AFETW Calibration Report

(Part I Deliverable B-2.5.1b)

KCOL Surface Water Supply Availability Study

(Contract No. 4600000933-W001)

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This Report Supplements the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report - Peer Review Copy dated August 31, 2007.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1 INTRODUCTION

1.1 Objectives of the AFET-W Model Documentation / Re-Calibration Report

The SFWMD has updated and refined the calibration of the Kissimmee Basin Modeling and Operations Study- (KBMOS) Alternative Formulation and Evaluation Tool (AFET) model to address peer review panel recommendations. A new Reference Evapotranspiration (RET) data acquired by the SFWMD's Hydrologic and Environmental Systems Modeling Department was incorporated into the model to replace the original RET data. Additional improvements were made to Upper Floridan Aquifer and Surficial Aquifer System dynamics. The newly calibrated AFET model (AFET-W) will be used to (1) evaluate KBMOS alternative plans (2) develop the "With Project", target, and reservation timeseries for the Kissimmee Basin Water Reservation and (3) evaluate proposed surface water supply withdrawals made under the selected plan for the KBMOS.

This report is considered a supplement to the AFET Model Development and Calibration Report (Earth Tech, 2007). Although the Table of Contents for this report was patterned after the Table of Contents for the AFET report, information produced in the AFET report was not repeated. This report focuses on the differences between this version of the calibration and the original calibration and new results obtained from the recalibrated model. Consequently where no changes were made in the model the relevant section of the report will simply state "no changes from AFET".

1.2 Overview of MIKE SHE/MIKE 11

MIKE SHE is a grid based dynamic modeling system that can be used to simulate integrated surface water and groundwater systems. It can simulate all the major land phase hydrological processes and is comprised of several independent modules that represent each hydrological process. A number of numerical approaches and/or conceptualizations are available within each module and allow users to tailor the model to meet the objectives and data constraints of a given project. The basic hydrologic flow processes incorporated into MIKE SHE are shown graphically in Figure 1-1.

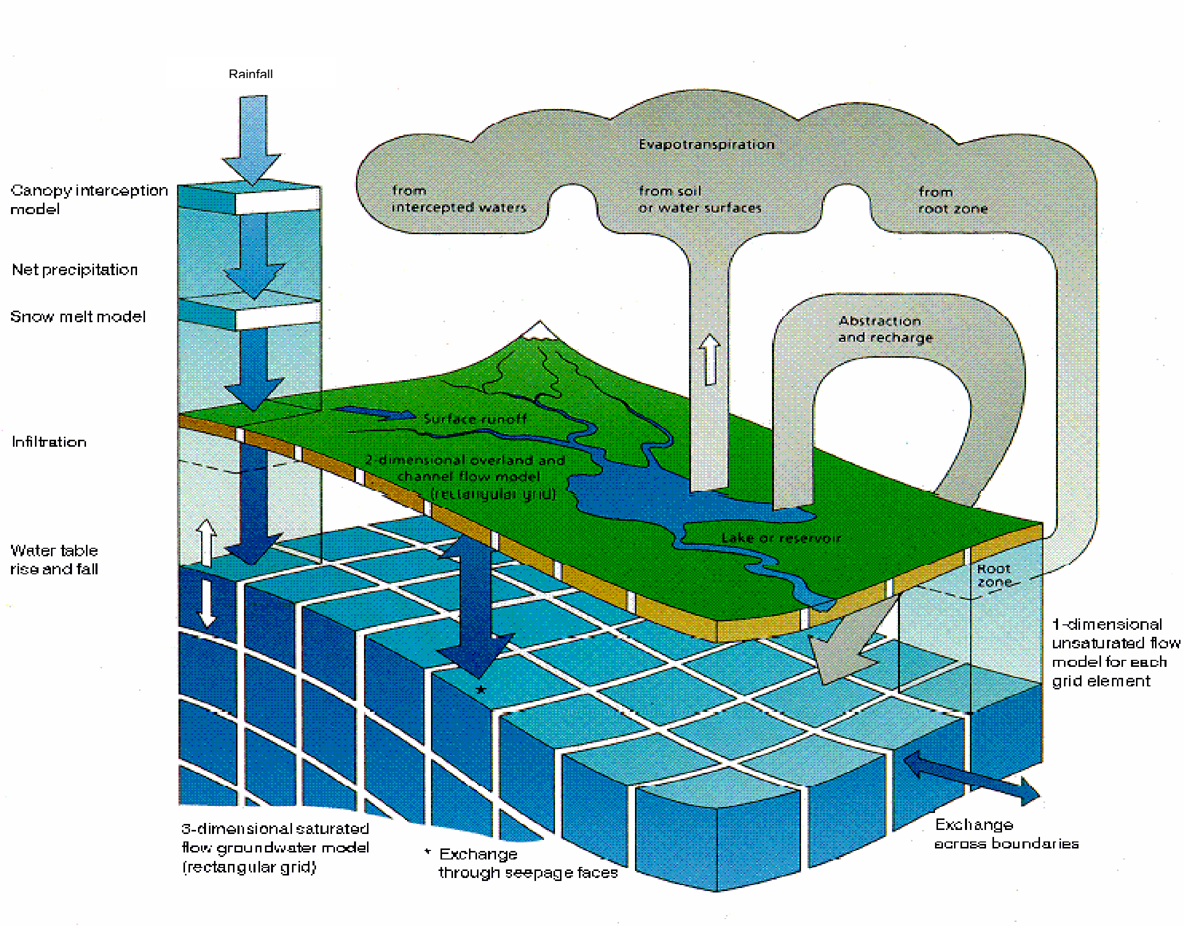

Figure 1-1: Hydrologic processes that can be represented in MIKE SHE/MIKE 11

The Kissimmee Basin MIKE SHE Model includes the following modules: overland flow, unsaturated zone, saturated zone, evapotranspiration processes, groundwater withdrawals, and irrigation. Channel flow is represented within the MIKE 11 portion of the model. The MIKE SHE and MIKE 11 models have been merged to create the integrated surface/groundwater AFET and AFET-W. As specified by the AFET Technical Design Document (TDD) (Earth Tech, 2006), the overland flow component used a two-dimensional finite difference diffusive wave approximation of the Saint Vennant equations and includes conceptual components to deal with runoff from urban areas, detention storage, and physical obstructions to flow. The unsaturated zone utilizes a simple conceptual two-layer approach water balance method that also accounts for evapotranspiration from: the canopy, ponded water, the unsaturated zone, and the saturated zone. Moisture contents or actual evapotranspiration rates simulated by the unsaturated zone module are used to determine irrigation demand. The saturated zone is solved using a three-dimensional finite difference form of the Darcy flow equation. The saturated zone module also accounts for groundwater withdrawals.

MIKE 11 simulates channel flow using a one-dimensional hydrodynamic calculation method and can be dynamically coupled to MIKE SHE (Alternative Evaluation Tool) or used in a stand-alone mode (Alternative Formulation Tool). Fixed and operable hydraulic control structures can be simulated with MIKE 11 model. When MIKE 11 is coupled with MIKE SHE, dynamic exchanges between the overland flow plain, groundwater system, and the river system are simulated.

1.3 Model Development

The AFET is a fully integrated model that couples the formulation tool (MIKE 11) with a watershed model that includes overland and groundwater flow (MIKE SHE) that was developed for application as part of the KBMOS. The development and calibration of AFET is documented in the "Alternative Formulation Evaluation Model Documentation and Calibration Report" (Earth Tech 2007). The MIKE 11 portion of AFET-W was initially developed by integrating information from existing models. This information was refined by the addition of available cross sections and bathymetry from Lake Tohopekaliga to S-65. The MIKE SHE portion of the model was developed using information collected during the first part of the KBMOS Phase II. The KBMOS MIKE SHE also builds on the results of similar modeling efforts developed and calibrated for large basins in South Florida. Peer Review of the development and proposed application of AFET was completed in June 2008. The Peer Review Panel recommended that new RET be used to calibrate the model. The main differences between AFET-W and AFET are that AFET-W is being calibrated with an improved set of RET data (differences between RET data sets will be detailed later in the document) and AFET-W is also being calibrated to match the behavior of observation wells in the Floridan Aquifer, while AFET used a qualitative approach based on seasonal potentiometric map.

1.4 Model Calibration

A report on the calibration approach was submitted and reviewed by the SFWMD on August 2008 (Earth Tech, 2008a). The calibration criteria proposed in the referenced document were revised in a meeting held at the SFWMD on August 15, 2008. The calibration approach report identified target calibration statistics which was used in the calibration process described in Section 4.

Earth Tech applied the approach, calibration statistics and stations identified in Section 4 also updated the calibration of the AFET model using new RET (Reference Evapotranspiration) data provided by HESM (SFWMD, 2008). A comparison of the original RET data with the revised RET data was submitted in a separate report dated August, 2008 (Earth Tech, 2008).

From June 20th to October 3rd, 2008, the Earth Tech team participated in a series of weekly calibration status discussion via conference call and meeting attendance. Interim calibration summary and model files were submitted to the District to show progress made towards reaching calibration. This report is the final report documenting the revised AFET Model referred to as AFET-W.

As specified in the calibration approach document (Earth Tech, 2007), the calibration of the KBMOS MIKE SHE/MIKE 11 model included calibration of the model for the period from January 1995 to December 1998 using daily rainfall data.

Calibration of the model is discussed in detail in Section 4, and included:

- Utilization of the new RET
- Modification of key surface water and groundwater parameters to improve model calibration at defined calibration locations.

Adjustment of model parameters was guided by sensitivity analyses performed with the AFET model. The sensitivity analyses are discussed in Section 3 of the AFET documentation report.

2 MODEL DEVELOPMENT

The following subsections describe the model development process. They are organized to follow the process required to build a MIKE SHE/MIKE 11 model, documenting the source of the information used to populate the model. Table 2-1 and Table 2-2 identify the calibration criteria defined for the model and how they were used to assess the ability of the model to address primary issues in the Kissimmee Basin.

Table 2-1: Statistical and additional criteria that have been applied to the KBMOS AFET and AFET-W MIKE SHE/MIKE 11 model during the calibration and verification periods

				1				2		
				Continuous Simulation				Event Simulation		
			Calibration/Verification Criteria	daily	monthly	annual	cumulative	hourly	daily	event
Structures	Stage	Headwater	Mean Error	✓					✓	
			Root Mean Square Error	✓					✓	
			Correlation Coefficient	✓					✓	
			Stage Duration			✓				✓
		Tailwater	Mean Error	✓					✓	
			Root Mean Square Error	✓					✓	
			Correlation Coefficient	✓					✓[1]	
			Stage Duration			✓				✓
	Flow		Correlation Coefficient	✓	✓			✓		
			Cumulative Error (S-65, S-65E)				✓			
			Peak Error							✓
			Peak Time Error							✓
			Flow Duration			✓	✓			✓
GW Wells	Groundwater levels		Mean Error	✓						
			Root Mean Square Error	✓						
			Correlation Coefficient	✓						
Water budget	Quantitative		Upper Kissimmee River Basin – Lake Budgets	✓					✓	
	Qualitative		Upper Kissimmee River Basin		✓[2]	✓				✓
			Lower Kissimmee River Basin		✓[2]	✓				✓

[1] Daily stage data will be used where hourly data is not available

[2] Seasonal water budget

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Table 2-2: Relationship of statistical and additional criteria applied to the KBMOS AFET and AFET-W MIKE SHE/MIKE 11 model during the calibration and verification periods to issues in the Kissimmee Basin

KB Issues	Primary Location	Primary Model Capabilities Needed	Temporal Scale (A)	Level First Simulated	Variable	Calibration Criteria Column
Seasonal Flooding	KB	Operations	Daily	Screening	OCSE*	1(B)
	KB	Water surface profiles	Daily	Screening	Stage	
	KB	Channel and structure hydraulics	Daily	Formulation	Flow	
	KB	Lake levels	Daily	Screening	Stage	
Hurricane or Storm Event Flooding	KB	Operations	Hourly	Formulation	Stage/Flow	2(C)
	KB	Flow Routing	Hourly	Formulation	Flow	
	KB	Lake levels	Hourly	Formulation	Stage	
	KB	Channel and structure hydraulics	Hourly	Formulation	Flow	
Improve range and duration of lake level fluctuations	KUB	Channel and structure hydraulics	Hourly	Formulation	Stage(D) / Water Budget	1
	KUB	Groundwater-SAS	Daily	Evaluation	Groundwater Levels	
	KUB	Surface water levels	Daily	Screening	Stage	
	KUB	Operations	Daily	Screening	OCSE*	
Water Supply – Surface Water	KB	Water budget	Daily	Screening	Stage(D) / Water Budget	1
	KB	Channel and structure hydraulics	Daily	Formulation	Stage/Flow	
	KB	Operations	Daily	Screening	OCSE*	
Hydrilla Management	KUB	Lake level fluctuations	Daily	Screening	Stage	1
	KUB	Operations	Daily	Screening	OCSE*	
Water Supply – Groundwater	KB	Groundwater flow	Daily	Evaluation	Groundwater Levels	1
	KB	Operations	Daily	Screening	OCSE*	
Increased Stormwater Volumes	KUB	Flow Routing	Hourly	Formulation	Flow	2
	KUB	Channel and structure hydraulics	Hourly	Formulation	Stage/Flow	
	KUB	Operations	Hourly	Formulation	Stage/Flow	
	KUB	Effects of land use change	Hourly	Evaluation	Stage/Flow/Ground water Levels	
Improve Stage Recession Rate	KB	Water surface profiles	Daily	Screening	Stage	1
	KB	Channel and Structure hydraulics	Daily	Formulation	Stage / Water Budget	
	KB	Operations	Daily	Screening	OCSE*	
Attain Pre-channelization Floodplain Inundation Frequency and Hydroperiod	LKB	Surface water hydrology	Daily	Screening	Flow / Lake Stages	1
	LKB	Groundwater (SAS,FAS) hydrology	Daily	Evaluation	Groundwater Levels	
	LKB	Water surface profiles	Daily	Screening	Stage	
	LKB	Channel and structure hydraulics	Daily	Formulation	Stage(D) / Water Budget	
	LKB	Operations	Daily	Screening	OCSE*	
Balance runoff impacts between upstream and	KB	Surface water hydrology	Daily	Screening	Flow / Lake Stages	1

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KB Issues	Primary Location	Primary Model Capabilities Needed	Temporal Scale (A)	Level First Simulated	Variable	Calibration Criteria Column
downstream ecosystems	KB	Groundwater (SAS,FAS) hydrology	Daily	Evaluation	Groundwater Levels	
	KB	Surface water levels	Daily	Formulation	Stage	
	KB	Operations	Daily	Screening	OCSE*	

OCSE* : Operation rules being evaluated through the Operation Criteria Simulation Engine (MIKE 11 control logics "POC")
(A) **Note:** Maximum model output time step will not exceed temporal scale.
(B) Continuous simulation criteria defined in Table 2.2
(C) Event simulation criteria defined in Table 2.2
(D) Stage Duration

2.1 Simulation Components

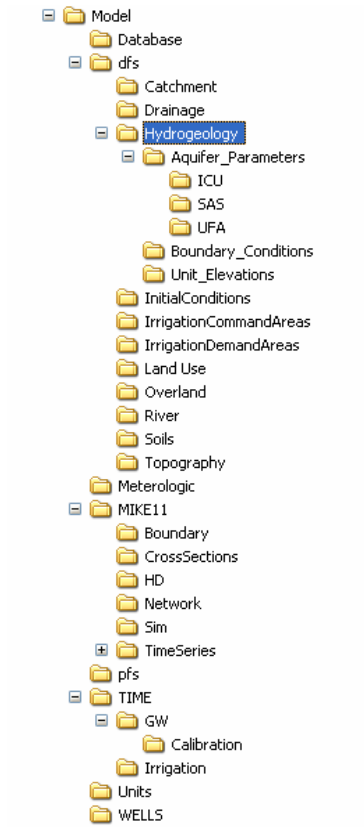
AFET-W used the simulation components documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.2 Model Domain and Grid

AFET-W used the model domain and grid documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.3 Model Characteristics and Model Run-Times

AFET-W was run on MIKE SHE version 2007. The complete set of input files has a folder size of 1.25 Gigabytes. Output from the 4-year run may reach several Gigabytes in size depending of how frequent is the model output being stored, currently the output from the calibration and verification runs occupies 2 DVDs. The folder structure used to run the AFET calibration model is included below. The time steps used in calibration were one minute for MIKE 11. The initial time step used for MIKE SHE was 15 minutes. Time steps in MIKE SHE are variable maximum time steps were 30 minutes for the overland flow module and 12 hours for the unsaturated and saturated flow module.



Run-times for the calibrated KBMOS AFET-W model range from 2.31 hours per year for the three-layer regional KBMOS AFET-W model to 3.79 hours per year for the one-layer, higher-resolution surficial aquifer KBMOS AFET-W model. These run-times meet the run-time goals (4 to 5 hours per year) defined in the TDD (Earth Tech, 2006).

2.4 Topography

AFET-W used the topography documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.5 Precipitation

AFET-W used the precipitation documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007, with the only exception that the calibration period was changed to 1995 to 1998 period.

2.6 Reference Evapotranspiration

The reference evapotranspiration (RET) is the rate of evapotranspiration from a reference vegetation type (i.e., grass) surface that is not short of water. It is independent of all variables except climate. AFET was developed with a RET data set that consisted of a single timeseries for the entire model domain. A spatially varied data set was made available for AFET-W. A Technical Memorandum (Earth Tech, 2008) was prepared documenting the effects of the different RET data sets on the calibration model. Figure 2-1 shows the annual average of the RET over the entire Kissimmee Basin obtained from the new RET data set.

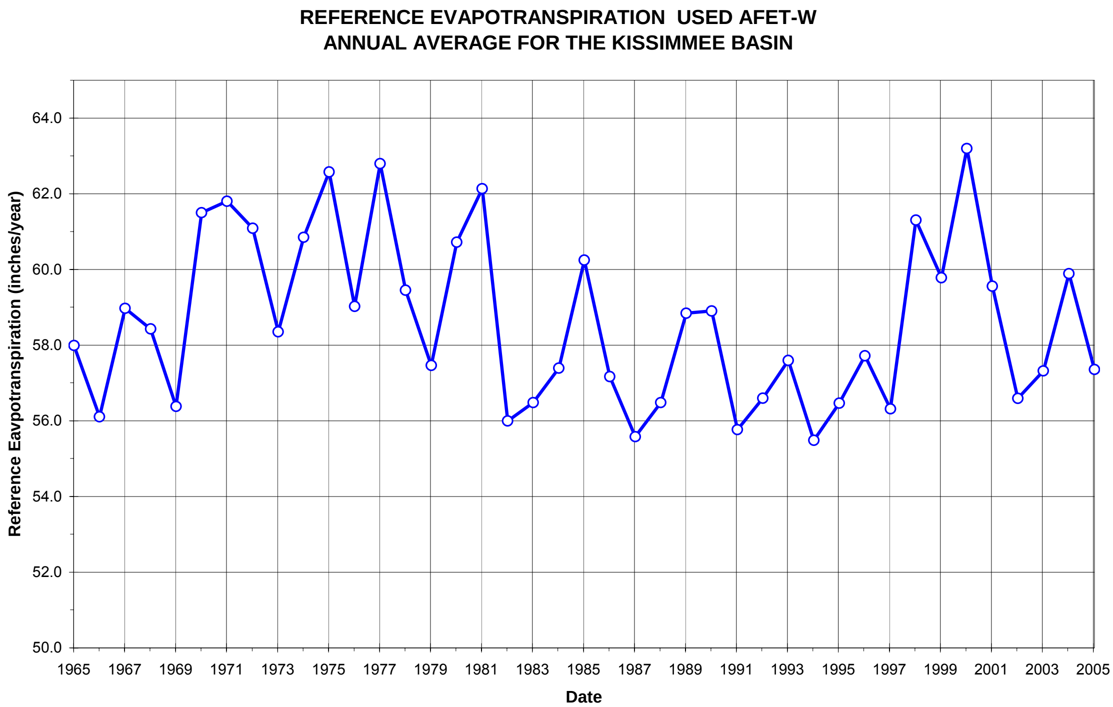


Figure 2-1: Reference Evapotranspiration in AFET-W (Annual Average)

The RET file is the basis from which the simulated evapotranspiration values are calculated on a cell-by-cell basis. The two-layer water balance evapotranspiration method is used to calculate the simulated ET. In this method, the actual evapotranspiration and the actual soil moisture status in the root zone are calculated from the reference evaporation rate, along with maximum root depth, leaf area index, and the simulated moisture content in the root zone.

2.7 Land Use

AFET-W used the land use documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.7.1 Vegetation/Land Use Classification Scheme

AFET-W used the vegetation/land use classification scheme documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.7.2 Vegetation Based Evapotranspiration Parameters

Initial estimates of the physically based parameters related to MIKE SHE for vegetation-based evapotranspiration (ET) were primarily developed from the Picayune Strand Restoration Project (PSRP) and LT MIKE SHE models. These parameters were adjusted during AFET model calibration to reflect values specific to the KBMOS as described in Sections 4 and 5 of the KBMOS calibration report. Crop coefficients (Table 2-5) were further adjusted during the

AFET-W calibration. Leaf area index was not changed. There was some modification to rooting depth, but it did not provide any improvement to the model, and was subsequently changed back to the original AFET values.

The spatially and temporally distributed ET parameters used by MIKE SHE are typically based on land use classifications. These parameters include the Leaf Area Index (LAI), the Root Depth (RD), and the crop coefficient (K_c). The LAI relates the ratio of total leaf area to total area for a particular type of vegetation category during the growing cycle. It is one of the primary variables used by MIKE SHE to calculate ET fluxes. RD defines the depth of the root system for a specific vegetation category and determines the vertical extent of ET in the soil profile. K_c is used to scale specified potential ET rates to individual vegetation types and growth stage. Monthly, land-use based LAI, RD, and K_c parameters values for the KBMOS AFET are given in Table 2-3, through Table 2-5 respectively. Values that were changed during the AFET-W calibration are highlighted in Table 2-5.

2.7.3 Irrigation Command Areas – ICA

AFET-W used the irrigation command areas - ICA documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

Table 2-3: Monthly Leaf Area Index (no units)

Land Use Type	MIKE SHE Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	1	3.38	3.38	3.75	4.12	4.5	4.5	4.5	4.5	4.5	3.38	3.38	3.38
Pasture	2	3	3.5	4	4	4	4	4	4	4	4	3.5	3
Truck Crops	5	3.75	4.5	3	3.75	4.5	3	3	3	3	3	3.75	4.5
Golf Courses	6	2	2.5	3	3	3	3	3	3	3	3	2.5	2
Flatwood	8	1.5	2.25	3	3	3	3	3	3	3	3	2.25	1.5
Hammock	9	2.5	3.25	4	4	4	4	4	4	4	4	3.25	2.5
Hydric Hammock	13	2.5	3.25	4	4	4	4	4	4	4	4	3.25	2.5
Wet Prairie	14	1.5	2.25	3	3	3	3	3	3	3	3	2.25	1.5
Marsh	16	2	3	4	4	4	4	4	4	4	4	3	2
Cypress	17	2	4	4	4	4	4	4	4	4	4	4	2
Swamp Forest	18	3	4	5	5	5	5	5	5	5	5	4	3
Water	20	0	0	0	0	0	0	0	0	0	0	0	0
Urban Low Density	41	0.9	1.25	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.25	0.9
Urban Medium Density	42	0.8	1.13	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.13	0.8
Urban High Density	43	0.7	0.98	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	0.98	0.7

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Table 2-4: Monthly Distribution of Root Depths (inches)

Land Use Type	MIKE SHE Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	1	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2	49.2
Pasture	2	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Truck Crops	5	17.7	29.5	5.98	17.7	29.5	5.98	5.98	5.98	5.98	5.98	17.7	29.5
Golf Courses	6	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
Flatwood	8	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9
Hammock	9	24	24	24	24	24	24	24	24	24	24	24	24
Hydric Hammock	13	24	24	24	24	24	24	24	24	24	24	24	24
Wet Prairie	14	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98
Marsh	16	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98	5.98
Cypress	17	60	60	60	60	60	60	60	60	60	60	60	60
Swamp Forest	18	60	60	60	60	60	60	60	60	60	60	60	60
Water	20	0	0	0	0	0	0	0	0	0	0	0	0
Urban Low Density	41	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Urban Medium Density	42	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Urban High Density	43	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9

Table 2-5: Monthly Distribution of Crop Coefficients

Land Use Type	MIKE SHE Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Citrus	1	0.49	0.49	0.51	0.52	0.54	0.54	0.54	0.54	0.54	0.52	0.51	0.51
Pasture	2	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Truck Crops	5	0.76	0.93	0.6	0.76	0.93	0.6	0.6	0.6	0.6	0.6	0.76	0.93
Golf Courses	6	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Flatwood	8	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
Hammock	9	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
Hydric Hammock	13	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
Wet Prairie	14	0.61	0.70	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.70	0.60
Marsh	16	0.61	0.70	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.70	0.60
Cypress	17	0.72	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.72
Swamp Forest	18	0.71	0.75	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.75	0.71
Water	20	1	1	1	1	1	1	1	1	1	1	1	1
Urban Low Density	41	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Urban Medium Density	42	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Urban High Density	43	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59

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2.7.4 Irrigation Demand

AFET-W used the irrigation demand documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.7.5 Water Reuse

AFET-W used the water reuse documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.7.6 Paved Runoff

AFET-W used the paved runoff documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8 Hydraulic Network

AFET-W used the hydraulic network documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8.1 Compiling Available Cross Sections

AFET-W used the cross sections documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8.2 Model Network

AFET-W used the model network documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8.3 Importing Cross Section Files into MIKE 11

AFET-W used the cross sections MIKE 11 files documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8.4 Information on Cross Sections

AFET-W used the information on cross sections documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8.5 Water Control Structures

AFET-W used the water control structures documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8.6 Pool B's Weirs 1, 2, and 3

AFET-W used the Pool B's weirs 1, 2, and 3 documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8.7 Boundary Conditions

AFET-W used the boundary conditions documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8.8 Manning's n

AFET-W used the Manning's n documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.8.9 Coupling MIKE 11 to MIKE SHE

AFET-W used the coupling MIKE 11 to MIKE SHE documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.9 Overland Flow

The overland flow module used in the KBMOS model is a grid cell based finite difference method that is driven by the discretized model topography. The finite difference overland method utilizes a two-dimensional finite difference diffusive wave approximation of the St. Venant equations. This approximation ignores momentum losses due to convective acceleration and lateral inflows perpendicular to the flow direction. The approximation is then further simplified by substituting Manning's equation into the diffusive wave approximation momentum equations. The resulting solutions in the x- and y-directions reduce to:

$$uh = M_x(-\partial z/\partial x)^{1/2}\, h^{5/3}$$

$$vh = M_y(-\partial z/\partial y)^{1/2}\, h^{5/3}$$

where:

h = depth of flow
u = velocity in the x direction
v = velocity in the y direction

z = total potential head
x = x direction unit length
y = y direction unit length
M = Manning's M friction coefficient = 1 / n

An explicit or iterative linear matrix modified Gauss Seidel method is then used to solve the numerical solution for the entire grid simultaneously. The five parameters associated with calculating overland flow are:

- Initial Water Depth – This is the initial water depth in the model domain. This initial condition has been developed from previous model runs and represents conditions at the start of the calibration, verification, and storm verification runs. Initial conditions were simulated in AFET-W by adding a one-year start up time.
- Manning's *M* values – Manning's *M* values lump the friction effects due to bedding and vegetation and directly impact the velocity of overland flow. These values are constant over the entire flow regime and spatially distributed based on the specified land-use types. Manning's *M* values are equal to the inverse of Manning's *n* values and are equivalent to the Stickler roughness coefficient. Manning's M values were modified during AFET-W calibration by increasing AFET values by 10 percent in the entire basin. Manning's M range from 1 to 10 (n = 0.100 to n = 1.00).
- Detention Storage – These values are storage depths that must be exceeded in a grid cell before overland flow can occur. This depth accounts for water detained in micro-topographic features that are not visible within the topographic resolution and grid extent. These values have been developed using land use relationships. Water in detention storage is not available for overland flow but is available for infiltration to the unsaturated zone and ET.
- Overland – Saturated Zone Leakage Coefficient – When the soil profile becomes completely saturated the overland flow and saturated zone modules exchange water directly. The overland – saturated zone leakage coefficient reduces the exchange of water if it is less than the equivalent vertical hydraulic properties defined for the water table aquifer (*i.e.,* model layer 1). The overland – saturated zone leakage coefficient is typically used to represent the effect of lower permeability sediments in areas that are inundated (*e.g.,* lakes) and where the hydraulic properties of the water table aquifer do not adequately reflect the presence of low permeability sediment. Although leakage coefficient were modified during AFET-W calibration, it did not result in model improvement and was subsequently changed back to the AFET values.
- Separated overland flow areas – This allows physical divides (*i.e.,* levees, roads, basin divides, *etc.*) that are not present in the model topography to be represented in the model. Separated overland flow areas were not changed during AFET-W.

Table 2-6 documents the Manning *M* (1/ n) roughness coefficients and detention storage depths used in the KBMOS model. These values are closely linked to land use type. The Manning's M values were further adjusted during calibration for the AFET-W model. AFET values were increased by 10 percent to provide values for AFET-W.

Table 2-6: Land Use Based Overland Flow Parameters

KBMOS Land Use Type	KBMOS MIKE SHE Land Use Code	Detention Storage (in)	Manning's *M* ()
Citrus	1	1.15	6.47
Pasture	2	1	7.85
Truck Crops	5	1.25	6.47
Golf Courses	6	1	7.85
Flatwoods	8	1.2	5.50
Hammock	9	1.2	3.66
Cypress	17	1.25	2.75
Hydric Hammock	13	1.2	2.75
Wet Prairie	14	1.25	3.66
Marsh	16	1.25	1.84
Swamp Forest	18	1.25	2.75
Water	20	0	0.00
Urban Low Density	41	2.5	7.85
Urban Medium Density	42	2.5	9.16
Urban High Density	43	2.5	9.91

It should be noted that overland flow parameters are effective parameters that are a function of both the grid sizes used in the model and conditions under which sheet-flow begins to occur in the watershed.

Initial estimates of physically based overland Manning's *M* values in KBMOS AFET were developed from the Picayune Strand Restoration Project (PSRP) and Lake Toho MIKE SHE models and were adjusted during model calibration. Figure 2-2 shows the area distribution of the Manning M values used in AFET-W.

The detention storage depths from the PSRP model for agriculture and urban areas were further evaluated for the KBMOS to develop initial estimates (Earth Tech, 2006a). The PSRP model detention storage depths for agricultural areas are considered reasonable for the KBMOS model because:

- It is assumed that agricultural areas have internally managed drainage facilities and are isolated from surrounding lands,
- It is assumed that topography features such as swales between crop beds and other significant depression storage exist, and
- Drainage features within the farms typically have available storage capacity that collects surface water during storm events and is used to convey water off-site in a controlled fashion.

Urban detention storage depths were developed based on surface water management practices in the area. Detention storage in urban areas has been set to 2.5 in based on current design criteria, which require that on-site storage in developed areas should be capable of retaining 2.5 in of runoff from a single event. This represents a maximum value for medium-density urban areas because it assumes that these areas were developed using the current design criteria. Older developments may not currently meet these criteria as a result of being developed when design criteria were less stringent. It is also likely that sediment accumulation within storage facilities has reduced available detention storage capacity. Low density urban areas might detain more than 2.5 inches because of features that exist within undisturbed areas of the development. High-density urban areas may have detention storage values less than 2.5 in due to greater percentages of impervious areas. Although up to 2.5 inches of water is retained on the overland flow plain in urban areas this water is available for ET and groundwater seepage to adjacent areas. Furthermore, paved areas runoff coefficients automatically route a specified fraction of the precipitation to defined outlet points.

The detention storage depths were modified during model calibration to better represent the effective detention storage values in the Kissimmee Basin. Initial detention storage depths used in the KBMOS AFET model are summarized in Earth Tech (2006a). Figure 2-3 shows the distribution of detention storage values used in the AFET. These values were maintained in AFET-W.

Overland – saturated zone leakage coefficients are shown in Figure 2-4. The smallest overland - saturated zone leakage coefficients are defined for the large lakes in the KUB. Separated overland flow areas are shown in Figure 2-5 and are based on the sub-watershed coverage provided by District staff. The correspondence of separated overland flow area codes and sub-watershed names is summarized in Table 2-7.

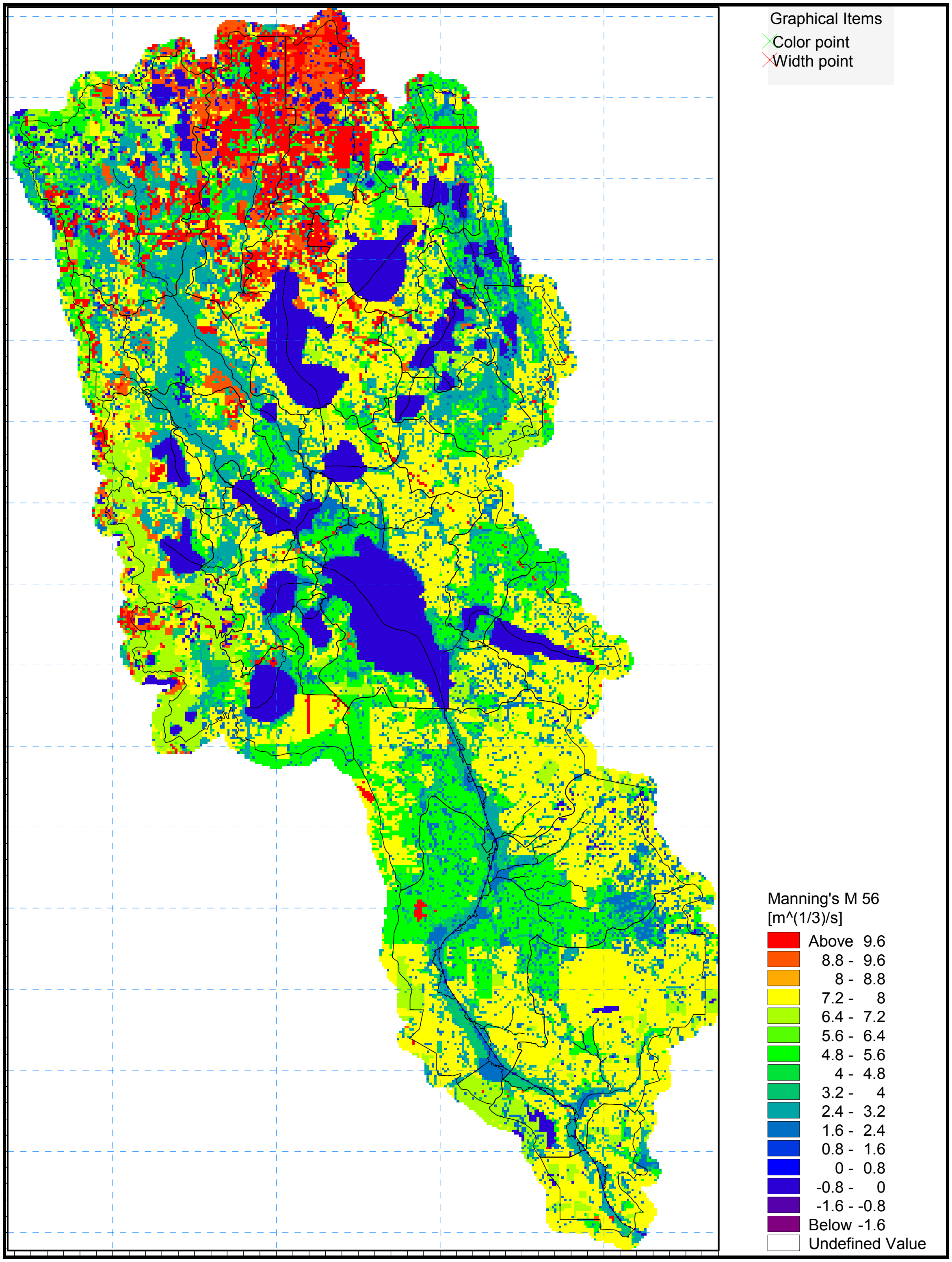

Figure 2-2: AFET-W Land Use Based Manning's M Values

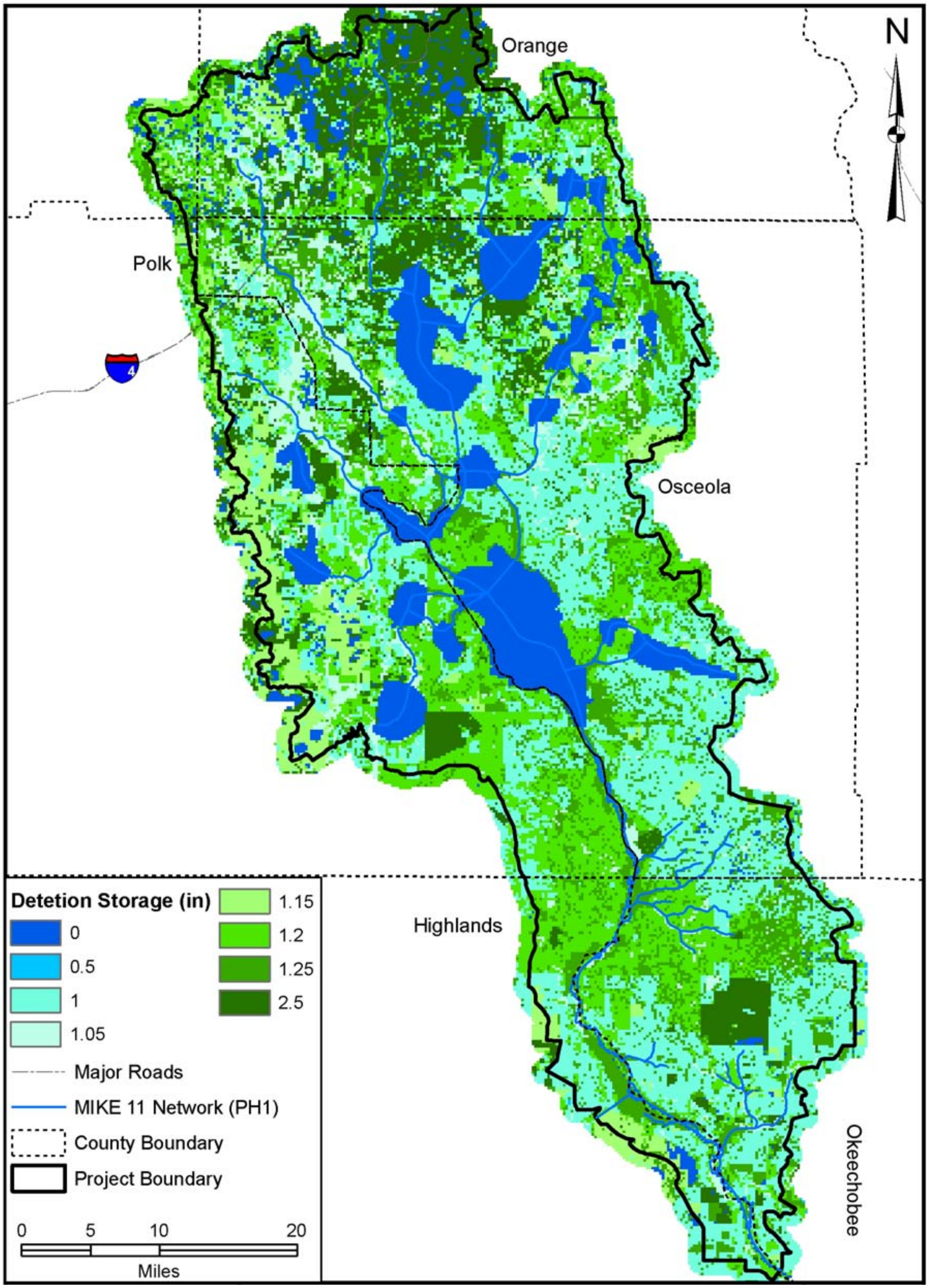

Figure 2-3: AFET and AFET-W Land Use Based Detention Storage Depths (ft)

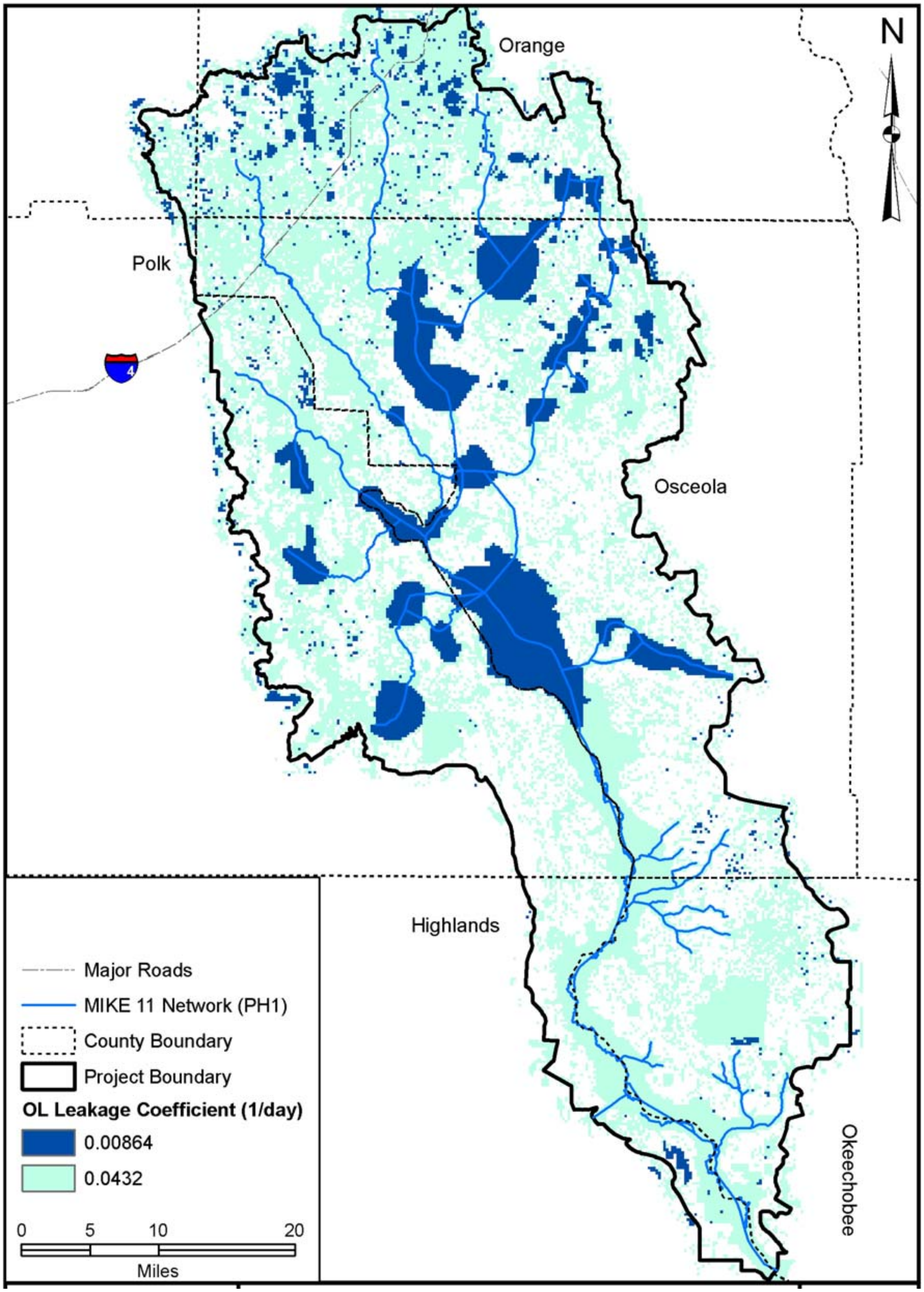

Figure 2-4: AFET and AFET-W Overland – Saturated Zone Leakage Coefficients (day^{-1})

