	STA 6 SECTION 1 (IN CELL3 ACROSS FROM SUPPLY CANAL)	HENDRY
G6565	G393B_H	STA 6 SECTION 1 IN CELL 3 AT OUTFLOW B	HENDRY
G6566	G393B_T	STA 6 SECTION 1 IN DISCHARGE CANAL AT OUTFLOW 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
GA115	G606	STA 6 SECTION 1 DISCHARGE CANAL OUTFLOW	HENDRY

Table A-3. Flow monitoring stations

DBKEY	STATION	STATION DESC	COUNTY
J5569	G393_C	STA 6 SECTION 1 CELL 3 COMBINED OUTFLOW FOR G393A,B,C	HENDRY
J0939	G354_C	STA 6 SECTION 1, DISCHARGE CANAL, COMBINED FLOW FOR G354A,B,C USING G354C+H/TN	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
GA116	G606	STA 6 SECTION 1 DISCHARGE CANAL OUTFLOW	HENDRY
HD889	STA6OUT	STA 6 ESTIMATED COMBINED OUTFLOW FROM CELLS 3 AND 5	HENDRY

Table A-4. Rainfall monitoring sites

DBKEY	STATION	STATION DESC	COUNTY
JJ025	G600_R	STA 6 SECTION 1 INFLOW PUMP STATION AT RAINGAGE	HENDRY
GE354	ROTNWX	ROTENBERGER TRACT WEATHER STATION, LOCATED BY G606 AT STA6	BROWARD

Table A-5. Evapotranspiration monitoring sites

DBKEY	STATION	STATION DESC	COUNTY	DATA
JD470	ENRP	AREAL COMPUTED PARAMETER FOR ENR PROJECT	PALM BEACH	ET
KN810	STA1W	AREAL COMPUTED PARAMETER FOR STA1W PROJECT	PALM BEACH	ET
GE352	ROTNWX	ROTENBERGER TRACT WEATHER STATION, LOCATED BY G606 AT STA6	BROWARD	AIRT
GE348	ROTNWX	ROTENBERGER TRACT WEATHER STATION, LOCATED BY G606 AT STA6	BROWARD	RADT

Appendix B – Rainfall Data

Table B-1. Rainfall at G600_R (inches), WY 98-99 to WY 01-02

WY 98-99

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	0.04	0	0.28	0	0	0.08	0	0	0.01	0.21	0	0.1
2	0	0	0	0	0	0.15	0	0	0.16	0.01	0	0
3	0	0	0	2.55	0	0	0	0	0.38	0.01	0.09	0
4	0.01	0	0	0	0.69	0.41	4.5	0.01	0.05	0	0	0
5	0	0	0	0.15	0.47	0	3.56	0.01	0.01	0	0	0
6	0	0.04	0.09	1.09	0.01	0.19	0	0	0	0.01	0	0
7	0	0	1.98	0	0.32	0	0	0.01	0.02	0	0	0
8	0	0.51	0.06	0	0	0	0	0	0	0.01	0	0
9	0	0	0	0.31	0.12	0	0.01	0	0.15	0	0	0
10	0	0	0.36	0.04	0.01	0.1	0	0.01	0.1	0.17	0	0
11	0.01	0	0.07	0.14	0	0	0	0.25	0	0	0	0
12	0	0.01	0	0	0	0.2	0	0.2	0	0.12	0	0.01
13	0	0.03	1.57	0	0	0	0	0.06	0	0	0	0
14	0	0	0.42	0.49	0	0.09	0	0.12	0.02	0	0.08	0
15	0	0	0.97	0.01	0.06	0	0	0	0.01	0	0.05	0
16	0	0	0.17	0.31	0.58	0	0	0	0.01	0	0	0
17	0	0	0	0.28	0.97	0	0	0	0	0	0	0.2
18	0	0	0.1	3.4	0.11	0.02	0	0	0.01	0.36	0	0.05
19	0	0	0.87	0.05	0.13	0.01	0.2	0	0	0	0	0
20	0	0	0.76	0	0.05	0.01	0	0	0	0	0	0
21	0	0.04	0.32	0.82	1.24	2.08	0.01	0	0.01	0	0	0
22	0	0.07	0.42	0.02	0	0	0	0	0.01	0	0	0
23	0	0.04	0	0.04	0.01	0	0	0.01	0	0	0	0
24	0	0.21	0	0	0.12	0	0.52	0	0.89	0	0	0
25	0	0.12	0	0.02	1.67	0	0.01	0	0.01	0	0	0
26	0	0.01	0.09	0	0.29	0	0.02	0.01	0.02	0	0.04	0.2
27	0	0	0	0	0.04	0	0	0	0.01	0	0	0.11
28	0.66	0	0	0	0	0	0	0.21	0	0.01	0	0.12
29	0.2	0	0	0	0	0	0	0	0		0	0
30	0.11	0.81	0	0	0	0.01	0	0	0		0	0.01
31	0.02		0	0		0		0	0		0	
MAX	0.66	0.81	1.98	3.4	1.67	2.08	4.5	0.25	0.89	0.36	0.09	0.2
MEAN	0.03	0.06	0.28	0.31	0.23	0.11	0.29	0.03	0.06	0.03	0.01	0.03
MIN	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1.05	1.89	8.53	9.72	6.89	3.35	8.83	0.9	1.88	0.91	0.26	0.8

WY99-00

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	0	0.01	0.05	0.01	0.01	0	0.04	0	0	0	0	0
2	0	0.67	0.99	0	0	0	0.68	0	0	0	0	0
3	0	0.91	0.03	2.32	0	0.03	0	0	0	0	0	0
4	0	0.01	0.13	0	0	0.86	0	0	0	0	0	0.01
5	0	0.77	0.06	0.68	0	0	0	0	0	0	0	0
6	0	0	0	0.62	0.22	0.02	0	0	0	0	0	0
7	1.19	2.2	0	0	1.3	0.78	0	0	0	0	0	0
8	0	1.58	0.04	0.18	0.84	0.41	0	0	0	0.63	0	0.17
9	2.08	0.48	0	1.29	0.77	0.21	0	0	0	0.1	0	0
10	0.06	0.19	0	0	0.49	0	0	0	0	0	0	0
11	0.44	1.47	1.31	0.13	0	0	0	0.02	0.01	0	0.17	0
12	0.66	0	0	0.06	0	0.03	0	0	0	0	0	0
13	0.48	0.02	0	0	0.02	0	0	0	0	0	0	0.13
14	0.01	0.67	0.18	0.02	0.04	2.52	0	0	0	0	0	2.85
15	0.93	0.27	0.18	0	0.01	4.3	0	0	0	0	0	0.05
16	0	0.38	0.19	0	0	0.02	0	0	0	0	0	0.42
17	0	0.83	0.8	0.21	0.02	0	0	0.06	0	0	0.01	0
18	0	0.21	0.01	0.09	0.84	0	0	0.02	0	0	1.05	0
19	0.3	0	0	0.14	1.3	0	0	0	0	0.18	0.02	0
20	0.01	0	0	0	0.31	1.88	0.18	0	0	0.08	0.01	0
21	2.02	0.13	0	0.66	0.79	0	0	0.02	0	0	0	0
22	0	0	0.09	0.09	0	0	0	0	0	0	0	0
23	0	0.14	0	1.36	0.01	0	0	0	0	0	0	0
24	0	0	0	0	0.15	0	0.23	0	0.3	0	0	0
25	0	0.46	0	0	0.21	0	0	0	0	0	0	0
26	0	1.62	0.54	0	0.64	0	0	0	0	0	0	0
27	0	1.56	0	0	2.1	0	0	0	0	0	0.4	0
28	0.27	0	0	0.04	0.03	0	0	0.24	0	0	0.61	0
29	1	0.01	0	0.3	0.04	0	0	0	0	0	0	0
30	1.49	0.32	0	1.16	0	0	0	0	0		0	0
31	0.01		0.19	0.1		0		0	0		0	
MAX	2.08	2.2	1.31	2.32	2.1	4.3	0.68	0.24	0.3	0.63	1.05	2.85
MEAN	0.35	0.5	0.16	0.31	0.34	0.36	0.04	0.01	0.01	0.03	0.07	0.12
MIN	0	0	0	0	0	0	0	0	0	0	0	0
SUM	10.95	14.93	4.79	9.46	10.14	11.06	1.13	0.36	0.31	0.99	2.27	3.63

WY 00-01

Days	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01
1	0	0	0.14	0.17	0	0	0	0	0	0	0	0.06
2	0	0	0.41	0.04	0	0.62	0	0	0	0	0	0
3	0	0	0.11	0	0	1.45	0	0	0	0	0	0
4	0	0	0.68	0.01	0.22	13.72	0	0	0.02	0	0.75	0
5	0	0.15	0.1	0.04	0.92	0	0	0	0	0	0	0.08
6	0	0.24	0	0.56	0.49	1.03	0	0.16	0	0	0	0
7	0	0.38	0	0.01	1.32	0	0	0	0	0	0	0
8	0.14	0.03	0	0	0.67	0	0	0	0	0	0	0
9	0.01	0.05	1.97	0	0	0	0	0	0.24	0	0	0
10	0	0	0	0.05	0.09	0	0	0.01	0	0	0	0
11	0	1.01	0.01	0	0	0	0	0	0	0	0	0
12	0	0.58	0	0	0	0	0	0.03	0	0	0	0
13	0	0	0.48	0.05	0	0	0	0	0	0	0	0.04
14	0	0	0	0	0.14	0	0	0	0	0	0	0
15	0	0	0.01	0	0.9	0	0	0	0	0	0	0
16	0	0.02	0.83	0	0.01	0	0	0	0	0	0	0
17	0	0	1.16	0	2.94	0	0	0	0	0	0	0
18	0	0.22	0.04	0	0.99	0	0	0	0	0	0.84	0
19	0	0	0	0	0.12	0	0	0	0	0	2.9	0
20	0	0.02	0	0	0	0	0.01	0	0.13	0	0.01	0
21	0	0	0.13	0	0	0	0	0	0	0	0.03	0
22	0	0	0	0.12	0	0	0	0	0.22	0	0	0
23	0	0	1.65	0.06	0	0.02	0	0	0	0	0	0
24	0	1.18	0.01	0	0	0.02	0	0	0	0	0	0
25	0	0.18	0	0.01	1.14	0.07	0	0	0	0	0	0
26	0.02	0	0.37	1.28	0.01	0	0	0	0	0	0	0
27	0	0.02	0.05	0.04	0	0	0	0	0	0	0	0
28	0	0.43	0.32	0.01	0	0	0	0.17	0	0	0	0
29	0	0.22	1.61	0	0.01	0	0	0	0		1.2	0
30	0.19	0	1.51	0.19	0	0	0	0	0		0	0.01
31	0		0.11	0.41		0		0	0		0	
MAX	0.19	1.18	1.97	1.28	2.94	13.72	0.01	0.17	0.24	0	2.9	0.08
MEAN	0.01	0.16	0.38	0.1	0.33	0.55	0	0.01	0.02	0	0.19	0.01
MIN	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0.36	4.73	11.7	3.05	9.97	16.93	0.01	0.37	0.61	0	5.73	0.19

WY 01-02

Days	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02
1	0.03	0.16	0	0.7	0.11	0	0	0	0.01	0	0	0
2	0	0.01	0	0.74	0	0	0.09	0.01	0.11	0	0	0
3	0.16	0.04	0.1	0.4	1.57	0	0	0	0	0	0	0.1
4	0.14	0	0.05	0.3	0.46	0	0.27	0	0	0	0.44	0
5	0.01	0.84	0	0	0	0	0.17	0.01	0	0	0	0
6	0	0.92	0	0	0.51	0	0	0.17	0.04	0	0	0
7	0	0.19	0	0	0.91	0	0	0.63	0	0	0.35	0
8	0	0.64	0	0	0.82	0	0	0	0	0	0	0
9	0	0.29	0.76	0.18	2.29	0	0	0.38	0.04	0	0	0
10	0	0.05	0.23	0	0.04	0	0	0.01	0	0	0	0
11	0	0	0	0.07	0.73	0	0	0	0	0	0.01	0.02
12	0	0.02	0.09	0	0.6	0	0	0	0	0	0	0
13	0	0.72	0.03	0.21	0.73	0	0	0	0.01	0.13	0	0
14	0	0.06	0.67	0.01	0.29	0	0	0	0.15	0.01	0	0.26
15	0.01	0	0.15	0	0.08	0.04	0	0	0.22	0	0	0.01
16	0	0	0.08	0	0	0.25	0	0	0	1.39	0	0.84
17	0	0	0	0	0	0.01	0	0	0.23	0	0	0
18	0	0.06	0.18	0	0.02	0	0	0.01	0	0	0	0
19	0	0	0.02	0	0.04	0.02	0	0	0	0	0	0
20	0	0.01	0	0.14	0	0	0	0	0	0	0	0
21	0	0.45	0.45	0	0	0.52	0	0	0	0.01	0	0
22	0.07	0.01	0.09	0.01	0.22	1.92	0	0	0	0.1	0	0
23	5.5	0.74	1.86	0	0.28	0.01	0	0	0.01	0.3	0	0
24	0.01	0.18	0	0	0	0.05	0	0	0	0	0	0
25	0	0	0	0	0	0.95	0	0.35	0	0	0	0
26	0.21	0.67	0	0	0.09	0.02	0	0.25	0	0	0.13	0
27	0.05	0.05	0.13	0	0.31	0	0	0	0	0	0	0
28	0	0.34	0	0.02	1.15	0	0	0	0	0	0	0
29	0.1	0	0	0.01	1.07	0	0	0.05	0		0	0
30	0.1	0	0	0	0	0.01	0	0.01	0		0	0
31	1.28		0.6	0		0		0.55	0		0	
MAX	5.5	0.92	1.86	0.74	2.29	1.92	0.27	0.63	0.23	1.39	0.44	0.84
MEAN	0.25	0.22	0.18	0.09	0.43	0.12	0.02	0.08	0.03	0.07	0.03	0.04
MIN	0	0	0	0	0	0	0	0	0	0	0	0
SUM	7.67	6.45	5.49	2.79	12.82	3.8	0.53	2.43	0.82	1.94	0.93	1.23

Table B-2. Rainfall at ROTNWX (inches), WY 98-99 to WY 01-02

WY 98-99

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sep-98	Oct-98	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	0.05	0	0.39	0	0.24	0	0	0	0	0.09	0	0.01
2	0	0	0	0	0.06	0	0	0	0.27	0.01	0	0.01
3	0	0	0	2.71	0	0	0	0	0.41	0	0.47	0
4	0.01	0	0	0	0	0.03	4.6	0	0.06	0	0.23	0
5	0.01	0	0	0	0	0	3.01	0.03	0.01	0	0	0
6	0.01	0	0.04	1.13	0	0.17	0	0	0	0	0	0
7	0	0.11	0.5	0	0	0	0	0	0	0	0	0
8	0	0.24	0.82	0.02	0	0	0	0	0	0.01	0	0
9	0	0	0	0.01	0.14	0	0	0	0.01	0	0	0
10	0.01	0	0.11	0.24	0.03	1.21	0	0	0.15	0.24	0	0
11	0	0	0.02	0.03	0	0.01	0	0.47	0	0	0.06	0
12	0	0	0	0	0	1.22	0	0.21	0	0.12	0	0
13	0	0	0.14	0	0	0	0	0.02	0	0	0	0
14	0	0	0.17	1.79	0	0	0	0.1	0	0	0.05	0
15	0	0	0.41	0	0.13	0	0	0	0.01	0	0.09	0
16	0	0	0.02	0	0.23	0.01	0	0	0	0	0	0
17	0	0	0	0.94	1.47	0	0	0	0	0	0	0.03
18	0	0	0.08	5.1	0.07	0.01	0	0	0	0.21	0	0.03
19	0.01	0	0.77	0.02	0.09	0.11	0.01	0	0	0	0	0
20	0	0	0.64	0	0.92	0	0	0	0	0	0	0
21	0	0.49	0.94	0.36	0	0.27	0.01	0	0	0	0	0
22	0	3.41	0.29	0.02	0	0	0	0.01	0.01	0.04	0	0
23	0	0.27	0	0.04	0	0	0	0.01	0	0	0	0
24	0	0.58	0	0	0	0	0.27	0	0.68	0	0	0
25	0	0.12	0	0.12	0	0	0	0	0	0	0	0
26	0	0	0.08	0	0.27	0	0	0.01		0	0	0.04
27	0	0	0	0	0	0	0.01	0	0	0	0	0.24
28	0.87	0	0	0	0.09	0	0	0.04	0	0	0	0.13
29	0.43	0	0	0	0	0	0	0	0		0	0.02
30	0.05	2.06	0.34	0	0	0	0	0	0		0	0.01
31	0.04		0.05	0		0		0	0		0	
MAX	0.87	3.41	0.94	5.1	1.47	1.22	4.6	0.47	0.68	0.24	0.47	0.24
MEAN	0.05	0.24	0.19	0.4	0.13	0.1	0.26	0.03	0.05	0.03	0.03	0.02
MIN	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1.49	7.28	5.82	12.53	3.74	3.04	7.91	0.9	1.61	0.72	0.9	0.52

WY 99-00

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	0	0.03	0.03	N	0	0	0	0	0	0	0	0
2	0	0.72	0.48	N	0	0	0.21	0	0	0	0	0
3	0	1.34	0.09	N	0	0.04	0	0	0	0.08	0	0
4	0	0.04	0.08	N	0	0.32	0	0	0	0	0	0
5	0	0.23	0.24	N	0	0.01	0	0	0	0	0	0
6	0	0	0	N	0	0.02	0	0	0	0	0	0
7	1.05	0.27	0	N	0.5	0	0	0	0.25	0	0	0
8	0	0.54	0.05	N	0.48	0.14	0	0	0	0.6	0	0.07
9	0.76	0.18	0	N	0.56	0.07	0	0	0	0.11	0	0
10	0.06	1.4	0	N	0	0	0	0	0	0	0	0
11	0.06	0.98	1.16	N	0	0	0	0	0	0	0.27	0
12	0.45	0	0.01	N	0	0.07	0	0	0	0	0	0
13	1.15	0	0	N	0	0.02	0	0	0	0	0	0.11
14	0.01	0.14	0.17	N	0	0.06	0	0	0	0	0	3.23
15	0.46	0.25	0.23	N	0	0.43	0	0	0	0	0	0.16
16	0	0.27	0.01	N	0	0.01	0	0	0	0	0.01	0.1
17	0	0.13	0.3	N	0.01	0	0	0	0	0	0	0
18	0	0.33	0.03	N	0.89	0	0	0	0	0	2.78	0
19	0.18	0.04	0.01	N	0	0	0	0	0	0.35	0.04	0
20	0	0.01	0	N	0.28	0.05	0	0	0	0.26	0.22	0
21	0.28	0.24	0	N	0.01	0	0	0	0	0	0	0
22	0	0.01	0.07	N	0	0	0	0	0	0	0	0
23	0	0.09	0.01	N	0.03	0	0	0	0	0	0	0
24	0	0	0	N	0.04	0	0	0	0.3	0	0	0
25	0	0.2	0	N	0.08	0	0	0	0	0.01	0	0
26	0	0.46	0.28	0	0.68	0	0	0	0	0	0	0
27	0	0.97	0	0.01	0.01	0	0	0	0	0	0.16	0
28	0.02	0	0.36	0.08	0	0	0	0	0	0	0.56	0
29	2.23	0.2	0	0.01	0.05	0	0	0	0	0	0	0
30	0.13	0.25	0	0	0	0	0	0	0		0	0
31	0		0	0		0.01		0	0		0	
MAX	2.23	1.4	1.16	0.08	0.89	0.43	0.21	0	0.3	0.6	2.78	3.23
MEAN	0.22	0.31	0.12	0.02	0.12	0.04	0.01	0	0.02	0.05	0.13	0.12
MIN	0	0	0	0	0	0	0	0	0	0	0	0
SUM	6.84	9.32	3.61	0.1	3.62	1.25	0.21	0	0.55	1.41	4.04	3.67

WY 00-01

Day	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01
1	0	0	0.05	0.13	0	0	0	0	0	0	0	0.1
2	0	0	0.59	0.09	0	0.14	0	0	0	0	0	0
3	0	0	0.04	0	0.05	2.16	0	0	0	0.03	0	0
4	0	0	0.4	0	0.36	11.87	0	0	0.02	0	0.22	0
5	0	0.11	0.04	0	1.17	0	0	0	0	0	0.01	0.05
6	0	1.22	0	0.11	0.07	0.47	0	0.24	0	0	0	0
7	0	0.17	0	0	0.83	0	0	0	0	0	0	0
8	0.08	1.65	0.05	0	1.04	0	0	0	0	0	0	0
9	0	0.03	2	0	0	0	0	0	0.1	0	0	0
10	0	0	0	0.07	0.25	0	0	0.01	0	0	0.15	0
11	0	0.92	0.1	0	0	0	0	0	0	0	0	0
12	0	0.37	0.04	0	0	0	0	0	0	0	0	0
13	0	0	0.04	0.03	0.9	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0.13	0	0	0.07	0.37	0	0	0	0	0	0	0
16	0	0.09	1.7	0	0	0	0	0	0	0	0	0
17	0	0	0.51	0	2.75	0	0	0.01	0	0	0	0
18	0	0.28	0.31	0	0.21	0	0	0	0	0	0.3	0
19	0	0	0	0	0.15	0	0	0	0.01	0	1.58	0
20	0	0.15	0	0	0	0	0	0	0.1	0	0.01	0
21	0	0	0	0	0	0	N	0	0	0	0.01	0
22	0	0	0	0.04	0	0	N	0	0.26	0	0	0
23	0	0	0	0.05	0	0	N	0	0	0	0	0
24	0	0.68	0	0	0	0.04	N	0	0	0	0	0
25	0	0.23	0	0	0.1	0.01	N	0	0	0	0	0
26	0	0	0	2.83	0.3	0	0	0	0	0	0	0
27	0	0.04	0.01	0.26	0	0	0	0	0	0	0	0
28	0	0.84	0.66	0	0.02	0	0	0.05	0	0	0	0
29	0	0.92	0.56	0	0.13	0	0	0	0		1.03	0
30	0.88	0.06	1.99	0.99	0.01	0	0	0	0		0.01	0
31	0		0.01	0.56		0.01		0	0		0	
MAX	0.88	1.65	2	2.83	2.75	11.87	0	0.24	0.26	0.03	1.58	0.1
MEAN	0.04	0.26	0.29	0.17	0.29	0.47	0	0.01	0.02	0	0.11	0.01
MIN	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1.09	7.76	9.1	5.23	8.71	14.7	0	0.31	0.49	0.03	3.32	0.15