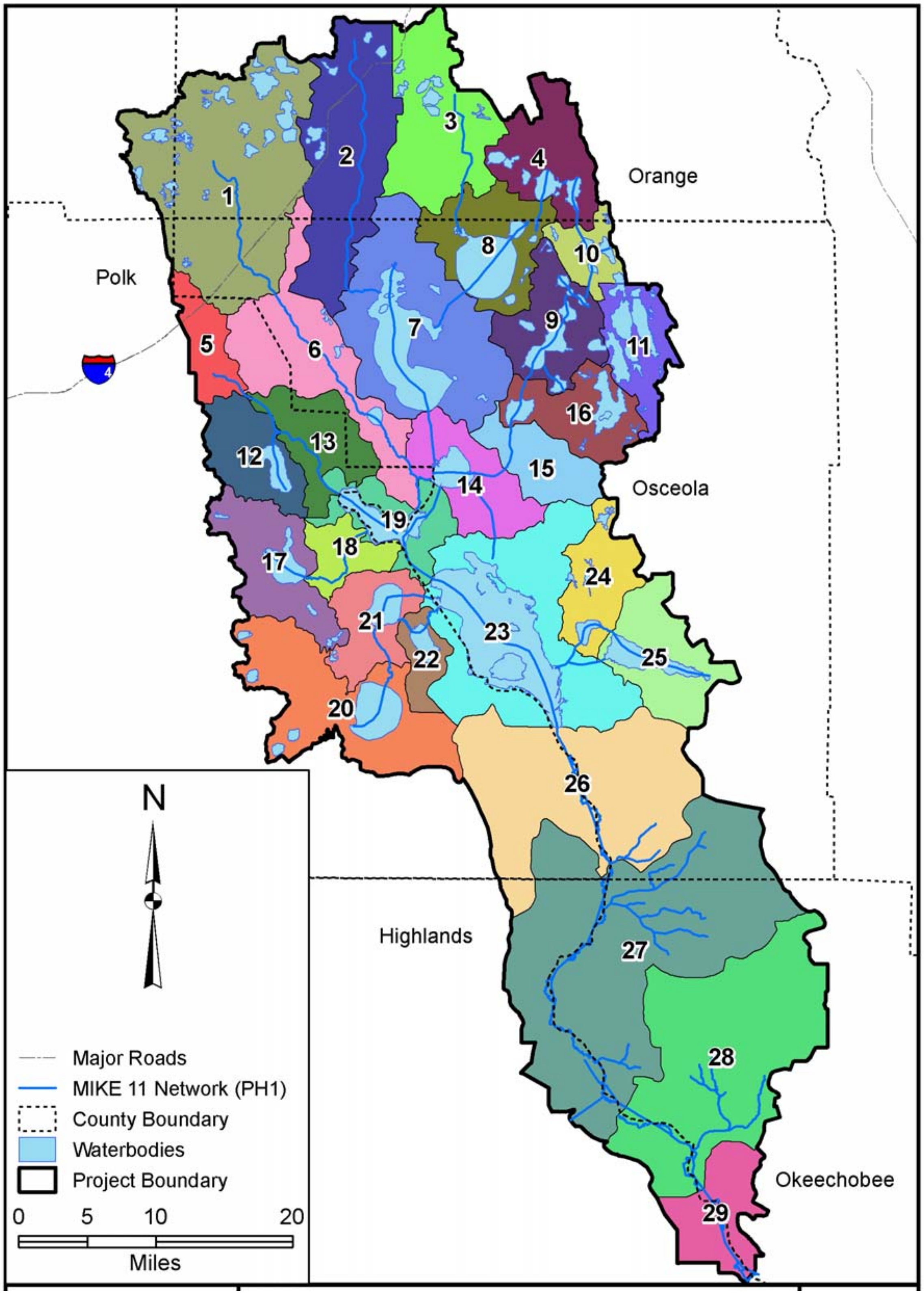

Figure 2-5: AFET and AFET-W Separated Overland Flow Areas

Table 2-7: Sub-watershed names for defined separated overland flow areas

Sub-Watershed	Separated Overland Flow Area Grid Code
Upper Reedy Creek	1
Shingle Creek	2
Boggy Creek	3
Lake Hart	4
Horse Creek (Closed Basin)	5
Lower Reedy Creek	6
Lake Tohopekaliga	7
East Lake Tohopekaliga	8
Alligator Lake	9
Lake Mrytle	10
Lake Conlin (Closed Basin)	11
Lake Marion	12
Marion Creek	13
Lake Cypress	14
S-63A	15
Lake Gentry	16
Lake Pierce	17
Catfish Creek	18
Lake Hatchineha	19
Lake Weohyakapaka	20
Lake Rosalie	21
Tiger Lake	22
Lake Kissimmee	23
Lake Jackson	24
Lake Marian	25
S-65A	26
S-65BC	27
S-65D	28
S-65E	29

2.10 Unsaturated Flow

AFET-W used the unsaturated flow documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.11 Saturated Zone

The AFET-W model represents the saturated zone using the three-dimensional finite difference option. The three-dimensional finite difference option implemented in the AFET-W model requires specification of data for the following components:

- Geological Layers
- Computational Layers
- Subsurface Drainage
- Pumping Wells

Hydrogeologic parameters may be distributed by geological layers or by geological units within layers. When applying the geological layer distribution, the lower level, horizontal hydraulic conductivities, vertical hydraulic conductivities, specific yield, and specific storage coefficients are assigned for each specified geologic layer (i.e., aquitards). Computational layers are used to discretize the geologic layers into numerical layers and require definition of initial heads, outer boundaries, and internal boundary conditions. Pumping wells are specified in a database that defined the locations, screen intervals, and reported pumping rates for each well. Drainage is a special boundary condition used to conceptually define drainage features that are not explicitly represented in the model. This water is routed to surface water bodies using a head-dependent flux boundary condition formulation that requires a specification of a drainage time constant (leakance value) and drainage level.

Aquifer parameters for each layer have been developed from the final parameters obtained during the calibration of AFET.

2.11.1 Geological Layers

In the AFET-W model geological layers correspond to the Surficial Aquifer, Intermediate Confining Unit, and the Upper Floridan Aquifer hydrostratigraphic units. A coarse and fine AFET-W groundwater model with one and three model layers have been developed. The one layer model is used to look at dynamic groundwater flow in the Surficial Aquifer (SAS) using the higher resolution 1,000 × 1,000 foot grid. The three layer model simulates groundwater flow in the SAS, the Intermediate Confining Unit (ICU), and the Upper Floridan Aquifer (UFA) using a coarser 3,000 × 3,000 foot grid. The three layer model has been developed primarily to provide UFA boundary conditions for the one layer SAS model. A conceptual model of the hydrostratigraphy in the AFET-W model domain is shown in Figure 2-6.

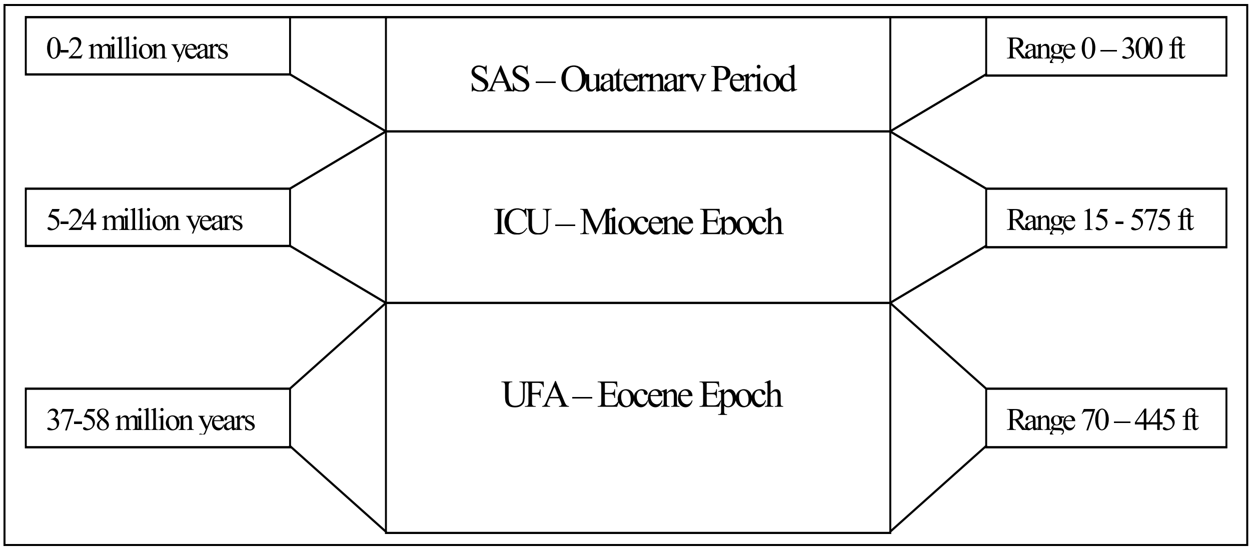

Figure 2-6: Conceptual Geological Model

During the AFET calibration, the three-layer geological model and related aquifer properties was originally developed from GIS coverage provided by the SFWMD. Each geologic layer contains a lower level, horizontal hydraulic conductivity, vertical hydraulic conductivity, specific yield, and specific storage dialogs. The lower level represents a surface dividing one geologic layer from another. The horizontal and vertical hydraulic conductivities represent the hydraulic properties of the geologic layer. The specific yield is the unit volume fraction of water that drains from the geologic layer under the influence of gravity alone. The specific storage is the unit volume fraction of water released from storage in a confined aquifer per unit change in hydraulic head and is related to aquifer and water compressibility. Specific yield and specific storage values are defined for each calculation regardless of the hydraulic characteristics of the layer (i.e., confined or unconfined).

2.11.1.1 Surficial Aquifer System (SAS)

The SAS in the AFET-W area is modeled as one continuous unconfined system. The water table fluctuates seasonally with direct response to rainfall and pumping. This system extends from ground surface to the top of the ICU that in general slopes to the southeast. The SAS is composed primarily of unconsolidated clayey-sands.

A spatially distributed dataset has been developed for the bottom of the SAS, the horizontal hydraulic conductivity, the vertical hydraulic conductivity, and the specific yield. The raw SAS parameters were provided by the SFWMD and were based on the physiographic zones of the geomorphology of the Florida Penisula: Tallahassee, Florida Geological Survey Bulletin (White, W.A., 1970). The physiographic shapefile used to develop a 1,000 × 1,000 foot raster dataset for the AFET-W model.

The initial horizontal hydraulic conductivity (K_h) (ft/day) of the model was developed using SAS transmissivity values (ft^2/day) and the SAS thickness. The horizontal to vertical hydraulic conductivity ratio of 10 was used to develop the initial vertical hydraulic conductivity (K_v) used in the model. The vertical hydraulic conductivity of the SAS was modified from initial values summarized in Earth Tech (2006a) during model calibration. The top of the ICU, the thickness of the SAS, and the specific yield of the SAS was the same as used in AFET. However the horizontal hydraulic conductivity of the SAS, and the vertical hydraulic conductivity of the SAS were modified during calibration (The final values are shown in Figure 2-7 and Figure 2-8). A default specific storage (S_s) coefficient of 3.048×10^{-6} 1/ft was assigned to the SAS but is not a significant parameter because the Surficial Aquifer remains unconfined at all times. Modification was based on information provided by the District (e.g., values of Kh should not exceed 100 ft per day, and the lower basin Kh should be around 30 ft per day).

2.11.1.2 Intermediate Aquifer System (IAS) and Intermediate Confining Unit (ICU)

The ICU in the AFET-W is modeled as a continuous semi-confined leaky layer separating the SAS from the UFA. In general, the top surface of the ICU and the UFA gradually slope towards the southeast. The IAS exists in the southwest portion of the AFET-W model area and is modeled as an area of relatively high horizontal hydraulic conductivity within the ICU. The thickness of the combined IAS and ICU gradually increases to the southeast. The ICU is primarily composed of low permeability interbedded marine sand, silt, and clays, but can contain zones of more permeable limestone. The top of the UFA and the thickness of the ICU are shown in Figure 2-33 and Figure 2-34 in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

There was significant modification to the extent of the IAS used in AFET. Information from two USGS reports Specher and Kroening, 2007, and Sepulveda 2002, were used by the District to develop three zones for horizontal hydraulic conductivity – zone 1 being the confining unit (0-1 ft/d), Zone 3 being the IAS (20-30 ft/d) and Zone 2 being the transition zone (1ft/d – 20ft/d). The arithmetic mean of these ranges was used to represent each zone.

Default ICU specific yield and specific storage values of 0.1 and 3.048×10^{-6}, respectively, have been assigned. The vertical hydraulic conductivity of the ICU was calculated as 10 percent of the horizontal hydraulic conductivity. The horizontal hydraulic conductivity of the IAS is shown in Figure 2-9; vertical hydraulic conductivity of the ICU is shown in Figure 2-10.

2.11.1.3 Upper Floridan Aquifer (UFA)

The UFA in the AFET-W is defined as continuous aquifer layer confined by the ICU on top and MCU on the bottom. It is the predominant source of groundwater for potable, irrigation, and industrial water used in the model domain. In generally, the top of the UFA and the Middle Confining Unit (MCU) gradually slope towards the southeast. Furthermore, the UFA generally increases in thickness to the southeast in the model domain. The UFA is composed of high permeability consolidated limestone. The top of the MCU and the thickness of the UFA are shown in Figure 2.37 and Figure 2.38 in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

For AFET, data provided by the SFWMD, was used to develop the initial UFA aquifer parameter data that was used for the AFET calibration. The initial K_h of the UFA was developed using UFA transmissivity and thickness data. A horizontal to vertical hydraulic conductivity ratio of 10 was assumed for the UFA. The UFA has been assigned default specific yield and specific storage values of 0.1 and 1.0×10^{-3} 1/ft. A specific yield value is required for each geologic layer by MIKE SHE but is not a significant parameter for the UFA since the aquifer is always confined in the AFET-W area. The specific storage value specified for the UFA is a representative value for the UFA and was not adjusted during calibration. AFET horizontal and vertical hydraulic conductivity were significantly modified. The horizontal hydraulic conductivity was re-initialized by substituting ECFT values where available (the ECFT model did not entirely cover the KBMOS model domain to the south). Where ECFT values were not available, KBMOS values were used. Values were subsequently modified during AFET-W calibration. The horizontal and vertical hydraulic conductivity of the UFA are shown in Figure 2-11 and Figure 2-12, respectively.

The groundwater parameters used in the AFET-W model are physically based. During the calibration process, detailed information was obtained from members of the study team. The areal delineation of the hydraulic parameters were based on reports by experts and in-house expertise from professional who have conducted hydrogeologic work in the watershed for numerous years. This information was used to develop the hydrogeologic parameters demarcation shown in this Section. Furthermore, the values (e.g. hydraulic conductivity) used in the model were examined by the study team experts and only values deemed appropriate were used.

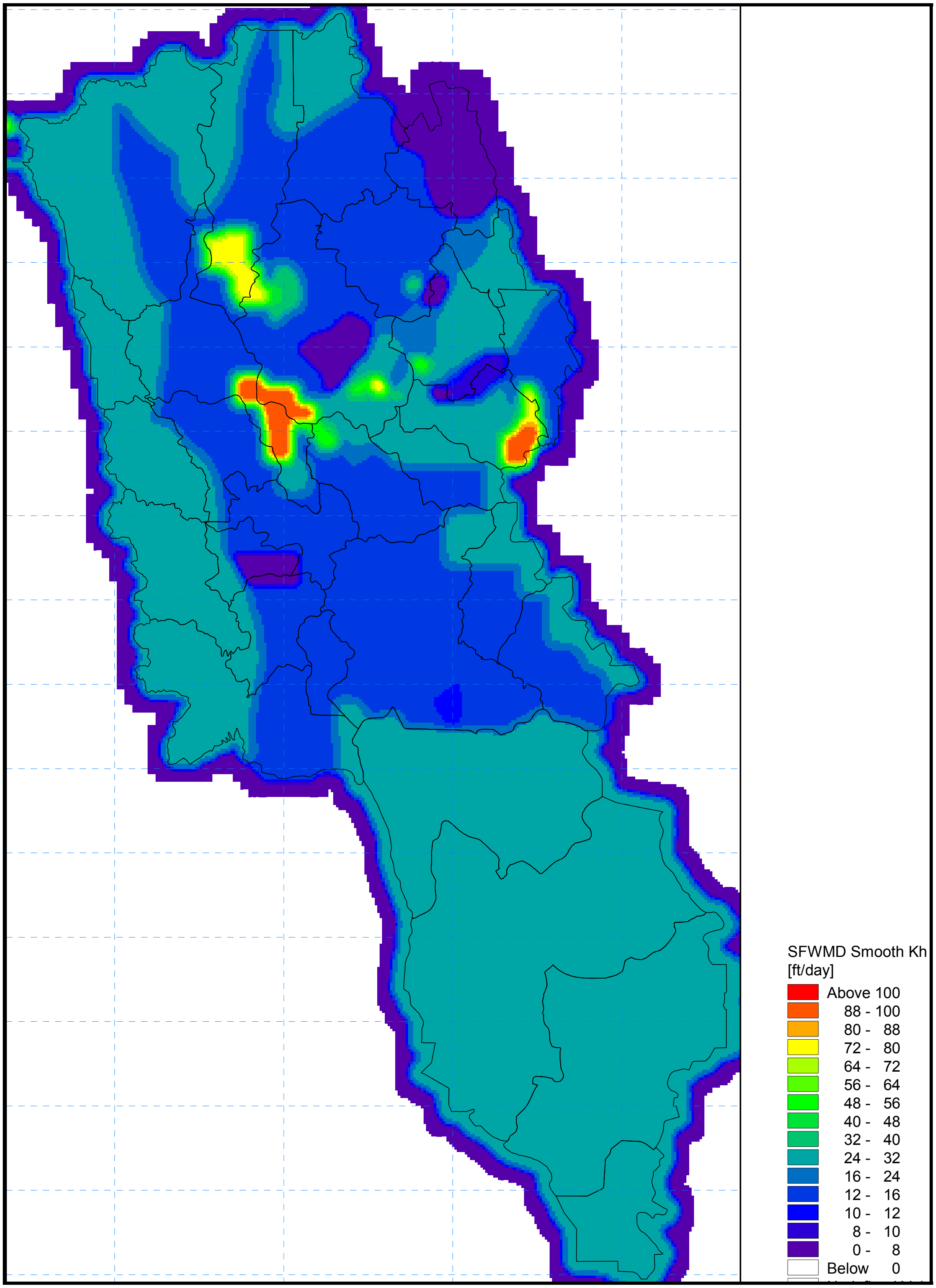

Figure 2-7: AFET-W Horizontal Hydraulic Conductivity of the Surficial Aquifer

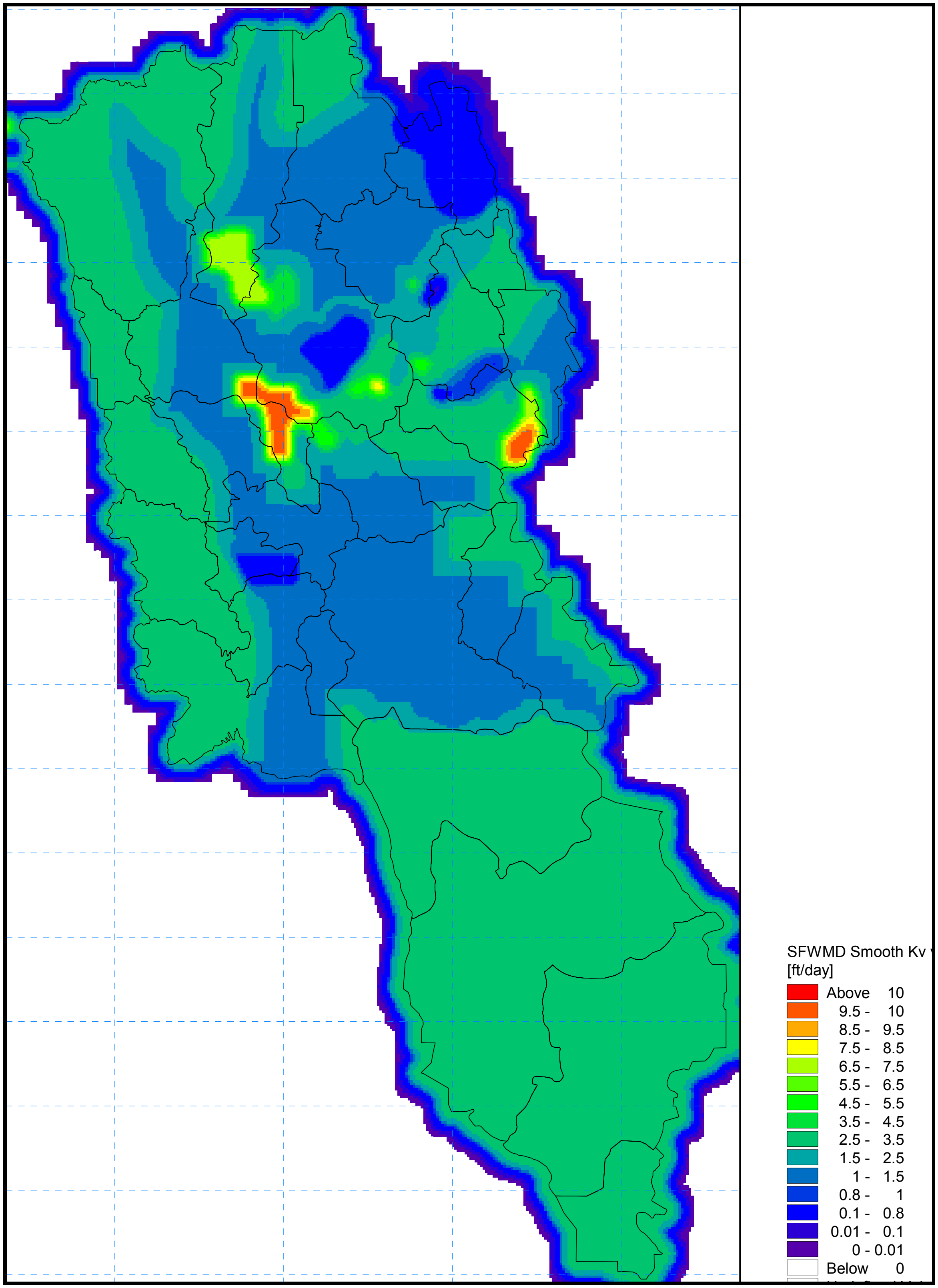

Figure 2-8: AFET-W Vertical Hydraulic Conductivity of the Surficial Aquifer

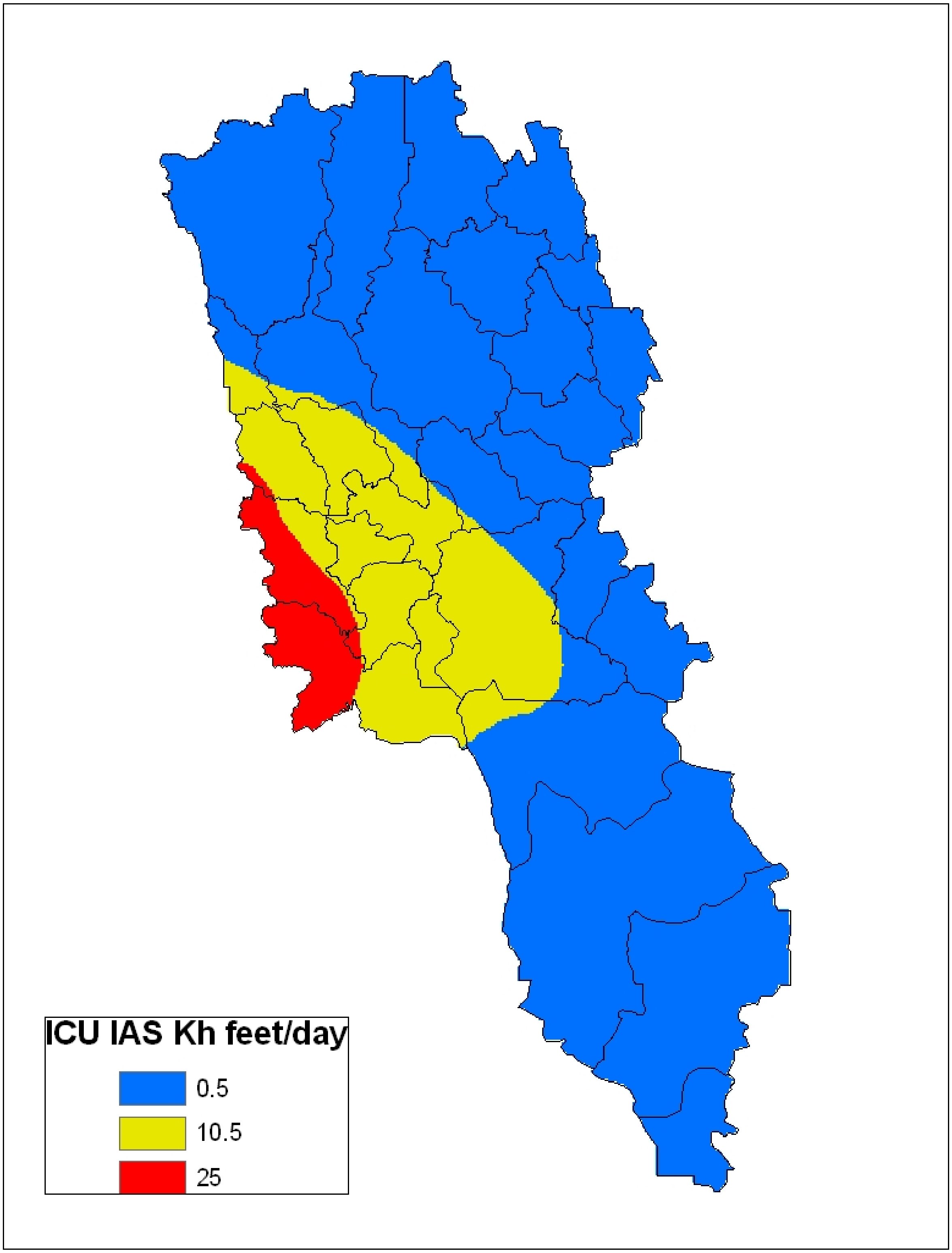

Figure 2-9: AFET-W Horizontal Hydraulic Conductivity of the Intermediate Aquifer System

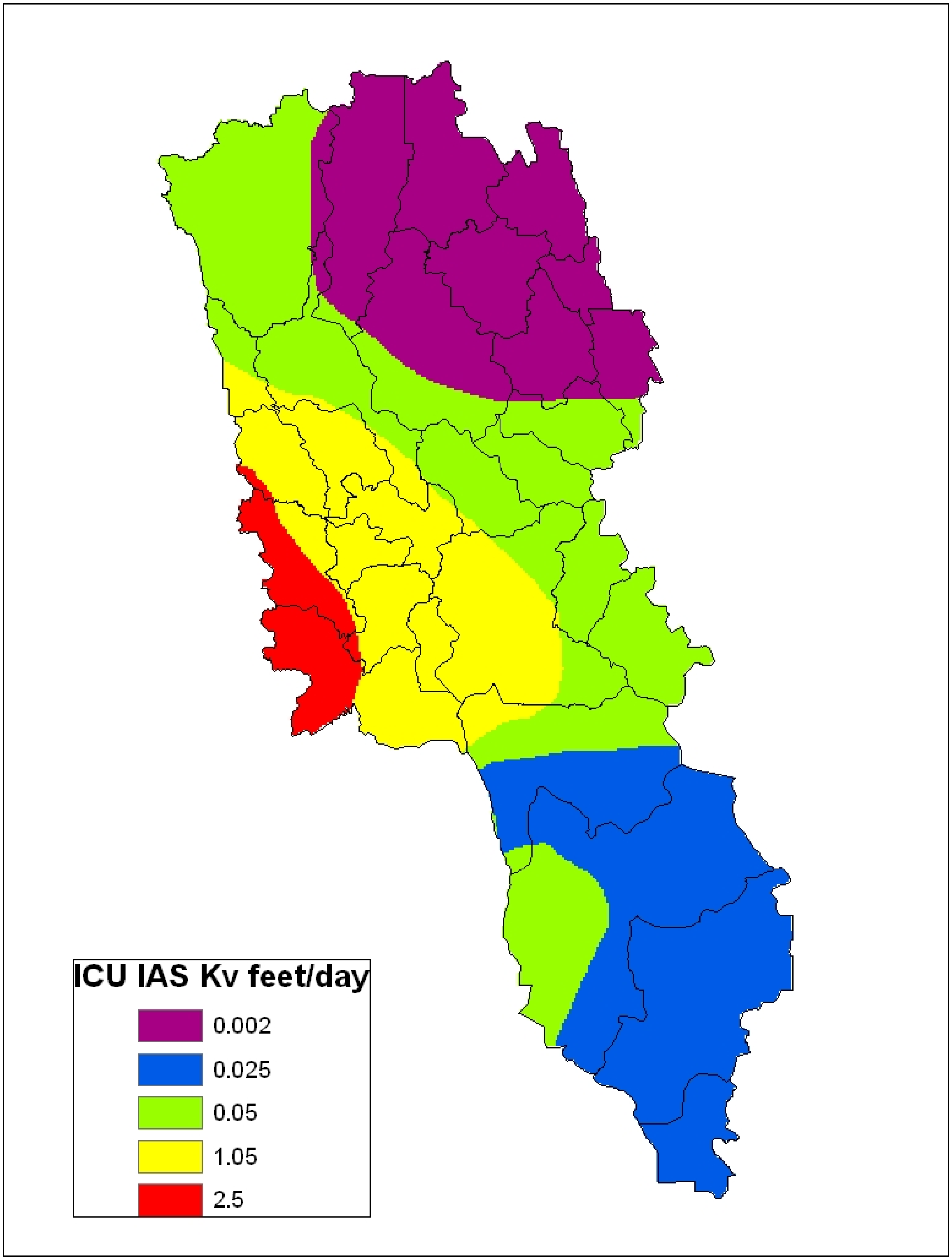

Figure 2-10: AFET-W Vertical Hydraulic Conductivity of the Intermediate Confining Unit

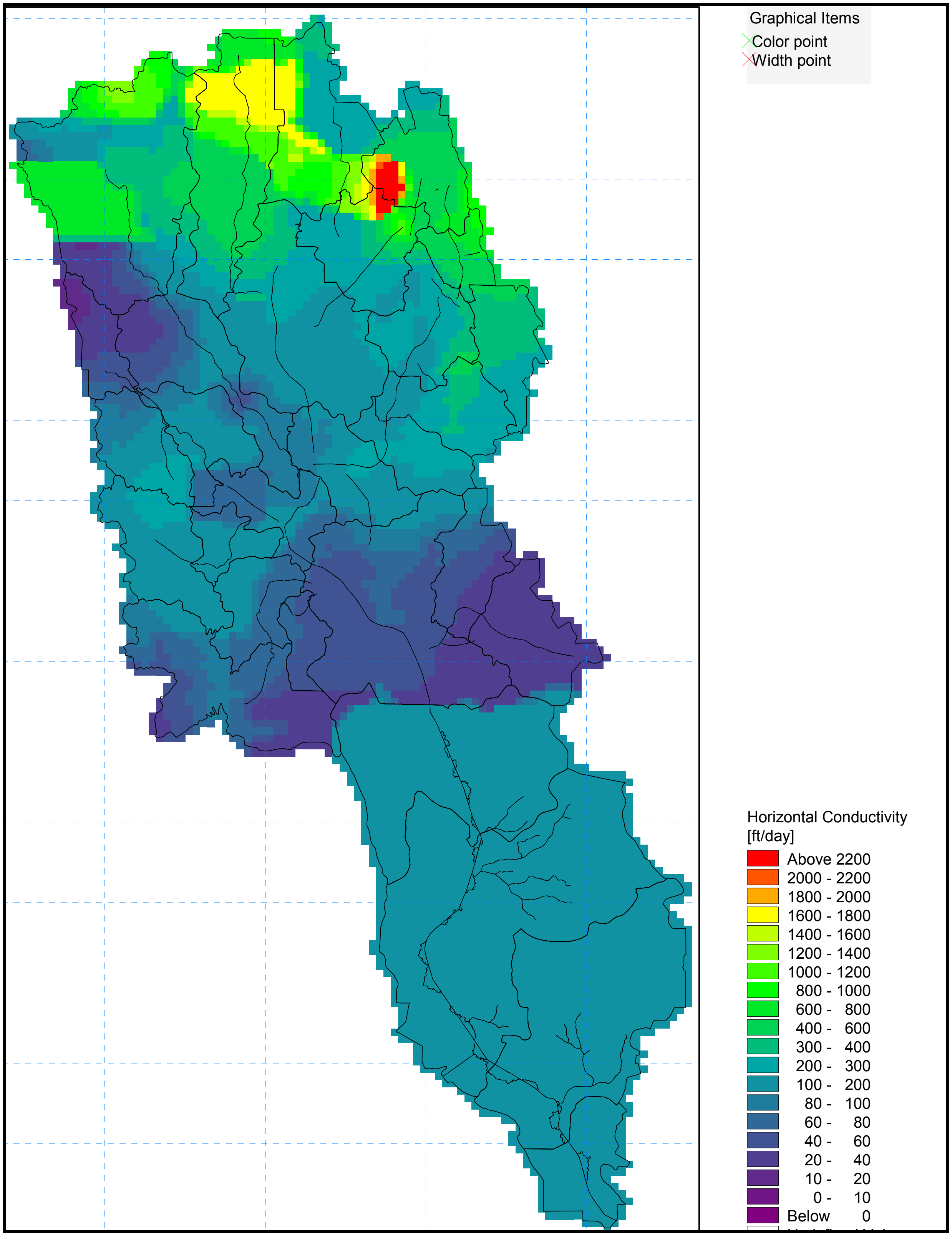

Figure 2-11: AFET-W Horizontal Hydraulic Conductivity of the Upper Floridan Aquifer

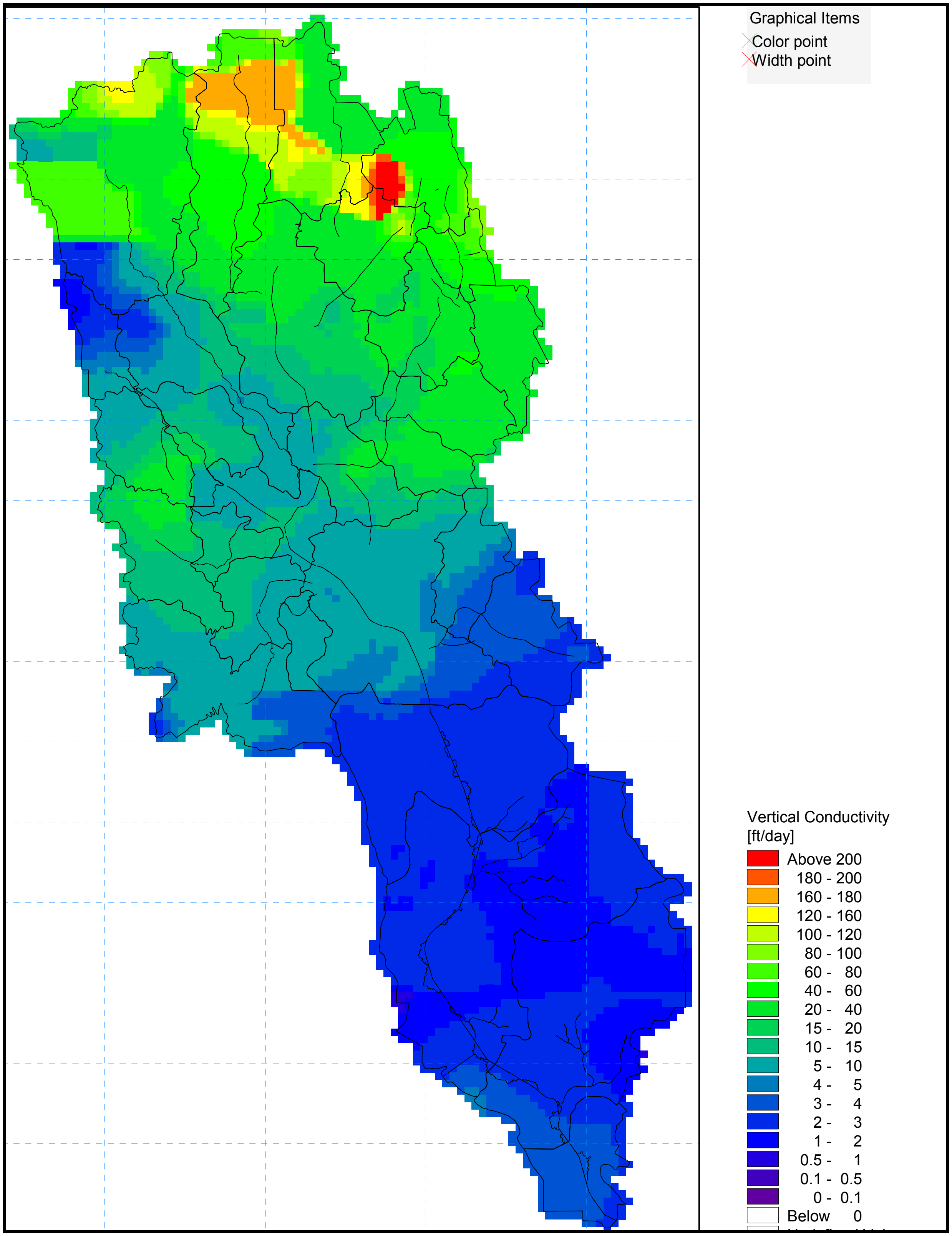

Figure 2-12: AFET-W Vertical Hydraulic Conductivity of the Upper Floridan Aquifer

2.11.2 Computational Layers

AFET-W used the computational layers documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.11.2.1 Saturated Zone Boundary Conditions

AFET-W used the saturated zone boundary conditions documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

2.11.3 Drainage

There were no changes in methodology from AFET but there was further adjustment of AFET drainage levels during AFET-W calibration. These changes were made after a review of aerial photographs showed that in some areas there were relatively large drainage systems that were not adequately represented. Consequently drainage levels were modified (Figure 2-13). The new drainage added to MIKE SHE are the areas in the southern portion of the model shown in dark blue and purple.

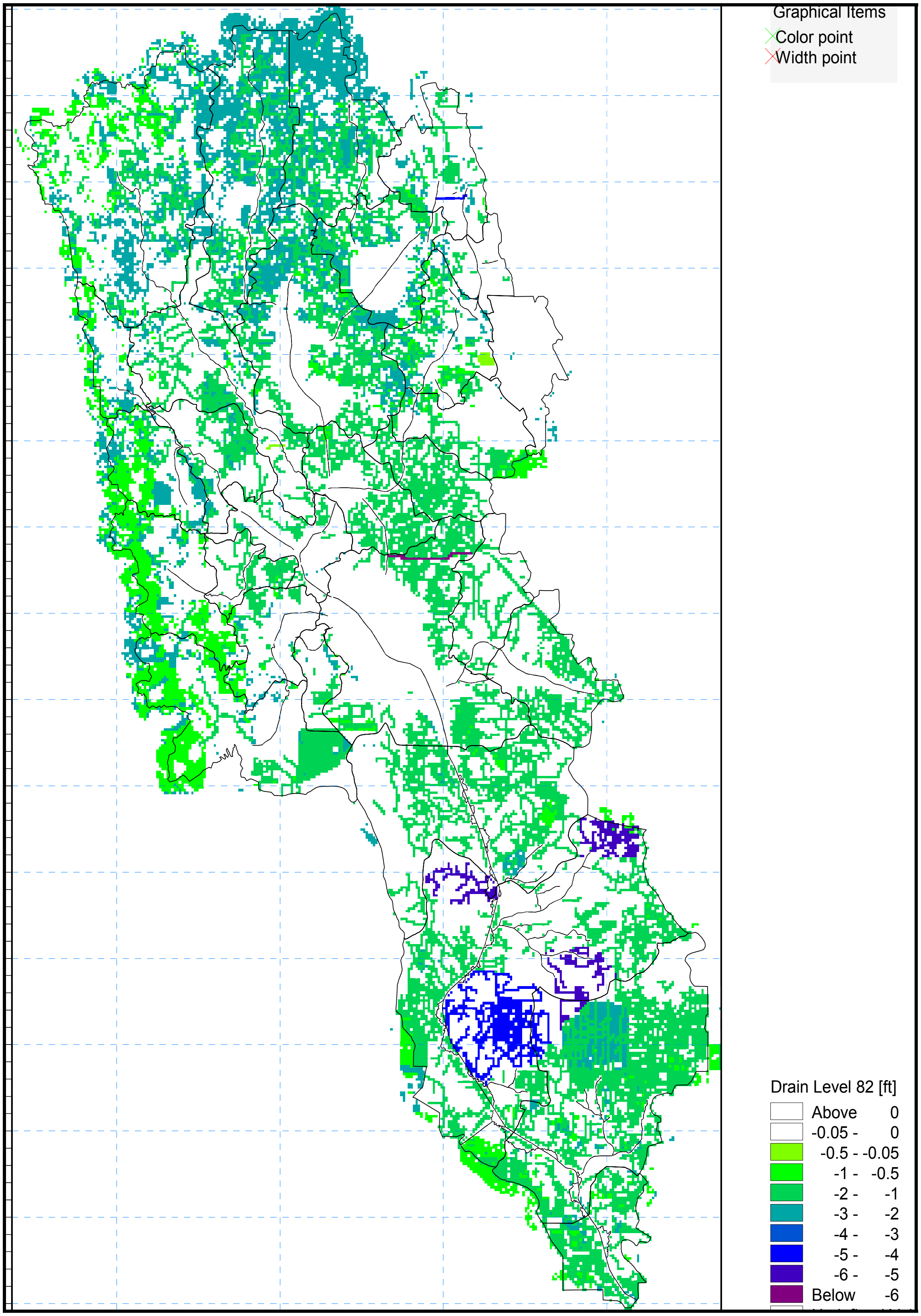

Figure 2-13: AFET-W Drain Levels (negative indicates ft below land surface)

2.11.4 Potable Groundwater Withdrawals

No changes from AFET except pumping wells identified in MIKE SHE as wells number 917 through 920 (corresponding to UNIQUE_ID:SF88 through SF91 in the original spreadsheet received from the SFWMD) , were all set to a cased depth of 20 feet below what was originally in the model. Also, pumping well data for wells 919 and 920, were set to the average of the previous and next year for month (8/1/1997), in the pumpage timeseries file. These changes were made due to an irregularity in UFA well ORA 017.