WY 01-02

Day	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02
1	0.01	0.23	0	0.65	0	0	0	0	0	0	0	0
2	0	0.01	0.19	0.64	0	0	0.17	0.02	0.11	0	0	0
3	0.21	0.01	0.04	0.35	0.73	0	0	0	0	0	0	0.08
4	0.08	0	0.07	0.1	0.01	0	0.28	0	0	0	0.1	0
5	0	0.72	0.01	0.12	0	0	0.18	0	0	0	0	0
6	0	0.83	0	0	0.32	0	0	0.16	0.07	0	0	0
7	0	0.03	0.08	0	0.54	0	0	0.09	0	0	0.12	0
8	0	0.44	0	1.17	0.78	0.07	0	0	0	0	0.01	0
9	0	0.28	1.67	0	2.77	0.01	0	0.05	0	1.46	0	0
10	0	0	0.34	0.09	0.24	0	0	0	0	0.4	0	0
11	0	0	0.02	0.24	0.93	0	0	0	0	0	0	0.01
12	0	0.03	0.03	0	0	0	0	0	0	0	0	0
13	0	0.22	0.02	0.01		0	0	0	0	0.14	0	0
14	0	0.72	1.1	0		0	0	0	0.04	0.02	0	0.17
15	0.08	0	0.16	0		0	0	0	0.08	0.03	0	0.01
16	0		0.01	0		0.41	0	0	0	2.04	0	0.06
17	0		0.03	0		0	0	0	0.09	0	0	0.03
18	0		0.08	0	0.07	0	0	0	0.01	0	0	0
19	0.01	0	0.02	0	0	0.09	0	0	0	0	0	0
20	0	0	0.62	1.95	0	0.01	0	0	0	0	0	0
21	0	0.08	0.38	0.01	0	0.56	0	0	0	0.01	0	0
22	0.05	0	0.1	0.25	0.68	0.5	0	0	0	0.13	0	0
23	2.43	0.35	1.89	0	0.28	0	0	0	0	0.39	0	0
24	0	0	0	0	0.38	0	0	0	0	0	0	0
25	0	0	0	0	0	0.74	0	0.38	0	0	0	0
26	0.02	0.68	0.02	0	0.03	0.18	0	0.22	0	0	0.17	0
27	0.21	0.5	0.24	0	0.22	0	0	0	0	0	0.01	0
28	0	0.14	0	0.01	1.28	0	0	0	0	0	0	0
29	0	0	0	0.13	2.77	0	0	0.02	0		0	0
30	0.05	0.01	0	0	0	0.02	0	0	0		0	0
31	0.81		1.22	0		0		0.73	0		0	
MAX	2.43	0.83	1.89	1.95	2.77	0.74	0.28	0.73	0.11	2.04	0.17	0.17
MEAN	0.13	0.20	0.27	0.18	0.48	0.08	0.02	0.05	0.01	0.17	0.01	0.01
MIN	0	0	0	0	0	0	0	0	0	0	0	0
SUM	3.96	5.28	8.34	5.72	12.03	2.59	0.63	1.67	0.4	4.62	0.41	0.36

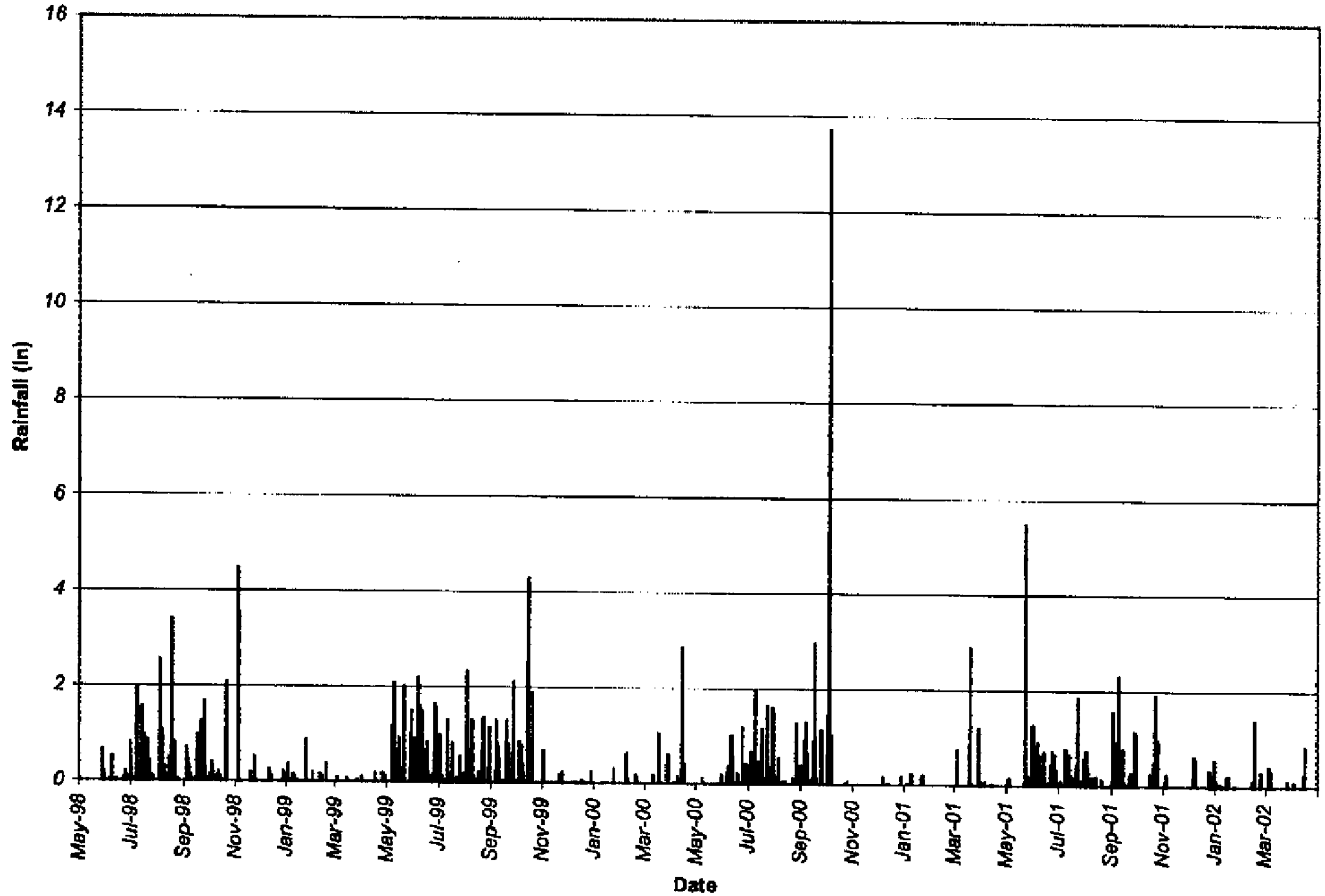

Figure B-1. Rainfall in inches at G600_R, WY 98-99 to WY 01-02

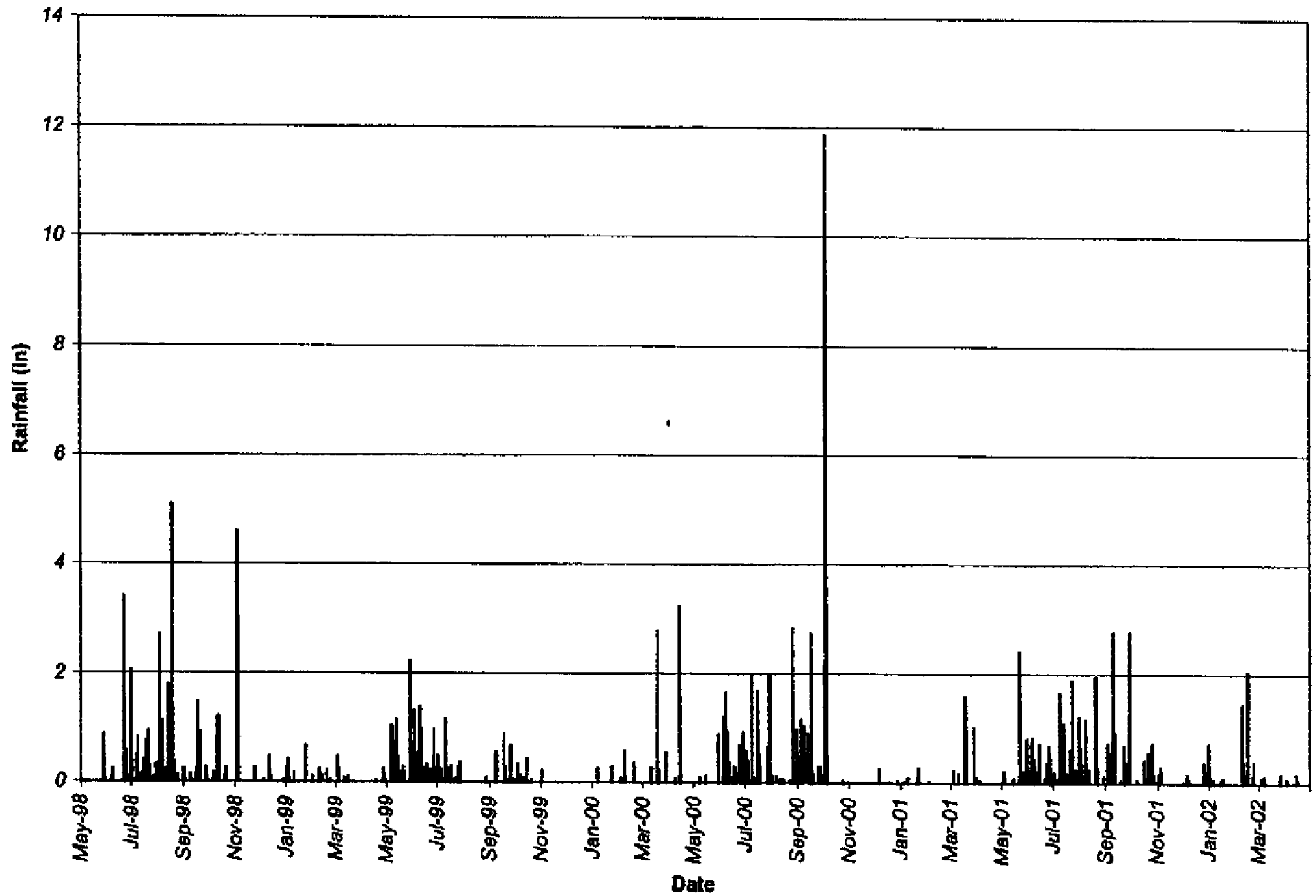

Figure B-2. Rainfall in inches at ROTNWX, WY 98-99 to WY 01-02

Appendix C – Evapotranspiration Data

Table C-1. ENRP evapotranspiration (inches), WY 98-99 to WY 99-00

WY 98-99

Day	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99	Apr-99
1	0.15	0.19	0.24	0.19	0.20	0.18	0.16	0.10	0.10	0.05	0.15	0.15
2	0.23	0.22	0.25	0.16	0.20	0.18	0.11	0.12	0.07	0.09	0.15	0.17
3	0.26	0.22	0.25	0.25	0.23	0.18	0.08	0.10	0.07	0.13	0.05	0.19
4	0.24	0.25	0.21	0.23	0.19	0.14	0.01	0.12	0.03	0.14	0.18	0.18
5	0.22	0.26	0.18	0.25	0.06	0.16	0.03	0.02	0.09	0.13	0.17	0.18
6	0.22	0.26	0.23	0.08	0.20	0.12	0.09	0.11	0.12	0.13	0.13	0.15
7	0.20	0.28	0.17	0.16	0.06	0.18	0.12	0.13	0.10	0.09	0.15	0.19
8	0.23	0.18	0.21	0.17	0.18	0.16	0.14	0.07	0.08	0.09	0.15	0.18
9	0.22	0.22	0.25	0.18	0.16	0.15	0.16	0.10	0.11	0.09	0.16	0.18
10	0.24	0.20	0.19	0.18	0.09	0.12	0.15	0.11	0.03	0.08	0.13	0.20
11	0.28	0.21	0.18	0.25	0.13	0.16	0.17	0.04	0.11	0.11	0.17	0.18
12	0.25	0.24	0.19	0.22	0.14	0.12	0.17	0.03	0.09	0.09	0.16	0.15
13	0.25	0.24	0.22	0.22	0.18	0.12	0.18	0.09	0.08	0.07	0.12	0.20
14	0.23	0.23	0.11	0.26	0.20	0.09	0.11	0.07	0.08	0.12	0.12	0.18
15	0.26	0.27	0.10	0.24	0.06	0.17	0.15	0.09	0.08	0.08	0.09	0.18
16	0.26	0.28	0.21	0.23	0.04	0.16	0.09	0.11	0.11	0.07	0.17	0.16
17	0.25	0.26	0.19	0.21	0.07	0.17	0.10	0.12	0.10	0.10	0.16	0.08
18	0.23	0.23	0.20	0.22	0.08	0.15	0.10	0.11	0.10	0.13	0.15	0.13
19	0.20	0.25	0.12	0.21	0.11	0.08	0.07	0.08	0.11	0.12	0.18	0.18
20	0.22	0.22	0.12	0.10	0.10	0.14	0.11	0.12	0.10	0.14	0.12	0.21
21	0.25	0.24	0.14	0.13	0.17	0.11	0.14	0.11	0.12	0.13	0.15	0.21
22	0.26	0.19	0.20	0.18	0.17	0.10	0.12	0.11	0.12	0.15	0.19	0.17
23	0.26	0.22	0.22	0.21	0.15	0.15	0.11	0.10	0.12	0.08	0.15	0.17
24	0.21	0.18	0.23	0.23	0.15	0.13	0.06	0.10	0.07	0.15	0.17	0.20
25	0.20	0.23	0.24	0.24	0.06	0.15	0.14	0.11	0.12	0.13	0.17	0.16
26	0.16	0.14	0.18	0.20	0.11	0.15	0.14	0.08	0.13	0.15	0.13	0.19
27	0.18	0.27	0.23	0.13	0.18	0.15	0.14	0.11	0.13	0.15	0.19	0.10
28	0.07	0.23	0.24	0.20	0.18	0.16	0.14	0.05	0.13	0.13	0.15	0.08
29	0.11	0.18	0.24	0.21	0.17	0.14	0.11	0.12	0.10		0.13	0.16
30	0.17	0.26	0.25	0.22	0.17	0.14	0.11	0.13	0.13		0.15	0.19
31	0.17		0.16	0.23		0.15		0.12	0.04		0.11	
MAX	0.28	0.28	0.25	0.26	0.23	0.18	0.18	0.13	0.13	0.15	0.19	0.21
MEAN	0.22	0.23	0.20	0.20	0.14	0.14	0.12	0.10	0.10	0.11	0.15	0.17
MIN	0.07	0.14	0.10	0.08	0.04	0.08	0.01	0.02	0.03	0.05	0.05	0.08
SUM	6.70	6.83	6.17	6.22	4.20	4.30	3.51	3.01	2.98	3.09	4.57	5.08

WY 99-00

Day	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00
1	0.18	0.10	0.10	0.23	0.20							
2	0.23	0.09	0.10	0.14	0.17							
3	0.18	0.14	0.11	0.16	0.23							
4	0.21	0.19	0.12	0.14	0.21							
5	0.16	0.18	0.19	0.15	0.19							
6	0.22	0.21	0.22	0.16	0.16							
7	0.22	0.03	0.19	0.16	0.07							
8	0.16	0.05	0.16	0.19	0.14							
9	0.16	0.16	0.17	0.12	0.11							
10	0.21	0.15	0.18	0.16	0.16							
11	0.13	0.15	0.13	0.20	0.19							
12	0.09	0.10	0.20	0.16	0.14							
13	0.21	0.19	0.20	0.10	0.15							
14	0.19	0.19	0.17	0.06	0.13							
15	0.07	0.13	0.18	0.18	0.13							
16	0.16	0.10	0.18	0.17	0.20							
17	0.18	0.14	0.19	0.14	0.10							
18	0.17	0.08	0.21	0.06	0.10							
19	0.19	0.08	0.19	0.10	0.09							
20	0.11	0.14	0.16	0.17	0.05							
21	0.17	0.23	0.19	0.12	0.09							
22	0.17	0.18	0.16	0.14	0.18							
23	0.23	0.16	0.19	0.12	0.16							
24	0.17	0.16	0.21	0.08	0.10							
25	0.20	0.13	0.21	0.20	0.04							
26	0.21	0.15	0.16	0.19	0.07							
27	0.22	0.15	0.18	0.21	0.11							
28	0.21	0.13	0.16	0.19	0.17							
29	0.13	0.13	0.21	0.21	0.15							
30	0.12	0.11	0.19	0.21	0.17							
31	0.17		0.20	0.11								
MAX	0.23	0.23	0.22	0.23	0.23							
MEAN	0.17	0.14	0.17	0.15	0.14							
MIN	0.07	0.03	0.10	0.06	0.04							
SUM	5.41	4.13	5.36	4.73	4.15							

Table C - 2. STA 1W evapotranspiration (inches), WY 99-00 to WY 00-01

WY 99-00

Day	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00
1						0.13	0.14	0.11	0.11	0.10	0.17	0.18
2						0.18	0.10	0.12	0.11	0.05	0.14	0.18
3						0.08	0.17	0.08	0.11	0.08	0.12	0.21
4						0.07	0.13	0.06	0.11	0.12	0.14	0.18
5						0.10	0.13	0.05	0.12	0.16	0.18	0.24
6						0.08	0.11	0.08	0.13	0.13	0.14	0.19
7						0.10	0.13	0.09	0.09	0.11	0.14	0.21
8						0.11	0.13	0.10	0.12	0.03	0.15	0.19
9						0.13	0.14	0.10	0.11	0.16	0.19	0.24
10						0.18	0.13	0.05	0.12	0.17	0.17	0.21
11						0.16	0.10	0.08	0.08	0.16	0.11	0.20
12						0.12	0.15	0.05	0.14	0.14	0.15	0.10
13						0.16	0.13	0.10	0.14	0.13	0.19	0.07
14						0.04	0.14	0.04	0.13	0.15	0.17	0.02
15						0.01	0.15	0.05	0.07	0.17	0.15	0.13
16						0.10	0.14	0.05	0.09	0.17	0.17	0.20
17						0.13	0.09	0.09	0.14	0.17	0.18	0.18
18						0.16	0.10	0.08	0.14	0.14	0.08	0.21
19						0.16	0.10	0.12	0.09	0.13	0.03	0.24
20						0.13	0.10	0.07	0.12	0.15	0.18	0.18
21						0.13	0.09	0.05	0.15	0.18	0.21	0.21
22						0.11	0.07	0.10	0.14	0.14	0.20	0.22
23						0.18	0.05	0.07	0.13	0.13	0.19	0.23
24						0.18	0.04	0.11	0.06	0.15	0.15	0.21
25						0.15	0.05	0.14	0.10	0.13	0.20	0.17
26						0.07	0.07	0.12	0.15	0.13	0.15	0.24
27						0.15	0.11	0.13	0.15	0.13	0.11	0.22
28						0.14	0.10	0.04	0.11	0.14	0.21	0.24
29						0.13	0.10	0.13	0.11	0.17	0.18	0.15
30						0.13	0.10	0.13	0.13		0.19	0.21
31						0.12		0.13	0.10		0.17	
MAX						0.18	0.17	0.14	0.15	0.18	0.21	0.24
MEAN						0.12	0.11	0.09	0.12	0.14	0.16	0.19
MIN						0.01	0.04	0.04	0.06	0.03	0.03	0.02
SUM						3.82	3.30	2.74	3.59	3.94	4.92	5.61

WY 00-01

Day	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01
1	0.23	0.22	0.10	0.18	0.21	0.15	0.16	0.12	0.14	0.15	0.16	0.23
2	0.21	0.24	0.18	0.08	0.21	0.07	0.14	0.09	0.13	0.13	0.14	0.24
3	0.11	0.23	0.13	0.13	0.15	0.03	0.15	0.11	0.13	0.10	0.15	0.24
4	0.22	0.18	0.10	0.21	0.17	0.06	0.13	0.11	0.15	0.12	0.14	0.20
5	0.24	0.24	0.21	0.13	0.12	0.15	0.15	0.09	0.13	0.09	0.18	0.18
6	0.21	0.21	0.24	0.13	0.11	0.13	0.14	0.10	0.14	0.15	0.21	0.17
7	0.21	0.19	0.21	0.18	0.10	0.17	0.15	0.12	0.14	0.15	0.21	0.16
8	0.13	0.08	0.13	0.21	0.14	0.15	0.15	0.13	0.13	0.15	0.20	0.21
9	0.23	0.18	0.19	0.18	0.12	0.07	0.14	0.11	0.14	0.13	0.20	0.21
10	0.24	0.21	0.17	0.22	0.16	0.15	0.10	0.06	0.14	0.14	0.08	0.21
11	0.23	0.12	0.17	0.20	0.18	0.15	0.15	0.09	0.12	0.10	0.15	0.18
12	0.24	0.23	0.15	0.15	0.19	0.16	0.14	0.10	0.10	0.15	0.17	0.19
13	0.20	0.18	0.18	0.15	0.19	0.18	0.14	0.10	0.13	0.14	0.18	0.18
14	0.24	0.20	0.22	0.18	0.20	0.14	0.10	0.11	0.10	0.15	0.14	0.23
15	0.21	0.21	0.21	0.19	0.14	0.16	0.15	0.10	0.11	0.15	0.13	0.18
16	0.23	0.25	0.23	0.21	0.07	0.17	0.15	0.09	0.14	0.14	0.13	0.21
17	0.15	0.23	0.17	0.18	0.05	0.18	0.14	0.10	0.12	0.13	0.11	0.23
18	0.22	0.21	0.18	0.15	0.14	0.16	0.12	0.11	0.11	0.13	0.09	0.23
19	0.21	0.15	0.19	0.17	0.16	0.16	0.13	0.11	0.14	0.14	0.02	0.19
20	0.25	0.23	0.23	0.15	0.16	0.14	0.04	0.14	0.04	0.12	0.21	0.19
21	0.25	0.15	0.20	0.14	0.15	0.10	0.14	0.11	0.15	0.15	0.15	0.18
22	0.21	0.19	0.16	0.15	0.14	0.15	0.15	0.13	0.01	0.15	0.21	0.20
23	0.19	0.22	0.10	0.16	0.16	0.12	0.12	0.09	0.13	0.13	0.22	0.18
24	0.20	0.16	0.13	0.18	0.18	0.12	0.10	0.04	0.15	0.16	0.21	0.21
25	0.23	0.07	0.13	0.18	0.20	0.18	0.04	0.08	0.15	0.14	0.21	0.20
26	0.23	0.18	0.10	0.15	0.16	0.16	0.07	0.09	0.13	0.15	0.19	0.17
27	0.17	0.09	0.15	0.16	0.15	0.15	0.10	0.10	0.10	0.16	0.16	0.21
28	0.22	0.15	0.16	0.16	0.09	0.15	0.13	0.09	0.13	0.15	0.16	0.16
29	0.24	0.12	0.17	0.16	0.10	0.14	0.07	0.08	0.14		0.15	0.05
30	0.19	0.18	0.10	0.13	0.14	0.13	0.14	0.13	0.07		0.07	0.07
31	0.21		0.22	0.10		0.13		0.14	0.15		0.18	
MAX	0.25	0.25	0.24	0.22	0.21	0.18	0.16	0.14	0.15	0.16	0.22	0.24
MEAN	0.21	0.18	0.17	0.16	0.15	0.14	0.12	0.10	0.12	0.14	0.16	0.19
MIN	0.11	0.07	0.10	0.08	0.05	0.03	0.04	0.04	0.01	0.09	0.02	0.05
SUM	6.53	5.50	5.19	5.08	4.43	4.27	3.69	3.17	3.75	3.85	4.90	5.68