3 SENSITIVITY ANALYSIS

During the Calibration of AFET-W, and to define the parameters that were going to be modified from one run to the next one, the sensitivity analysis documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007 was used as the main reference.

4 MODEL CALIBRATION

Calibration of the AFET-W model for the period from January 1, 1995 through December 31, 1998 is discussed below. The approach used to calibrate the model is defined along with the criteria that were used to evaluate model performance. The calibration criteria are also described in the following sub-sections.

4.1 Approach

The calibration effort initially focused on the UFA portion of the model in an attempt to duplicate the level of accuracy obtained by another SFWMD modeling effort currently that was in progress (the East and Central Florida Transient - ECFT Model) at the time of the calibration. It was assumed that improving the calibration of the UFA would also improve the calibration of the SAS. The calibration approach followed during the calibration effort is summarized in Figure 4-1. Each circle in Figure 4-1 identifies a step or a procedure that was followed or completed within the process. These procedures are grouped by levels. Levels represent procedures that were followed simultaneously. All of the procedures within one level must have been successfully completed before the calibration process could move to the next level. The first three circles corresponded to the preparation of the KBMOS AFET verification model data sets used for the calibration refinement and update process. The calibration process actually started with the procedures (circles) marked with Numbers 1 through 7. Each procedure is described below. It should be noted that some procedures were repeated at different levels of the calibration process.

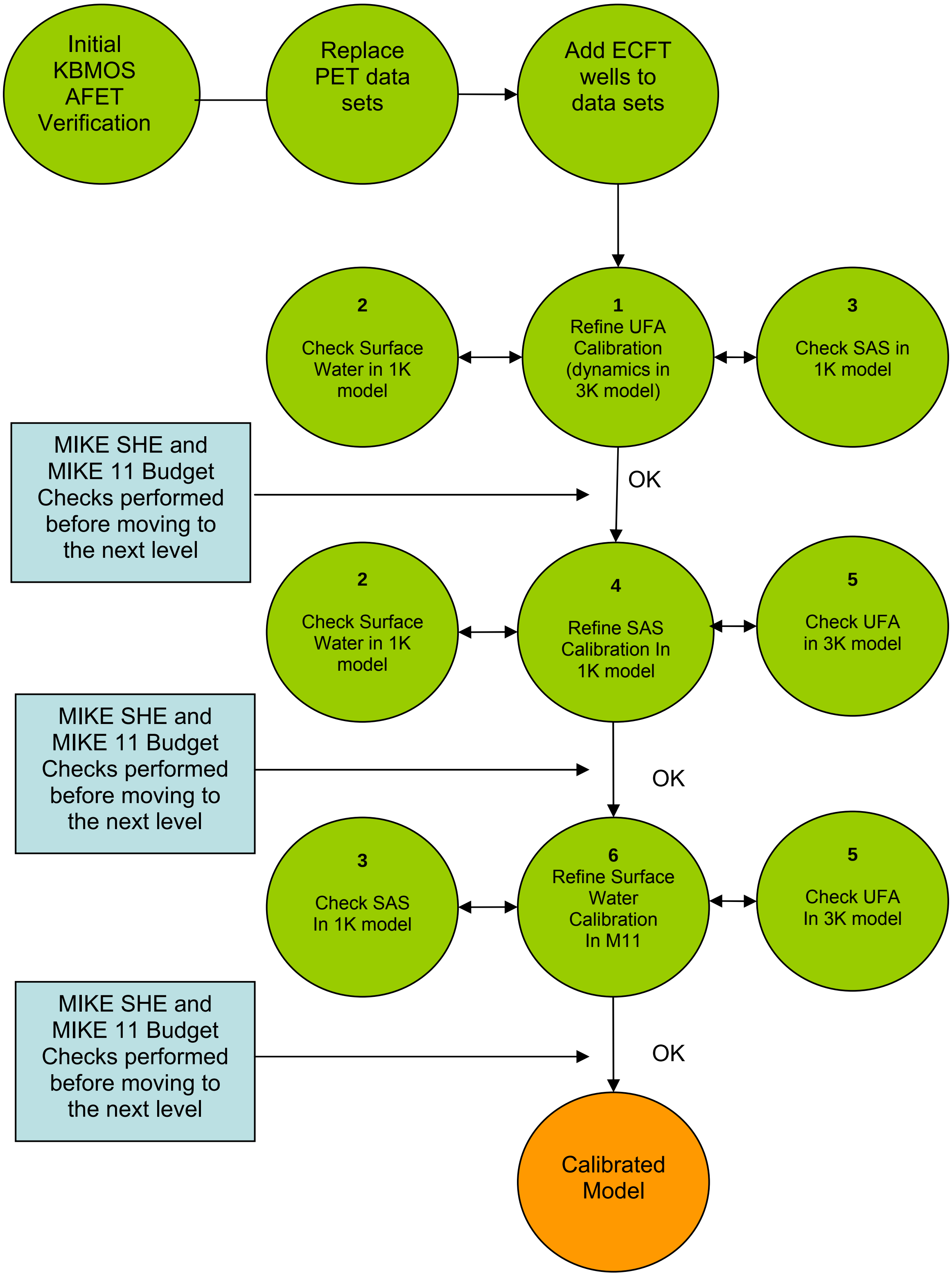

Figure 4-1: Process Followed During the Refinement and Update of the AFET Calibration

4.1.1 Level 1

Procedure 1: Refine UFA Calibration (dynamics in 3K model)

As mentioned above, the initial calibration of AFET included a qualitative comparison of seasonal potentiometric maps for the UFA. Therefore, this part of the model is where the majority of the uncertainty in model results was concentrated. The AFET-W calibration effort started by tuning the UFA layer first. The main objective of this procedure was to get AFET-W to accurately represent the dynamics of the UFA. Visual comparison of hydrographs was performed to assess the dynamics of the aquifer during the first few runs, until the comparison indicated that the model was near calibration, at which time both the statistics and visualization were used. Observed heads and calibration statistics were used as a point of comparison. Hydrogeologic parameters (Kh and Kv) of the UFA in AFET-W were replaced by those values determined by the final ECFT Model calibration. This setup for the UFA was used as the starting point for the calibration. In the current level (Level 1), the dominant procedure was Procedure 1. Therefore, most runs were focused to improve the results being examined under that procedure. When the study team considered that the model produced results that were worth considering, or when the study team considered that there have been enough changes to the previous run, the results of Procedures 2 and 3 were reviewed.

Procedure 2: Check Surface Water Statistics in 1K Model

The purpose of the calibration refinement and update were to improve the calibration of the groundwater portion of AFET without affecting the surface water calibration statistics, or at least keeping those statistics within the targets established in this document. Therefore, once the study team considered it necessary, results of Procedure 1 (3K model) were used to prepare a 1K model. Results from this model run were used to check the calibration statistics set for stages and flows. Differences identified in this procedure were informational only, unless they were considered to be of such magnitude that they required going back to Procedure 1 to undo the changes that produced them.

Procedure 3: Check SAS Heads in 1K Model

This was done simultaneously with the same runs prepared for Procedure 2. Results from this model run were used to check the calibration statistics set for the SAS. Differences identified in this procedure were informational only, unless they were considered to be of such magnitude that they required going back to Procedure 1 to undo the changes that produced them.

After the first level was done and before moving to the second level, a check of MIKE SHE and MIKE 11 water budgets was performed. MIKE SHE and MIKE 11 water budget tables were discussed with the SFWMD during the weekly meetings. Suggestions and comments obtained from these meetings were incorporated in the next level of the calibration process.

4.1.2 Level 2

Procedure 4: Refine SAS Calibration (1K model)

The pivotal procedure of this level was the SAS. At this point of the calibration, results for the UFA heads were already acceptable and the calibration effort focused on the SAS wells. Observed heads were compared with model results. Special emphasis was given to parameters that under the calibration conditions may not have a large influence in the water budget, but if perturbed (i.e. by urbanization), may increase their influence on model results.

Procedure 2: Check Surface Water Statistics in 1K Model
Described above

Procedure 5: Check UFA in 3K Model
This was done simultaneously with the same runs prepared for Procedure 4, since these runs were required to prepare the boundary conditions for the UFA. Results from this model run were used to check the calibration statistics set for the UFA. Differences identified in this procedure were used for informational purposes only, unless they were considered to be of such magnitude that they required going back to Procedure 4 to undo the changes that produced them.

After the second level was done and before moving to the third level, a check of MIKE SHE and MIKE 11 water budgets was performed. MIKE SHE and MIKE 11 water budgets tables were discussed with the SFWMD during the weekly meetings. Suggestions and comments obtained from these meetings were incorporated in the next level of the calibration process.

4.1.3 Level 3

Procedure 6: Refine Surface Water Calibration in MIKE 11 (1K model)
The pivotal procedure of this level was the surface water calibration. This area of the model was the one that had most of the attention during the AFET calibration. This portion of the calibration focused on the long term cumulative error (10-year run). Cumulative plots were used as the main tool to assess model calibration in this procedure.

Procedure 3: Check SAS heads in 1K Model
See the description above.

Procedure 5: Check UFA in 3K Model
See the description above.

4.2 Calibration Criteria

The selection of statistical targets for the calibration of a semi-regional integrated model can be a complex task. There is always the risk to set extremely high and unachievable targets that will make the calibration process an endless and painful process. On the other hand, if the targets are set too loose, there is the risk to end up with a calibrated model that does meet the expectations of its potential users.

The approach used in this calibration update and refinement defined an initial set of calibration targets. The selection of the initial set of calibration statistics and targets follows the same approach used to select the calibration wells and period (discussed in the following section). The calibration statistics and targets used by AFET for the surface water network were merged with the statistics and targets used by ECFT Model. These initial targets were revised by the study team based on the initial testing and model runs completed over the first two months of the calibration effort. The final of targets are summarized below:

- Surface Network
    - Stages*
        - RMSE ≤ 2.5
        - R ≥ 0.5

- Flow*
    - CE ≤15 percent
    - R ≥ 0.84
- Groundwater (both SAS and UFA)
  - Heads
    - For primary wells, the Mean Error (ME) and the mean absolute error (MAE) should be less than or equal to ± 2.5 feet for 50 percent of the wells.
    - For primary wells, the ME and MAE should be less than or equal to ± 5.0 feet for 80 percent of the wells.
    - For primary wells, the root mean squared error (RMSE) should be less than or equal to ± 5.0 feet for 80 percent of the wells.
    - The overall ME should be within ± 1.0 feet and should approach zero.
    - R ≥ 0.5 - (R is used only for the SAS)

*: For surface water calibration, only stations listed in the AFET documentation as "high" priority were used in the calibration refinement.

The main difference between the set of targets described here and the set of targets originally used during the calibration of AFET for the groundwater portion of the model, lies in the use of observation wells to calibrate the UFA. In the AFET calibration, a qualitative comparison with seasonal potentiometric maps was used. This approach was used since most of the observation wells did not have data during the AFET calibration period. The use of seasonal potentiometric maps as a reference did not allow the calibration to accurately represent the dynamics of the UFA. As expected, by introducing the ECFT Model wells and using an earlier calibration period, the dynamics of the UFA was more accurately represented, thus addressing the majority of the comments the SFWMD had on the groundwater portion of AFET calibration.

4.3 Calibration Data

This effort will use the same location of calibration points used during the KBMOS AFET calibration for the surface water portion of the model (stages and flows). Since the emphasis of the calibration refinement and update is on the groundwater portion of the model, the set of groundwater calibration data was enhanced using the data points obtained from the ECFT Model as described below.

4.3.1 Observation Wells

Available observation wells were selected by the study team. The team's intention was to select at least one well in the SAS and one well in the Upper Floridan Aquifer (UFA) for each watershed within the Basin. The data the team used to start these analyses was the QA/QCed ECFT Model calibration data set. Any wells that were already rejected by ECFT Model Team were not considered.

During the study team meetings, it was concluded that two sets of wells should be identified. The first set or the primary calibration wells, as seen in Table 4-1 and Figure 4-2 (where UFA wells are shown in green and SAS wells are shown in red), will be the wells where the calibration will be focused and where the calibration statistics will be evaluated. The second set of wells, or the secondary calibration wells (Figure 4-3), are those wells that are close to the model boundary but did not cover the entire calibration period or their data were to sparse to produce meaningful calibration statistics. Calibration statistics were not evaluated for the secondary calibration wells. However plots comparing the observed versus simulated heads were prepared to qualitatively incorporate into the calibration the information available at the location of the secondary wells.

Table 4-1: Primary Calibration Wells in the Kissimmee Basin

STATION	Water Control Unit	Layer
ALL1	LAKE ALLIGATOR	SAS
ALL2	LAKE ALLIGATOR	SAS
CAST	LAKE GENTRY	SAS
CHAP	LAKE KISSIMMEE	SAS
DISNEY	UPPER REEDY CREEK	SAS
ELMAX	S-65A	SAS
EXOT	LAKE GENTRY	SAS
GRIF	S-65D	SAS
GS827	UPPER REEDY CREEK	UFA
KIRCH	LOWER REEDY CREEK	SAS
KISSFS	SHINGLE CREEK	SAS
MAXYN	S-65BC	SAS
MAXYS	S-65BC	SAS
ORA001	EAST LAKE TOHOPEKALIGA	UFA
ORA004	UPPER REEDY CREEK	UFA
ORA005	UPPER REEDY CREEK	SAS
ORA007	LAKE HART	SAS
ORA013	SHINGLE CREEK	UFA
ORA017	UPPER REEDY CREEK	UFA
ORA019	LAKE HART	UFA
ORA025	BOGGY CREEK	UFA
ORA027	UPPER REEDY CREEK	UFA
OS0228	LOWER REEDY CREEK	UFA
OSC023	LAKE TOHOPEKALIGA	UFA
PEAV	S-65BC	SAS
PINE	LAKE GENTRY	SAS
POL012	LAKE MARION	UFA
REEDGW	UPPER REEDY CREEK	SAS
SNIVELY	CATFISH CREEK	SAS
TAFT	BOGGY CREEK	SAS
TICK	S-65BC	SAS
WR11	LOWER REEDY CREEK	SAS
WR6	LOWER REEDY CREEK	SAS

4.3.2 Calibration Period

The KBMOS AFET was verified for the period from January 1, 1994 to December 31, 1998. The AFET calibration refinement period was selected by merging the ECFT Model calibration and verification with the AFET verification periods. The resulting calibration period ranges from January 1, 1995 to December 31, 1998. A twelve-month warm-up period (calendar year 1994) was added to the simulations to tune up the starting conditions. This warm-up period will not be used to calculate any of the calibration statistics.

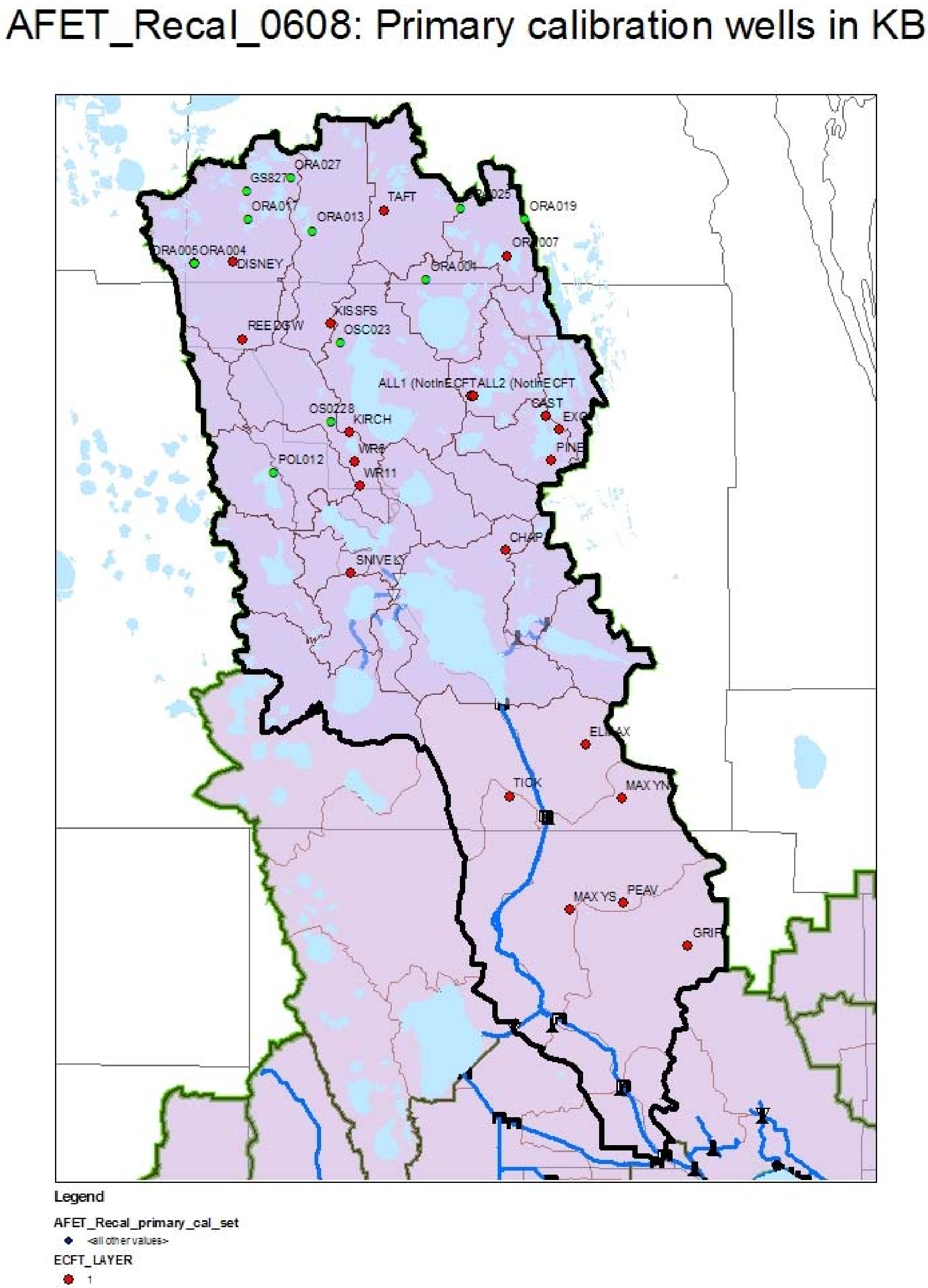

Figure 4-2: Primary Calibration Wells in Kissimmee Basin

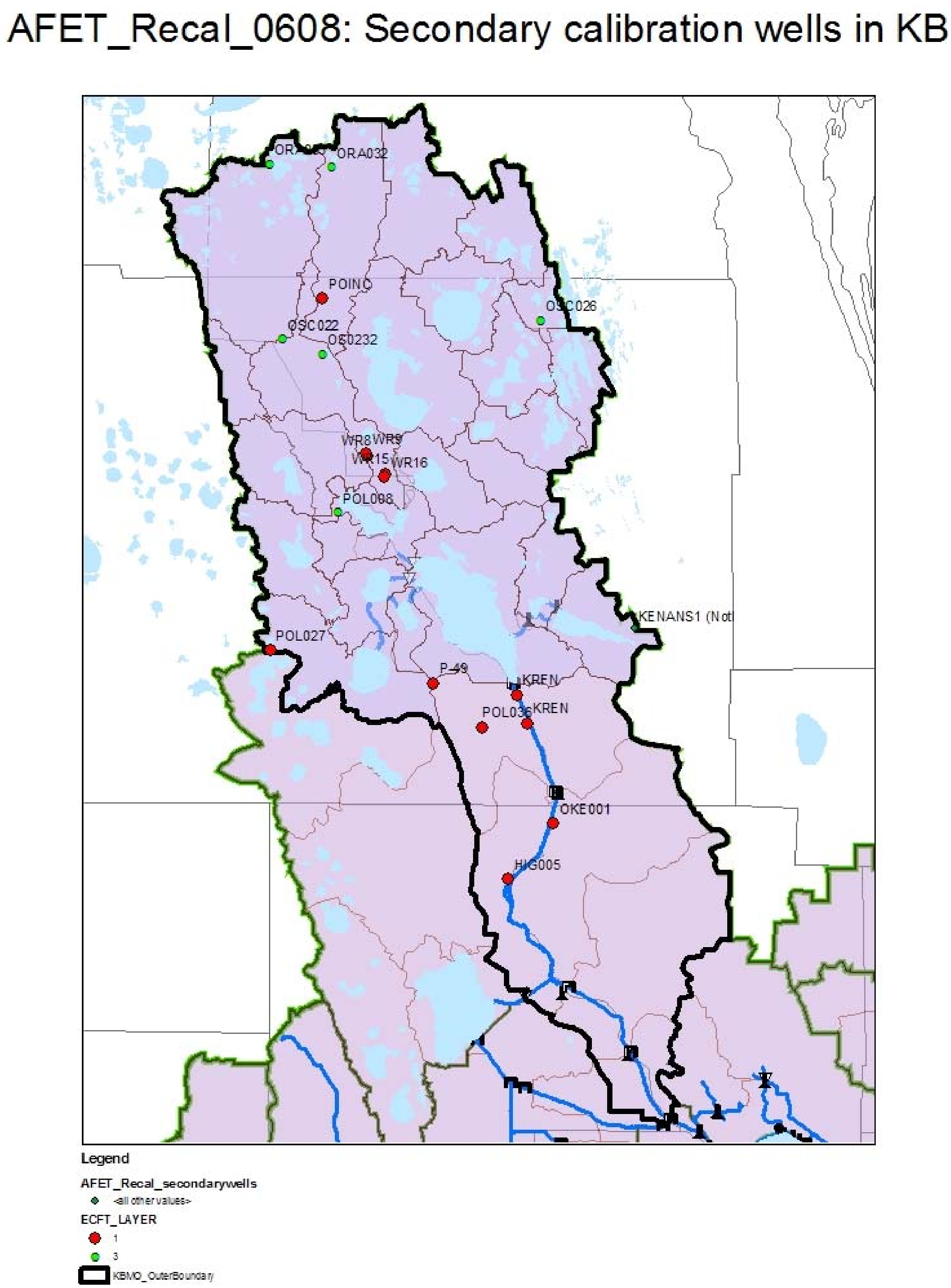

Figure 4-3: Secondary Calibration Wells in Kissimmee Basin

4.4 Restored Kissimmee River MIKE 11 Sub-Model

AFET-W used the restored Kissimmee River MIKE 11 sub-model documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

4.4.1 Results for the Restored Kissimmee River Model

AFET-W used the results for the restored Kissimmee River Model documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

4.4.1.1 Storm Verification Period

The calibration of AFET-W did not include a storm event verification period similar to the storm verification period documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

4.5 Calibration Results

The results are discussed relative to locations of key performance measures that will be used as part of the alternatives analysis phase of the project. Results presented for the FAS correspond to the coarse grid RM model while results presented for the SAS and surface water correspond to the finer grid SM model.

The evaluation of all quantitative and qualitative calibration points identified in the Section 4.3 is included in the following sections.

4.5.1 Surface Water Calibration

Surface water results for the calibration period at key surface water calibration locations within the Kissimmee Basin are presented in Figure 4-4 to Figure 4-44.

4.5.1.1 Upper Basin

The current results for the upper basin during the calibration period indicate that the model is adequately capturing surface water process and responses in the KUB. Surface water results for the upper basin are presented in Figure 4-4 to Figure 4-28.

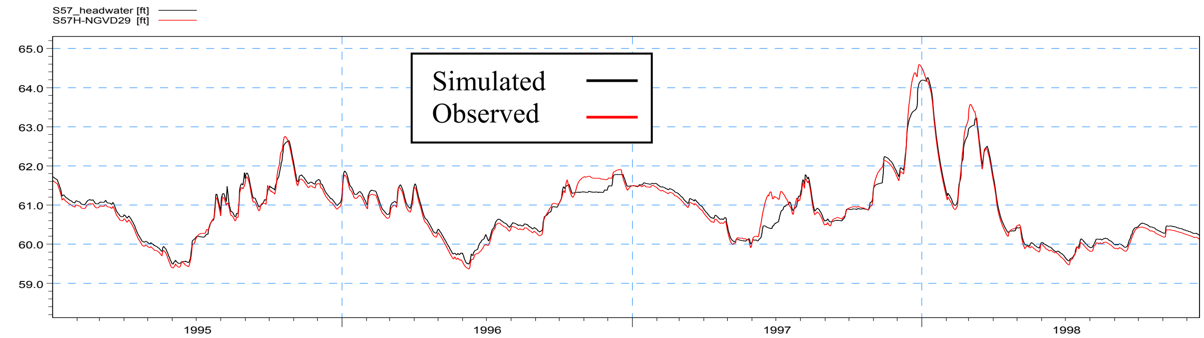

Figure 4-4: Simulated and observed headwater stage at S-57 during the calibration period

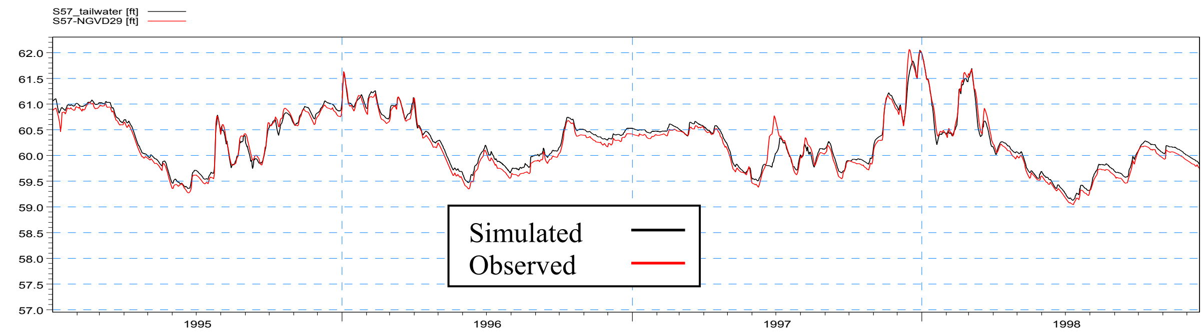

Figure 4-5: Simulated and observed tailwater stages at S-57 during the calibration period

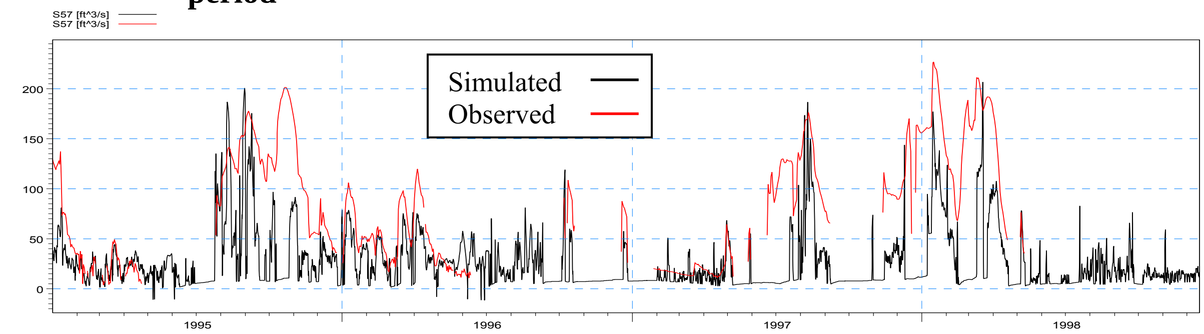

Figure 4-6: Simulated and observed discharge at S-57 during the calibration period

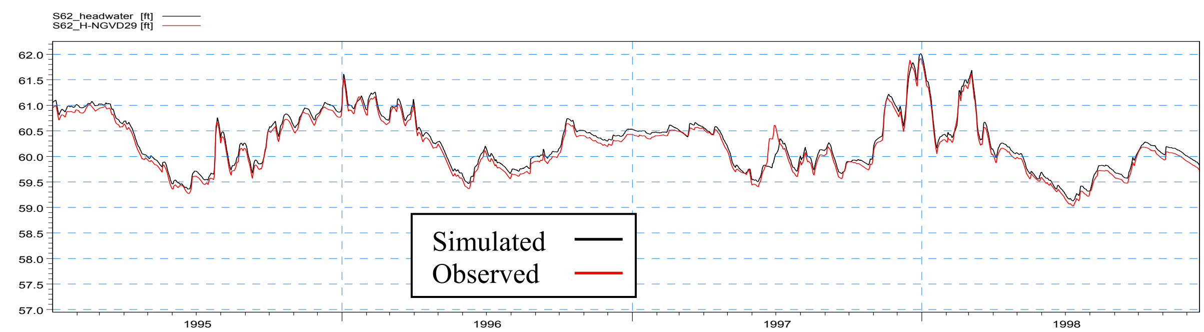

Figure 4-7: Simulated and observed headwater stage at S-62 during the calibration period

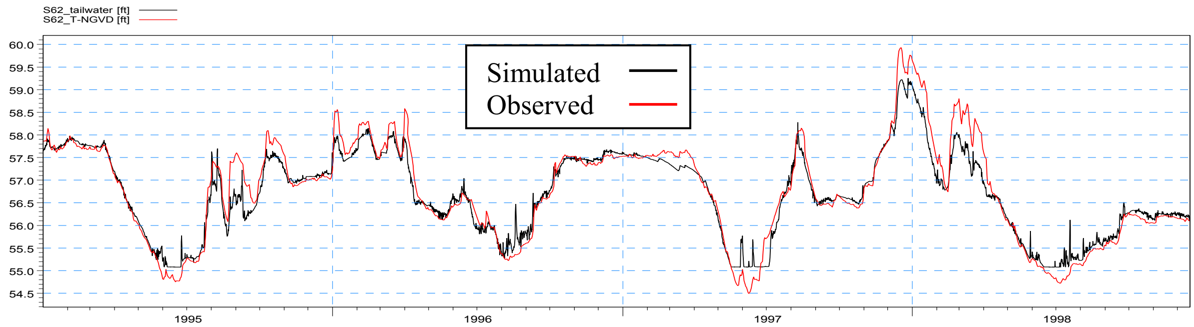

Figure 4-8: Simulated and observed tailwater stage at S-62 during the calibration period

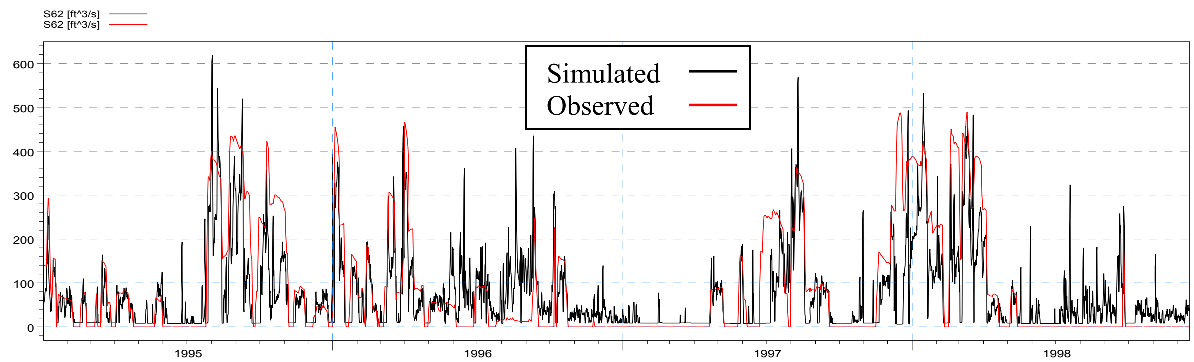

Figure 4-9: Simulated and observed discharge at S-62 during the calibration period

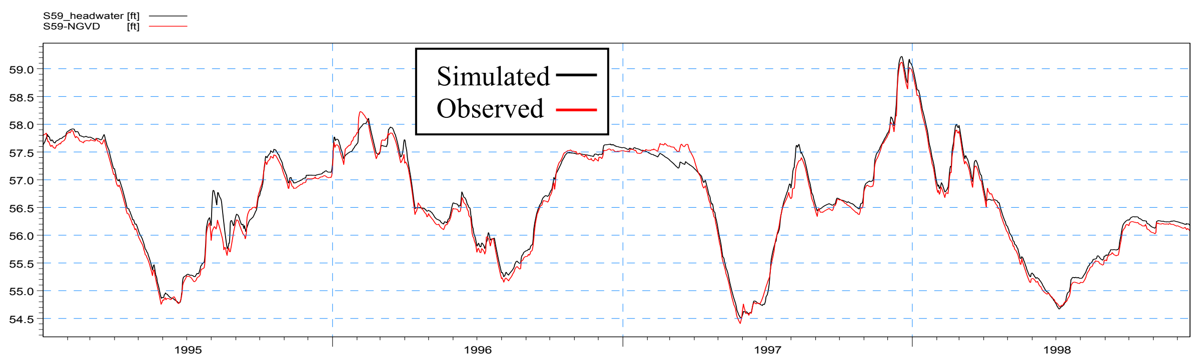

Figure 4-10: Simulated and observed headwater stage at S-59 during the calibration period

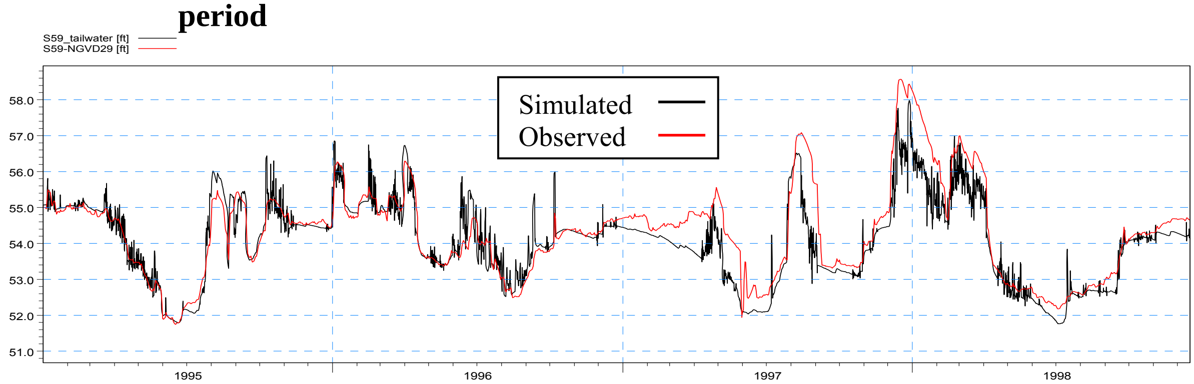

Figure 4-11: Simulated and observed tailwater stage at S-59 during the calibration period

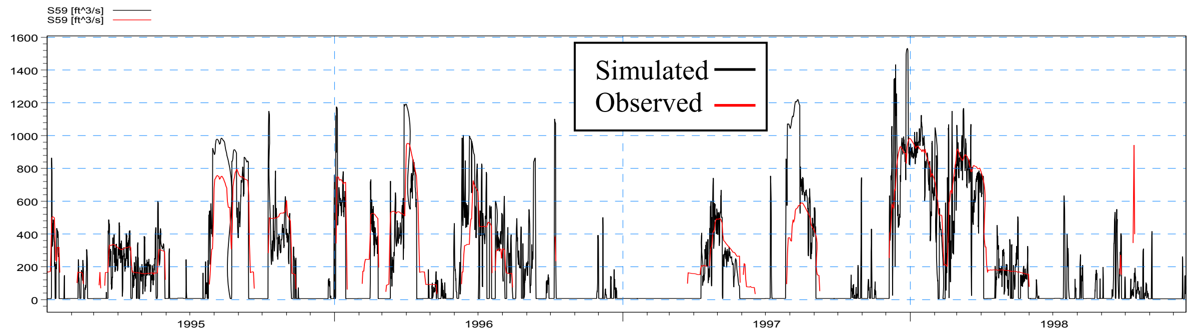

Figure 4-12: Simulated and observed discharge at S-59 during the calibration period

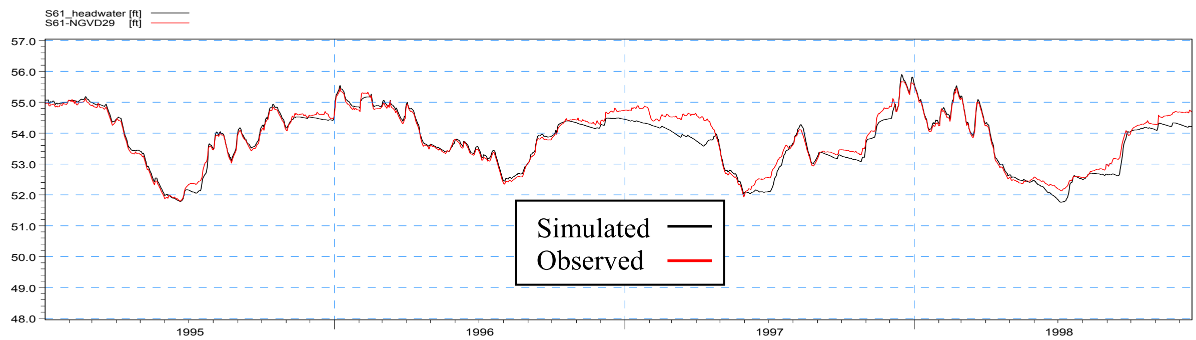

Figure 4-13: Simulated and observed headwater stage at S-61 during the calibration period

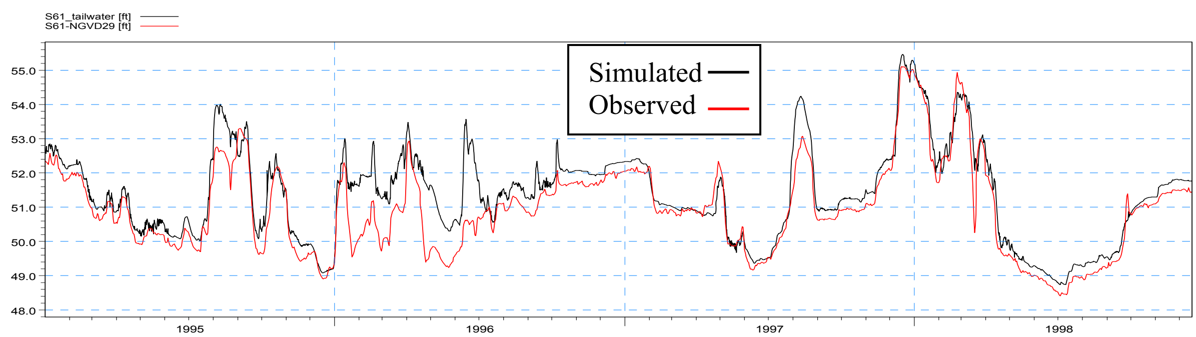

Figure 4-14: Simulated and observed tailwater stage at S-61 during the calibration period

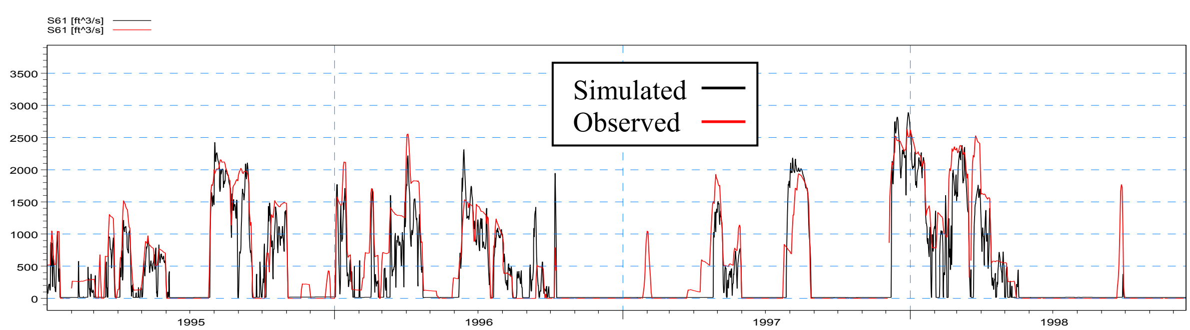

Figure 4-15: Simulated and observed discharge at S-61 during the calibration period

AECOM

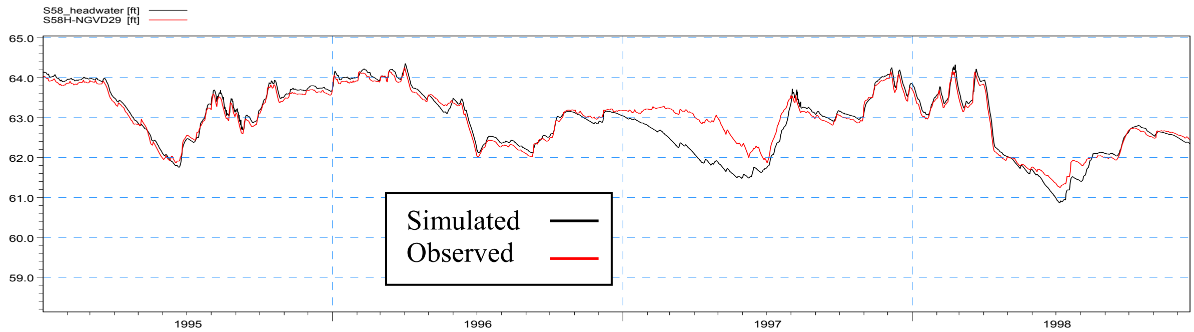

Figure 4-16: Simulated and observed headwater stages at S-58 during the calibration period

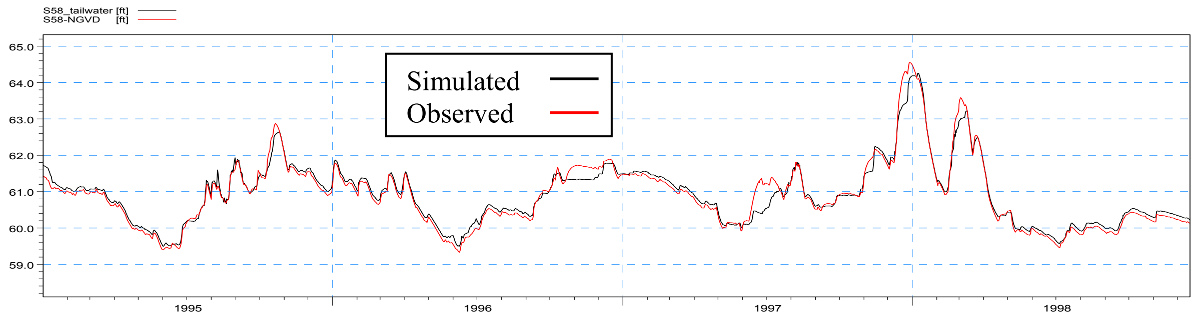

Figure 4-17: Simulated and observed tailwater stages at S-58 during the calibration period

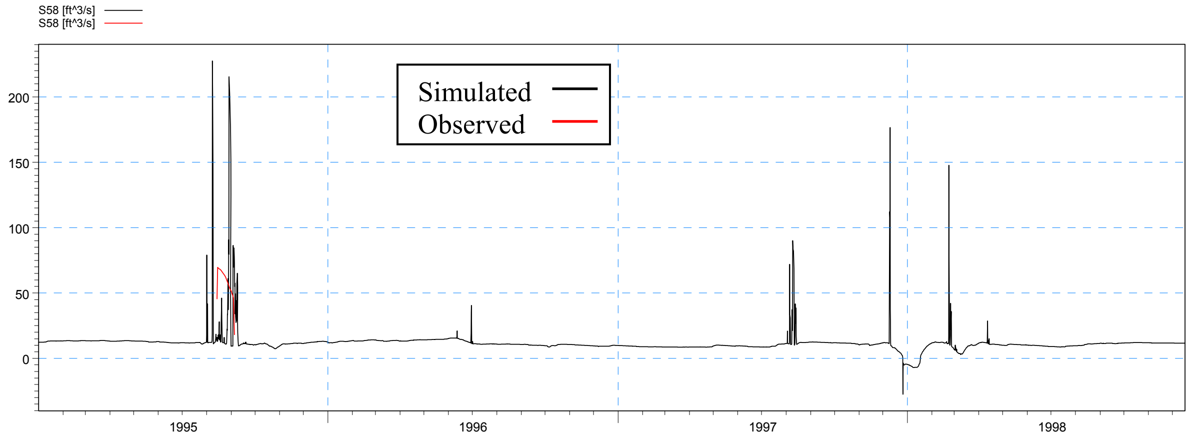

Figure 4-18: Simulated and observed discharge at S-58 during the calibration period

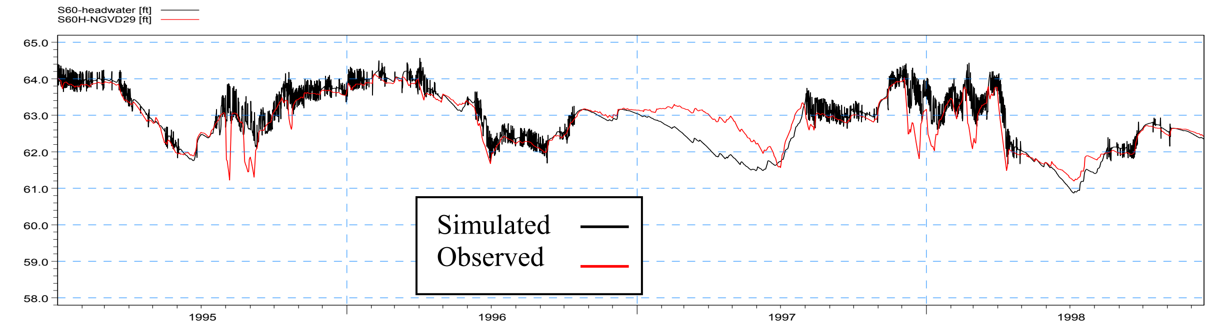

Figure 4-19: Simulated and observed headwater stage at S-60 during the calibration period

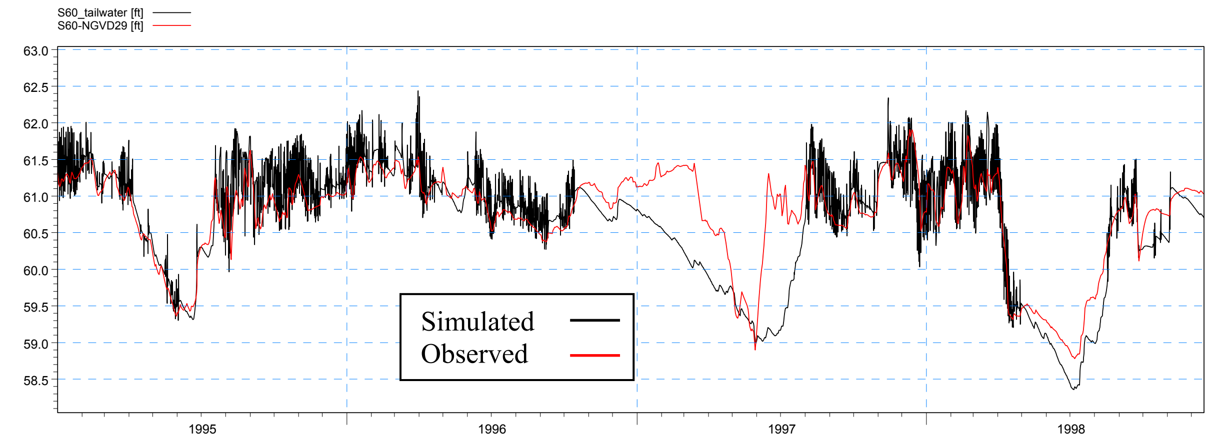

Figure 4-20: Simulated and observed tailwater stage at S-60 during the calibration period

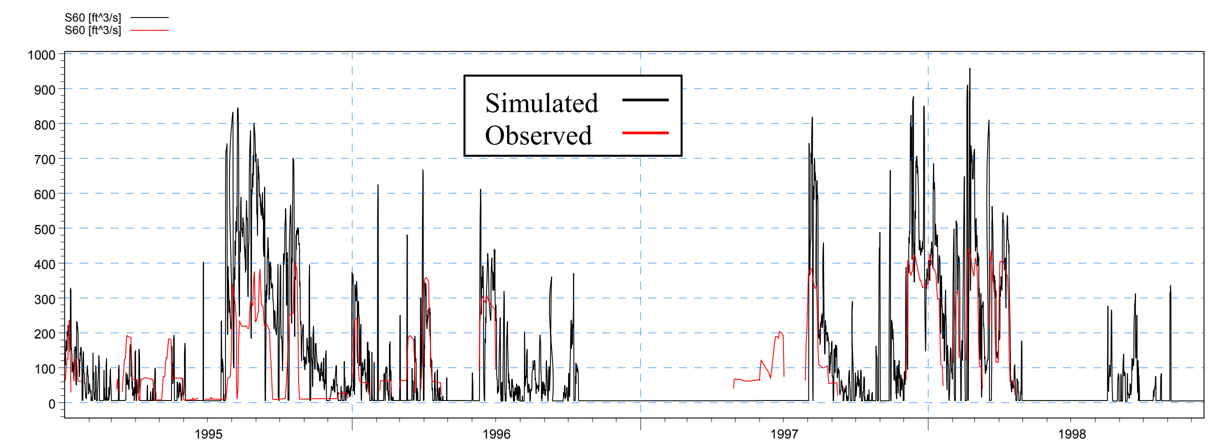

Figure 4-21: Simulated and observed discharge at S-60 during the calibration period

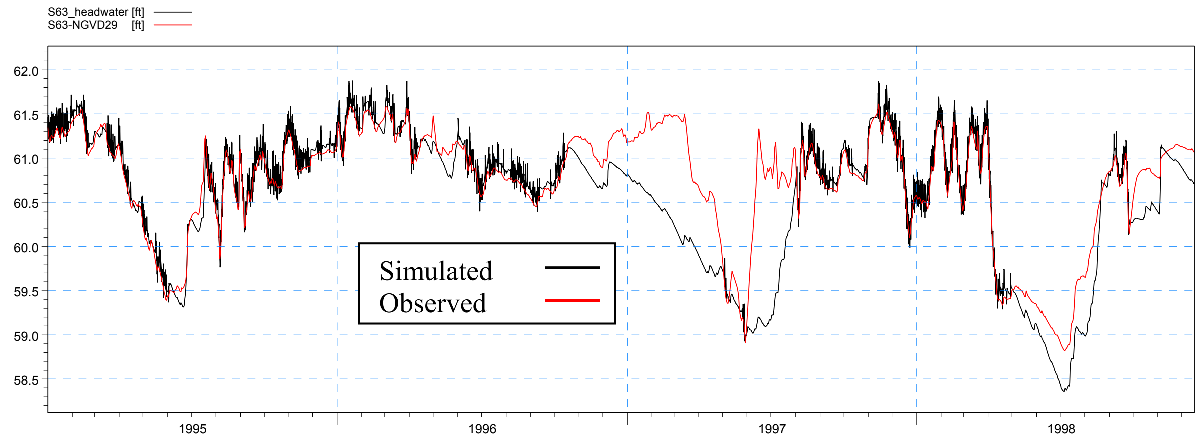

Figure 4-22: Simulated and observed headwater stage at S-63 during the calibration period

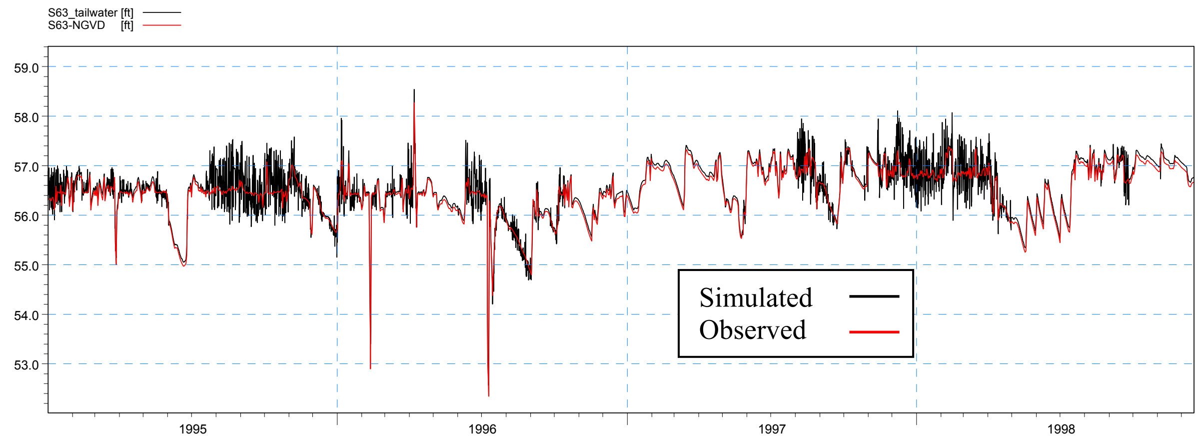

Figure 4-23: Simulated and observed tailwater stage at S-63 during the calibration period

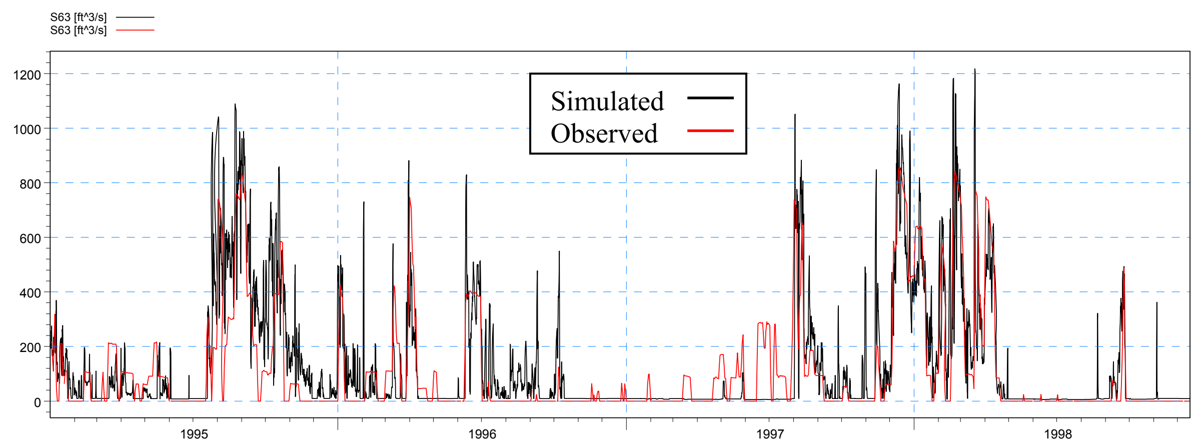

Figure 4-24: Simulated and observed discharge at S-63 during the calibration period

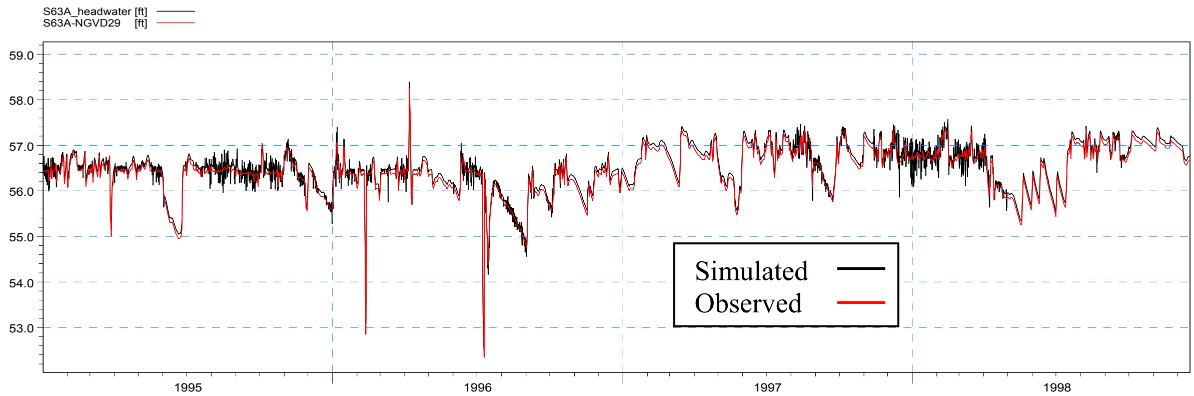

Figure 4-25: Simulated and observed stage at S-63-A during the calibration period

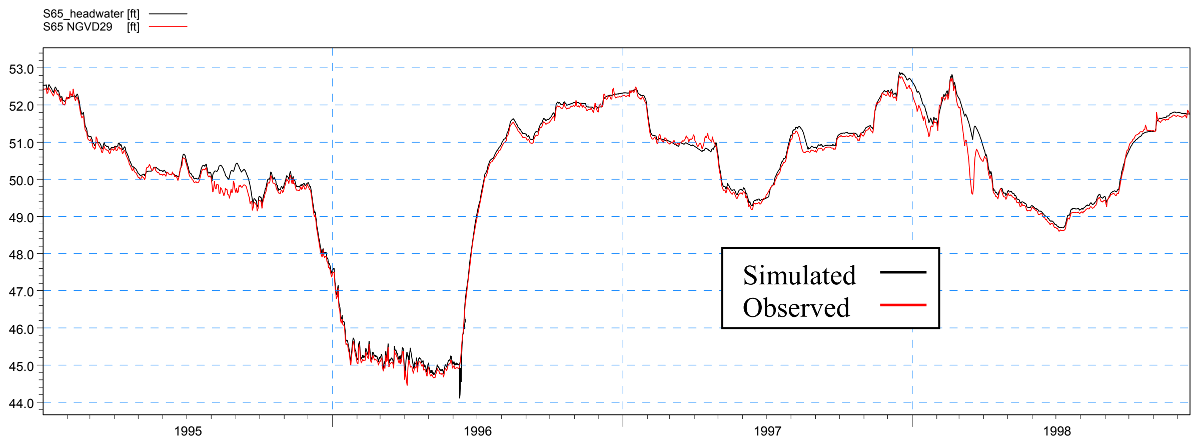

Figure 4-26: Simulated and observed headwater stage at S-65 during the calibration period

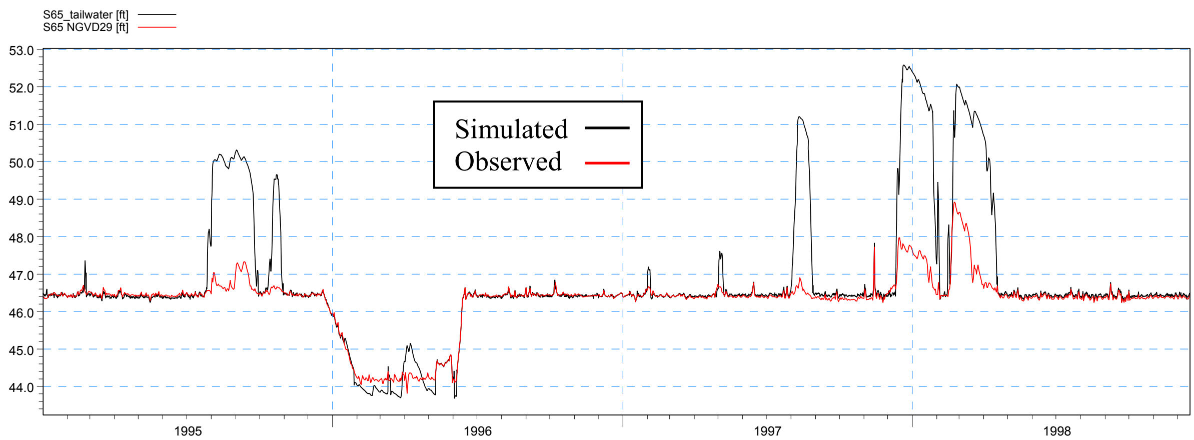

Figure 4-27: Simulated and observed tailwater stage at S-65 during the calibration period

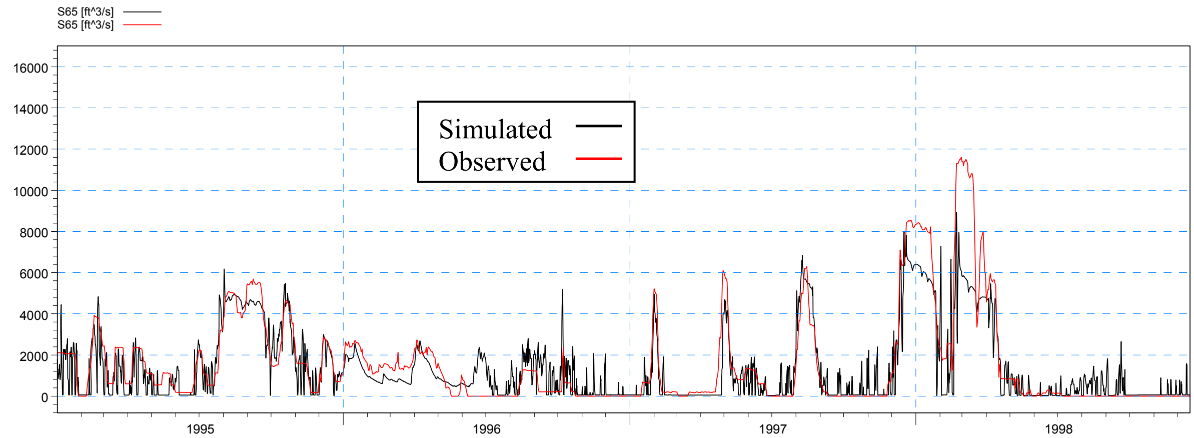

Figure 4-28: Simulated and observed discharge at S-65 during the calibration period

4.5.1.2 Lower Basin

Results for the lower basin during the calibration period are presented in Figure 4-30 through Figure 4-44 and indicate that the model is adequately capturing surface water process and responses in the LKB. Relatively poor performance at the S-65D tailwater gage is a result of datum issues. Stages of the calibration locations located outside of the main channel of the restored portion of the river are often affected by local hydrography not represented in the sub-regional model.

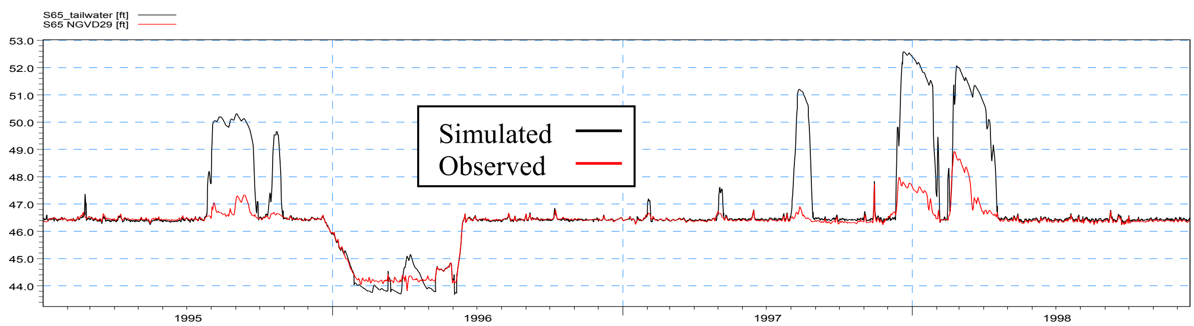

Figure 4-29: Simulated and observed tailwater stage at S-65 during the calibration period

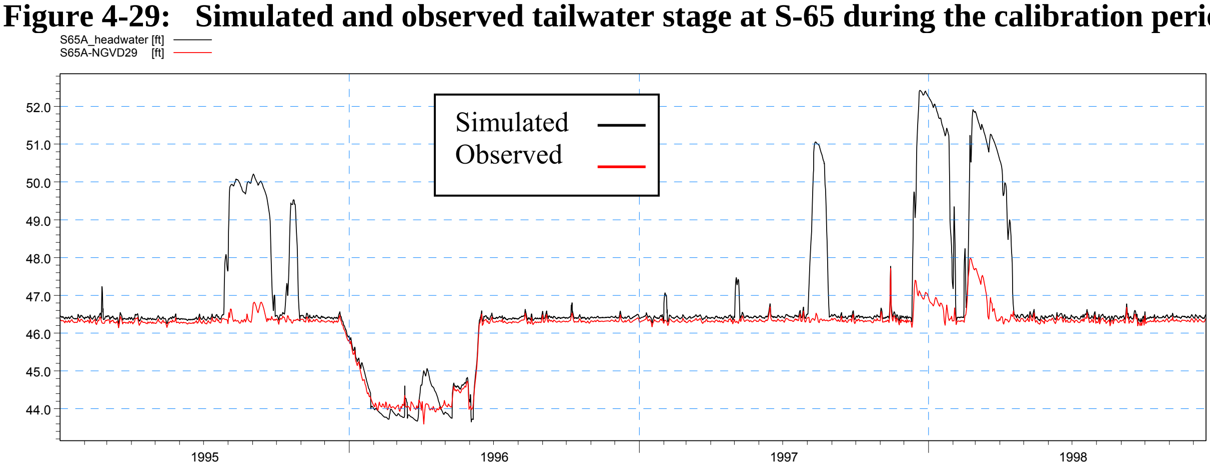

Figure 4-30: Simulated and observed headwater stage at S-65A during the calibration period

AECOM

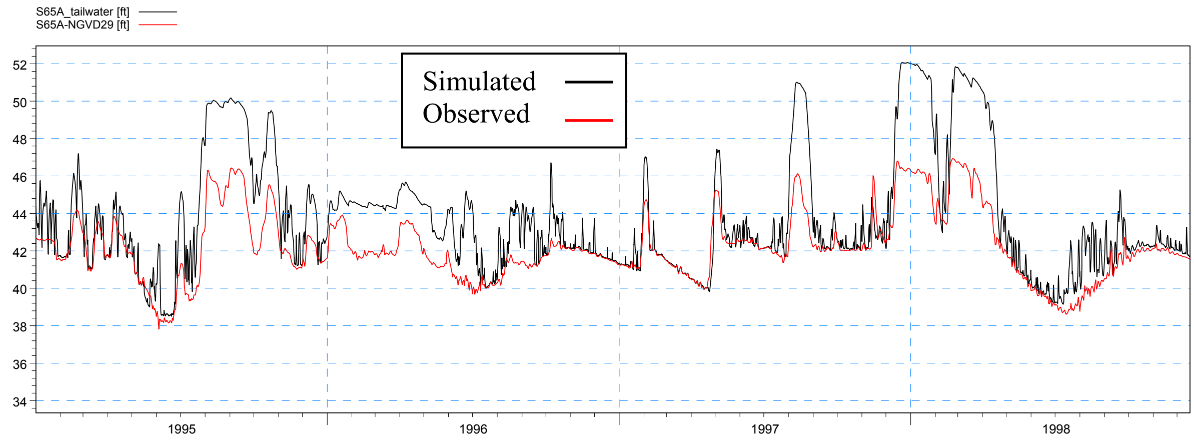

Figure 4-31: Simulated and observed tailwater stage at S-65A during the calibration period

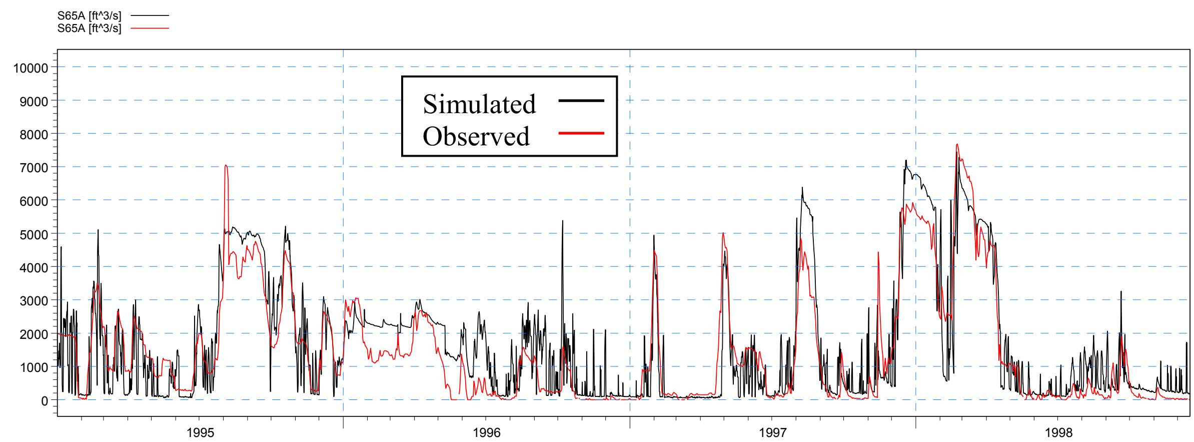

Figure 4-32: Simulated and observed discharge at S-65A during the calibration period

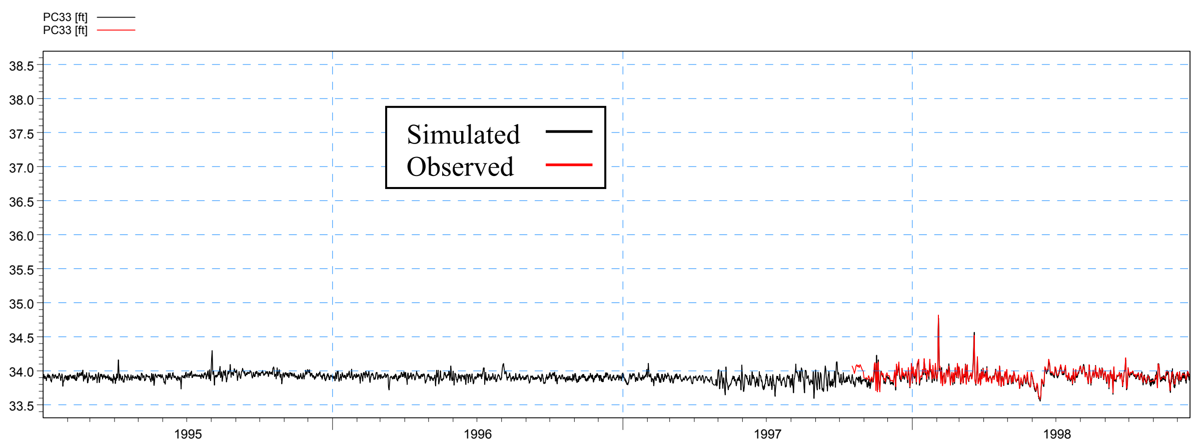

Figure 4-33: Simulated and observed stage at PC33 during the calibration period

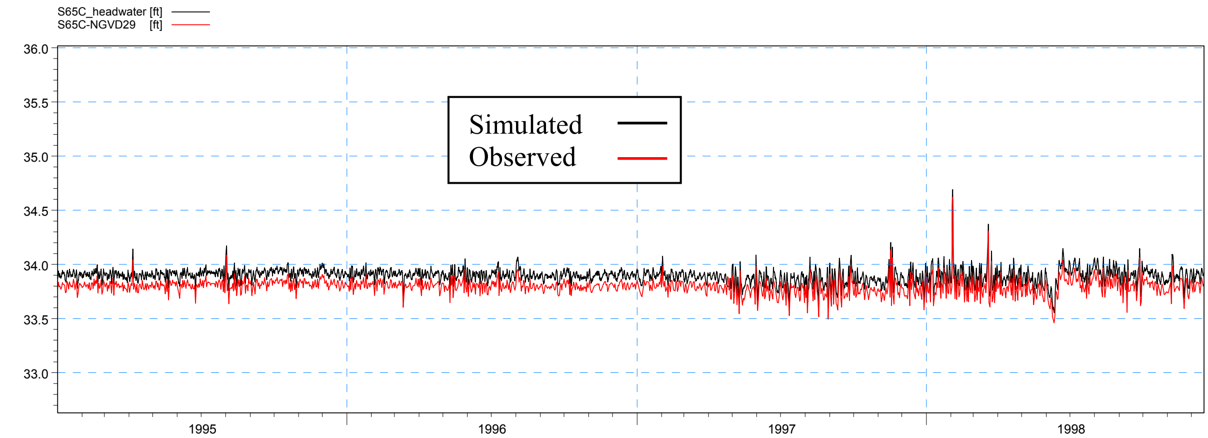

Figure 4-34: Simulated and observed headwater stage at S-65C during the calibration period

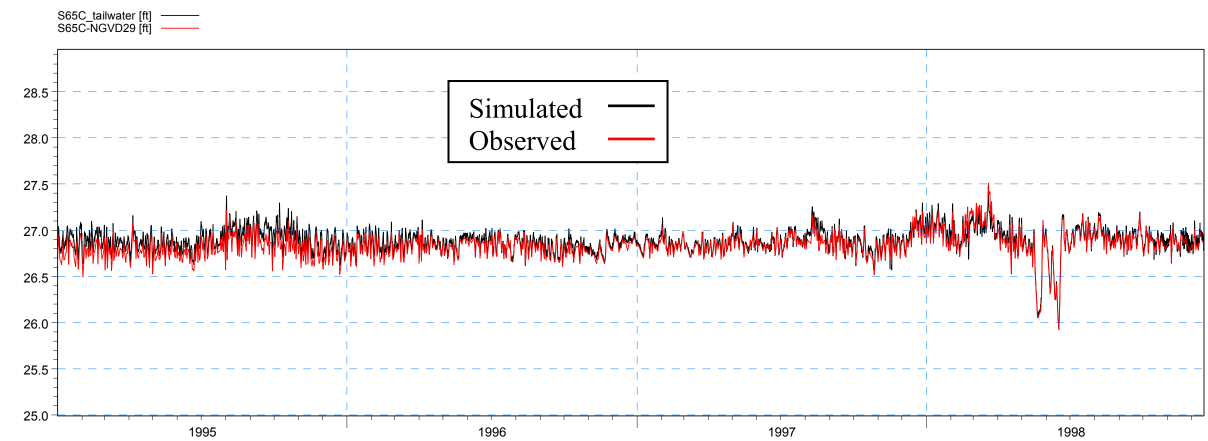

Figure 4-35: Simulated and observed tailwater stage at S-65C during the calibration period

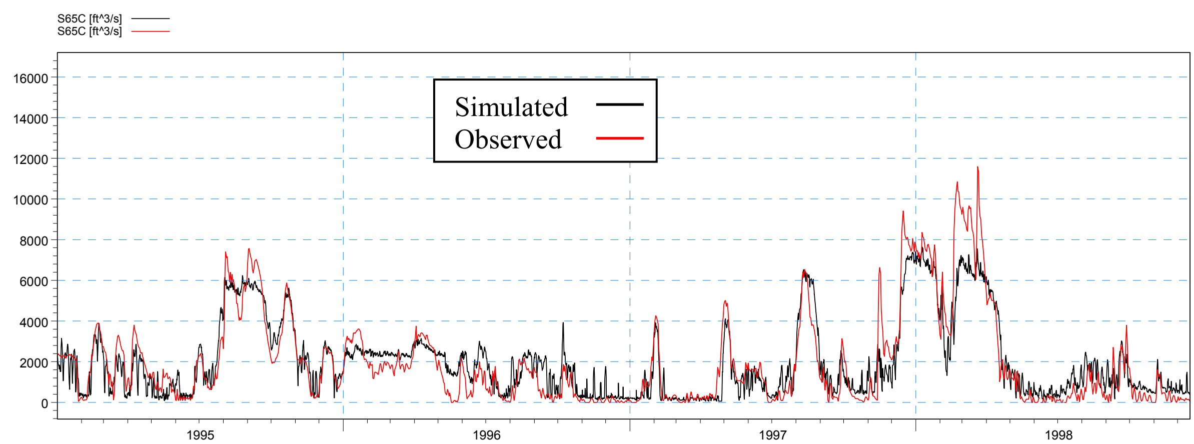

Figure 4-36: Simulated and observed discharge at S-65C during the calibration period

AECOM

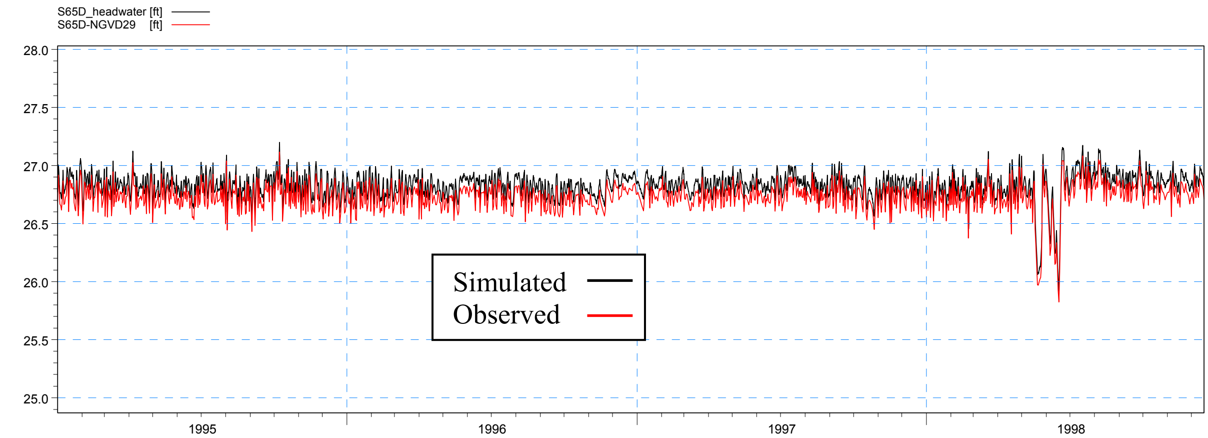

Figure 4-37: Simulated and observed headwater stage at S-65D during the calibration period

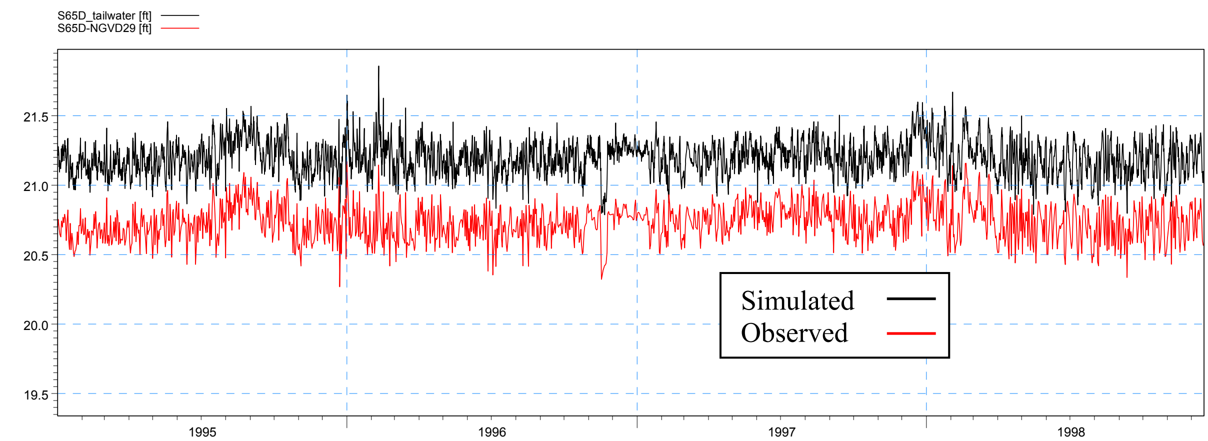

Figure 4-38: Simulated and observed tailwater stage at S-65D during the calibration period

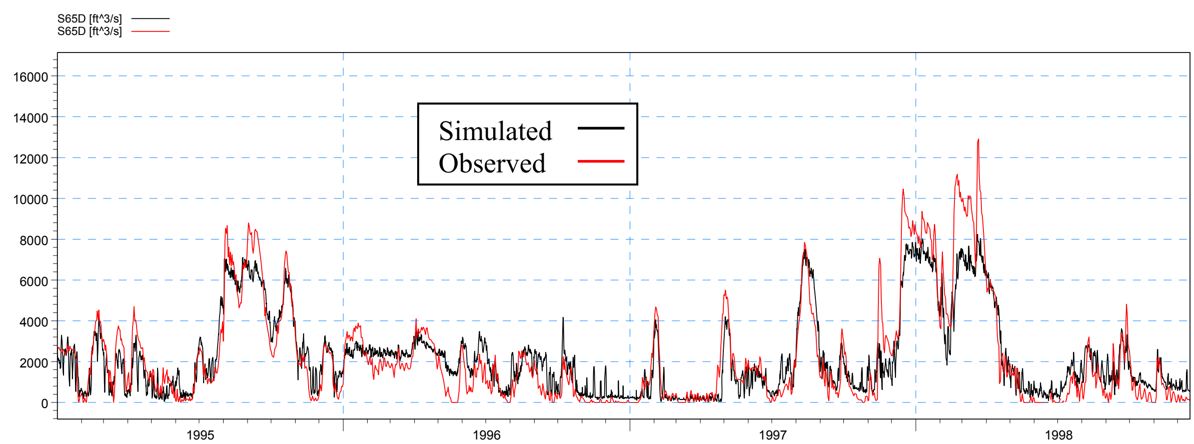

Figure 4-39: Simulated and observed discharge at S-65D during the calibration period

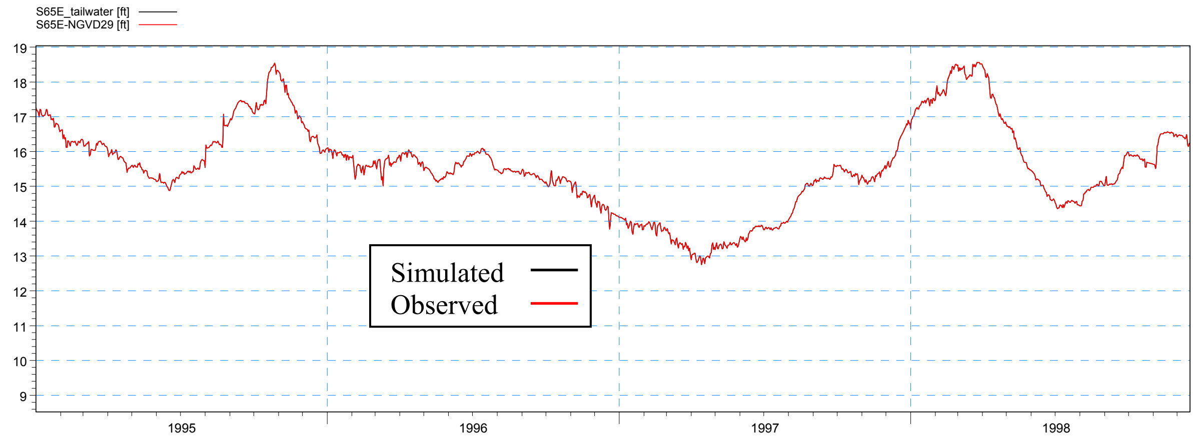

Figure 4-40: Simulated and observed headwater stage at S-65E during the calibration period

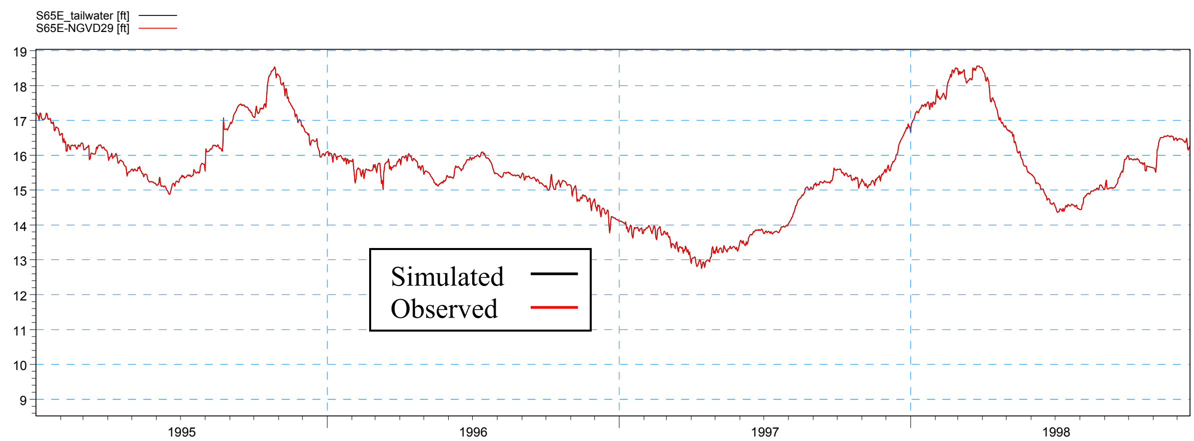

Figure 4-41: Simulated and observed tailwater stage at S-65E during the calibration period

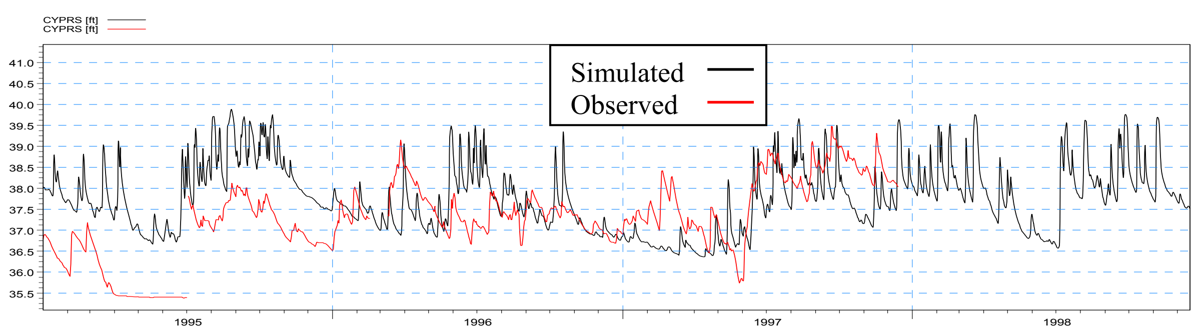

Figure 4-42: Simulated and observed stage at CYPRS during the calibration period

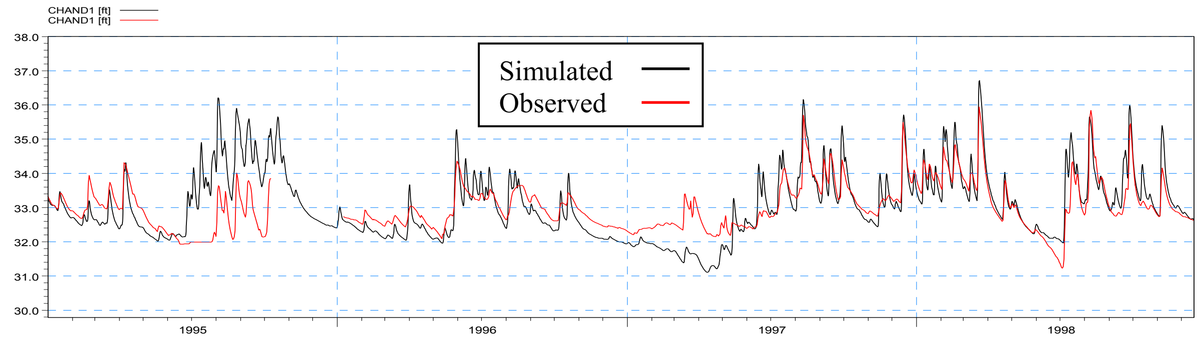

Figure 4-43: Simulated and observed stage at CHAND1 during the calibration period

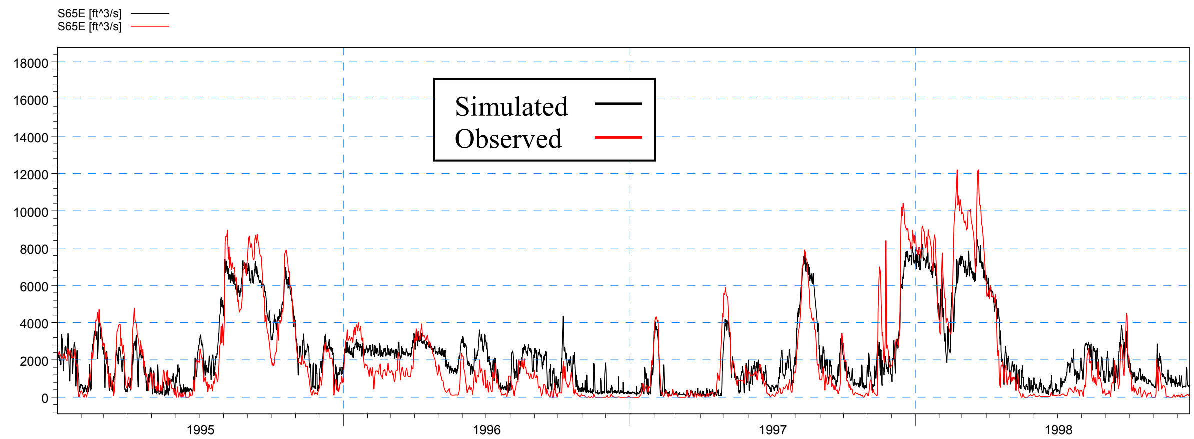

Figure 4-44: Simulated and observed discharge at S-65E during the calibration period

4.5.1.3 Surface Water Calibration Statistics

A table of calibration statistics for stage and flow in the Kissimmee are summarized in Table 4-2 and Table 4-3, respectively. All stage stations met the proposed calibration statistics and 90 % of the stations presented better results than the AFET calibration (as compared to the AFET verification period). Most of the flow stations met the proposed calibration statistics. Table 4-3 shows an improvement from the AFET statistics in the stations located in the lower basin.