Table C - 3. ROTNWX evapotranspiration (inches), WY 01-02

WY 01-02

Day	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02
1	0.13	0.20	0.20	0.06	0.16	0.19	0.13	0.10	0.12	0.12	0.07	0.14
2	0.18	0.17	0.21	0.06	0.22	0.19	0.09	0.08	0.02	0.10	0.14	0.15
3	0.12	0.15	0.20	0.07	0.15	0.19	0.13	0.10	0.06	0.09	0.13	0.15
4	0.14	0.16	0.12	0.15	0.13	0.15	0.04	0.10	0.14	0.14	0.07	0.23
5	0.22	0.13	0.23	0.17	0.13	0.14	0.05	0.11	0.08	0.13	0.13	0.21
6	0.23	0.12	0.21	0.15	0.13	0.18	0.15	0.08	0.07	0.12	0.05	0.20
7	0.23	0.11	0.17	0.15	0.10	0.17	0.12	0.09	0.09	0.12	0.05	0.18
8	0.17	0.22	0.19	0.16	0.08	0.14	0.13	0.12	0.13	0.13	0.19	0.20
9	0.24	0.22	0.07	0.19	0.07	0.08	0.15	0.06	0.12	0.08	0.18	0.19
10	0.19	0.22	0.13	0.14	0.12	0.17	0.14	0.11	0.12	0.10	0.19	0.19
11	0.25	0.23	0.19	0.15	0.10	0.15	0.11	0.12	0.13	0.10	0.15	0.10
12	0.24	0.23	0.22	0.18	0.08	0.14	0.13	0.11	0.11	0.15	0.19	0.17
13	0.25	0.18	0.16	0.17	0.08	0.15	0.15	0.11	0.08	0.14	0.18	0.18
14	0.22	0.19	0.10	0.17	0.12	0.09	0.08	0.12	0.05	0.08	0.18	0.13
15	0.15	0.21	0.15	0.19	0.16	0.16	0.05	0.10	0.04	0.11	0.19	0.17
16	0.24	0.22	0.20	0.21	0.18	0.13	0.12	0.11	0.10	0.02	0.18	0.15
17	0.25	0.18	0.14	0.19	0.18	0.11	0.13	0.09	0.11	0.17	0.22	0.16
18	0.24	0.18	0.16	0.20	0.19	0.07	0.12	0.08	0.10	0.16	0.17	0.19
19	0.23	0.21	0.20	0.19	0.18	0.12	0.12	0.13	0.11	0.12	0.20	0.19
20	0.20	0.13	0.16	0.17	0.18	0.08	0.13	0.12	0.13	0.13	0.20	0.19
21	0.19	0.15	0.12	0.11	0.17	0.05	0.13	0.12	0.13	0.11	0.20	0.23
22	0.17	0.13	0.11	0.14	0.16	0.05	0.12	0.11	0.11	0.11	0.14	0.23
23	0.08	0.13	0.03	0.23	0.18	0.12	0.11	0.09	0.12	0.04	0.18	0.22
24	0.21	0.20	0.20	0.23	0.16	0.12	0.10	0.08	0.14	0.18	0.20	0.19
25	0.08	0.17	0.19	0.23	0.19	0.10	0.12	0.07	0.12	0.16	0.20	0.22
26	0.11	0.18	0.20	0.21	0.09	0.09	0.13	0.10	0.13	0.17	0.16	0.23
27	0.12	0.11	0.11	0.18	0.03	0.15	0.13	0.06	0.12	0.14	0.20	0.23
28	0.09	0.11	0.21	0.19	0.04	0.13	0.13	0.11	0.12	0.08	0.17	0.24
29	0.15	0.18	0.18	0.11	0.07	0.10	0.13	0.06	0.10		0.19	0.17
30	0.16	0.22	0.21	0.15	0.15	0.09	0.13	0.07	0.13		0.21	0.18
31	0.15		0.13	0.18		0.10		0.02	0.13		0.21	
MAX	0.25	0.23	0.23	0.23	0.22	0.19	0.15	0.13	0.14	0.18	0.22	0.24
MEAN	0.18	0.17	0.16	0.16	0.13	0.13	0.12	0.09	0.10	0.12	0.17	0.19
MIN	0.08	0.11	0.03	0.06	0.03	0.05	0.04	0.02	0.02	0.02	0.05	0.10
SUM	5.61	5.23	5.10	5.06	3.97	3.88	3.49	2.93	3.25	3.30	5.13	5.61

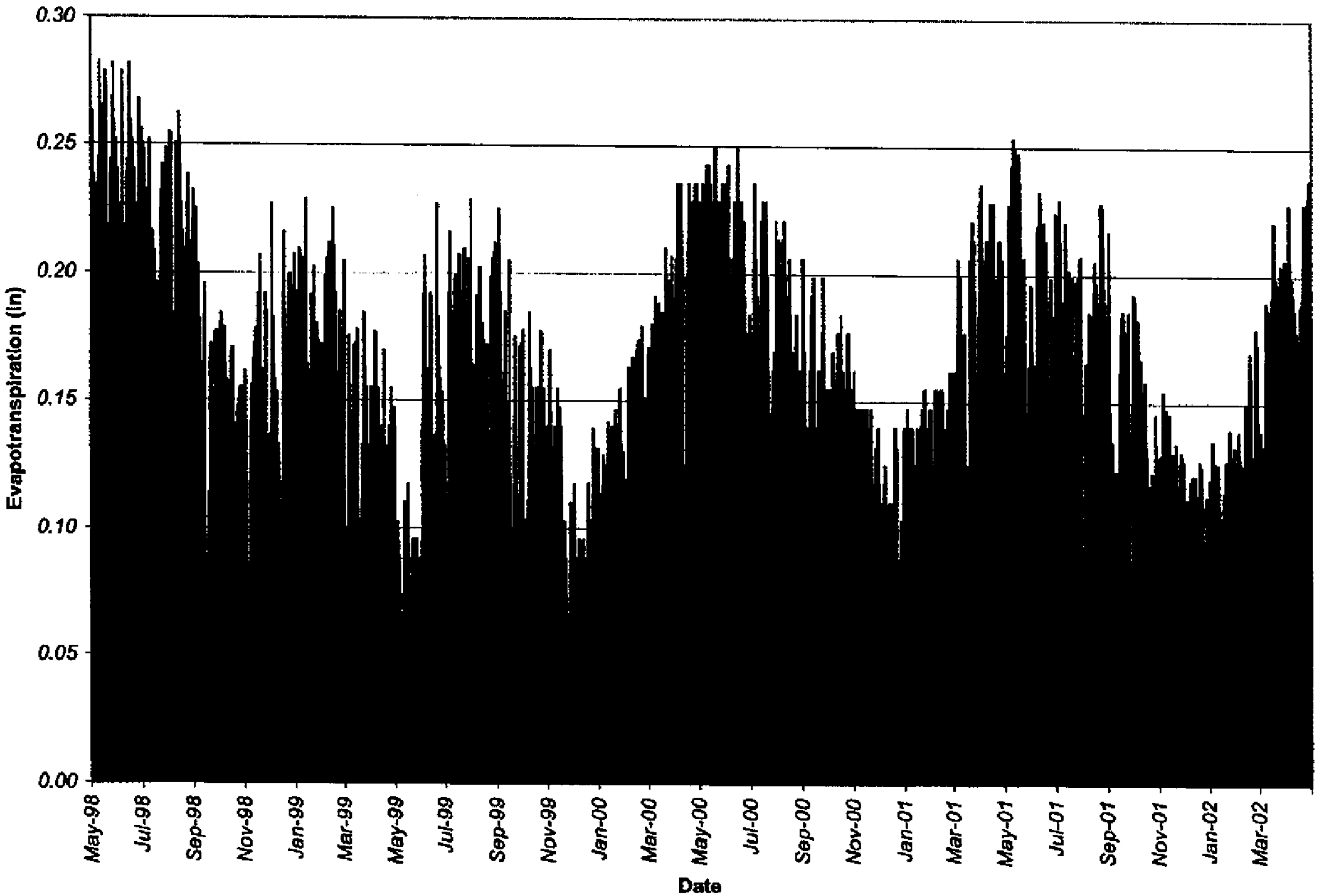

Figure C-1. Evapotranspiration (inches) at ENR, STA 1W and ROTNWX, WY 98-99 to WY 01-02

Appendix D – Stage Data and Soil Moisture Equations

Table D-1. Cell 3 daily average stage

Day	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99	Apr-99
1	13.21	11.60	12.25	13.77	13.89	14.36	13.56	13.75	13.89	13.89	13.61	11.36
2	13.12	11.58	12.26	13.72	13.83	14.35	13.51	13.72	14.00	13.96	13.57	11.37
3	13.01	11.50	12.12	13.73	13.78	14.14	13.48	13.68	14.08	13.91	13.54	11.33
4	12.90	11.40	11.99	14.02	13.76	13.98	13.60	13.65	14.09	13.84	13.51	11.30
5	12.82	11.35	11.87	14.35	13.96	13.88	14.56	13.61	14.02	13.78	13.48	11.30
6	12.77	11.34	11.79	14.44	14.18	13.88	14.99	13.58	14.03	13.73	13.45	11.30
7	12.68	11.30	11.76	14.60	14.27	13.90	15.21	13.75	13.93	13.68	13.41	11.28
8	12.57	11.28	12.23	14.75	14.25	13.92	15.21	13.85	13.85	13.65	13.37	11.26
9	12.49	11.34	12.81	14.68	14.25	13.90	15.13	13.86	13.84	13.71	13.33	11.25
10	12.35	11.30	12.53	14.64	14.18	13.85	15.15	13.79	14.05	13.66	13.28	11.16
11	12.14	11.19	12.62	14.60	14.01	13.85	15.14	13.76	14.10	13.68	13.20	11.14
12	11.95	11.14	12.76	14.57	13.90	13.80	15.03	13.92	14.06	13.68	13.09	11.12
13	11.83	11.10	12.68	14.47	13.82	13.78	14.84	14.03	13.95	13.88	12.98	11.12
14	11.80	11.08	12.92	14.39	13.76	13.73	14.66	14.16	14.03	13.90	12.88	11.13
15	11.79	11.04	13.54	14.39	13.71	13.81	14.56	14.14	14.08	13.95	12.79	11.17
16	11.74	11.02	13.96	14.31	13.71	13.75	14.50	14.15	14.10	13.88	12.72	11.18
17	11.72	10.96	14.25	14.21	13.72	13.71	14.46	14.09	14.09	13.84	12.65	11.25
18	11.70	10.97	14.25	14.27	13.86	13.67	14.41	13.96	13.97	13.98	12.58	11.31
19	11.62	10.93	14.07	14.56	14.04	13.64	14.43	14.01	13.88	14.04	12.52	11.31
20	11.55	10.85	14.09	14.78	14.07	13.67	14.36	14.05	13.81	14.07	12.42	11.19
21	11.49	10.86	14.32	14.79	14.12	13.61	14.33	14.02	13.75	14.05	12.23	10.95
22	11.42	11.21	14.39	14.69	14.27	13.78	14.27	13.91	13.70	13.93	11.99	10.83
23	11.39	11.76	14.61	14.67	14.40	13.87	14.23	13.84	13.65	13.85	11.83	10.71
24	11.39	11.79	14.55	14.55	14.46	13.79	14.25	13.79	13.71	13.80	11.71	10.88
25	11.36	12.09	14.42	14.42	14.57	13.76	14.27	13.75	13.79	13.75	11.65	10.95
26	11.31	12.60	14.27	14.23	14.75	13.79	14.16	13.74	13.71	13.71	11.57	10.97
27	11.27	12.37	14.10	14.33	14.82	13.74	14.01	13.71	13.71	13.68	11.51	10.94
28	11.36	12.17	14.01	14.34	14.65	13.71	13.93	13.68	13.85	13.64	11.50	11.00
29	11.69	11.92	13.97	14.33	14.57	13.67	13.86	13.71	13.77		11.46	11.11
30	11.68	12.00	13.90	14.13	14.51	13.63	13.80	13.92	13.78		11.40	11.02
31	11.62		13.83	13.98		13.60		13.93	13.79		11.38	