In addition to the statistics presented in the aforementioned tables, 10-year runs were carried out to evaluate the performance of the model beyond the selected calibration period. Table 4-4 shows the results obtained with the long term error. The CE obtained fell within the calibration target and showed a very good agreement between modeled flows and observed data for the 94 to 2004 period, which is the time period with more confidence on the accuracy on the observed flows timeseries.

Table 4-2: Stage statistics for the calibration period

Surface Water Flow Network: Stage Statistics
Run 81

		AFET (1994 to 1998)		AFET - W (1995 to 1998)		COMPARISON	
MODEL AREA	Station	RMSE	R(correlation)	RMSE	R(correlation)	RMSE	R(correlation)
Stages in Upper Basin Lake Management Units							
LMU K-H-C	S65H	0.32	0.99	0.20	1.00	BETTER THAN AFET	BETTER THAN AFET
LMU K-H-C	S61T	0.73	0.92	0.64	0.93	BETTER THAN AFET	BETTER THAN AFET
LMU Toho	S61H	0.17	0.98	0.23	0.97	WITHIN TARGET	WITHIN TARGET
LMU Toho	S59T	0.73	0.85	0.58	0.91	BETTER THAN AFET	BETTER THAN AFET
LMU Etoho	S59H	0.15	0.99	0.12	0.99	BETTER THAN AFET	BETTER THAN AFET
Stages in Lower Basin Lake Management Units							
Pool A	S65T	1.58	0.70	1.32	0.77	BETTER THAN AFET	BETTER THAN AFET
Pool A	S65AH	1.68	0.59	1.45	0.66	BETTER THAN AFET	BETTER THAN AFET
Pool BC	S65AT	3.01	0.83	2.32	0.89	BETTER THAN AFET	BETTER THAN AFET
Pool BC	PC33	0.07	0.79	0.04	0.93	BETTER THAN AFET	BETTER THAN AFET
Pool BC	S65CH	0.11	0.84	0.10	0.99	BETTER THAN AFET	BETTER THAN AFET
Pool D	S65CT	0.11	0.82	0.07	0.94	BETTER THAN AFET	BETTER THAN AFET
Pool D	S65DH	0.11	0.89	0.09	1.00	BETTER THAN AFET	BETTER THAN AFET
Pool E	S65DT	X	0.83	0.47	0.93	WITHIN TARGET	BETTER THAN AFET
Pool E	S65EH	0.12	0.86	0.10	0.98	BETTER THAN AFET	BETTER THAN AFET
Stages in Lower Basin's unmanaged watersheds							
D_Chandler	CYPRS	10.54	0.06	1.13	0.23	BETTER THAN AFET	BETTER THAN AFET
D_Chandler	CHAND1	0.73	0.70	0.67	0.73	BETTER THAN AFET	BETTER THAN AFET
Lake O	S65ET	0.04	1.00	0.004	1.00	BETTER THAN AFET	BETTER THAN AFET

X : There is a datum issue with this station therefore only R will be used

Calibration Statistics	Targets
RMSE	≤2.5
R	≥0.5

Table 4-3: Flow statistics for the calibration period. Shading is used to indicate locations that do not meet specified criteria

Surface Water Flow Network: Flow Statistics
Run 81

			AFET		AFET - W		COMPARISON	
Upstream WCU	Downstream WCU	Station	CE %	R(correlation)	CE %	R(correlation)	CE%	R(correlation)
Flows in Upper Basin Lake Management Units								
LMU Toho	LMU KHC	S61	9%	0.86	23%	0.88		BETTER THAN AFET
LMU KHC	PoolA	S65	10%	0.82	10%	0.88	WITHIN TARGET	BETTER THAN AFET
Flows in Lower Basin Lake Management Units								
PoolB	PoolC	S65B			-6%	0.92	BETTER THAN AFET	BETTER THAN AFET
PoolC	PoolD	S65C	20%	0.86	-13%	0.92	BETTER THAN AFET	BETTER THAN AFET
PoolD	PoolE	S65D	18%	0.87	-11%	0.92	BETTER THAN AFET	BETTER THAN AFET
PoolE	Lake O	S65E	28%	0.86	-3%	0.92	BETTER THAN AFET	BETTER THAN AFET

Calibration Statistics	Targets for non-shaded cells
CE	≤15%
R	≥0.84

Table 4-4: Cumulative Error for the 10-year run at S-65 and S-65E Structures

Structure S65			
Run	Cumulative Modeled (cfs)	Cumulative Observed (cfs)*	Cumulative Error
Run 81 10 year run (94-04)	5,072,582.42	5,367,838.72	6%

* Uses the Preferred DBKEY HO289

Structure S65E			
Run	Cumulative Modeled (cfs)	Cumulative Observed (cfs)	Cumulative Error
Run 81 10 year run (94-04)	7,859,587.17	7,562,106.57	-4%

4.5.2 Groundwater Calibration

Model performance of the groundwater component during the calibration period is discussed in the following sections. Current results for the calibration period indicate that the current model is capable of simulating groundwater processes and levels at the level of accuracy according to the purpose of the study.

4.5.2.1 Surficial Aquifer

The following graphs (Figure 4-45 through Figure 4-67) present a comparison of predicted groundwater head versus observed data sets. Results indicate that calibration is good, with a few exceptions, at all primary calibration stations. Graphics for secondary wells are added to Appendix A.

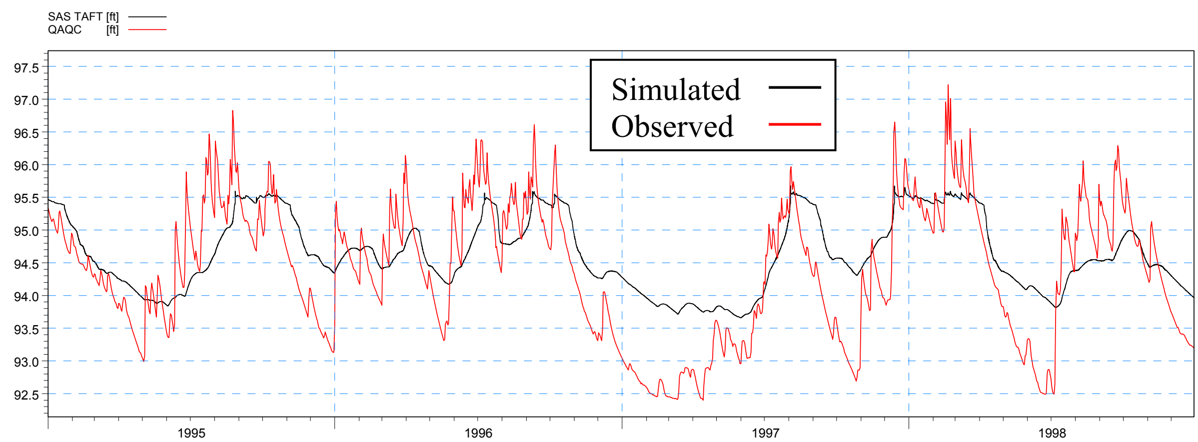

Figure 4-45: Simulated and observed heads at SAS TAFT during the calibration period

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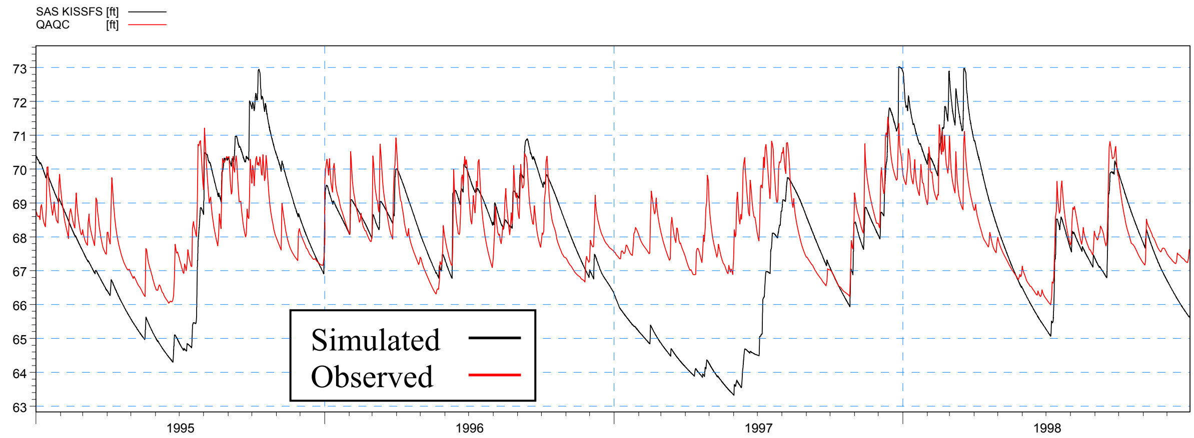

Figure 4-46: Simulated and observed heads at KISSFS during the calibration period

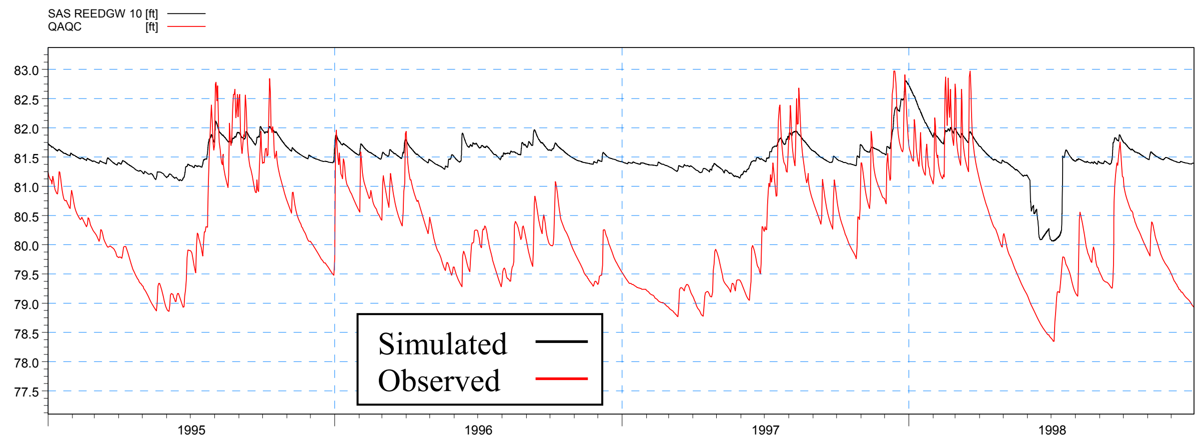

Figure 4-47: Simulated and observed heads at SAS REEDGW 10 during the calibration period

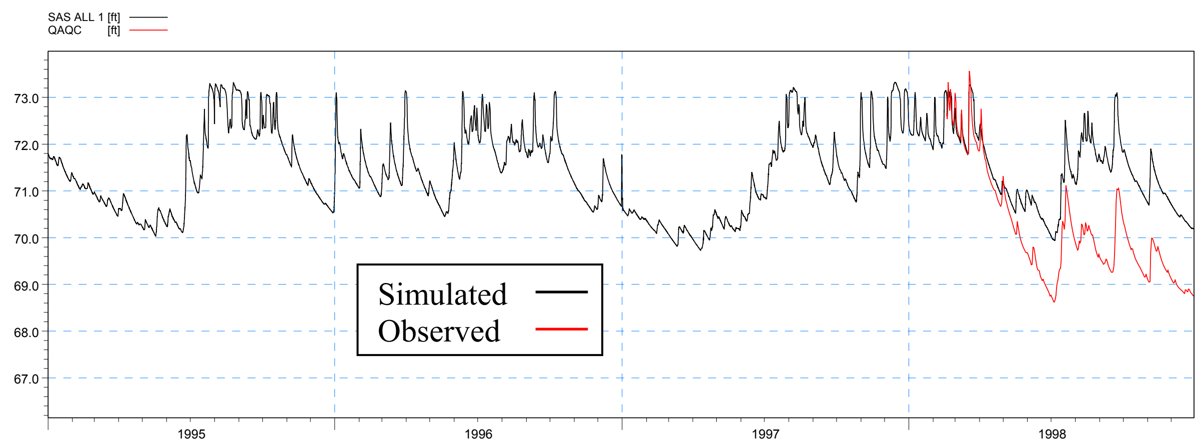

Figure 4-48: Simulated and observed heads at SAS ALL 1 during the calibration period

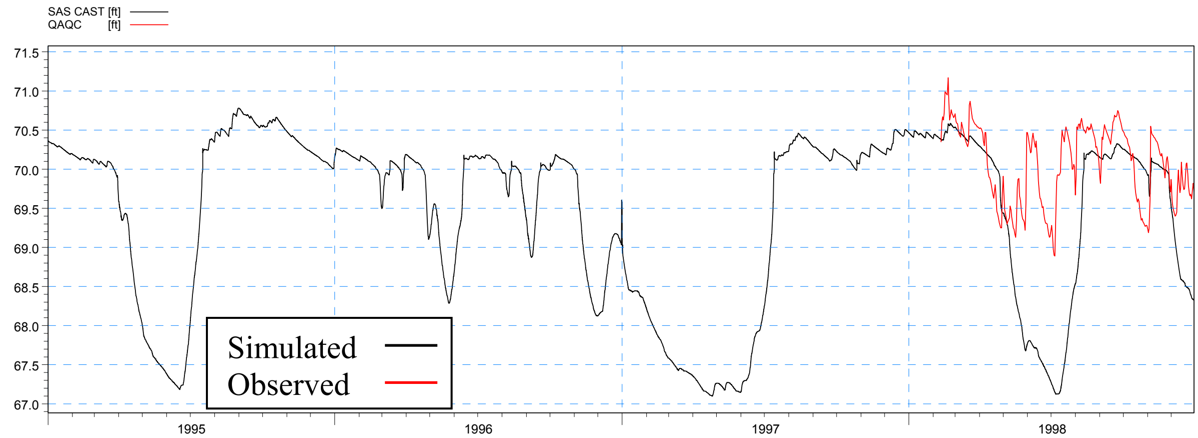

Figure 4-49: Simulated and observed heads at SAS CAST during the calibration period

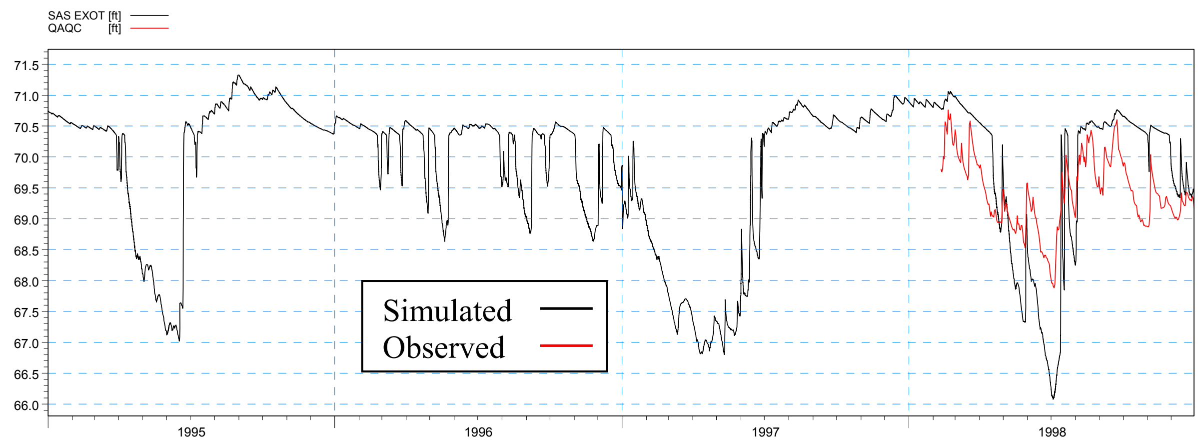

Figure 4-50: Simulated and observed heads at SAS EXOT during the calibration period

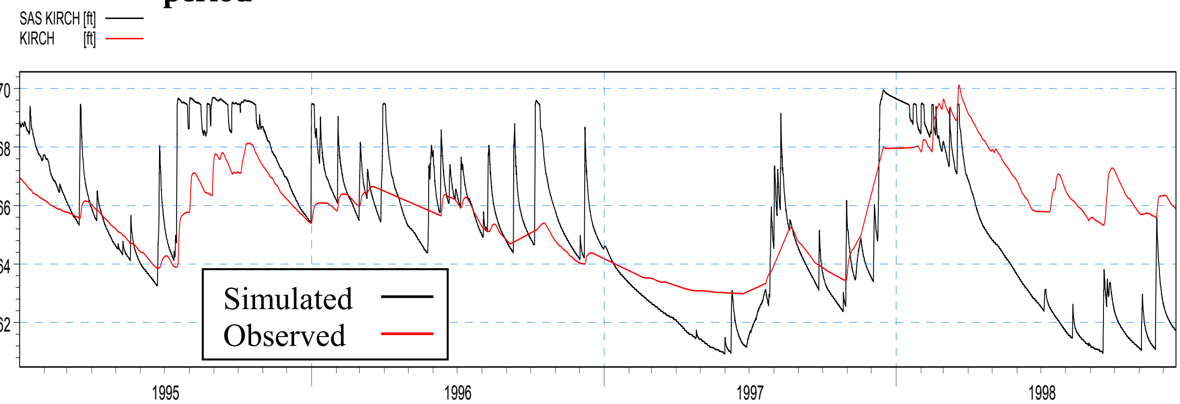

Figure 4-51: Simulated and observed heads at SAS KIRCH during the calibration period

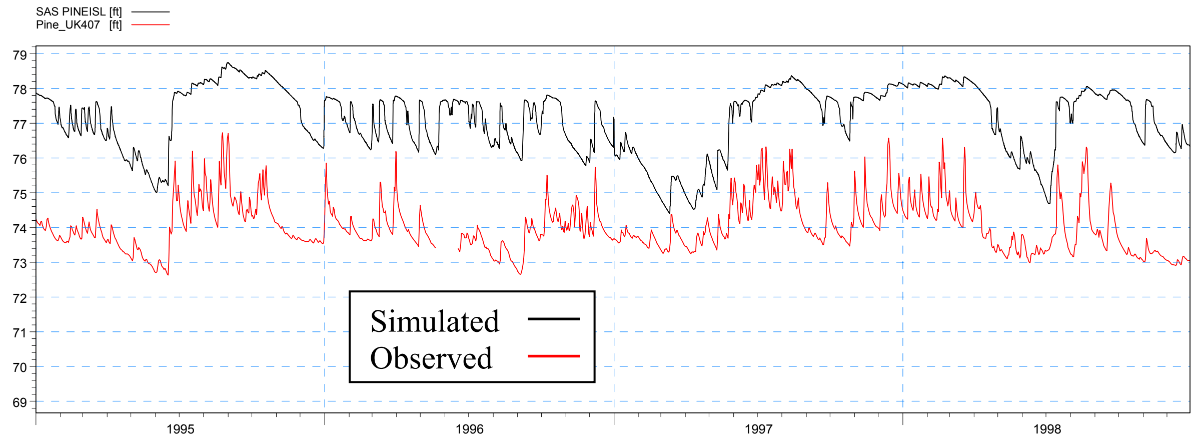

Figure 4-52: Simulated and observed heads at SAS PINEISL during the calibration period

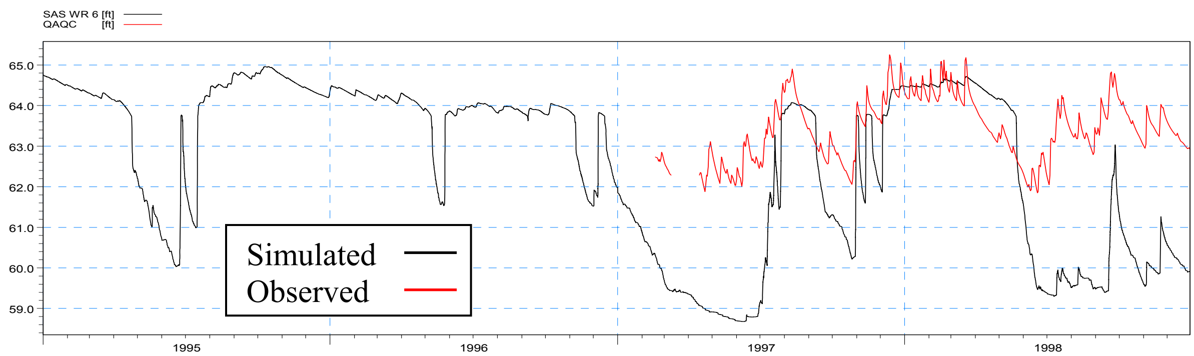

Figure 4-53: Simulated and observed heads at SAS WR6 during the calibration period

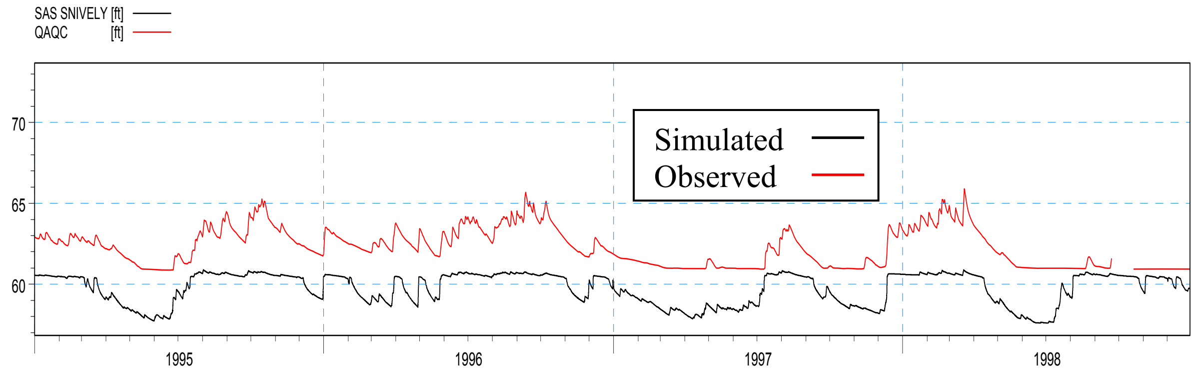

Figure 4-54: Simulated and observed heads at SAS SNIVELY during the calibration period

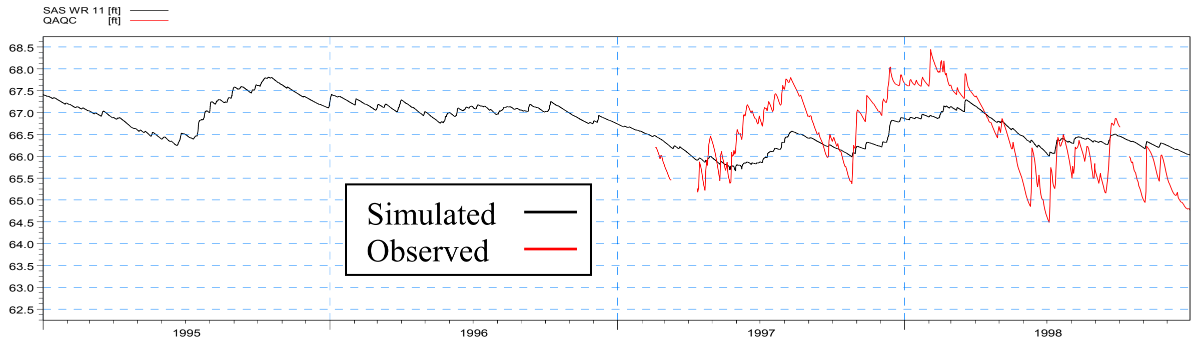

Figure 4-55: Simulated and observed heads at SAS WR 11 during the calibration period

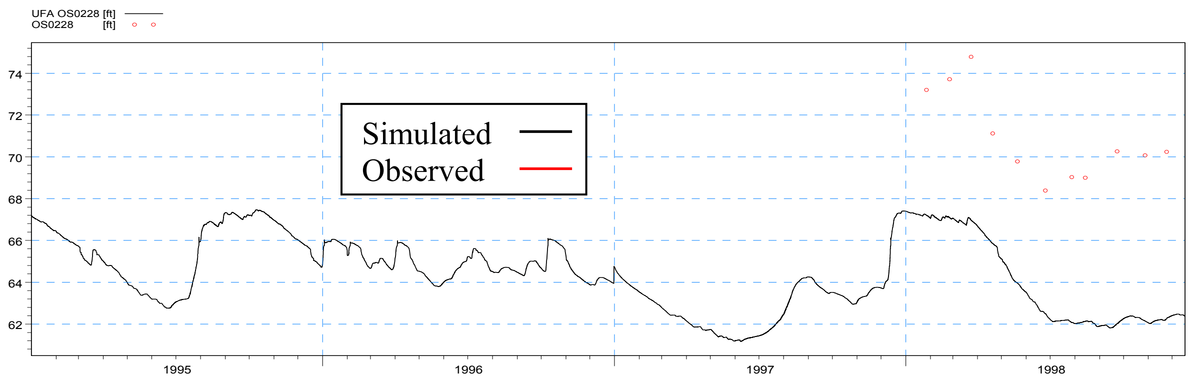

Figure 4-56: Simulated and observed heads at SAS OSO228 during the calibration period

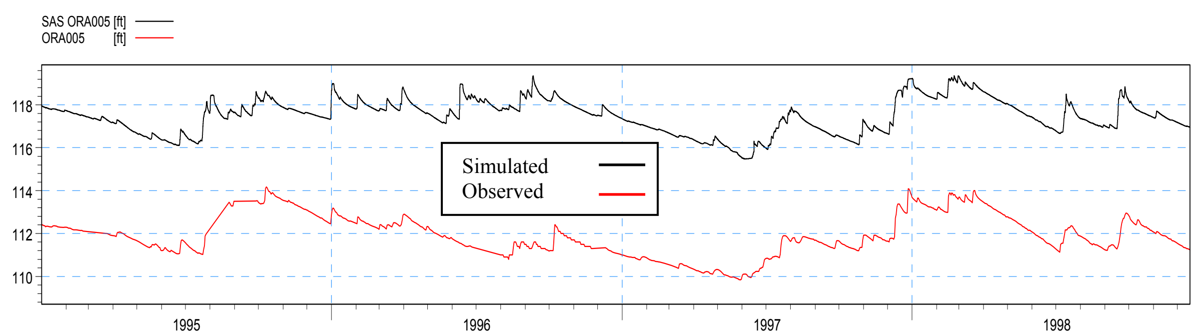

Figure 4-57: Simulated and observed heads at SAS ORA005 during the calibration period

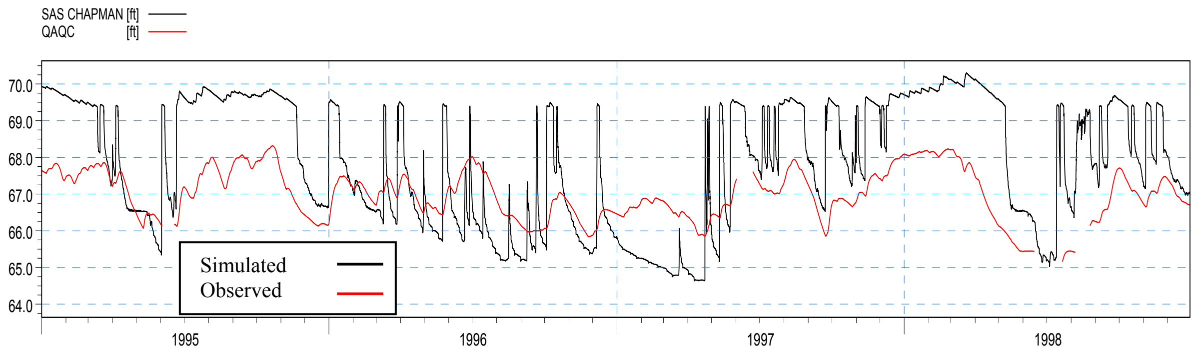

Figure 4-58: Simulated and observed heads at SAS CHAPMAN during the calibration period

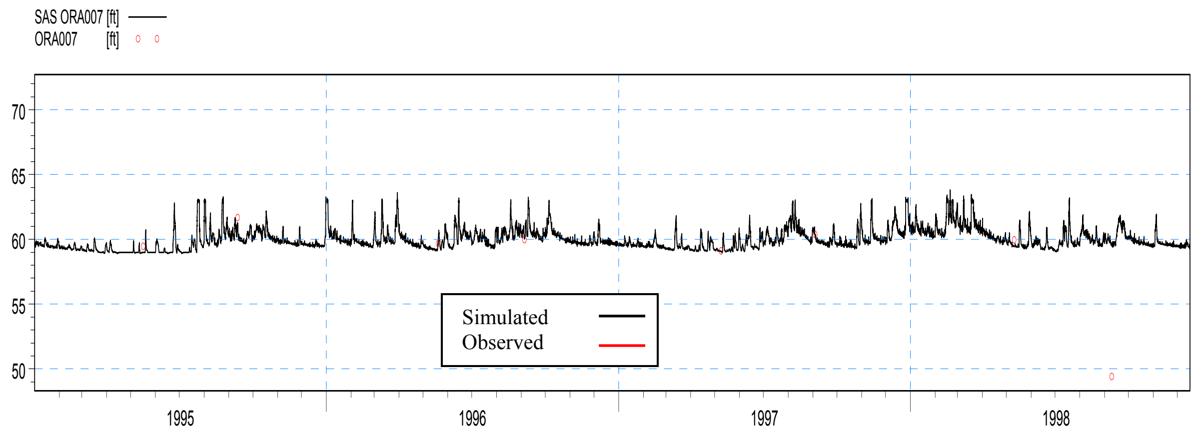

Figure 4-59: Simulated and observed heads at SAS ORA007 during the calibration period

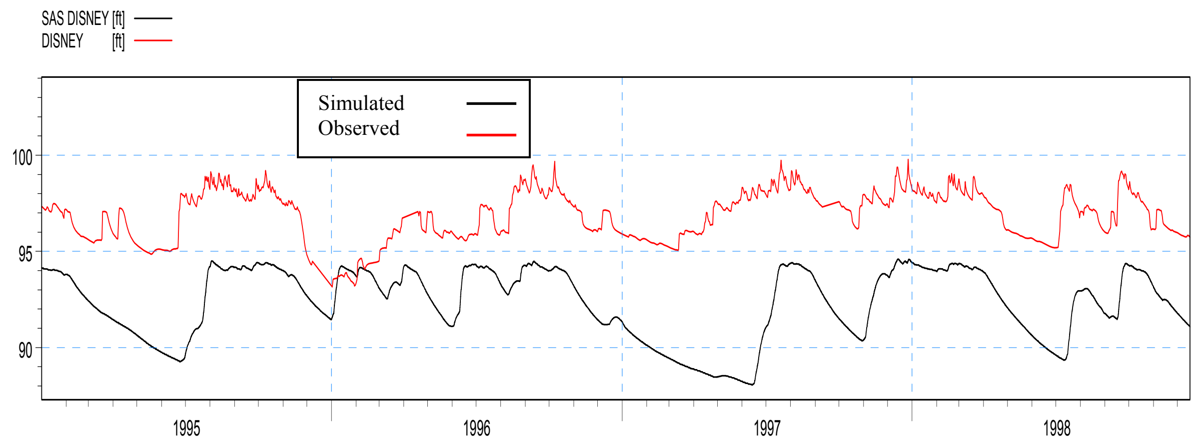

Figure 4-60: Simulated and observed heads at SAS DISNEY during the calibration period

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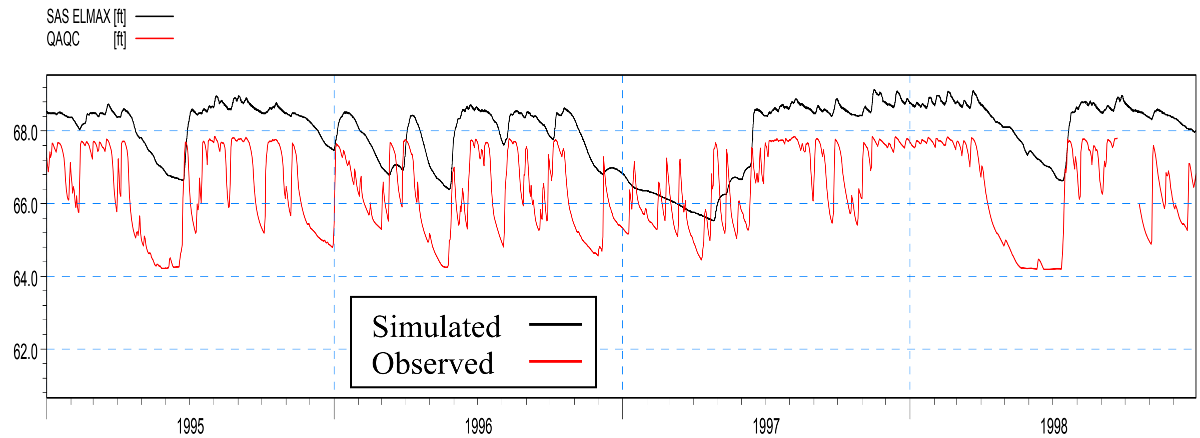

Figure 4-61: Simulated and observed heads at SAS ELMAX during the calibration period

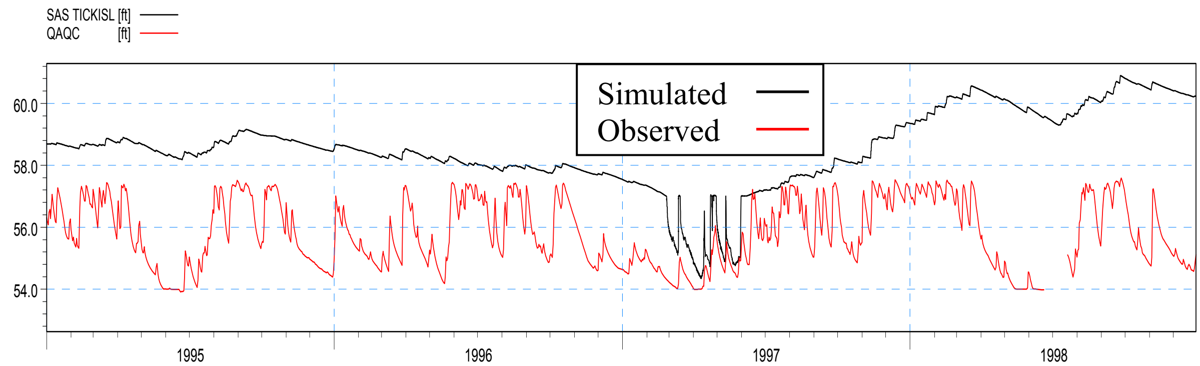

Figure 4-62: Simulated and observed heads at SAS TICKISL during the calibration period

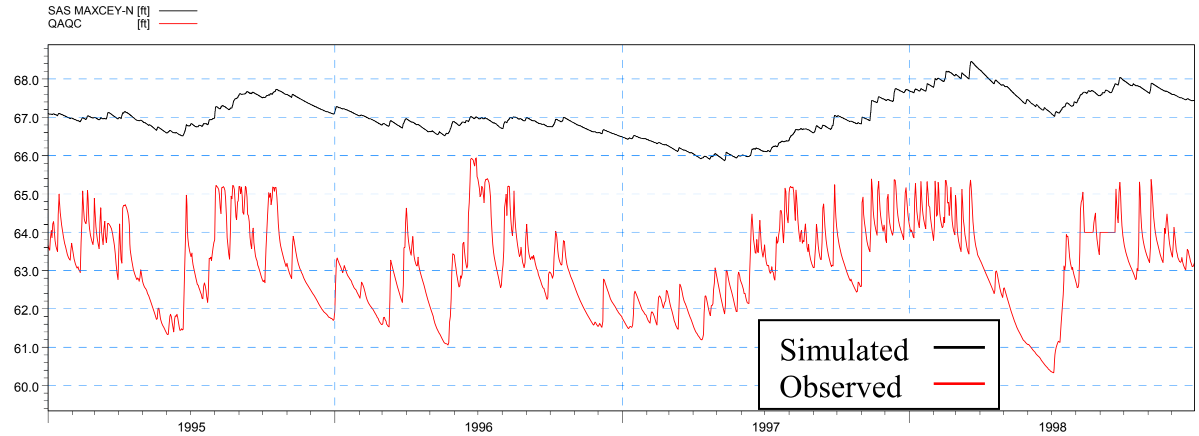

Figure 4-63: Simulated and observed heads at SAS MAXCEY-N during the calibration period

AECOM

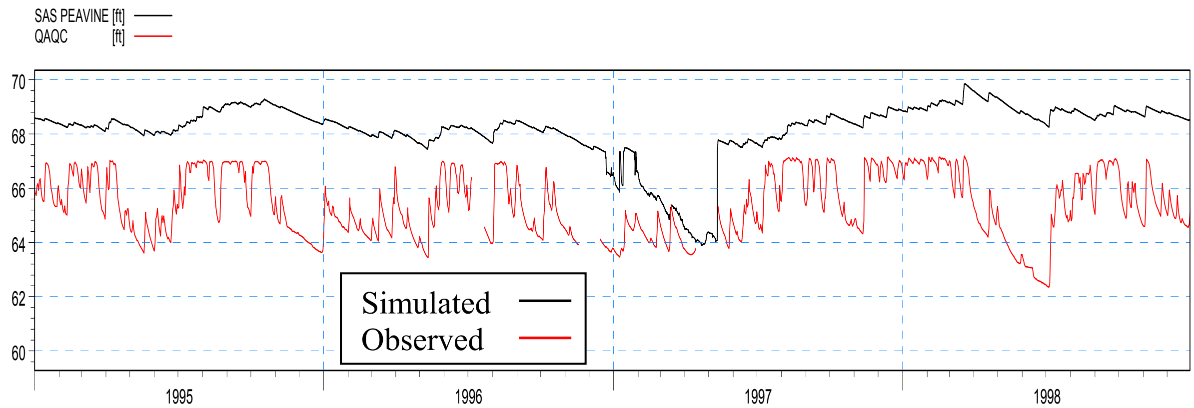

Figure 4-64: Simulated and observed heads at SAS PEAVINE during the calibration period

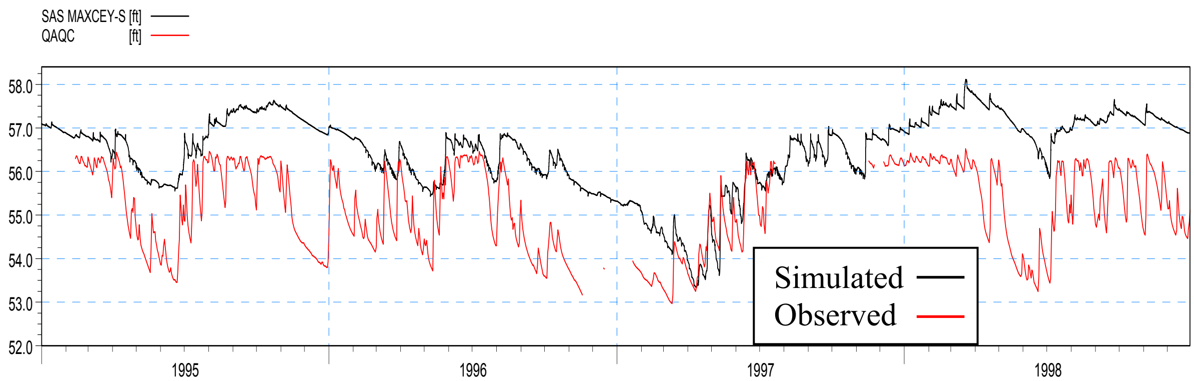

Figure 4-65: Simulated and observed heads at SAS MAXCEY-S during the calibration period

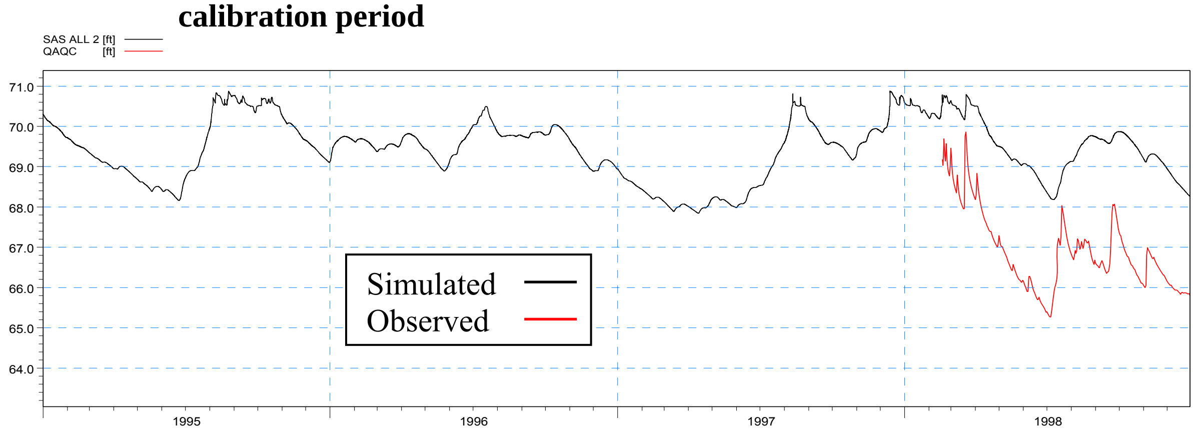

Figure 4-66: Simulated and observed heads at SAS ALL 2 during the calibration period

AECOM

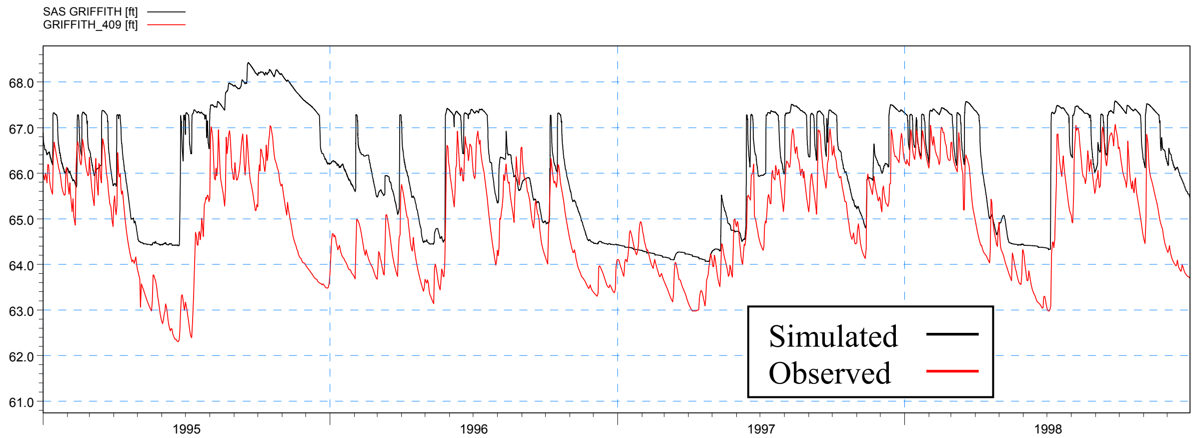

Figure 4-67: Simulated and observed heads at SAS GRIFFITH during the calibration period

4.5.2.2 Upper Floridan Aquifer

Simulated results at nine UFA groundwater wells are shown in Figure 4-68 to Figure 4-76. Secondary wells are included in Appendix A. Although the calibration appears reasonable and the calibration criteria is met, the hydrographs of some wells do not show the expected variation. Some of these wells are close to the boundary (ORA-27 and ORA-19) and are highly influenced by the UFA boundary condition obtained from the mega-model. Lack of an appropriate response is also noted in ORA-001 and ORA-13 despite adjustments of model parameters (within reason).

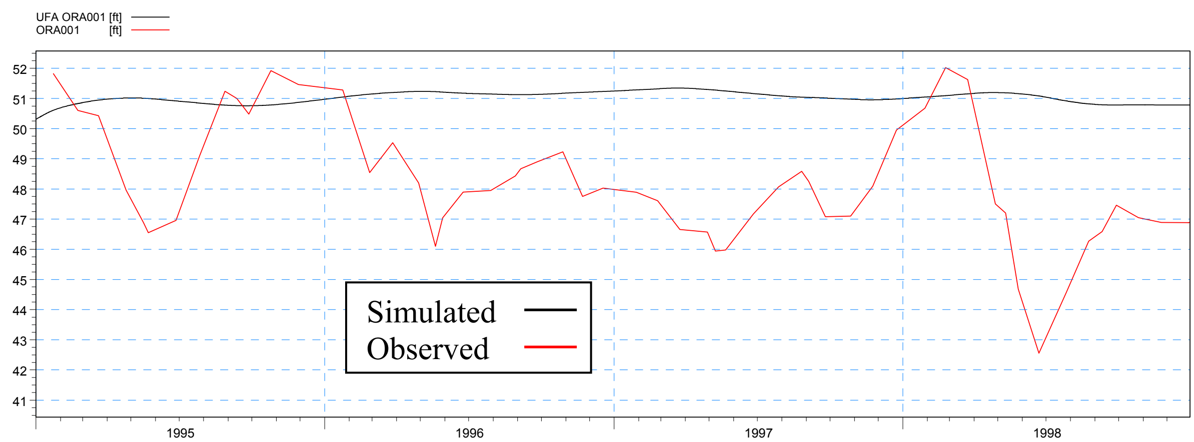

Figure 4-68: Simulated and observed heads at UFA ORA 001 during the calibration period

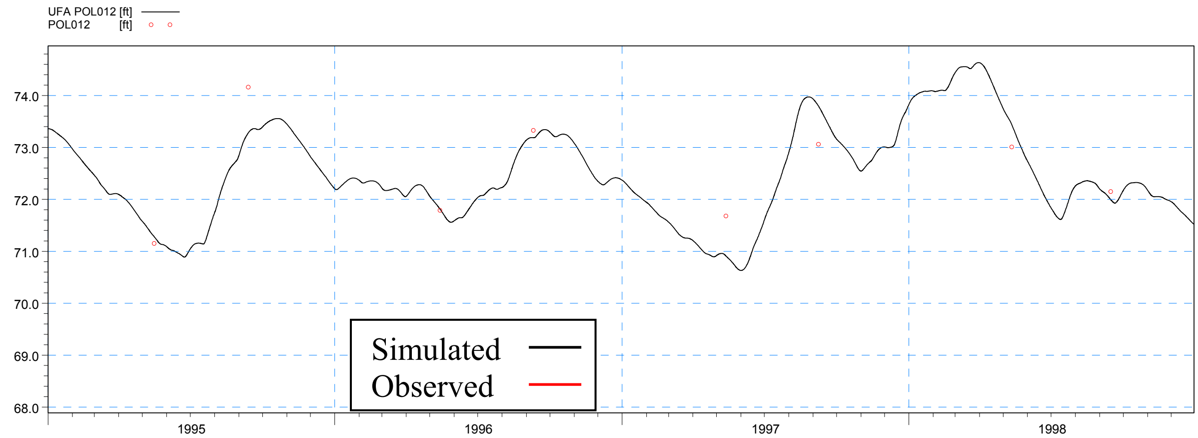

Figure 4-69: Simulated and observed heads at UFA POL 012 during the calibration period (Observed data shown as red dots)

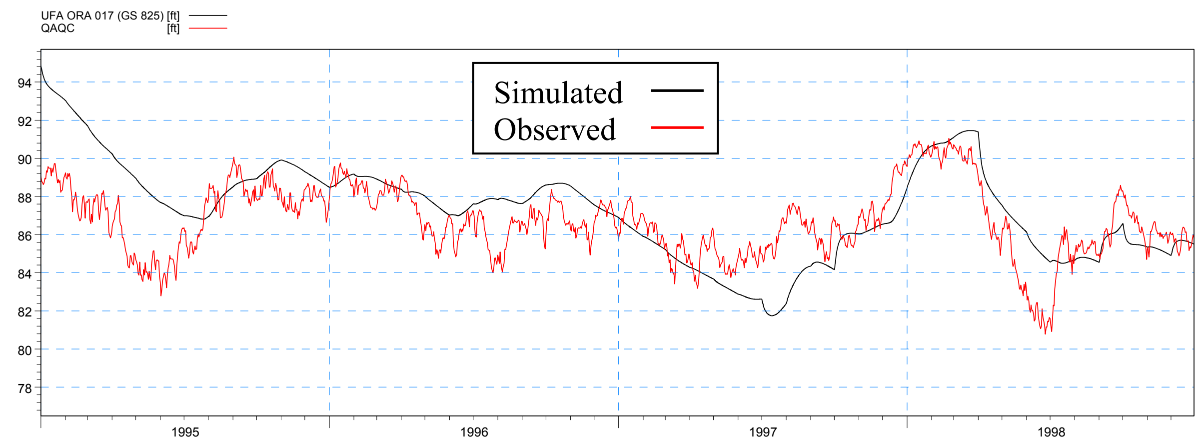

Figure 4-70: Simulated and observed heads at UFA ORA 017/GS 825 during the calibration period

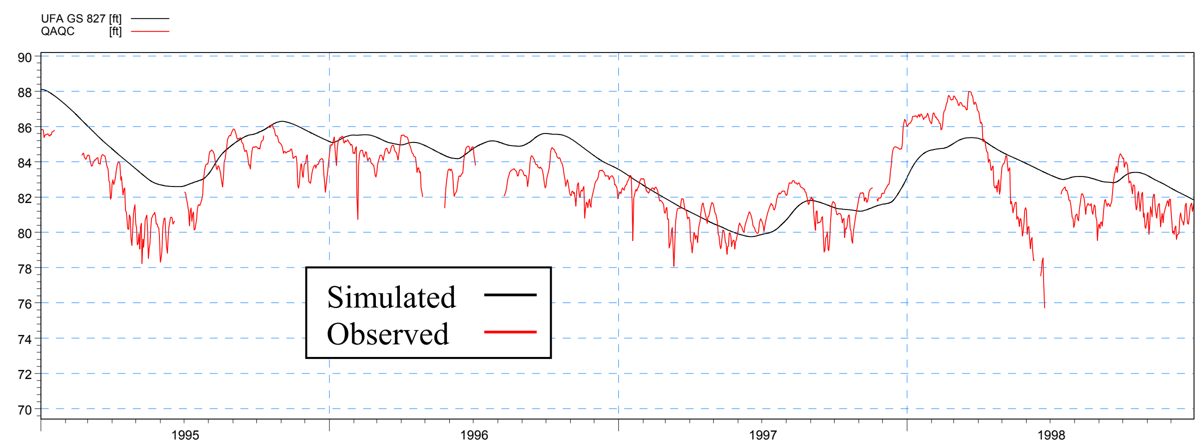

Figure 4-71: Simulated and observed heads at UFA GS 827 during the calibration period

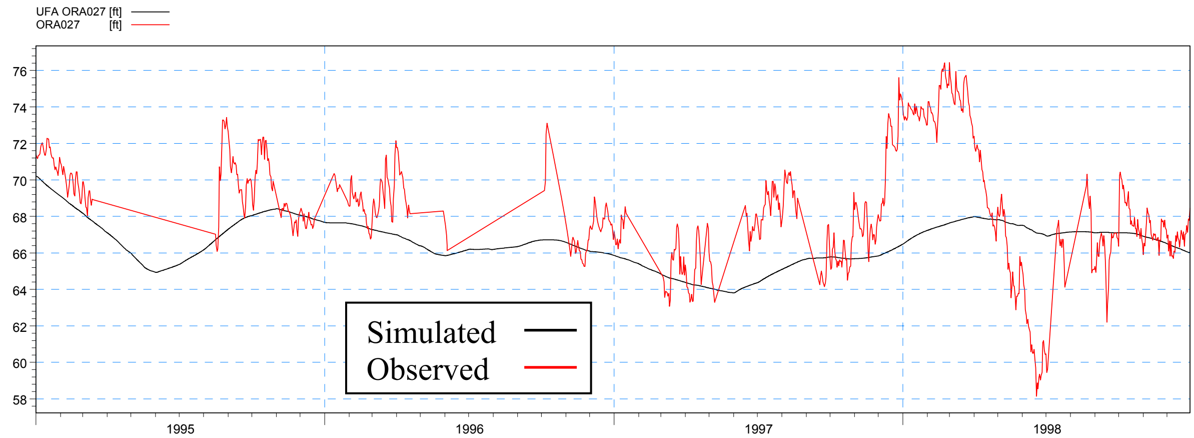

Figure 4-72: Simulated and observed heads at UFA ORA 027 during the calibration period

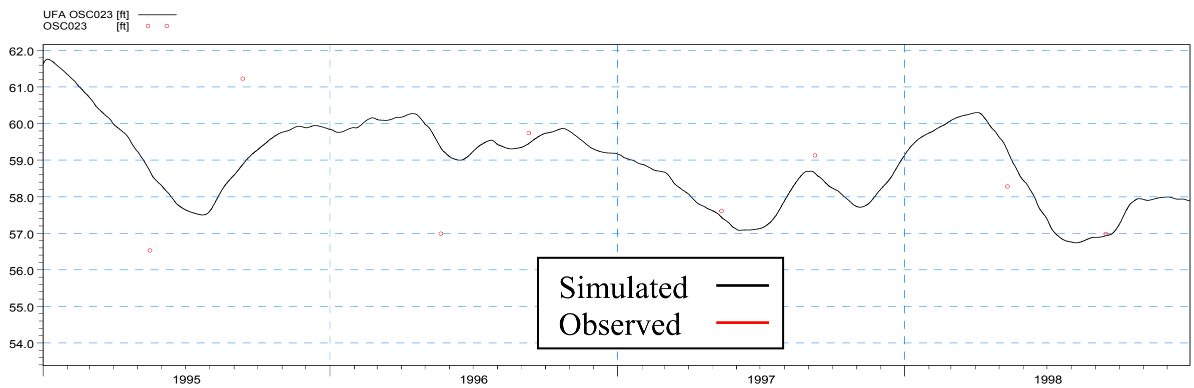

Figure 4-73: Simulated and observed heads at UFA OSC 023 during the calibration period (Observed data shown as red dots)

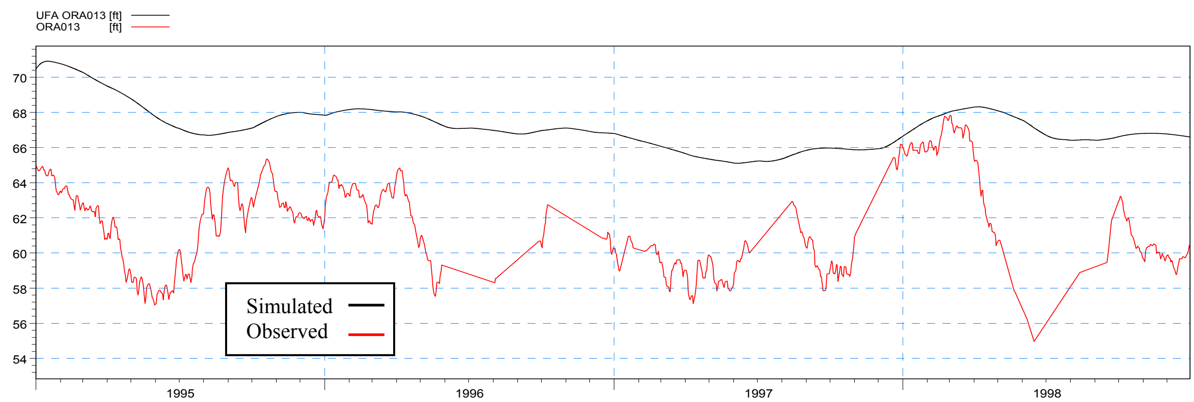

Figure 4-74: Simulated and observed heads at UFA ORA 013 during the calibration period

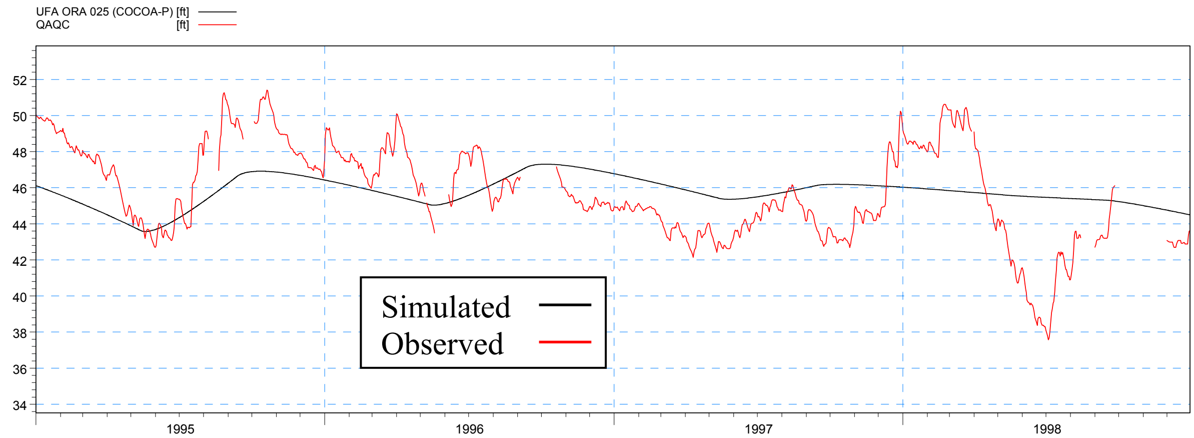

Figure 4-75: Simulated and observed heads at UFA ORA 025/Cocoa-P during the calibration period

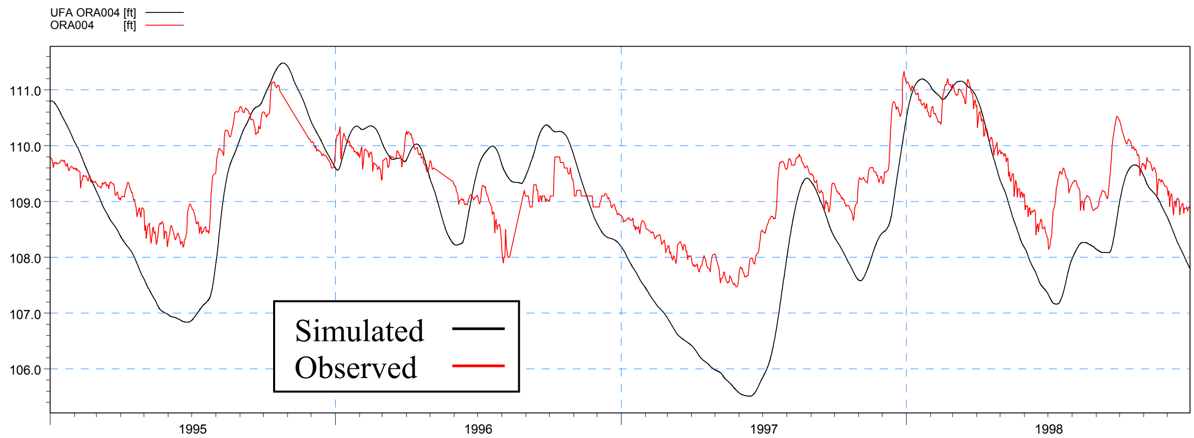

Figure 4-76: Simulated and observed heads at UFA ORA 004 during the calibration period

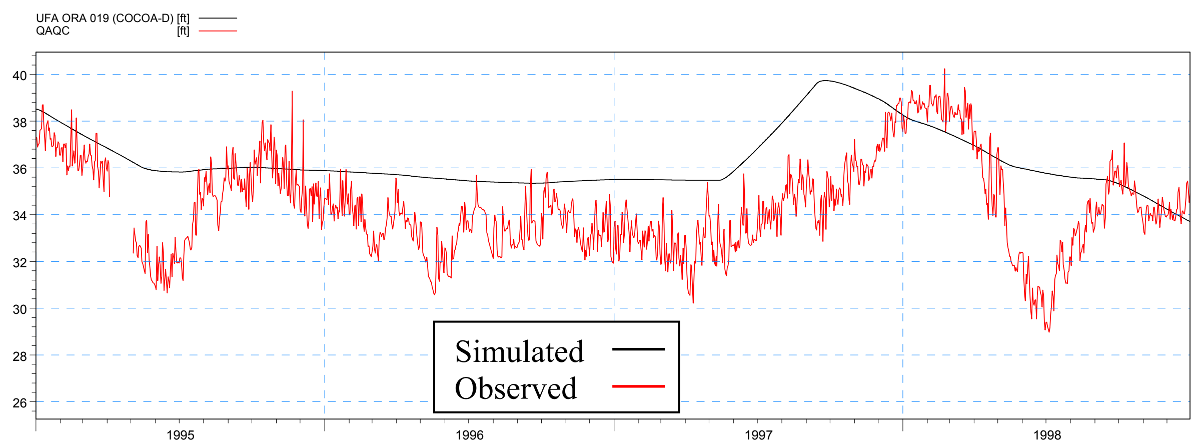

Figure 4-77: Simulated and observed heads at UFA ORA 019 (COCOA-D) during the calibration period

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4.5.2.3 Groundwater Calibration Statistics

Calibration statistics for the 23 selected SAS wells are summarized in Table 4-5. As shown in the cells shaded in yellow, the model meets all the criteria established at the beginning of the calibration.

Table 4-5: Surficial Aquifer groundwater statistics for the calibration period

Groundwater Network: MBE
Run 81

		AFET (1994 to 1998)		AFET - W (1995 to 1998)						
ECFT Name	**AFET Name**	**RMSE**	**R**	**ME**	**MAE**	**RMSE**	**R**	**RMSE**	**R**	**MBE**
UKB SAS Calibration Wells for the 1000 x 1000 ft model										
TAFT	TAFT	0.70	0.81	-0.26	0.62	0.74	0.75	WITHIN TARGET	WITHIN TARGET	-0.3%
KISSFS	KISSFS	1.70	0.65	0.39	1.29	1.70	0.64	WITHIN TARGET	WITHIN TARGET	0.6%
REEDGW	REEDGW10	0.85	0.78	-1.26	1.31	1.46	0.77	WITHIN TARGET	WITHIN TARGET	-1.6%
ALL1	ALL1	0.92	0.78	-1.17	1.19	1.38	0.77	WITHIN TARGET	WITHIN TARGET	-1.7%
CAST	CAST	0.97	0.50	0.70	0.83	1.19	0.48	WITHIN TARGET		1.0%
EXOT	EXOT	0.87	0.79	-0.22	0.83	0.96	0.78	WITHIN TARGET	WITHIN TARGET	-0.3%
PINE	PINEISL	5.63	0.74	-3.07	3.07	3.15	0.67	BETTER THAN AFET	WITHIN TARGET	-4.4%
WR6	WR6	2.22	0.86	1.80	2.03	2.47	0.68	WITHIN TARGET	WITHIN TARGET	2.8%
WR11	WR11	0.78	0.59	0.08	0.64	0.75	0.59	BETTER THAN AFET	BETTER THAN AFET	0.1%
CHAP	CHAPMAN	1.49	0.57	-0.86	1.40	1.64	0.61	WITHIN TARGET	BETTER THAN AFET	-1.3%
SNIVELY	na	na	na	2.54	2.54	2.67	0.71	BETTER THAN AFET	WITHIN TARGET	4.1%
OSO0228	na	na	na	6.87	6.87	6.94	0.89	BETTER THAN AFET	WITHIN TARGET	9.8%
ORA005	na	na	na	-5.55	5.55	5.59	0.78	BETTER THAN AFET	WITHIN TARGET	-5.0%
KIRCH	na	na	na	0.52	1.73	2.26	0.57	BETTER THAN AFET	WITHIN TARGET	0.8%
ORA007	na	na	na	-1.11	1.51	3.62	0.29	BETTER THAN AFET		-1.9%
DISNEY	na	na	na	4.53	4.55	4.88	0.37	BETTER THAN AFET		4.7%
ALL2	na	na	na	-2.51	2.51	2.56	0.87	BETTER THAN AFET	WITHIN TARGET	-3.8%
LKB SAS Calibration Wells for the 1000 x 1000 ft model										
ELMAX	ELMAX	1.57	0.68	-1.58	1.63	1.84	0.60	WITHIN TARGET	WITHIN TARGET	-2.4%
TICK	TICKICL	2.88	0.32	-2.70	2.70	3.04	0.29			-5.5%
MAXYN	MAXCEY-N	3.62	0.33	-3.91	3.91	4.04	0.42		BETTER THAN AFET	-6.2%
PEAV	PEAVINE	3.17	0.48	-2.88	2.88	3.09	0.44	BETTER THAN AFET		-4.4%
MAXYS	MAXCEY-S	2.50	0.52	-1.36	1.37	1.58	0.64	BETTER THAN AFET	BETTER THAN AFET	-2.5%
GRIF	GRIFFITH	1.80	0.85	-1.18	1.20	1.45	0.76	BETTER THAN AFET	WITHIN TARGET	-1.8%

Average MBE = -0.82%

Calibration Statistics	**Targets**	**Run 81**
Percent of primary wells with Mean Error (ME) and Mean Absolute Error (MAE) less or equal to +/- 2.5 feet	50%	**61%**
Percent of primary wells with Mean Error (ME) and Mean Absolute Error (MAE) less or equal to +/- 5.0 feet	80%	**91%**
Percent of primary wells with Root Mean Squared Error (RMSE) less or equal to +/- 5.0 feet	80%	**91%**
Overall Mean Error	+/-1.0	**-0.53**

$$MBE = \frac{\sum (O_i - S_i)}{\sum (O_i)} x100$$

Where:
O_i = Observed Value
S_i = Simulated Value

Or

$$MBE = \frac{\text{Mean Error}}{\text{Mean of Observed Values}} x100$$

Calibration statistics for the ten selected UFA wells are summarized in Table 4-6. As shown in the cells shaded in yellow, the model meets all the criteria establish at the beginning of the calibration. Only one out of ten wells did not meet the criteria (90%), while the target in most of the parameters was two out of ten.

Table 4-6: Upper Floridan Aquifer groundwater statistics for the calibration period

Groundwater Network: UFA Head Statistics
Run 80

Name	Data type	Layer	ME	MAE	RMSE	R
UFA GS 827	head elevation in saturated zone	3	-1.61	2.16	2.95	0.36
UFA ORA 017 (GS 825)	head elevation in saturated zone	3	-1.07	1.96	2.6	0.6
UFA ORA 019 (COCOA-D)	head elevation in saturated zone	3	-1.76	1.96	2.6	0.6
UFA ORA 025 (COCOA-P)	head elevation in saturated zone	3	-1.76	2.06	2.49	0.6
UFA ORA001	head elevation in saturated zone	3	0.4	2.12	2.52	0.42
UFA POL012	head elevation in saturated zone	3	0.07	0.41	0.52	0.87
UFA OSC023	head elevation in saturated zone	3	-0.3	1.1	1.46	0.4
UFA ORA013	head elevation in saturated zone	3	-5.77	5.77	6.24	0.44
UFA ORA004	head elevation in saturated zone	3	0.6	0.86	1.1	0.84
UFA ORA027	head elevation in saturated zone	3	1.64	2.5	3.35	0.4

Calibration Statistics	Targets	Run 80
Percent of primary wells with Mean Error (ME) and Mean Absolute Error (MAE) less or equal to +/- 2.5 feet	50%	90%
Percent of primary wells with Mean Error (ME) and Mean Absolute Error (MAE) less or equal to +/- 5.0 feet	80%	90%
Percent of primary wells with Root Mean Squared Error (RMSE) less or equal to +/- 5.0 feet	80%	90%
Overall Mean Error	+/-1.0	-0.96

4.5.3 Additional Qualitative Groundwater Calibration Criteria

AFET-W used the additional qualitative groundwater calibration criteria documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

4.5.3.1 Upper Floridan Aquifer Recharge

The average annual recharge to the UFA developed by Aucott (1988) in the Kissimmee River Basin is shown in Figure 4-78. In general, the UFA receives recharge in the KUB except in the vicinity of Lake Tohopekaliga, Lake Cypress, Lake Hatchineha, Lake Marion, Lake Pierce, Lake Rosalie, Lake Weohyakapaka, Tiger Lake and Lake Kissimmee. UFA recharge rates are highest on the western side of the KUB in the ridge areas. Discharge from the UFA occurs in the LKB in the vicinity of the Kissimmee River and at the southern end of the watershed near Lake Okeechobee. UFA recharge rates are generally low in the LKB.

Simulated UFA recharge rates for the 3,000 ft regional model are shown in Figure 4-79 and shows similarity to the data of Aucott (1988). Simulated discharge rates in the KUB are, in general, comparable to Aucott. Simulated UFA recharge rates for the 1,000 ft surficial aquifer model are shown in Figure 4-80**.** The aforementioned figures have a different resolution. To facilitate their comparison, a table was created (Table 4-7) with values extracted at important locations within the Kissimmee Basin. Table 4-7 also includes for comparative purposes Discharge/Recharge values found in the literature, which includes the SFWMD Water Supply Plan 2000 (SFWMD. 2000), Hydrology of the Floridan Aquifer System in East-Central Florida, 1990. (Tibbals, C.H., 1990) and Mapping Recharge (Inflitration/Leakage) throughout the South Florida Water Management District (Fairbank, P.K. and Hohner, S.M., 1995).

Table 4-7: Comparison of Recharge / Discharge values obtained with AFET-W with other values obtained in the literature

Location / Source	AFETW 3K	AFETW 1K	Fairbanks and Hohner	Tibbals	W.S. Plan	Aucott
Lake Kissimmee	0 to 5	0 to 1	< 4	2 to 6	0 to 8	1 to 5
Lake Toho	0 to 5	0 to 1	< 0.75	0.5 to 1	0 to 3	1 to 5
Lake East Toho	0 to 1	0 to 1	< 4	1	0 to 3	< 1
Alligator	0 to 1	0 to 1	< 4	1	3 to 20	< 1
Mary Jane	0 to 1	0 to 1	< 4	1	3 to 20	< 1
Gentry	0 to 1	0 to 1	< 4	1	0 to 3	< 1
Pool A	1 to 5	1 to 5	< 4	1.5 to 2	0 to 3	1 to 5
Pool BC	1 to 5	0 to 5	< 0.75	1.3	0 to 8	< 1 to 5
Pool D	1 to 5	0 to 5	< 0.75	1.3	0 to 8	< 1

Legend:

Discharge (yellow)

Recharge (green)

Flux in inch/yr

4.5.3.2 River Leakage

AFET-W used the river leakage documented in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007.

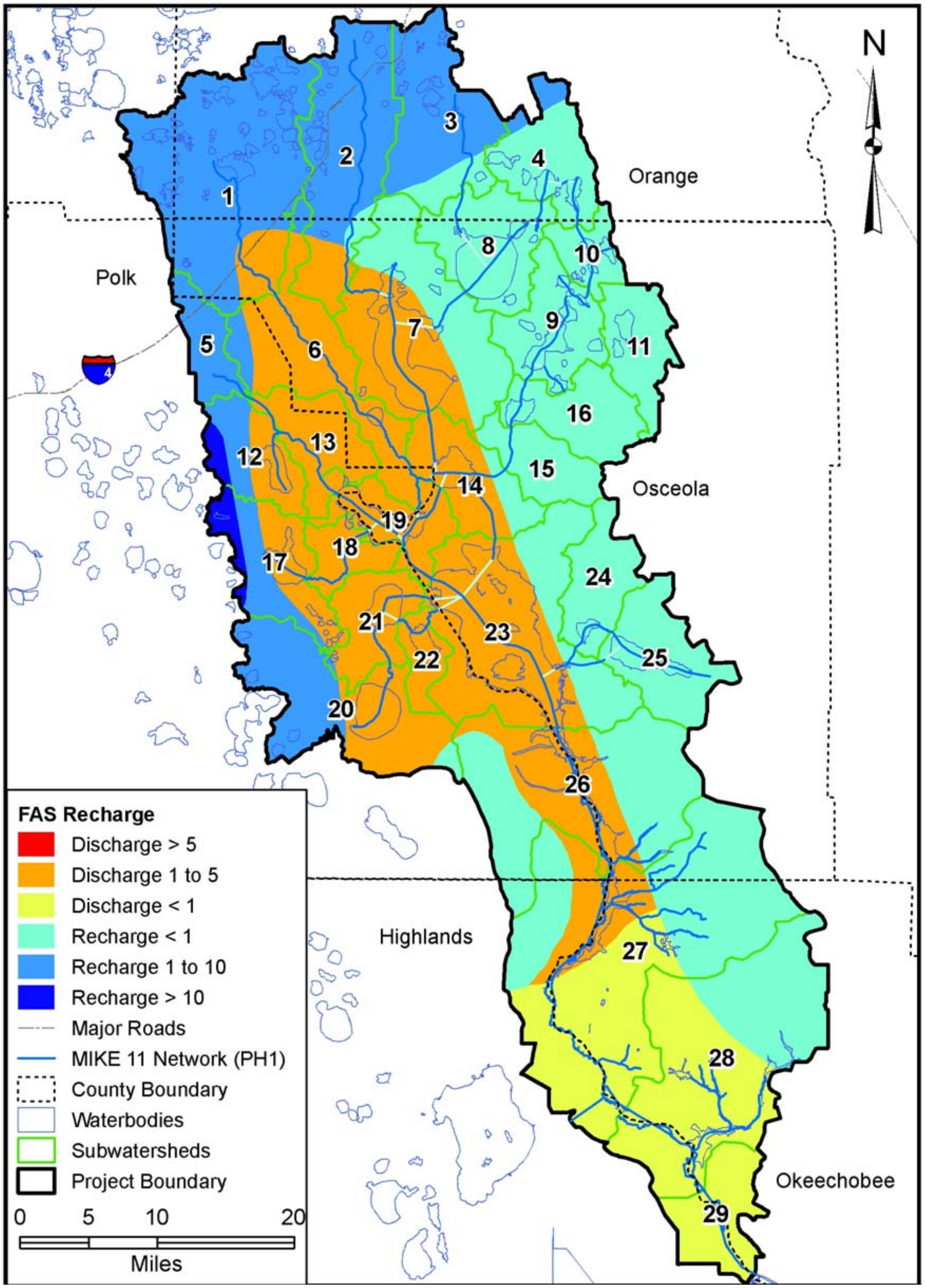

Figure 4-78: Upper Floridan Aquifer recharge rates from Aucott (1988)

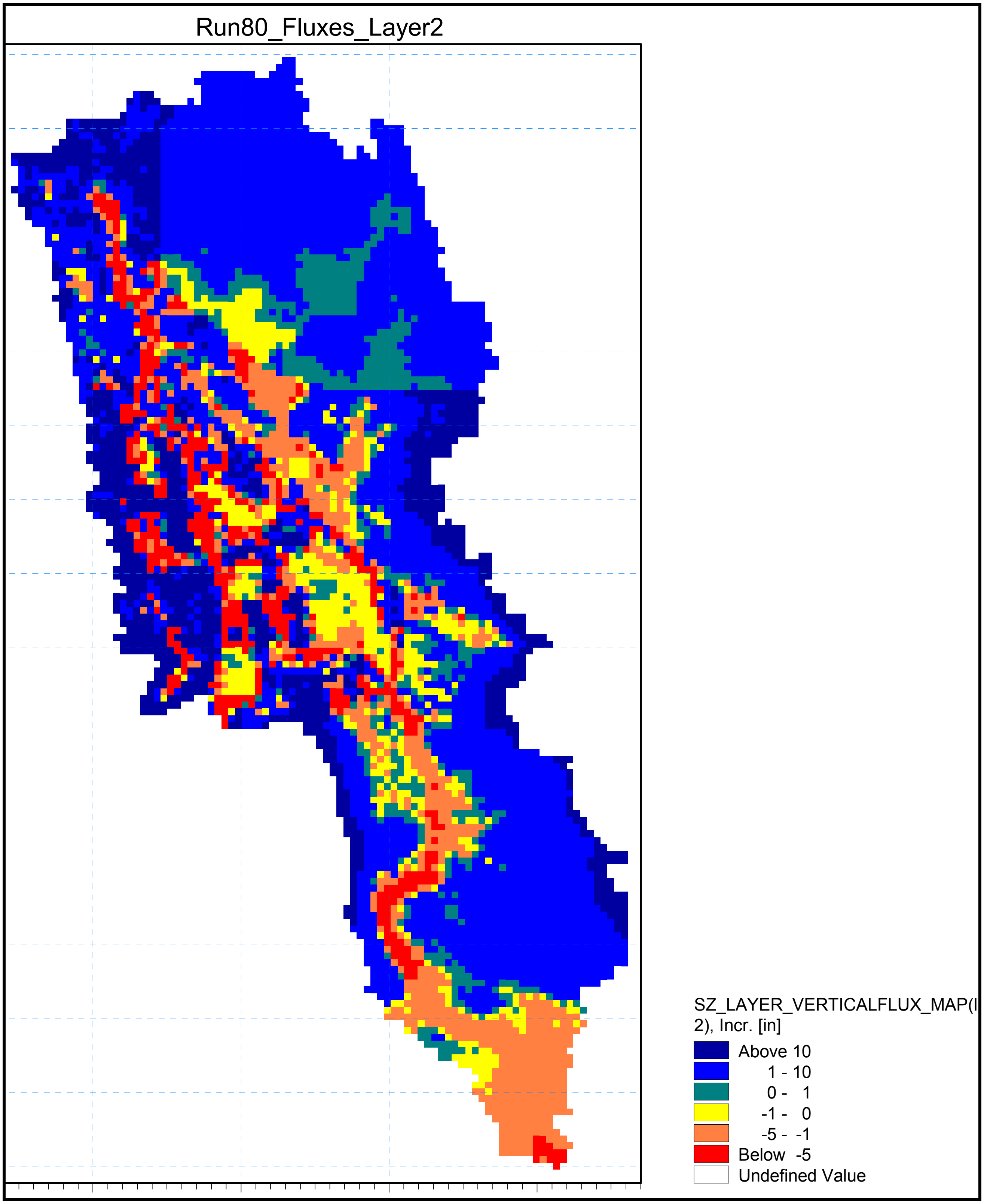

Figure 4-79: Simulated Upper Floridan Aquifer recharge rates from the 3,000 ft regional model

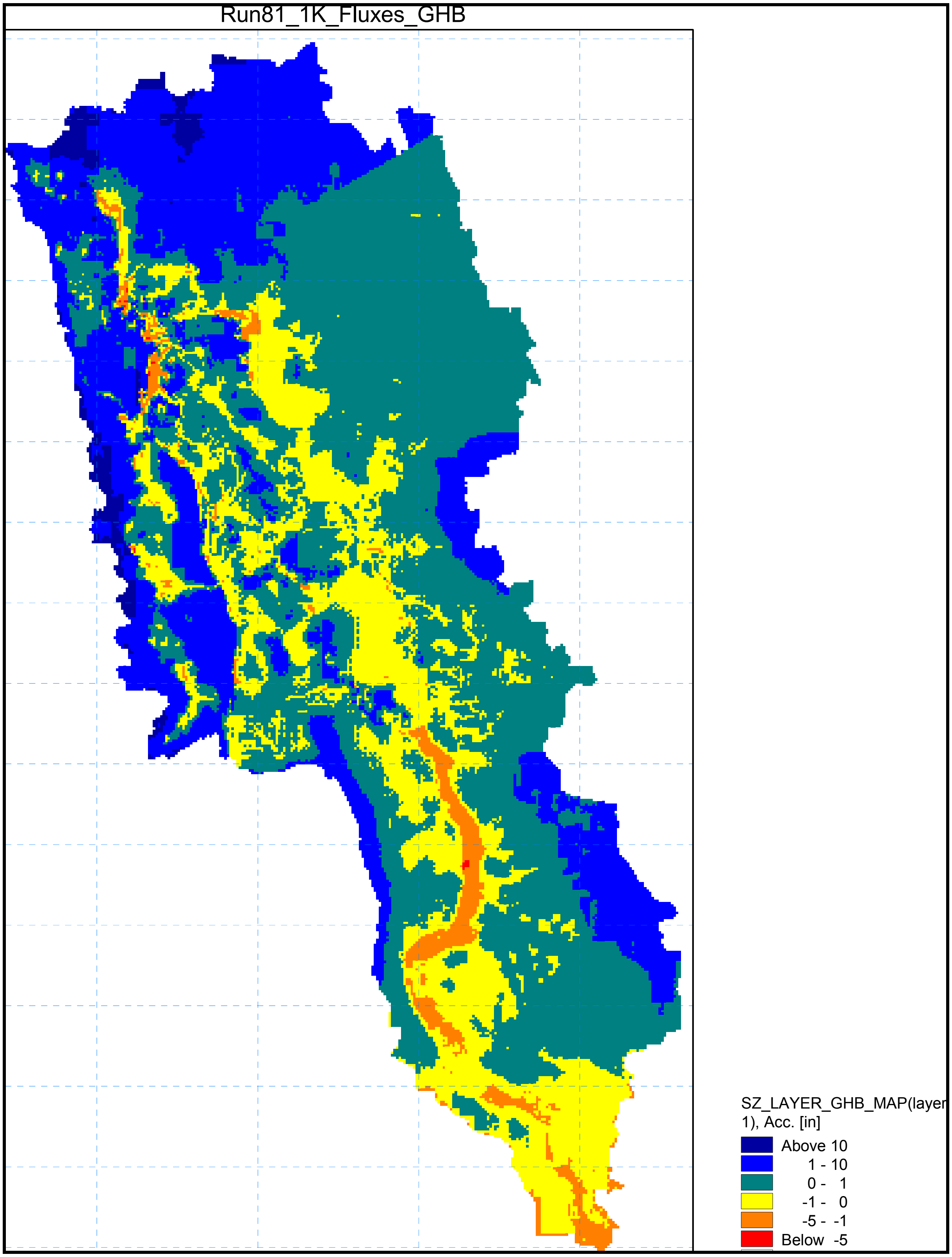

Figure 4-80: Simulated Upper Floridan Aquifer recharge rates from the 1,000 ft surficial aquifer model

4.5.4 Qualitative Water Budgets for the Calibration Period

Seasonal MIKE SHE water budgets for 29 sub-watersheds are summarized in Appendix B. Seasonal MIKE SHE water budgets for the SAS for the 29 sub-watersheds are also summarized in Appendix B MIKE SHE water budgets for the entire calibration period are included in Appendix B (see sub-watersheds delineation in Figure 2.25 in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007). The terms included in the water budgets and equations used to calculate the total model error (*Err*) are also defined in Appendix B. The Lake Management Unit Budget was also prepared. The results of this analysis are presented in a separate set of Excel spreadsheets (in digital format) and correspond to the water budget from the MIKE 11 perspective. The Excel spreadsheets summarize the lateral inflows (runoff + base flow) for each Lake Management Unit.

Water budgets are presented in Appendix B for the 1995 to 1998 calibration period. In general, the water budgets appear to be reasonable based on review of available data (*e.g.*, McGurk and Presley, 2002).

4.5.5 Calibration Log

An electronic version of the Calibration Log is provided in a CD attached to this document.