Table D-1. Cell 3 daily average stage – continued

Day	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00
1	10.81	12.84	14.63	13.96	14.29	15.09	14.52	13.99	13.51	13.41	13.41	11.46
2	10.78	13.17	14.64	13.90	14.25	14.98	14.53	14.00	13.47	13.39	13.46	11.43
3	10.79	13.79	14.63	13.91	14.24	14.92	14.59	13.97	13.42	13.38	13.54	11.39
4	10.82	14.13	14.61	14.08	14.20	14.89	14.59	13.99	13.37	13.37	13.40	11.32
5	10.93	14.40	14.58	14.25	14.16	14.94	14.50	14.04	13.31	13.34	13.30	11.27
6	10.87	14.49	14.51	14.25	14.08	14.92	14.47	14.00	13.25	13.30	13.21	11.26
7	10.79	14.45	14.43	14.44	14.14	14.91	14.41	13.91	13.21	13.25	13.22	11.24
8	10.77	14.57	14.35	14.37	14.20	14.85	14.35	13.85	13.18	13.22	13.14	11.25
9	10.69	14.62	14.31	14.30	14.30	14.89	14.38	13.80	13.18	13.32	13.04	11.27
10	10.80	14.64	14.16	14.33	14.38	14.88	14.34	13.76	13.15	13.47	12.94	11.27
11	10.66	14.67	14.13	14.29	14.43	14.89	14.28	13.73	13.12	13.36	12.87	11.27
12	10.60	14.79	14.24	14.26	14.33	14.80	14.25	13.69	13.08	13.34	12.82	11.20
13	10.78	14.85	14.32	14.13	14.35	14.73	14.27	13.66	13.07	13.32	12.75	11.08
14	11.09	14.76	14.30	14.13	14.44	14.83	14.28	13.81	13.03	13.30	12.66	11.50
15	11.10	14.69	14.28	13.98	14.38	15.08	14.25	13.92	13.39	13.54	12.58	12.73
16	11.31	14.76	14.33	13.99	14.31	15.34	14.24	13.97	13.37	13.57	12.50	13.11
17	11.51	14.77	14.28	14.15	14.27	15.46	14.22	13.95	13.41	13.44	12.35	13.85
18	11.50	14.82	14.29	14.10	14.32	15.57	14.27	13.92	13.54	13.52	12.30	14.11
19	11.35	14.83	14.43	14.02	14.47	15.60	14.26	14.00	13.47	13.59	12.78	14.18
20	11.23	14.74	14.32	14.08	14.56	15.48	14.24	13.97	13.57	13.58	12.75	14.08
21	11.22	14.64	14.10	14.12	14.74	15.24	14.23	13.88	13.58	13.59	12.71	14.02
22	12.24	14.57	13.96	14.19	14.76	15.09	14.23	13.83	13.49	13.53	12.62	13.97
23	12.17	14.50	13.88	14.21	14.78	15.10	14.23	13.79	13.45	13.50	12.46	13.93
24	11.94	14.43	13.81	14.30	14.83	15.10	14.22	13.75	13.56	13.48	12.16	13.89
25	12.04	14.35	13.75	14.36	14.87	14.99	14.12	13.72	13.63	13.51	11.90	13.84
26	12.08	14.44	13.81	14.28	14.97	14.90	14.16	13.68	13.54	13.60	11.73	13.79
27	12.01	14.59	14.19	14.28	15.16	14.78	14.16	13.65	13.52	13.50	11.62	13.74
28	11.89	14.77	14.38	14.24	15.21	14.74	14.10	13.63	13.50	13.47	11.72	13.69
29	11.98	14.72	14.34	14.19	15.20	14.73	14.07	13.60	13.48	13.44	11.66	13.64
30	12.32	14.66	14.13	14.25	15.13	14.62	14.02	13.57	13.46		11.64	13.60
31	12.37		14.01	14.18		14.55		13.54	13.44		11.53	

Table D-1. Cell 3 daily average stage - continued

Day	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01
1	13.55	11.66	13.35	14.72	13.79	14.30	14.40	13.91	13.51	12.07	12.58	14.62
2	13.50	11.70	13.61	14.79	13.74	14.23	14.33	13.88	13.48	12.00	12.37	14.46
3	13.45	11.62	13.86	14.74	13.70	14.41	14.37	13.85	13.45	11.97	12.15	14.29
4	13.40	11.49	14.16	14.73	13.68	15.62	14.39	13.82	13.41	11.93	11.98	14.18
5	13.34	11.40	14.36	14.60	13.68	15.72	14.30	14.13	13.35	11.89	11.97	14.11
6	13.26	11.34	14.25	14.48	13.85	15.75	14.31	14.14	13.30	11.84	11.83	14.21
7	13.22	11.36	14.22	14.63	14.19	15.78	14.25	14.08	13.25	11.79	11.70	14.32
8	13.20	11.43	14.16	14.73	14.46	15.64	14.17	14.17	13.20	11.75	11.59	14.22
9	13.18	11.48	14.30	14.58	14.50	15.57	14.11	14.21	13.17	11.70	11.49	14.14
10	13.16	11.41	14.47	14.54	14.37	15.68	14.26	14.14	13.12	11.66	11.41	14.08
11	13.13	11.48	14.30	14.34	14.36	15.74	14.30	14.09	13.08	11.99	11.34	14.03
12	13.10	11.59	14.18	14.20	14.37	15.75	14.20	14.05	13.03	12.41	11.28	13.99
13	13.03	11.64	14.11	14.12	14.36	15.67	14.13	14.02	12.99	12.45	11.23	13.96
14	12.94	11.62	14.14	14.06	14.42	15.58	14.09	14.00	12.95	12.59	11.17	13.93
15	12.87	11.57	14.28	14.02	14.35	15.27	14.05	13.98	12.91	12.61	11.12	13.89
16	12.80	11.53	14.34	13.98	14.24	15.19	14.15	13.96	12.88	12.50	11.07	13.85
17	12.72	11.39	14.40	13.93	14.36	15.10	14.19	13.94	12.85	12.58	11.01	13.80
18	12.64	11.24	14.38	13.88	14.60	14.93	14.28	13.91	12.82	12.55	11.00	13.75
19	12.53	11.20	14.46	13.83	14.92	14.80	14.23	13.89	12.78	12.59	11.78	13.69
20	12.48	11.15	14.40	13.77	15.07	14.73	14.15	13.85	12.76	12.58	13.43	13.64
21	12.52	11.03	14.25	13.72	15.19	14.61	14.09	13.82	12.74	12.84	14.66	13.59
22	12.50	10.91	14.34	13.67	15.22	14.65	14.05	13.80	12.72	13.17	14.97	13.54
23	12.28	10.87	14.34	13.73	15.04	14.52	14.01	13.77	12.72	13.17	14.95	13.48
24	11.99	10.81	14.46	13.78	14.85	14.56	14.06	13.74	12.68	13.22	14.88	13.41
25	11.80	11.57	14.55	13.69	14.59	14.44	14.03	13.71	12.64	13.17	14.74	13.31
26	11.67	12.45	14.59	13.70	14.38	14.32	14.05	13.68	12.59	13.10	14.53	13.20
27	11.59	12.42	14.57	13.83	14.25	14.42	14.03	13.65	12.52	12.98	14.39	13.06
28	11.58	12.49	14.45	13.79	14.22	14.34	13.99	13.63	12.43	12.80	14.46	12.93
29	11.58	12.48	14.40	13.74	14.26	14.33	13.97	13.61	12.33		14.43	12.82
30	11.63	12.84	14.47	13.74	14.35	14.42	13.94	13.58	12.24		14.56	12.74
31	11.72		14.62	13.78		14.35		13.55	12.15		14.74	

Table D-1. Cell 3 daily average stage - continued

Day	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02
1	12.66	12.45	14.15	14.27	13.76	15.61	14.65	14.03	14.49	13.99	14.32	13.40
2	12.58	12.66	14.10	14.41	13.71	15.71	14.65	14.03	14.46	13.95	14.38	13.38
3	12.50	13.72	14.06	14.67	13.70	15.49	14.59	14.07	14.51	13.90	14.27	13.32
4	12.46	13.93	14.03	14.74	13.75	15.29	14.58	14.08	14.53	13.90	14.31	13.29
5	12.40	13.95	14.00	14.73	13.83	15.04	14.57	14.08	14.47	13.90	14.42	13.23
6	12.23	14.31	13.97	14.79	13.87	14.88	14.60	14.05	14.40	13.95	14.44	13.13
7	11.94	14.63	13.93	14.57	14.03	14.64	14.57	14.10	14.38	13.87	14.48	13.03
8	11.64	14.81	13.90	14.52	14.25	14.62	14.50	14.15	14.48	14.06	14.47	12.93
9	11.41	14.91	13.94	14.40	14.41	14.63	14.53	14.24	14.42	14.05	14.46	12.83
10	11.24	14.92	14.02	14.32	14.57	14.53	14.53	14.26	14.39	14.18	14.35	12.73
11	11.11	14.90	14.18	14.25	14.83	14.42	14.48	14.29	14.42	14.27	14.34	12.62
12	10.99	14.77	14.24	14.27	14.99	14.44	14.44	14.31	14.39	14.41	14.42	12.52
13	10.91	14.60	14.29	14.22	15.06	14.45	14.42	14.30	14.30	14.50	14.41	12.41
14	10.83	14.51	14.25	14.22	15.21	14.43	14.44	14.30	14.33	14.54	14.28	12.29
15	10.75	14.54	14.23	14.23	15.52	14.44	14.42	14.31	14.43	14.49	14.18	12.18
16	10.69	14.41	14.35	14.28	15.37	14.40	14.45	14.34	14.41	14.52	14.11	12.24
17	10.62	14.25	14.52	14.20	15.10	14.38	14.39	14.33	14.37	14.55	14.06	12.68
18	10.56	14.17	14.68	14.13	14.78	14.39	14.31	14.30	14.39	14.46	14.02	12.66
19	10.51	14.21	14.71	14.07	14.59	14.40	14.31	14.21	14.43	14.49	13.98	12.57
20	10.46	14.32	14.50	14.06	14.60	14.38	14.31	14.18	14.34	14.51	13.95	12.41
21	10.42	14.21	14.44	14.10	14.62	14.41	14.27	14.27	14.35	14.54	13.91	12.21
22	10.39	14.16	14.41	14.06	14.53	14.49	14.29	14.27	14.39	14.53	13.87	12.01
23	10.69	14.21	14.65	14.03	14.56	14.60	14.23	14.30	14.26	14.54	13.83	11.84
24	11.60	14.18	14.99	14.02	14.59	14.51	14.19	14.28	14.16	14.49	13.78	11.66
25	11.86	14.16	15.07	13.99	14.49	14.51	14.18	14.27	14.12	14.47	13.73	11.48
26	11.90	14.30	14.94	13.96	14.68	14.60	14.19	14.30	14.06	14.41	13.70	11.32
27	11.89	14.33	14.61	13.93	14.59	14.88	14.13	14.32	14.03	14.43	13.68	11.17
28	11.87	14.45	14.41	13.89	14.66	14.85	14.08	14.31	14.11	14.30	13.63	11.05
29	11.82	14.36	14.25	13.87	14.95	14.74	14.05	14.39	14.15		13.58	10.93
30	11.77	14.24	14.23	13.84	15.28	14.77	14.05	14.35	14.10		13.53	10.79
31	11.95		14.20	13.80		14.68		14.37	14.04		13.46	