4.6 Overland Flow Depth and Hydro-Period Maps

Maximum and average overland flow depths for the 1996 to 1997 dry season, 1997 to 1998 dry season, 1996 wet season, and 1997 wet season are shown in Figure 4-81 to Figure 4-88. These periods represent extreme conditions during the calibration period (see Figure 2.4 in the KBMOS Alternative Formulation Evaluation Tool Model Documentation / Calibration Report Peer Review Copy dated August 31, 2007). Overland depth hydro-period maps showing the percentage of time overland depths exceed 1 inch and 1 foot are shown in Figure 4-89 and Figure 4-90, respectively.

Although a rigorous analysis of simulated hydro-periods for specific vegetation types was not performed, simulated overland depths and hydro-periods appear reasonable for the selected periods based on comparison with KBMOS land-use categories. Areas with significant overland water depths generally correspond to land-use categories that are typically inundated for significant periods of time (water, swamp forest, etc.). Qualitative correspondence of simulated overland results to land-use suggests that overland parameters are adequate to meet the objectives of the KBMOS.

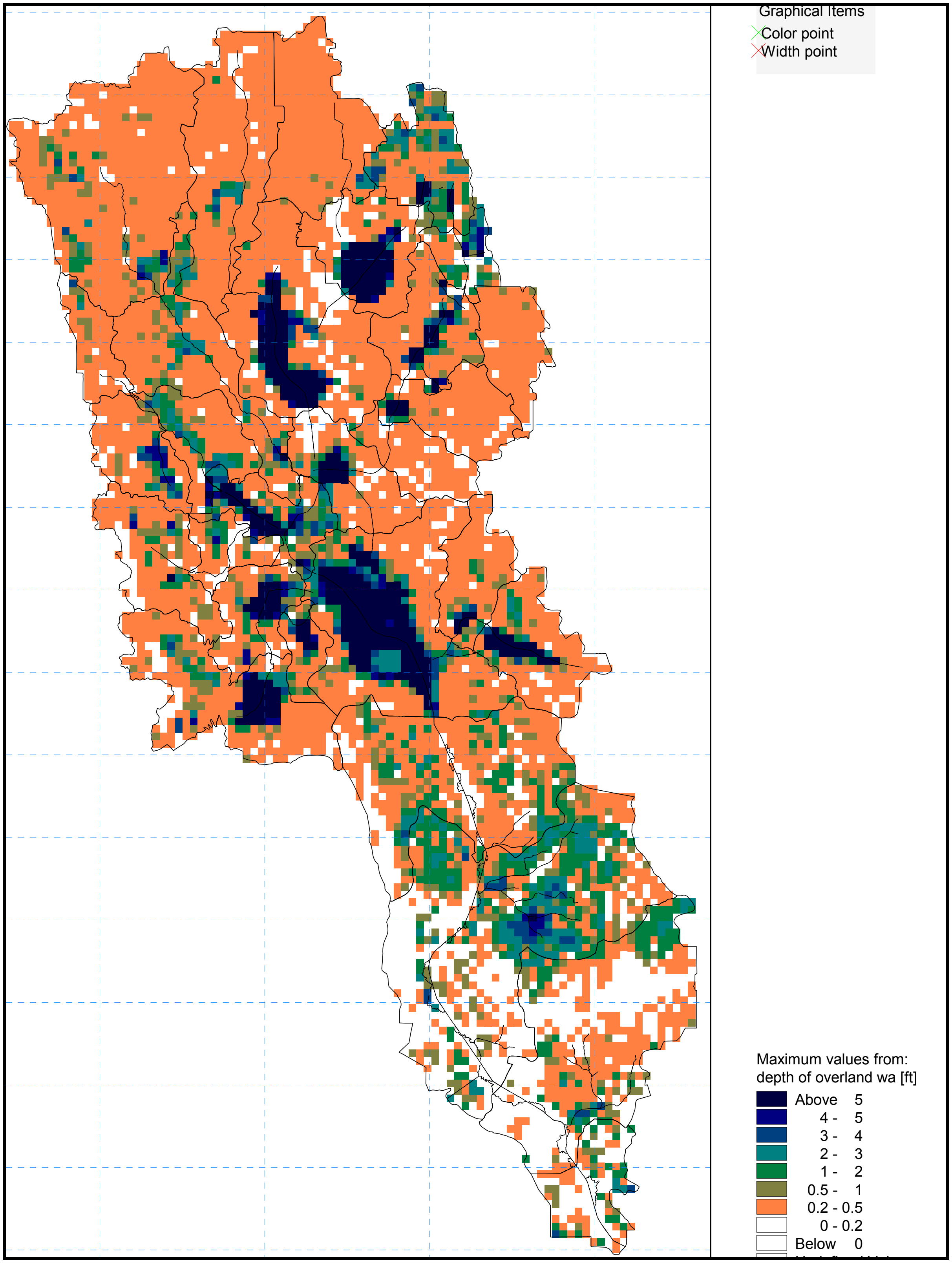

Figure 4-81: Maximum overland flow depths for the 1996 to 1997 dry period

AECOM

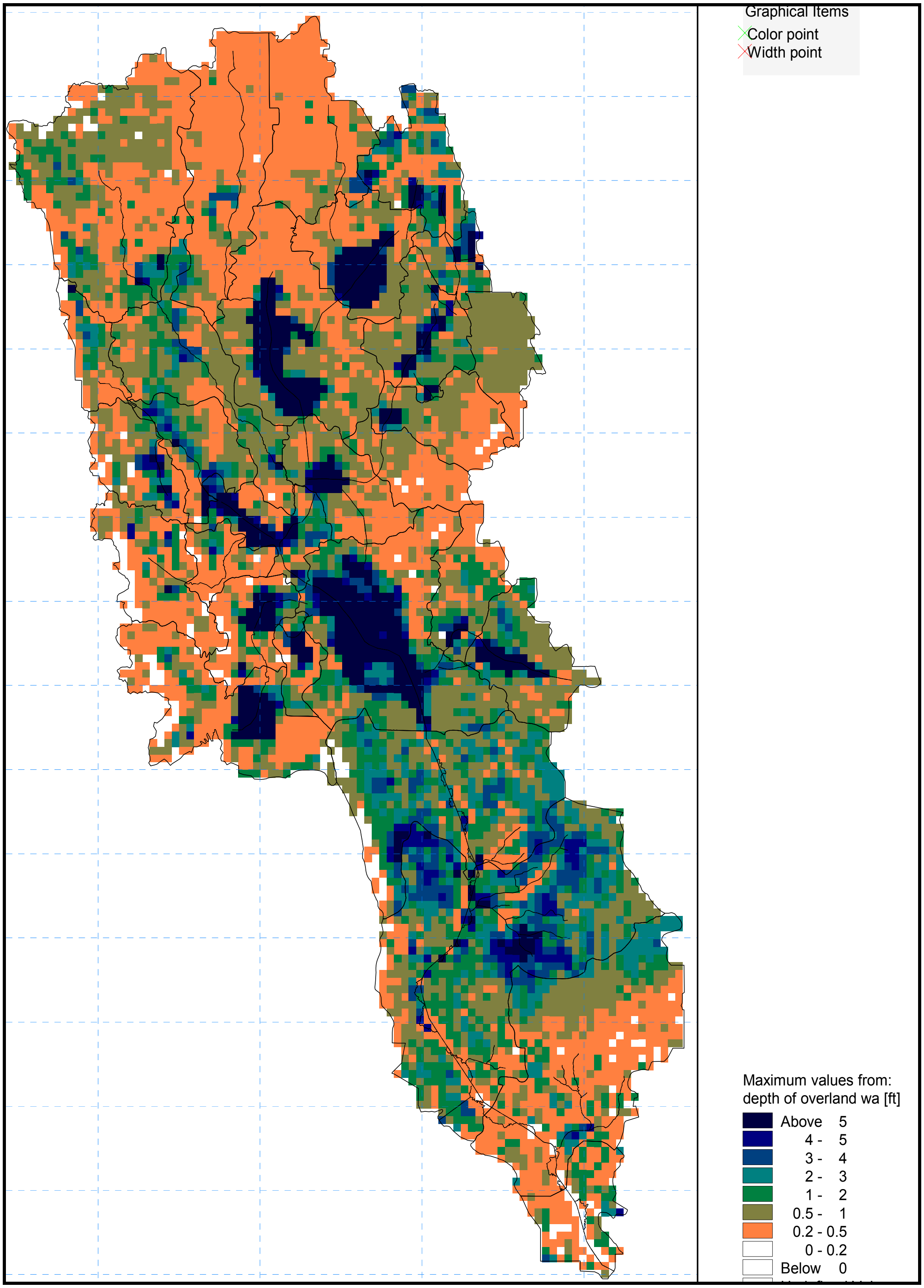

Figure 4-82: Maximum overland flow depths for the 1997 to 1998 dry period

AECOM

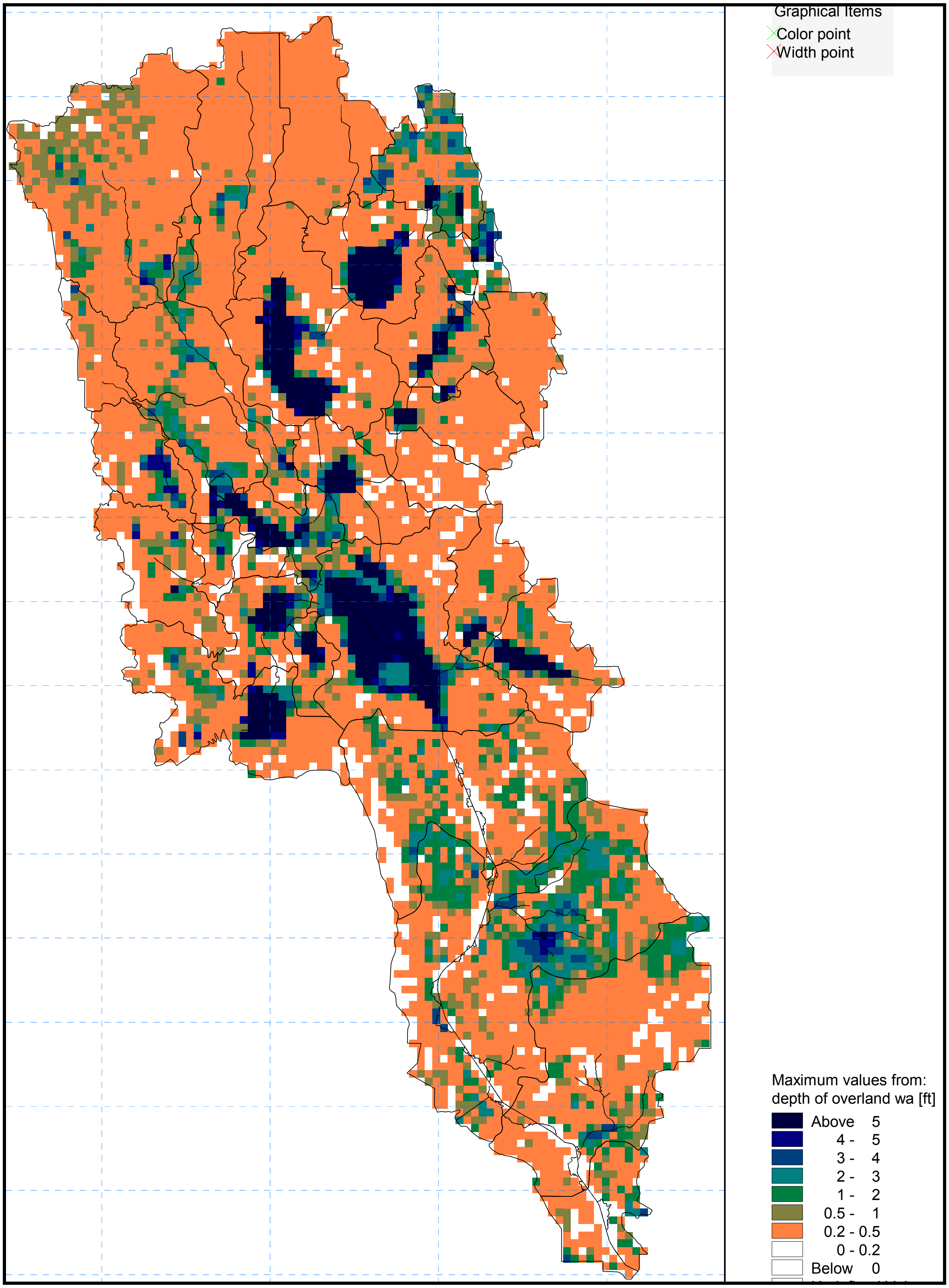

Figure 4-83: Maximum overland flow depths for the 1996 wet period

AECOM

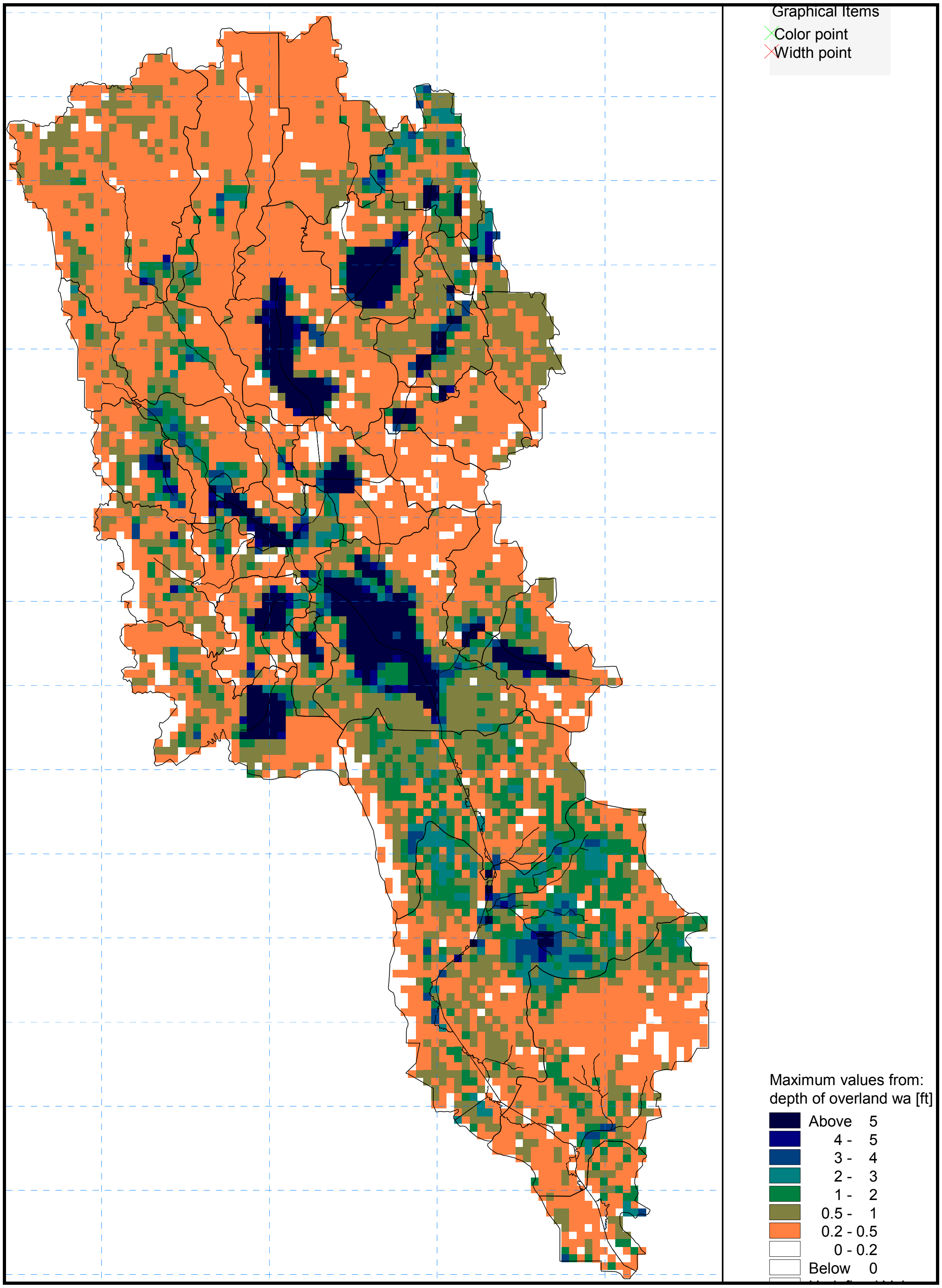

Figure 4-84: Maximum overland flow depths for the 1997 wet period

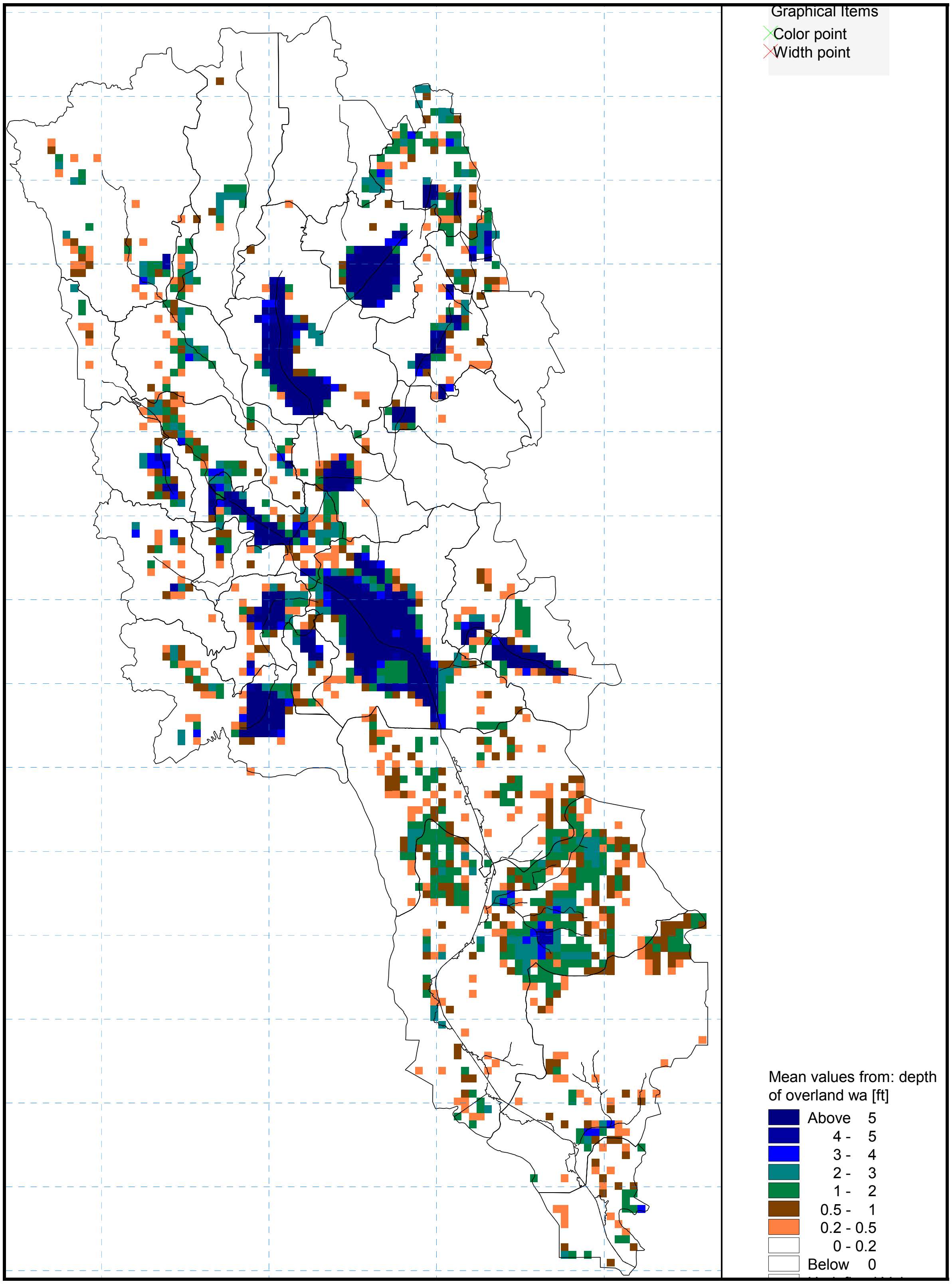

Figure 4-85: Average overland flow depths for the 1996 to 1997 dry period

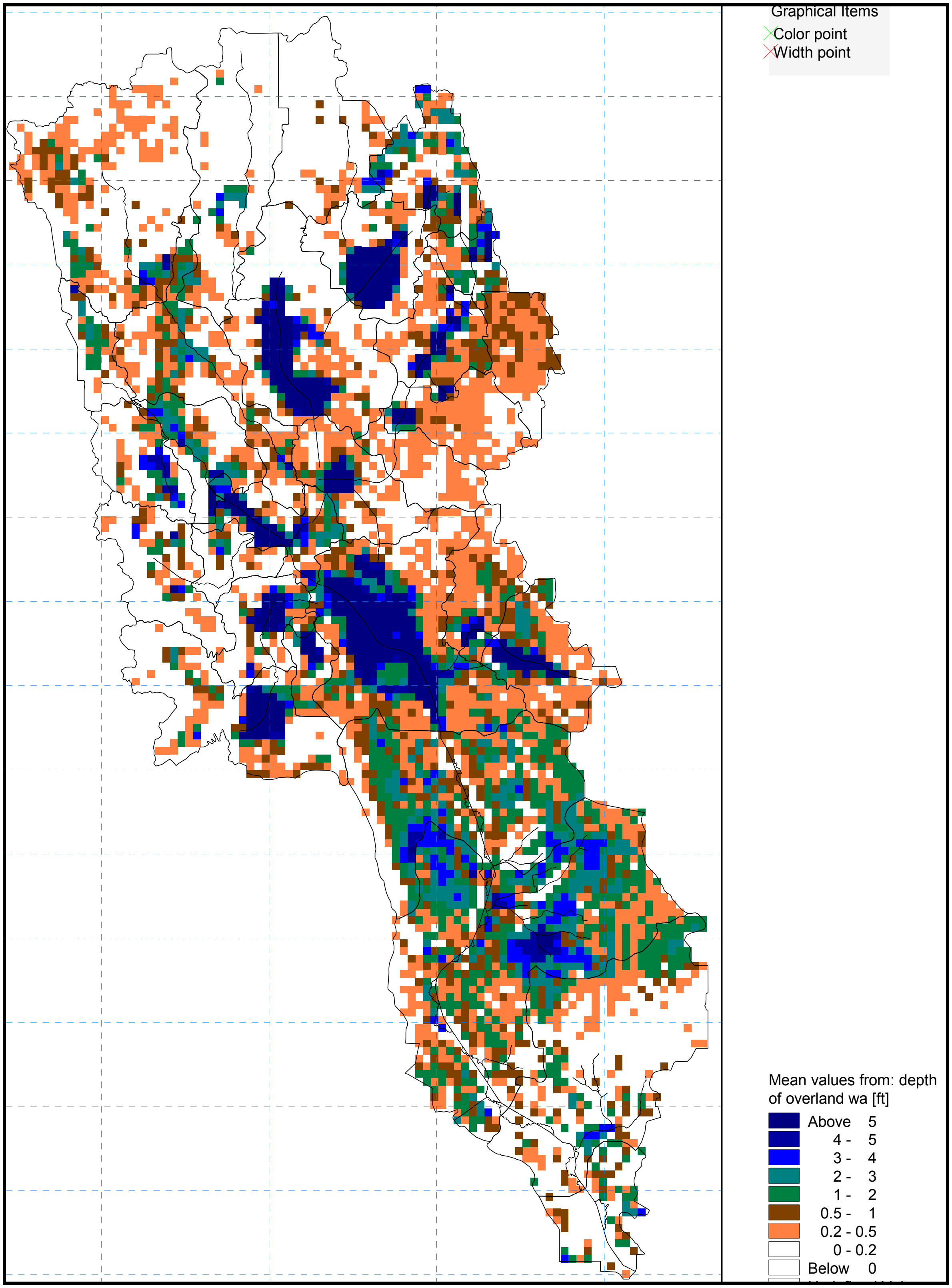

Figure 4-86: Average overland flow depths for the 1997 to 1998 dry period

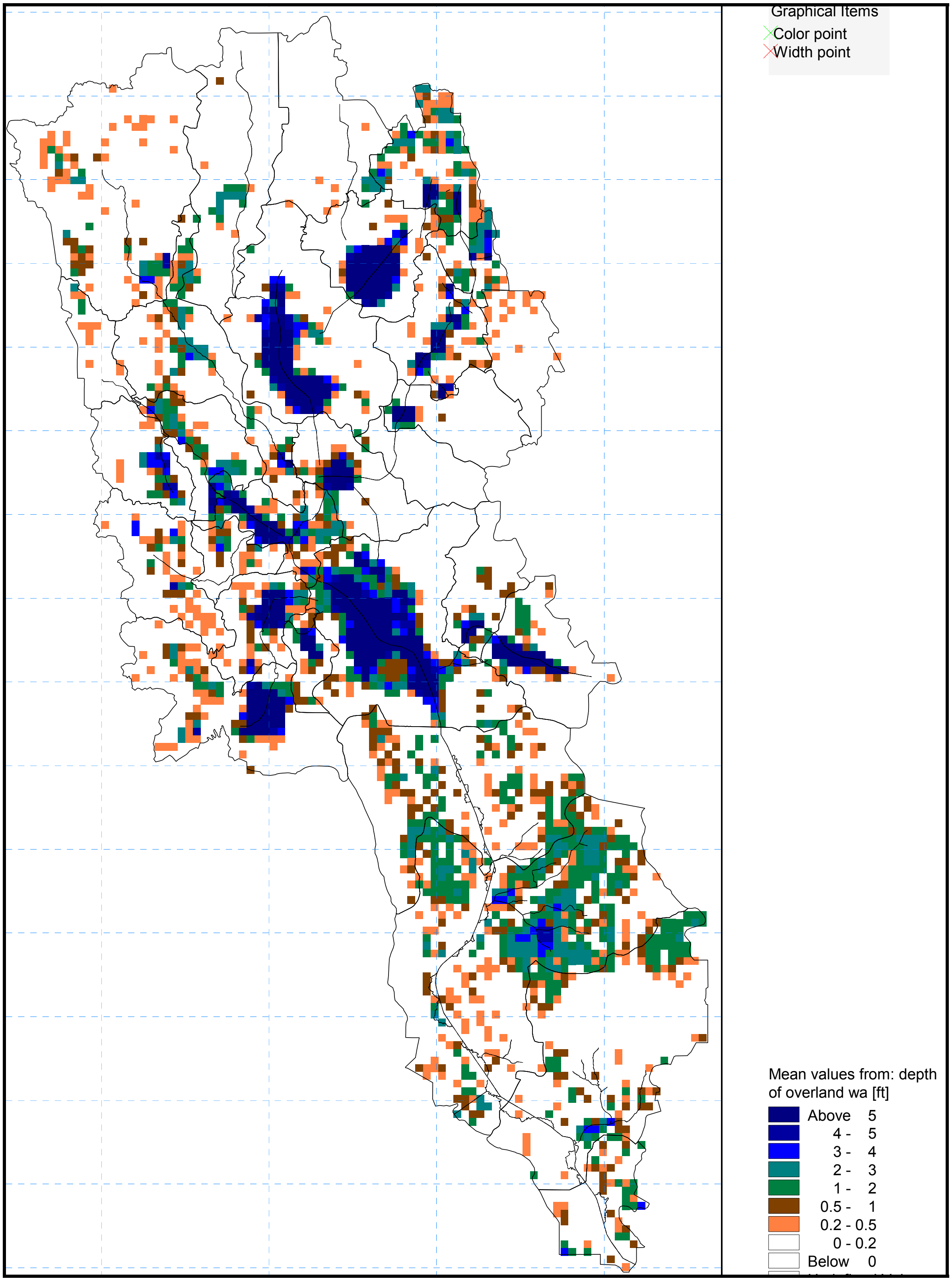

Figure 4-87: Average overland flow depths for the 1996 wet period

AECOM

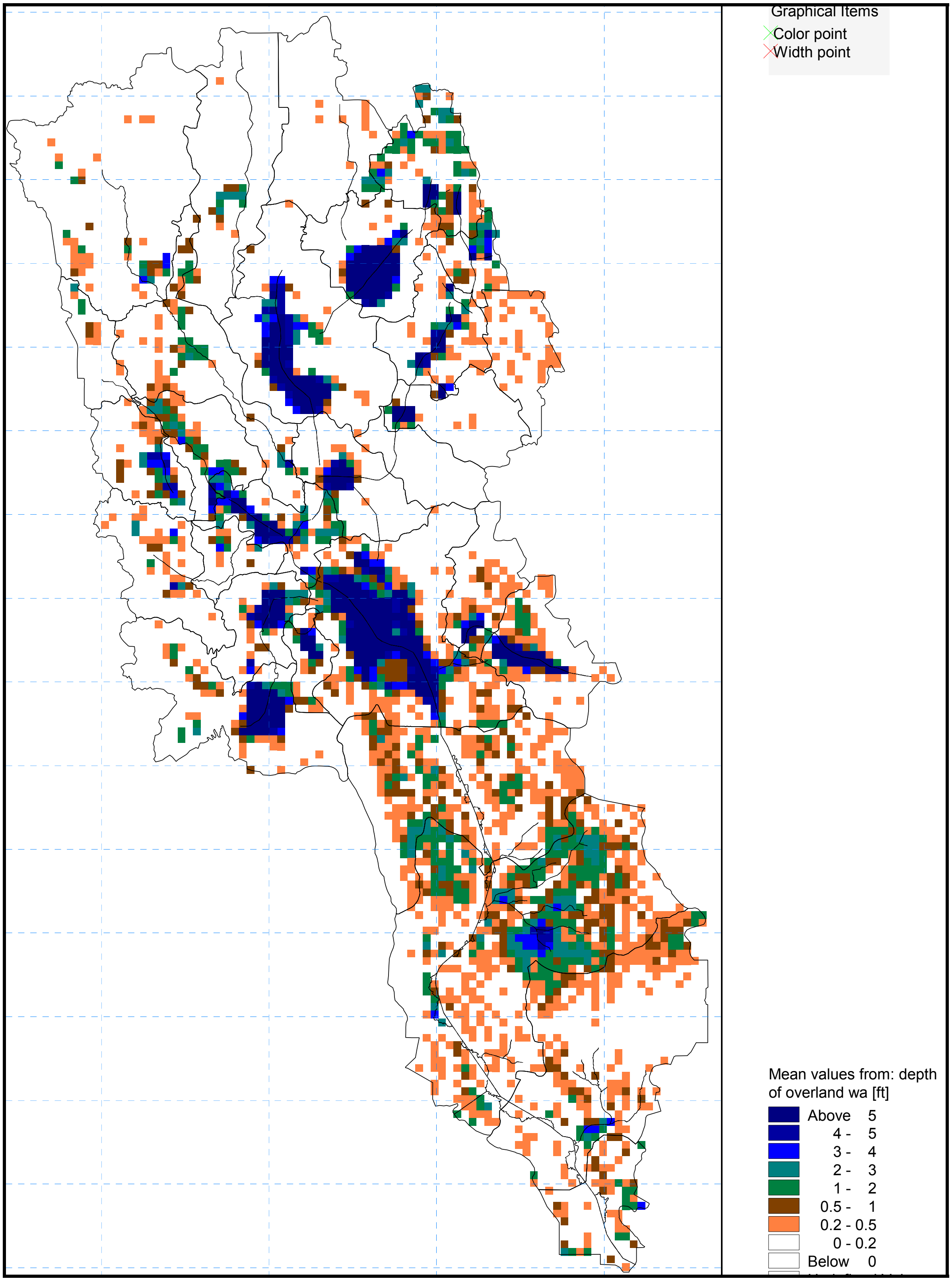

Figure 4-88: Average overland flow depths for the 1997 wet period

AECOM

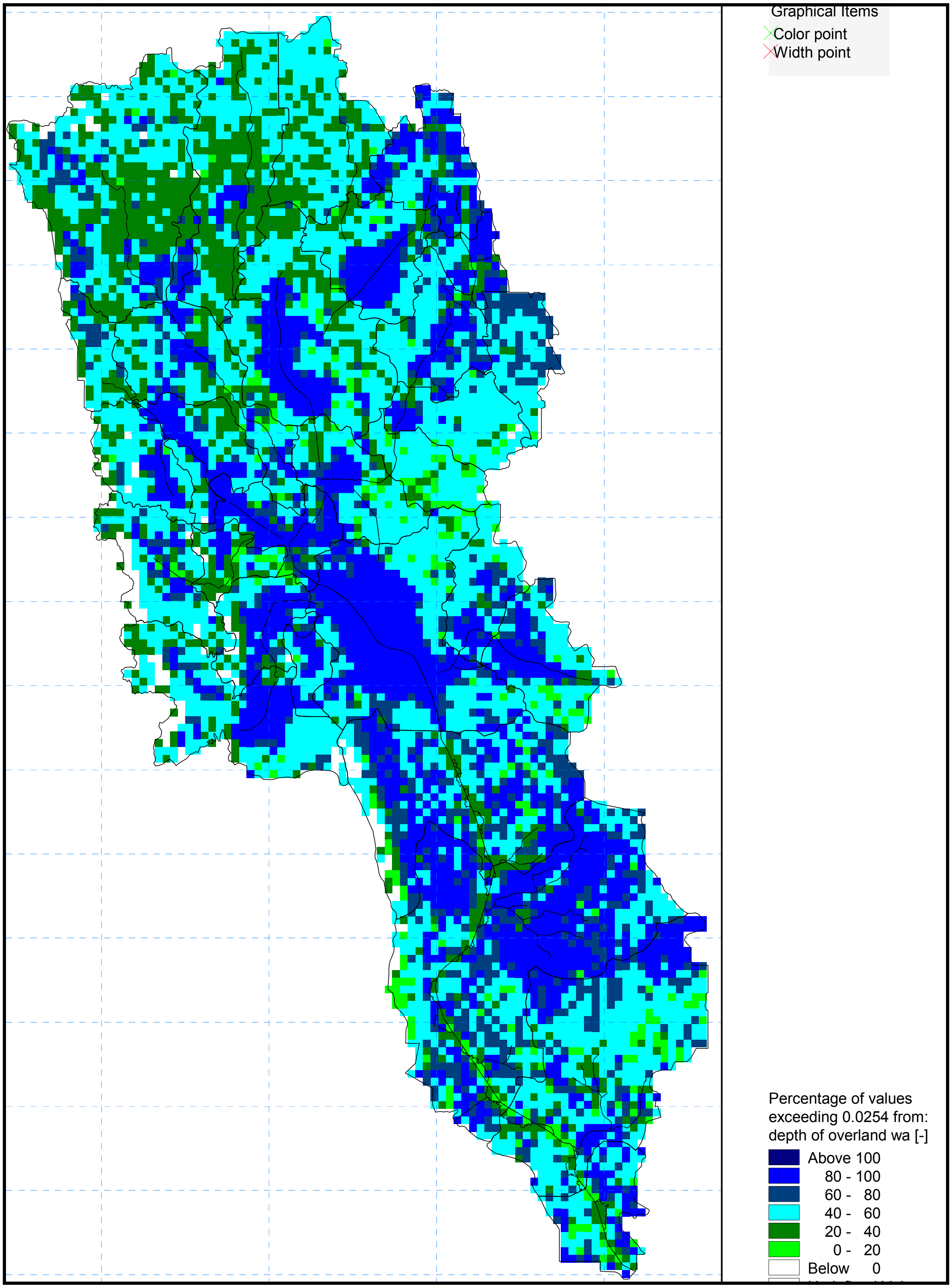

Figure 4-89: Percentage of time overland flow depths exceed 1 inch during the period from 1996 to 1997

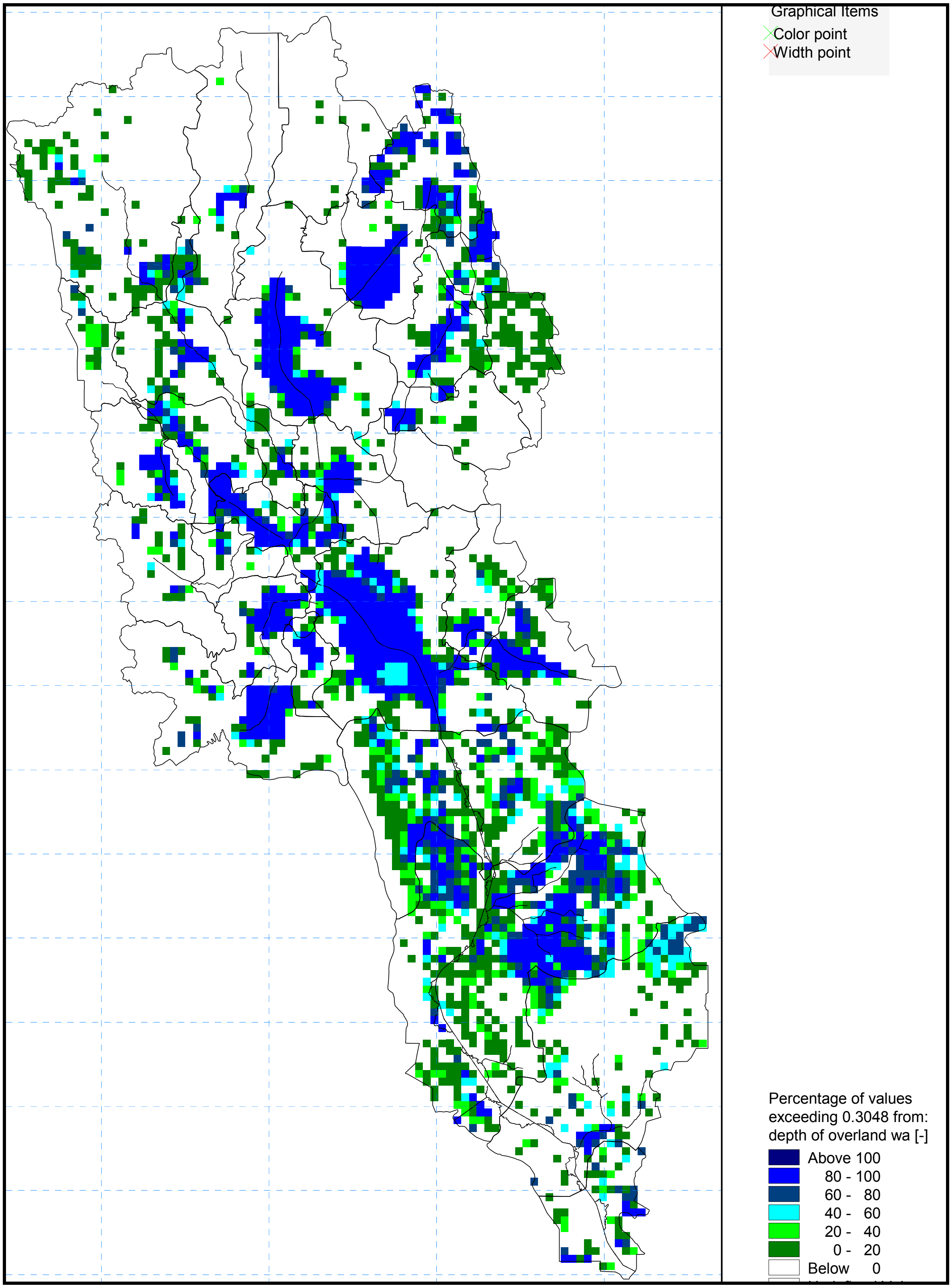

Figure 4-90: Percentage of time overland flow depths exceed 1 foot during the period from 1996-1997

5 MODEL LIMITATIONS

5.1 Limitations of Current Model to Meet the Objectives of the Current Project and Non-KBMOS Studies

The newly calibrated AFET model (AFET-W) will be used to (1) evaluate KBMOS alternative plans (2) develop the "With Project", target, and reservation timeseries for the Kissimmee Basin Water Reservation and (3) evaluate proposed surface water supply withdrawals made under the selected plan for the KBMOS. Limitations of AFET-W relative to uses that are not related to the previously stated objectives are summarized below.

5.1.1 Changes in Local Drainage

The 1,000 foot grid size used to simulate the surficial aquifer and overland flow components in the KBMOS AFET model may be too coarse to study local-scale hydrologic changes in the restored section of the Kissimmee River. Development of a higher-resolution, local scale model of the LKB and refinement of the aquifer parameters used in the calibrated KBMOS AFET-W model may be required to evaluate local-scale drainage issues in more detail.

5.1.2 Groundwater Supply

The KBMOS AFET-W model was developed specifically to evaluate surface water issues in the Kissimmee Basin. The Phase 1 Basin Assessment indicated that the KBMOS AFET model was not envisioned to specifically simulate water demand from the FAS or the impact that those withdrawals may have on aquifer recharge and/or discharge but the capabilities of the model could be expanded to evaluate these processes in future projects. Although the AFET-W model provided a better FAS calibration than the AFET model, the purpose was not to anyalze FAS withdrawal scenarios, but to provide acceptable boundary condition for the one layer SAS model and to evaluate the effect of FAS heads on the SAS and surface water conditions. The SFWMD does not plan to rely on the AFET-W to evaluate the withdrawal scenarios.

5.1.3 Restoration of Fodderstack Slough and Surrounding Areas

Evaluation of the restoration of Fodderstack Slough and surrounding areas is not a component of the KBMOS. As a result, the ability of the model to simulate the effects of restoration was not evaluated using the KBMOS AFET-W model. Evaluation of the effect of restoration of Fodderstack Slough may require development of a higher-resolution, local-scale model and use of higher-resolution topographic data and/or additional ground survey information than used in the 1,000 foot KBMOS AFET model.

5.2 Data Limitations

In general, the data used to calibrate the model were sufficient to meet the objectives defined for the KBMOS AFET-W model. In several cases, the available data were sparse and this limited the precision of the AFET-W model for some processes. Data items that were limited are discussed below.

5.2.1 Limitations With Data Distribution

The spatial, and in some instances the temporal distribution of the data for calibration is limited, particularly for the Floridan and the intermediate aquifers. Figure 4-2 and Figure 4-3 show the calibration wells. Floridan aquifer wells are shown in green on the figures. It should be noted that there were no wells in the southern part of the watershed, and the wells in the northern part of the watershed have poor spatial distribution. The SFWMD has installed more wells in the Lower Basin, but those wells will require some time before they start producing useful information for modeling purposes. There was much better spatial distribution of the surficial aquifer wells but in some instances the temporal distribution was inadequate. There were also concerns with the reliability of some data, particularly with regards to the datum. In comparing water level elevation with land surface elevation in the model, there were sometimes discrepancies. The calibration wells did not include the intermediate aquifer. It is evident that, in general wells were installed for other purposes (e.g., water supply) and since there is not much interest in the confining unit of the intermediate aquifer, the wells have not been installed. However, for calibration of the models, wells in all model layers are useful. Furthermore, if additional wells are installed, pumping tests in a comprehensive manner should be conducted to better define the hydraulic parameters of the aquifers. It is assumed that any additional wells drilled in the area should also have detailed geologic logs for an assessment of the hydrogeology.