Table D-2. Cell 5 daily average stage

Day	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99	Apr-99
1	12.62	11.67	12.17	13.63	13.80	14.45	12.95	13.66	13.95	13.99	13.43	11.61
2	12.51	11.65	12.13	13.56	13.71	14.44	12.81	13.59	14.12	14.07	13.36	11.61
3	12.43	11.60	12.04	13.55	13.63	14.11	12.68	13.52	14.21	14.03	13.27	11.60
4	12.34	11.55	11.94	13.96	13.59	13.93	13.01	13.47	14.23	13.86	13.20	11.60
5	12.25	11.51	11.86	14.32	13.95	13.81	14.42	13.40	14.15	13.75	13.10	11.60
6	12.17	11.51	11.82	14.45	14.20	14.01	14.86	13.36	14.19	13.67	12.99	11.60
7	12.08	11.51	11.78	14.61	14.30	14.03	15.04	13.85	13.99	13.60	12.92	11.60
8	12.03	11.51	12.37	14.71	14.32	14.07	15.04	13.87	13.85	13.58	12.84	11.60
9	12.04	11.50	13.11	14.64	14.32	13.98	15.01	13.82	13.88	13.86	12.75	11.60
10	12.01	11.50	13.00	14.62	14.17	13.79	15.02	13.65	14.18	13.68	12.66	11.60
11	11.98	11.50	12.99	14.59	13.94	13.72	15.03	13.64	14.23	13.63	12.58	11.60
12	11.95	11.50	12.92	14.57	13.80	13.65	14.93	13.99	14.18	13.64	12.48	11.60
13	11.90	11.50	12.87	14.48	13.69	13.59	14.81	14.07	14.03	13.99	12.39	11.60
14	11.85	11.50	13.26	14.41	13.61	13.58	14.69	14.22	14.20	13.97	12.30	11.60
15	11.82	11.50	13.59	14.41	13.53	13.89	14.62	14.26	14.24	14.03	12.26	11.60
16	11.79	11.51	13.90	14.36	13.50	13.63	14.59	14.28	14.26	13.98	12.23	11.60
17	11.75	11.51	14.24	14.29	13.50	13.53	14.54	14.18	14.25	13.95	12.20	11.61
18	11.73	11.51	14.25	14.37	13.93	13.45	14.52	14.01	14.03	14.14	12.17	11.65
19	11.68	11.51	14.02	14.63	14.06	13.40	14.55	14.17	13.88	14.19	12.14	11.66
20	11.62	11.51	14.11	14.79	14.11	13.67	14.45	14.21	13.78	14.24	12.10	11.62
21	11.59	11.50	14.35	14.76	14.21	13.47	14.45	14.13	13.69	14.21	12.07	11.61
22	11.55	11.57	14.45	14.70	14.39	13.77	14.40	13.93	13.60	14.00	12.04	11.61
23	11.53	11.76	14.58	14.67	14.50	13.73	14.37	13.81	13.52	13.85	12.01	11.60
24	11.54	11.78	14.50	14.58	14.56	13.54	14.41	13.72	13.70	13.75	11.97	11.60
25	11.53	12.23	14.40	14.42	14.65	13.61	14.38	13.66	13.89	13.67	11.93	11.60
26	11.52	12.82	14.21	14.28	14.80	13.71	14.29	13.76	13.69	13.61	11.86	11.60
27	11.52	12.60	14.08	14.43	14.82	13.49	14.03	13.72	13.71	13.55	11.79	11.59
28	11.57	12.35	14.02	14.42	14.67	13.41	14.01	13.60	13.95	13.49	11.75	11.59
29	11.72	12.10	14.01	14.40	14.63	13.34	13.87	13.72	13.80		11.70	11.59
30	11.72	11.99	13.83	14.10	14.57	13.26	13.74	14.01	13.87		11.64	11.59
31	11.70		13.71	13.92		13.13		13.94	13.88		11.62	

Table D-2. Cell 5 daily average stage - continued

Day	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00
1	11.59	13.38	14.67	13.97	14.39	15.02	14.61	14.18	13.20	13.03	12.96	11.62
2	11.60	13.49	14.67	13.88	14.37	14.93	14.62	14.20	13.11	12.94	13.09	11.62
3	11.60	13.74	14.67	13.80	14.37	14.90	14.67	14.15	13.01	12.89	13.33	11.62
4	11.60	14.19	14.65	14.12	14.34	14.88	14.66	14.18	12.93	12.81	13.07	11.62
5	11.60	14.48	14.63	14.27	14.30	14.92	14.57	14.22	12.86	12.71	12.97	11.62
6	11.60	14.56	14.56	14.28	14.20	14.89	14.57	14.13	12.80	12.60	12.84	11.62
7	11.59	14.54	14.50	14.46	14.29	14.89	14.52	13.93	12.74	12.51	12.69	11.61
8	11.59	14.63	14.45	14.41	14.36	14.85	14.48	13.82	12.68	12.44	12.50	11.61
9	11.59	14.68	14.37	14.37	14.45	14.88	14.50	13.74	12.65	12.74	12.31	11.61
10	11.59	14.67	14.20	14.42	14.52	14.87	14.48	13.66	12.64	13.45	12.16	11.61
11	11.59	14.68	14.18	14.36	14.53	14.88	14.43	13.59	12.62	13.21	12.05	11.61
12	11.59	14.79	14.32	14.34	14.45	14.79	14.41	13.52	12.59	13.09	12.00	11.61
13	11.59	14.82	14.39	14.16	14.49	14.74	14.44	13.46	12.54	13.01	11.94	11.61
14	11.59	14.75	14.38	14.19	14.56	14.85	14.45	13.89	12.49	12.97	11.87	12.00
15	11.59	14.72	14.37	13.95	14.51	15.02	14.42	13.96	13.47	13.45	11.81	13.36
16	11.68	14.77	14.40	14.01	14.46	15.16	14.42	13.99	13.45	13.43	11.76	13.47
17	11.72	14.78	14.37	14.21	14.43	15.27	14.41	13.98	13.39	13.21	11.69	13.75
18	11.67	14.81	14.38	14.18	14.47	15.34	14.45	13.96	13.53	13.33	11.69	14.10
19	11.60	14.80	14.48	14.09	14.59	15.37	14.43	14.11	13.43	13.46	12.01	14.16
20	11.60	14.72	14.32	14.20	14.65	15.30	14.42	14.04	13.57	13.44	12.06	14.00
21	11.61	14.66	14.03	14.24	14.78	15.13	14.41	13.87	13.61	13.48	12.06	13.93
22	12.85	14.62	13.87	14.32	14.78	15.06	14.41	13.78	13.55	13.36	12.01	13.87
23	12.81	14.57	13.77	14.35	14.79	15.03	14.41	13.71	13.46	13.24	11.92	13.78
24	12.67	14.50	13.67	14.43	14.84	15.00	14.40	13.64	13.60	13.17	11.80	13.69
25	12.92	14.46	13.60	14.46	14.85	14.91	14.29	13.57	13.72	13.25	11.72	13.60
26	12.85	14.56	13.77	14.39	14.93	14.85	14.36	13.51	13.50	13.51	11.63	13.50
27	12.66	14.68	14.15	14.37	15.07	14.75	14.35	13.45	13.41	13.25	11.62	13.41
28	12.40	14.79	14.35	14.31	15.10	14.76	14.30	13.41	13.34	13.15	11.64	13.29
29	12.31	14.72	14.29	14.23	15.09	14.74	14.27	13.37	13.28	13.06	11.64	13.12
30	12.46	14.68	14.06	14.29	15.04	14.65	14.21	13.32	13.21		11.65	12.93
31	12.57		13.96	14.26		14.62		13.26	13.14		11.62	

Table D-2. Cell 5 daily average stage - continued

Day	May-00	June-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01
1	12.78	11.73	14.06	14.84	13.79	14.39	14.37	13.72	12.71	11.86	12.57	14.67
2	12.65	11.80	14.08	14.87	13.54	14.26	14.31	13.68	12.66	11.82	12.42	14.51
3	12.53	11.69	14.13	14.80	13.43	14.53	14.35	13.65	12.62	11.79	12.21	14.27
4	12.43	11.55	14.34	14.81	13.36	15.56	14.36	13.61	12.59	11.75	12.01	14.14
5	12.36	11.46	14.43	14.67	13.31	15.53	14.29	13.58	12.52	11.70	12.05	14.06
6	12.33	11.41	14.27	14.58	13.70	15.49	14.29	13.65	12.47	11.65	11.93	14.26
7	12.32	11.38	14.31	14.79	14.14	15.51	14.23	13.80	12.45	11.60	11.83	14.41
8	12.30	11.36	14.26	14.81	14.55	15.40	14.17	13.81	12.42	11.55	11.77	14.22
9	12.29	11.34	14.47	14.66	14.67	15.35	14.11	13.88	12.38	11.50	11.72	14.10
10	12.28	11.30	14.56	14.64	14.47	15.41	14.22	13.97	12.36	11.47	11.69	14.02
11	12.27	11.39	14.29	14.34	14.50	15.45	14.25	13.95	12.34	11.82	11.65	13.96
12	12.25	11.53	14.16	14.18	14.52	15.46	14.19	13.92	12.32	12.26	11.63	13.89
13	12.23	11.62	14.08	14.10	14.53	15.41	14.13	13.95	12.30	12.31	11.60	13.83
14	12.20	11.62	14.23	14.03	14.50	15.33	14.08	13.90	12.28	12.46	11.58	13.76
15	12.16	11.57	14.43	13.97	14.33	15.13	14.00	13.81	12.26	12.48	11.56	13.70
16	12.13	11.51	14.47	13.92	14.22	15.10	14.21	13.76	12.25	12.39	11.53	13.62
17	12.51	11.41	14.49	13.85	14.43	14.99	14.27	13.71	12.23	12.47	11.50	13.54
18	12.41	11.34	14.53	13.77	14.68	14.91	14.38	13.68	12.20	12.56	11.50	13.41
19	12.32	11.27	14.60	13.69	14.95	14.82	14.24	13.62	12.17	12.92	12.18	13.21
20	12.26	11.20	14.51	13.58	15.05	14.73	14.13	13.55	12.15	12.97	13.69	13.18
21	12.24	11.13	14.27	13.41	15.11	14.67	14.08	13.48	12.13	12.92	14.37	13.19
22	12.17	11.06	14.46	13.17	15.11	14.70	14.03	13.42	12.12	12.91	14.85	13.16
23	12.05	10.99	14.44	13.53	14.95	14.57	13.99	13.33	12.13	12.89	14.88	13.14
24	11.89	10.92	14.62	13.88	14.81	14.60	14.02	13.23	12.10	12.95	14.85	13.11
25	11.76	11.90	14.68	13.60	14.54	14.43	13.97	13.13	12.07	12.90	14.72	13.07
26	11.63	12.76	14.72	13.53	14.35	14.38	13.99	13.05	12.04	12.83	14.55	13.07
27	11.57	12.78	14.65	13.55	14.21	14.44	13.95	12.97	12.02	12.77	14.41	13.09
28	11.59	13.46	14.57	13.44	14.29	14.37	13.85	12.93	12.00	12.69	14.57	13.05
29	11.62	13.60	14.55	13.29	14.38	14.35	13.81	12.89	11.96		14.52	13.01
30	11.68	13.85	14.65	13.15	14.45	14.39	13.77	12.85	11.93		14.65	12.98
31	11.75		14.77	13.17		14.33		12.79	11.90		14.78	

Table D-2. Cell 5 daily average stage - continued

Day	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02
1	12.94	13.35	14.18	14.33	13.02	15.35	14.71	13.96	14.61	13.99	14.45	12.58
2	12.88	13.52	14.07	14.50	12.89	15.44	14.72	14.02	14.55	13.93	14.51	12.54
3	12.80	13.63	14.01	14.74	12.83	15.34	14.65	14.09	14.63	13.91	14.30	12.50
4	12.87	13.87	13.96	14.77	13.09	15.20	14.66	14.07	14.63	14.00	14.43	12.49
5	12.80	14.00	13.91	14.77	13.67	15.01	14.63	14.07	14.58	14.09	14.57	12.46
6	12.73	14.34	13.85	14.78	13.80	14.83	14.69	13.94	14.49	14.10	14.58	12.43
7	12.65	14.70	13.80	14.59	13.92	14.65	14.65	14.13	14.51	13.91	14.62	12.39
8	12.48	14.88	13.74	14.58	14.07	14.64	14.58	14.22	14.61	14.21	14.60	12.35
9	12.26	14.95	13.74	14.43	14.26	14.68	14.63	14.32	14.53	14.14	14.58	12.31
10	12.18	14.93	13.93	14.40	14.49	14.51	14.64	14.30	14.54	14.24	14.43	12.27
11	12.11	14.89	14.12	14.26	14.77	14.45	14.58	14.36	14.59	14.39	14.47	12.21
12	12.04	14.75	14.17	14.33	14.90	14.50	14.54	14.40	14.54	14.54	14.57	12.15
13	11.98	14.54	14.26	14.32	14.96	14.51	14.55	14.41	14.44	14.64	14.54	12.10
14	11.92	14.54	14.15	14.34	15.08	14.51	14.59	14.43	14.49	14.64	14.33	12.06
15	11.87	14.57	14.22	14.36	15.29	14.50	14.55	14.43	14.60	14.58	14.17	12.04
16	11.81	14.36	14.39	14.41	15.19	14.47	14.60	14.46	14.57	14.60	14.08	12.06
17	11.75	14.20	14.58	14.25	14.98	14.47	14.48	14.46	14.52	14.62	14.01	12.14
18	11.69	14.11	14.71	14.12	14.71	14.48	14.42	14.42	14.53	14.54	13.95	12.12
19	11.63	14.28	14.71	14.05	14.60	14.50	14.45	14.23	14.57	14.61	13.88	12.09
20	11.56	14.37	14.43	14.00	14.65	14.48	14.42	14.26	14.45	14.63	13.81	12.04
21	11.50	14.18	14.44	13.99	14.65	14.51	14.39	14.41	14.49	14.66	13.74	11.99
22	11.46	14.20	14.45	14.01	14.55	14.59	14.41	14.39	14.53	14.64	13.64	11.94
23	11.64	14.28	14.70	13.91	14.57	14.70	14.31	14.41	14.32	14.65	13.51	11.84
24	12.68	14.22	14.94	13.99	14.52	14.70	14.30	14.40	14.20	14.60	13.35	11.69
25	13.03	14.26	14.97	13.88	14.49	14.69	14.29	14.40	14.26	14.59	13.20	11.63
26	13.06	14.42	14.83	13.75	14.70	14.81	14.30	14.40	14.08	14.53	13.08	11.63
27	13.01	14.42	14.59	13.67	14.61	14.89	14.15	14.44	14.08	14.58	13.00	11.62
28	12.94	14.52	14.36	13.59	14.69	14.84	14.06	14.43	14.24	14.35	12.90	11.62
29	12.83	14.43	14.20	13.48	14.93	14.75	14.04	14.52	14.26		12.81	11.62
30	12.71	14.26	14.29	13.34	15.16	14.79	14.07	14.46	14.18		12.73	11.62
31	12.85		14.20	13.18		14.72		14.49	14.05		12.65	

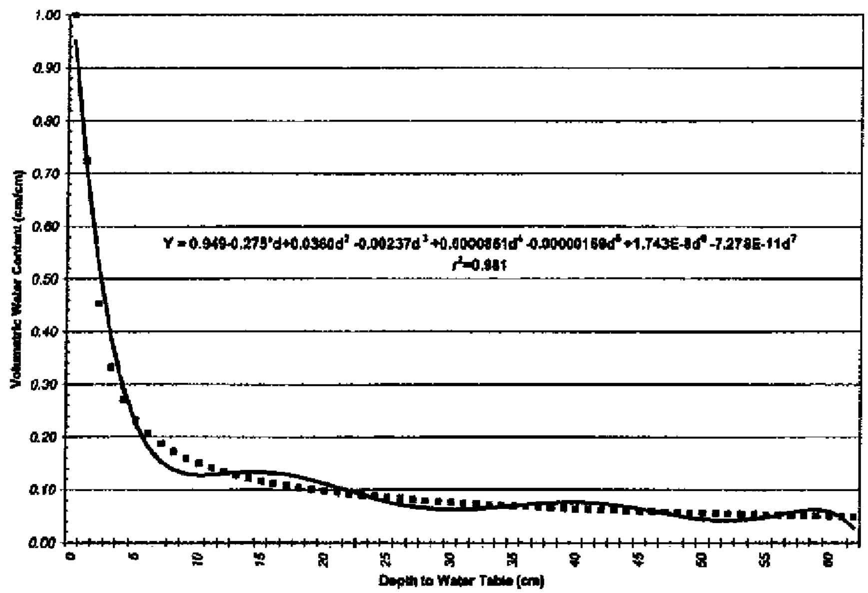

Figure D-1. Falling water table (drying front) equation

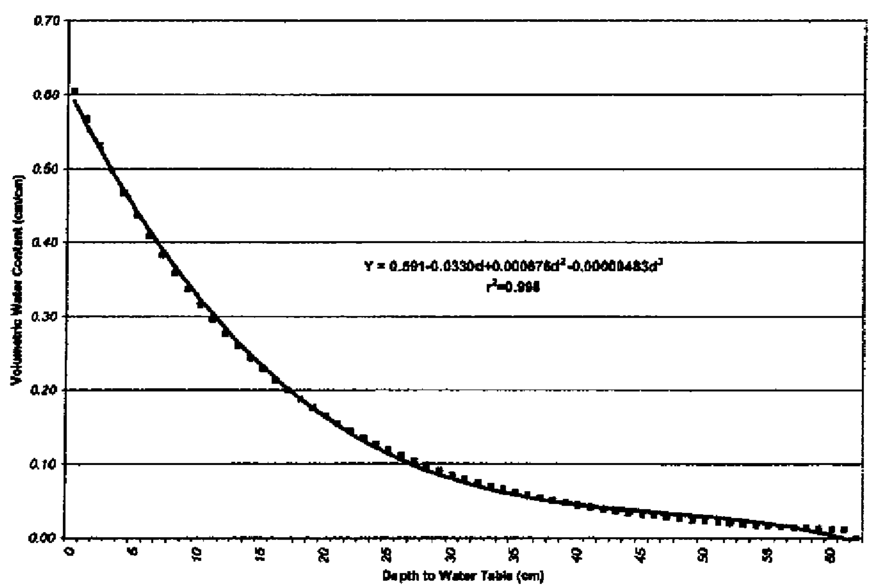

Figure D-2. Rising water table (wetting front) equation

Appendix E – Daily Water Budget Error Analysis

Daily data for WY 98-99 to WY 01-02 were used to investigate the relationship between measured and estimated values in the daily water budget and the residual or error term in the daily water budget. Correlation matrices were developed for STA 6, Cell 3 and Cell 5 and are shown in Tables E-1, E-2 and E-3, respectively. The strongest relationship is the inverse one shown between change in storage and daily error for Cell 5, a correlation coefficient, *r*, of –0.71. This implies that nearly 50 percent of the variation in the daily error over the four years can be explained by the variation in change in storage. It also indicates that as the change in storage increases, the daily error decreases. Unfortunately, other than indicating an area that might be investigated with respect to reducing water budget error for Cell 5, the same relationship was not shown for Cell 3. The relationship shown between change in storage and daily water budget error for STA 6 is probably influenced by the results for Cell 5 and presents no new information. Additional analysis of this kind may help to identify the source of error and lead to more accurate water budgets.

Table E-1. Correlation coefficient matrix for daily values - STA 6, WY 98-99 to WY 01-02

	Inflow	*Outflow*	*Rainfall*	*ET*	*Δ Storage*	*Seepage*	*Error*
Inflow	1						
Outflow	0.814384	1					
Rainfall	0.167144	0.139228	1				
ET	-0.121551	-0.052181	-0.187742	1			
ΔStorage	0.416084	0.026961	0.276281	-0.113154	1		
Seepage	-0.092653	-0.083383	-0.013405	0.015383	-0.132109	1	
Error	-0.049744	-0.24087	0.105829	-0.10457	-0.448613	-0.045217	1

Table E-2. Correlation coefficient matrix for daily values - Cell 3, WY 98-99 to WY 01-02

	Inflow	*Outflow*	*Rainfall*	*ET*	*Δ Storage*	*Seepage*	*Error*
Inflow	1						
Outflow	0.773214	1					
Rainfall	0.144343	0.124978	1				
ET	-0.126841	-0.039736	-0.187775	1			
ΔStorage	0.425559	0.037838	0.292282	-0.115555	1		
Seepage	-0.363158	-0.200892	-0.056682	0.091819	-0.266636	1	
Error	0.184977	-0.29687	-0.083389	-0.156242	-0.071611	0.309205	1

Table E-3. Correlation coefficient matrix for daily values - Cell 5, WY 98-99 to WY 01-02

	Inflow	*Outflow*	*Rainfall*	*ET*	*Δ Storage*	*Seepage*	*Error*
Inflow	*1*						
Outflow	*0.75552*	*1*					
Rainfall	*0.156471*	*0.172158*	*1*				
ET	*-0.106986*	*-0.050606*	*-0.187775*	*1*			
ΔStorage	*0.399848*	*0.025744*	*0.257318*	*-0.106279*	*1*		
Seepage	*0.118738*	*-0.143238*	*0.019149*	*-0.039554*	*0.019557*	*1*	
Error	*0.61737*	*-0.036639*	*0.051688*	*0.04691*	*-0.71368*	*0.122393*	*1*