5.2.2 Reference Evapotranspiration Data

A single-station, composite-source RET dataset was used in the KBMOS AFET model. The single-station, composite-source RET dataset was used because it represented the best dataset available at this time. It is recognized that there are spatial differences in RET rates and it is suspected that the calibration of the AFET model could be improved with a spatially-varying RET dataset. Subsequent to the development of the AFET model, SFWMD developed a spatially-variable, single-source RET dataset which was used to calibrate the AFET-W model.

5.2.3 Analytical Water Budget Data

A key component of the KBMOS AFET model is its ability to evaluate the effect of modifications of structure operating criteria and restoration of Pool C on the sub-watershed scale water budgets. Analytical lake water budgets developed by the SFWMD and water budget data from McGurk and Presley (2002) were used to evaluate model results. The current analytical water budget analyses are restricted by errors in the flow data and a limited understanding of the hydrology of Kissimmee Basin. It is recommended that the SFWMD continue to improve the analytical water budget data available for the Kissimmee Basin in order to refine the calibration of the AFET-W model for future applications.

Being AFET-W a regional model that covers a rather large spatial domain, and to keep running time and model complexity within reasonable limits, it was defined during the preparation of the TDD (Earth Tech, 2006) to use daily rainfall instead of hourly increments. The TDD also specified the network of channels that was to be modeled in MIKE 11. The density of this network was also limited by other factors in addition to the run time and model complexity, such as the amount of survey information available. As a consequence of the above (daily rainfall and density of MIKE 11 network), much of the infiltrated water is routed in the model through the drainage term in MIKE SHE. The use of the drainage term offers an alternative way to route the otherwise runoff that would have reached the MIKE 11 network as overland flow should a shorter rainfall time step and a denser MIKE 11 network were available. Therefore, it will be noted that the drainage term is relatively high but drain to river is also high as much of the drainage water returns to the surface water channel system. This has to be taken into account when interpreting the results of the water budgets. Smaller scale or zoomed in models should consider shorter rainfall time steps and a denser MIKE 11 network.

5.2.4 Un-gauged Structure Flows

During development of the AFET model it was determined that significant un-gauged flows were occurring from lock structures and poorly seated gate structures. Very little data was available to quantify these flows but analysis of headwater and structure discharge data indicated that significant stage changes, that exceeded evaporation losses, occurred when structure gates were reported to be closed. These un-gauged flows were conceptually represented in the AFET model. It is recommended that the SFWMD obtain additional information on lock operations and structure seepage from poorly seated gates to further refine the calibration of the AFET model for future applications.

5.2.5 Flow Data

During the calibration effort, preferred flow timeseries were identified for both S-65 and S-65E Structures. These timeseries represent the most recent QA/QCed data source. The preferred timeseries were used to compute the Cumulative Error (CE) values shown in Section 4. The SFWMD also provided a list of DBKEYS with the best available flow data (preferred DBKEYS) for the recording stations within the Kissimmee Basin (written communication- email from John Raymond to Rama Rani on September 3, 2008). The list, included in Table 5-1 includes up to two DBKEYS per stations depending on the period of record available at each DBKEY. Emile Damisse from HESM (SFWMD) performed an elaborated analysis of the available flow data for structure S-65 to be used to calibrate AFET-W and to compare the base conditions results. Based on this study, it was concluded that, although a more updated set of flows will be available soon, that set has not been completely QA/QCed yet, therefore the preferred DBKEY for the S-65 Structure is H0289 (written communication - email from Rama Rani to Guillermo Regalado on August 27, 2008).

Table 5-1: Preferred flow DBKEYS in Kissimmee Basin

Water Control Unit	STATION	DBKEY
Myrtle - Preston - Joel	S-57	4394
	S-57	15525
Alligator	S-58	4400
	S-58	15528
	S-60	4608
	S-60	15536
East Lake Tohopekaliga	S-59	4406
	S-59	15533
Tohopekaliga	S-61	4412
	S-61	15560
Hart - Mary Jane	S-62	4418
	S-62	15539
Gentry	S-63A	4796
	S-63A	15798
	S-63	4424
	S-63	15542
Pool A	S-65A	4430
	S-65A	6801
	S-65A	V7564
Pool B	S-65B	4436
	S-65B	6841
Pool C	S-65C	4458
	S-65C	6959
	S-65C	15338
Pool D	S-65D	4470
	S-65D	6962
Pool E	S-65E	8066
	S-65E	KO585
Kissimmee - Hatchineha - Cypress	S-65NEW	OB347
	S-65	K3015
	S-65	***HO289***

The District is constantly updating and adjusting the timeseries, in the event that these timeseries undergo significant changes in future revisions, the calibration effort might have to be reviewed to evaluate the effect of the adjustments in the calibration statistics.

5.3 Potential Benefits of Additional Calibration

Although the AFET-W model met the calibration criteria defined for the project there are several parameters that could be refined to improve model results. Potential parameters that could be evaluated further are discussed below.

5.3.1 Groundwater

AFET-W started with initial FAS parameters from an interim ECFT MODFLOW model and may be updated in future projects with data sets from the fully calibrated ECFT MODFLOW model when they become available, if significant changes in the data set are proven valid. However, the parameters in the model were adjusted in the calibration process, and are believed to appropriate by the Study Team.

5.3.2 Drainage Parameters

The drainage parameters (drainage time constant and drainage level) used in the KBMOS AFET model were distributed using a land-use based approach except for the Lake Conlin sub-watershed where drainage parameters were used to conceptualize surface water conveyance in wetland features connected to Alligator and Brick Lakes. It is possible that adjustment of the land-use based drainage parameters on a sub-watershed basis could improve the calibration of the AFET model in some areas. During the AFET-W calibration drainage levels were adjusted to improve the calibration.

6 CONCLUSIONS

The SFWMD has updated and refined the calibration of the KBMOS AFET model to address peer review panel recommendations. A new Reference Evapotranspiration (RET) data acquired by the SFWMD's Hydrologic and Environmental Systems Modeling Department was incorporated into the model to replace the original RET data. Additional improvements were made to Upper Floridan Aquifer and Surficial Aquifer System dynamics. The newly calibrated model was termed AFET-W to differentiate it from the previous model (AFET).

The AFET-W model meets the calibration criteria defined in the calibration approach document submitted to SFWMD on August 2008 (Earth Tech, 2008 a) and modified in the August 14 Study Team meeting . Gauges or wells that do not meet defined calibration criteria can be explained by uncertainties in datum or other data oddities. Surface water stage and flow gauges show a high degree of correlation with observed data in the calibration and verification period. Groundwater calibration meets the defined criteria showing a great improvement from the original AFET being sufficient to meet the objectives of the AFET-W.

Simulated UFA recharge rates are consistent with the data of Aucott (1988) and other references. Simulated water budgets for the calibration with other studies (*i.e.,* McGurk and Presley 2002). Simulated overland depths during critical periods seem reasonable. And, based on a qualitative comparisons to land-use classifications, simulated hydro-periods appear reasonable and consistent with the presence of wetland and lakes in the watershed.

The AFET-W model is considered to be adequate to be used to (1) evaluate KBMOS alternative plans (2) develop the "With Project", target, and reservation timeseries for the Kissimmee Basin Water Reservation and (3) evaluate proposed surface water supply withdrawals made under the selected plan for the KBMOS, based on the statistical fit at critical surface water and groundwater locations, graphical evaluation of the temporal response of the model at critical calibration locations, simulated UFA heads, simulated UFA recharge rates, simulated river fluxes, water budgets, and simulated overland results. The modeling team believes the calibrated AFET-W model is ready to be used to evaluate current and future condition scenarios in future phases of the project. As it is the case with all seminal models, AFET-W calibration might be further refined for its application to other water resource projects in the Kissimmee Basin.

6.1 Recommendation for Future Work

As it is the case of any seminal model, there is always room for improvement, the following are some of the few recommendations for future work that could improve the quality of the work describe in this document:

- Divide the SAS into multiple layers. An examination of geologic and geophysical data indicates that there is more than one producing zone in the SAS.
- Improve the transient response for the UFA monitoring well calibration, which could be done as more information at the model boundaries becomes available (i.e. through the ECFT or other modeling efforts)
- A post-model monitoring program should be established. This could verify the accuracy of the model. Also, any data and knowledge obtained will be useful for future modeling efforts.

- This model was calibrated by manual trial and error. Therefore, a possible improvement for future modeling efforts include automated calibration techniques. The AUTOCAL automatic technique was used in this effort because of time constraints. However, since this technique does not require an intense resource dedication and can be attempted in the future.

7 REFERENCE

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Aucott, W.R., 1988. Areal Variation in Recharge to and Discharge from the Floridan Aquifer System in Florida. U.S. Geological Survey, Water-Resources Investigations Report 88-4057, map with text.

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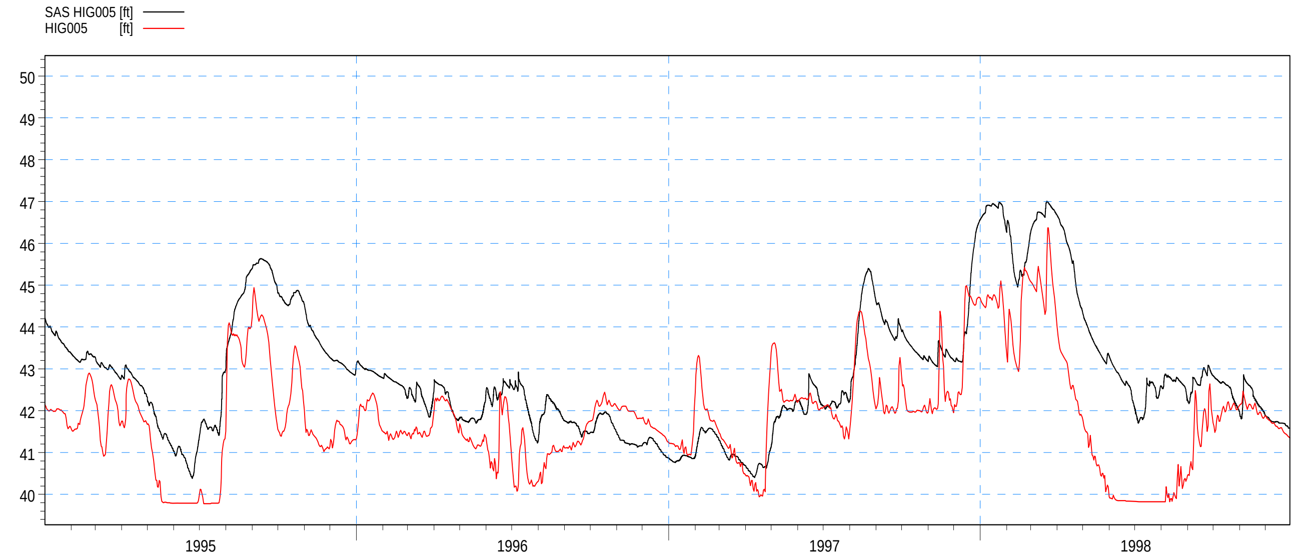
Tibbals, C.H., 1990. Hydrology of the Floridan Aquifer System in East-Central Florida.

White, W.A., 1970. The geomorphology of the Florida Penisula: Tallahassee, Florida Geological Survey Bulletin 51, 164p.

APPENDIX A

Calibration Plots for Secondary Wells

SAS WELLS



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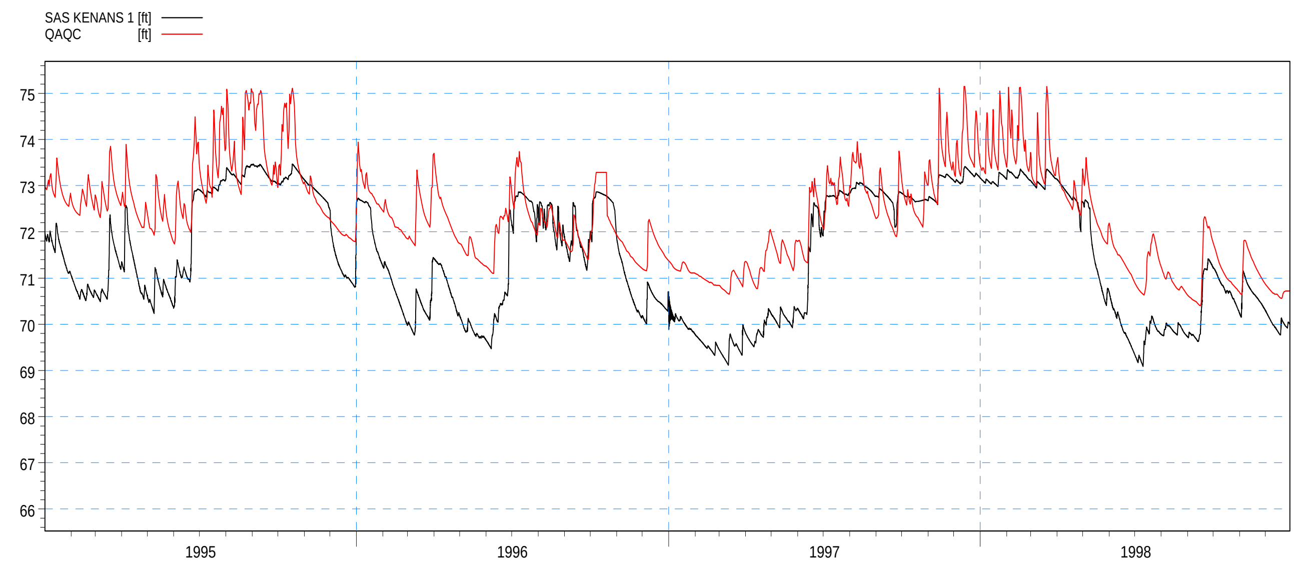
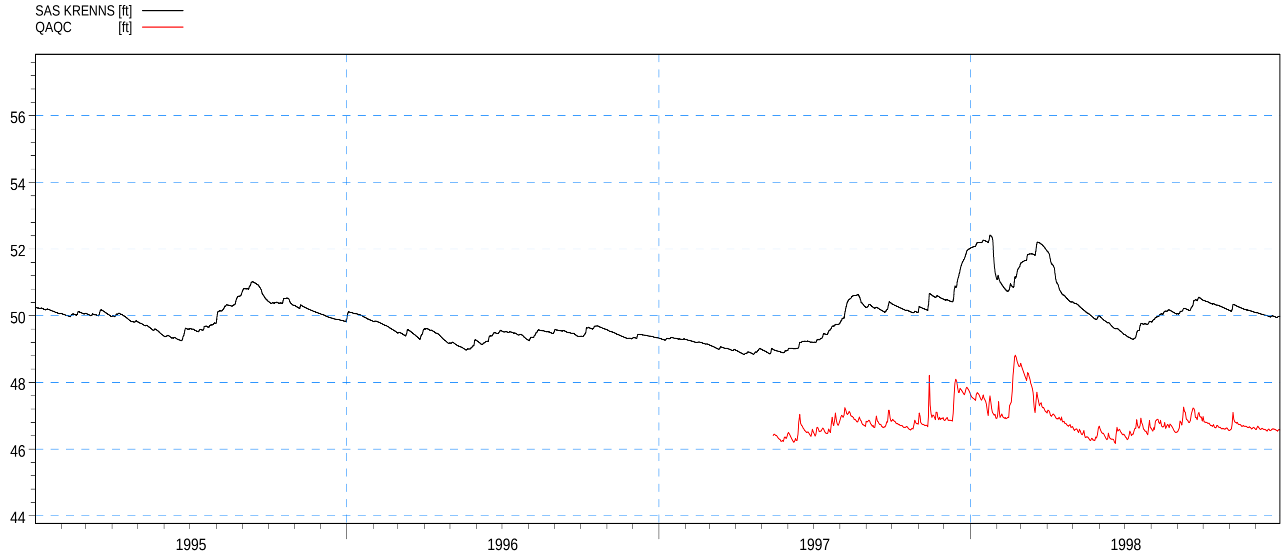


SAS - KENANS1

SAS WELLS



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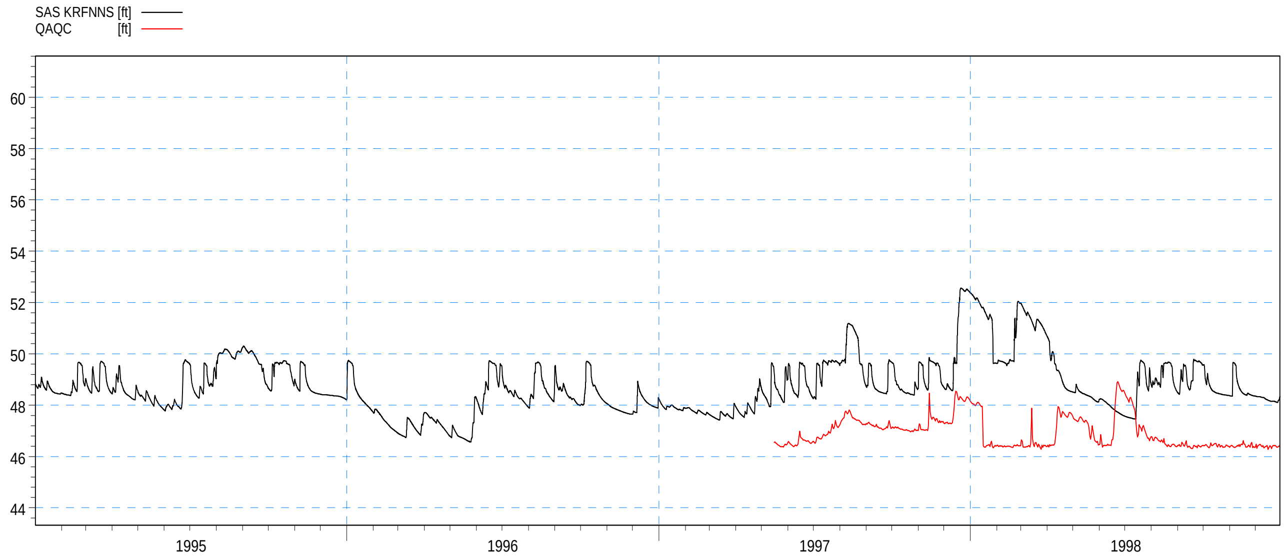

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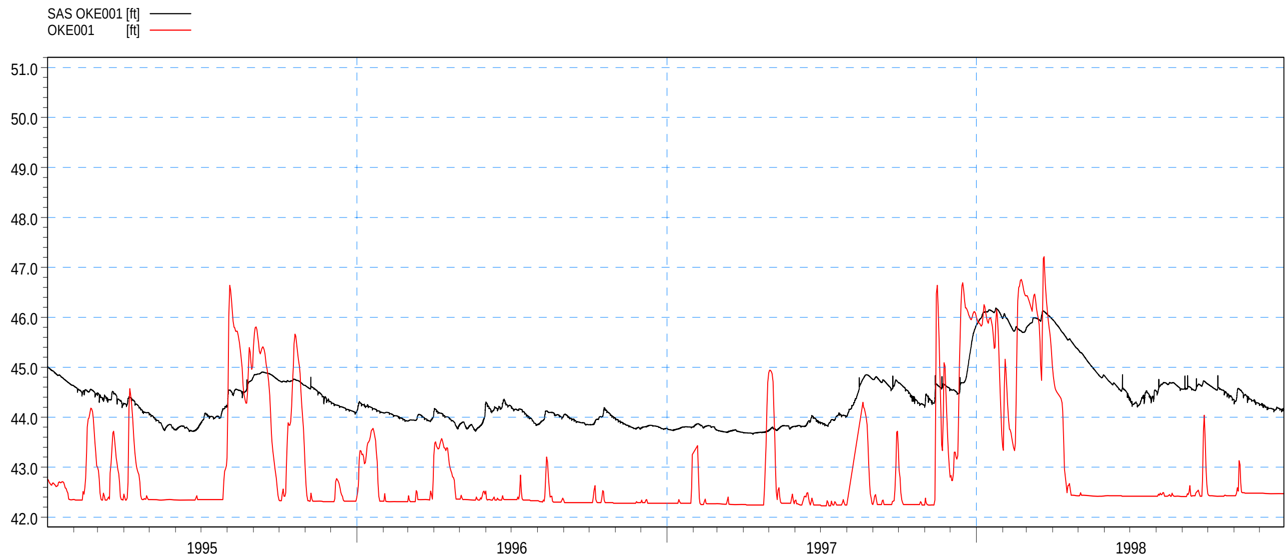

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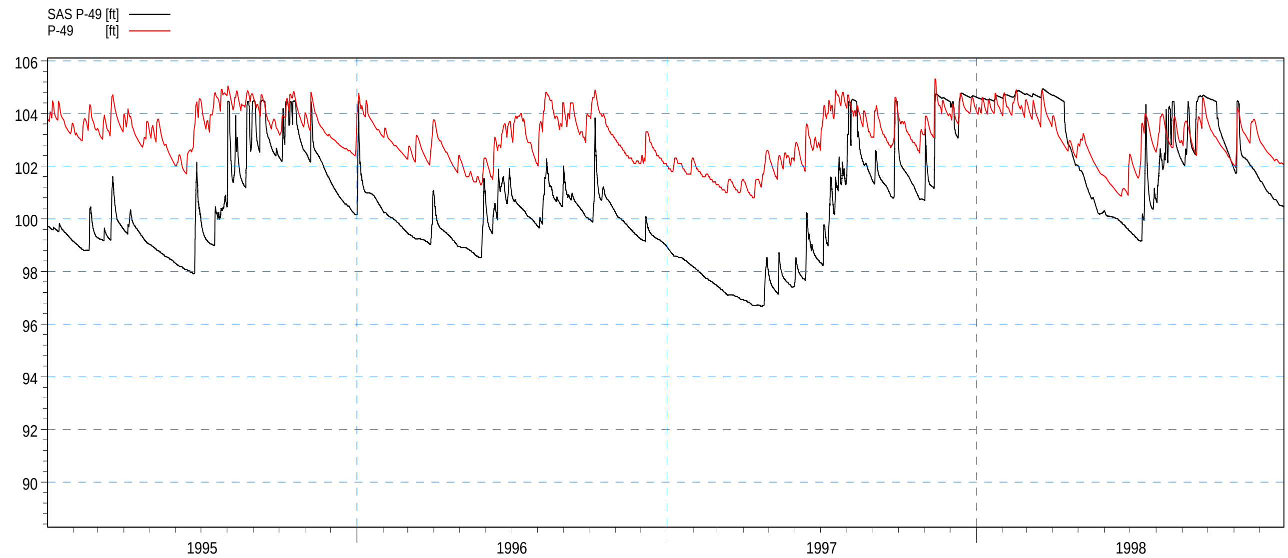

SAS - P49

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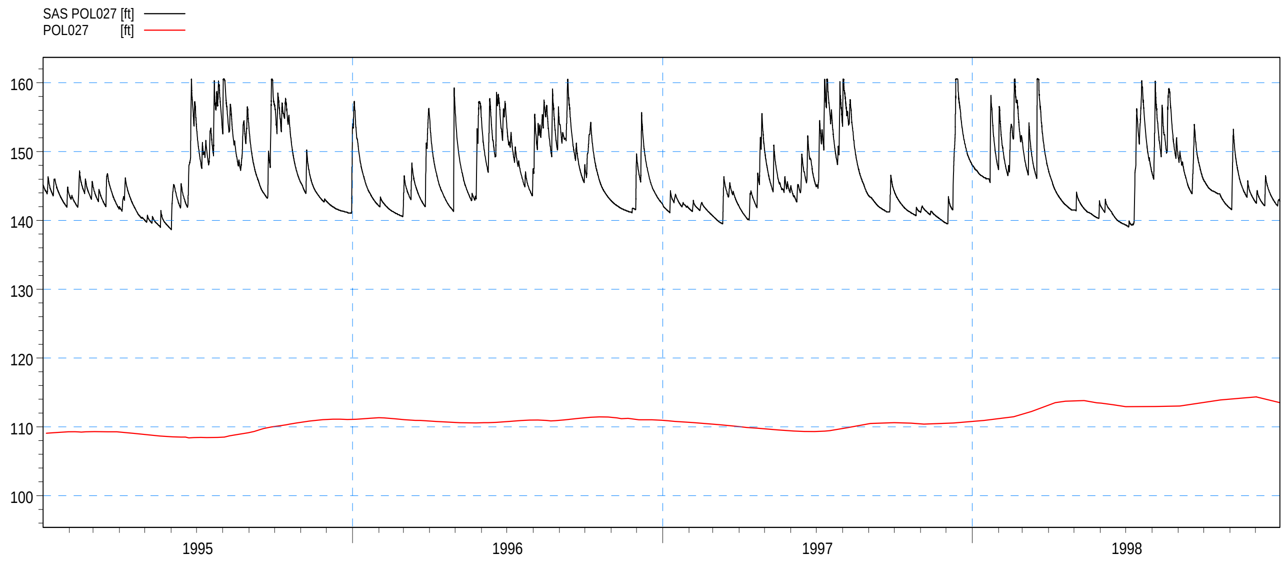

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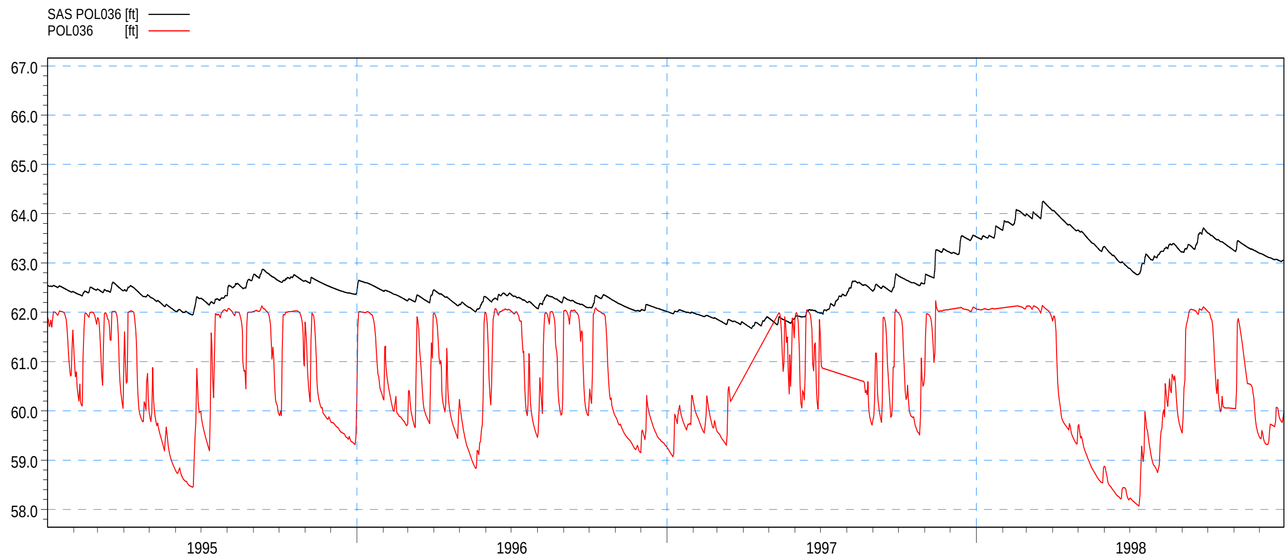
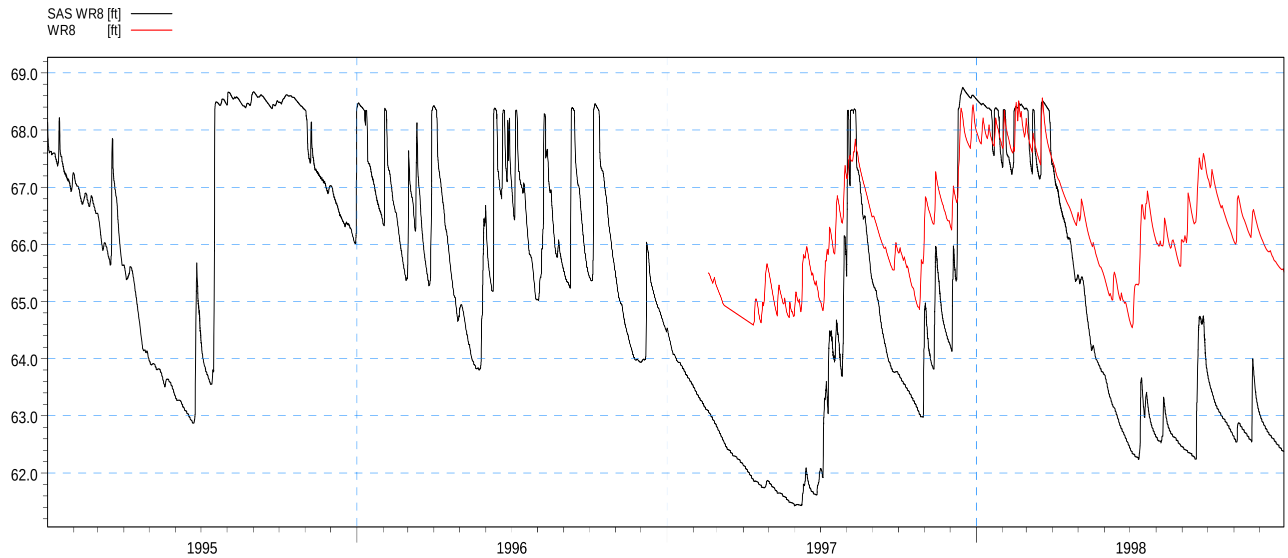
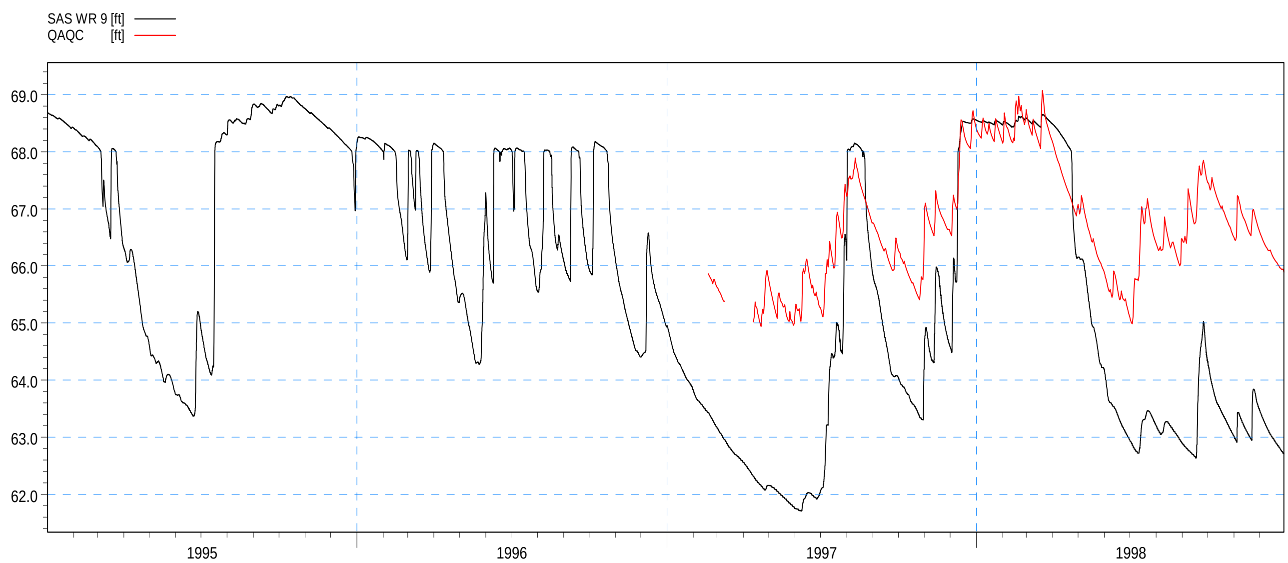


SAS - POL036

SAS WELLS

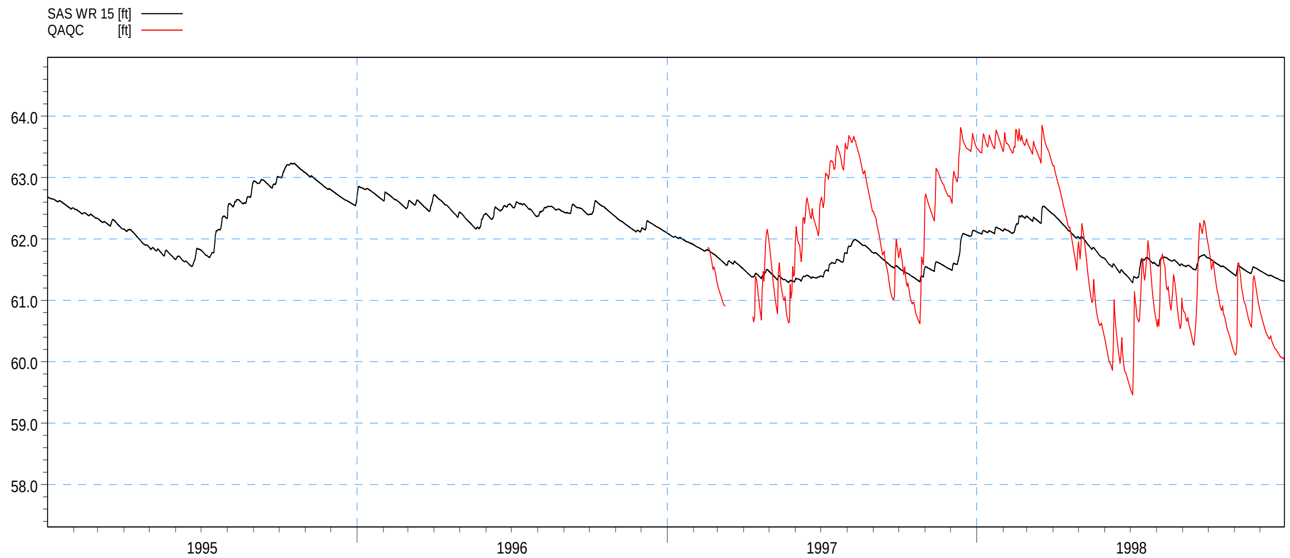


SAS - WR8



SAS - WR9

SAS WELLS



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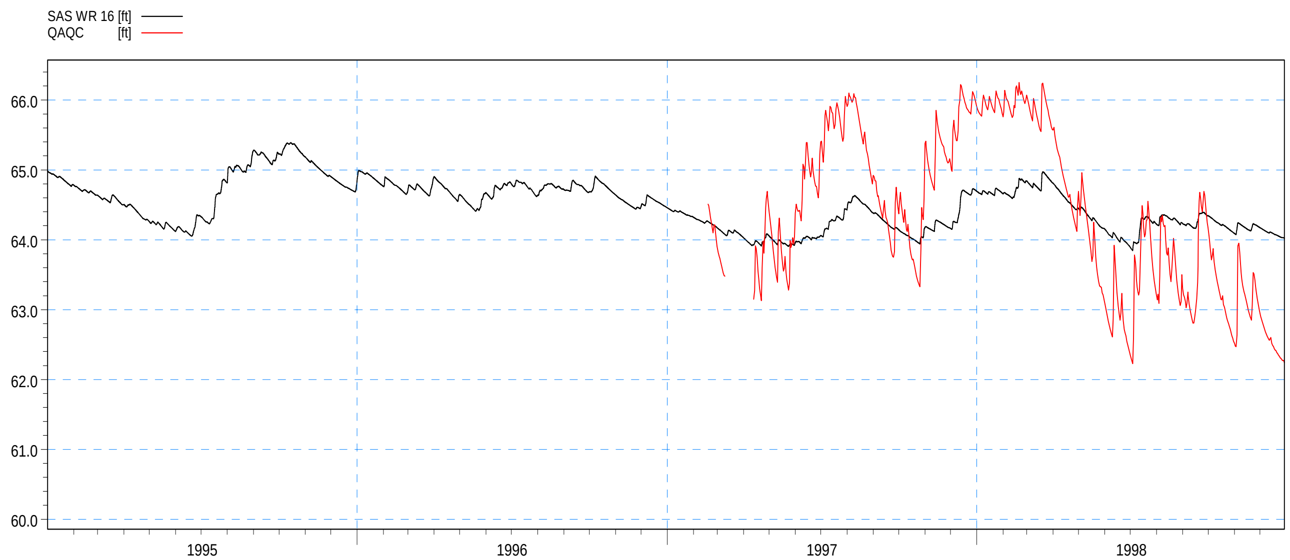
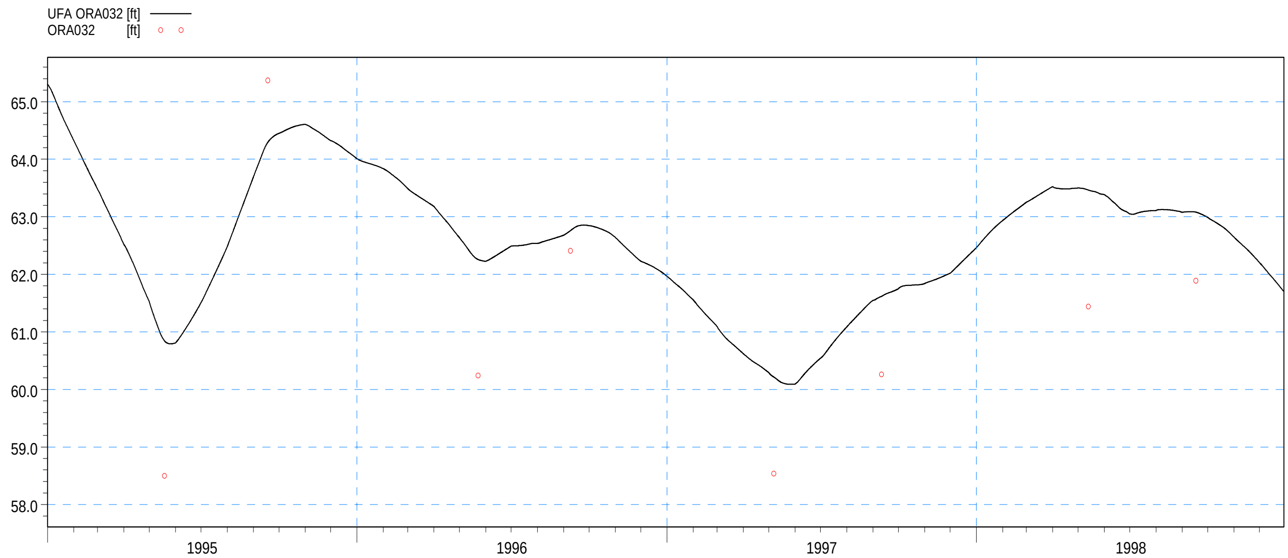


SAS - WR16

UFA WELLS



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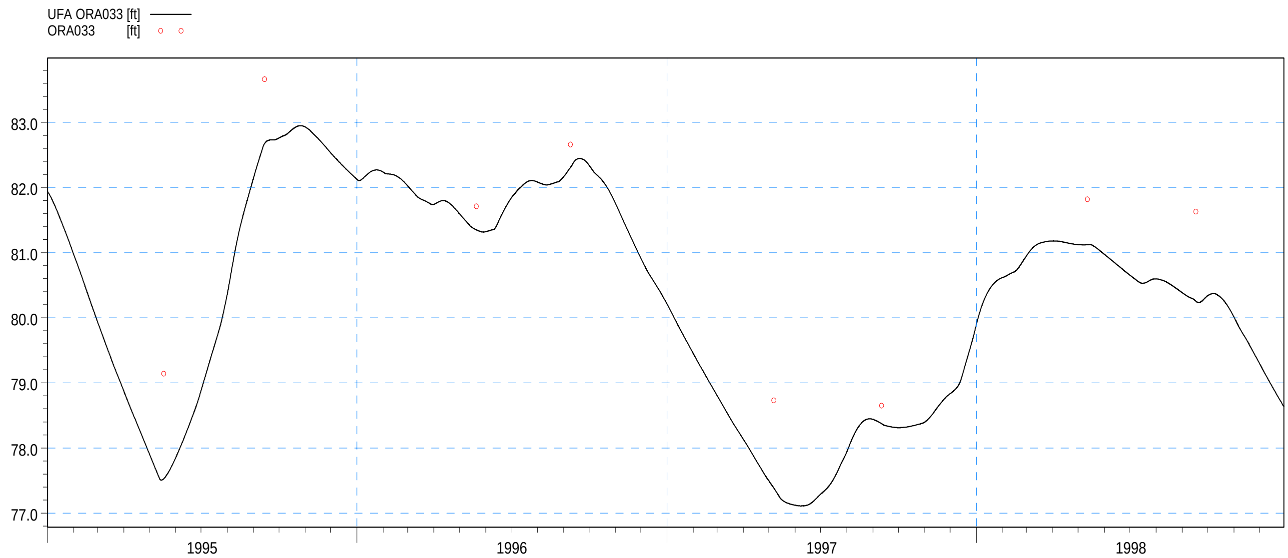
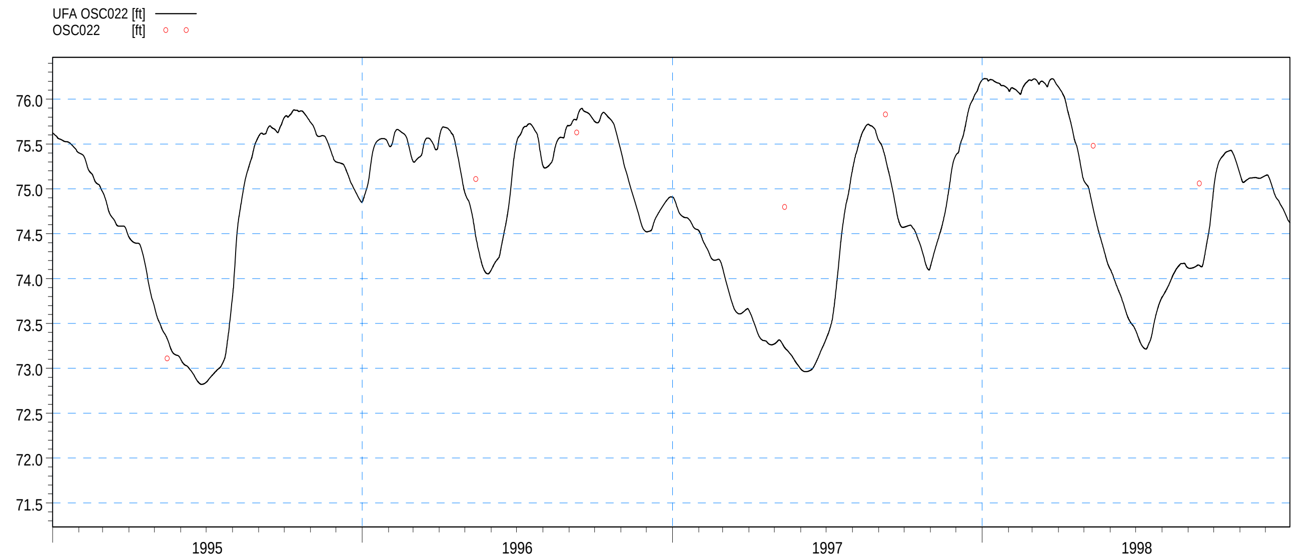


UFA ORA033

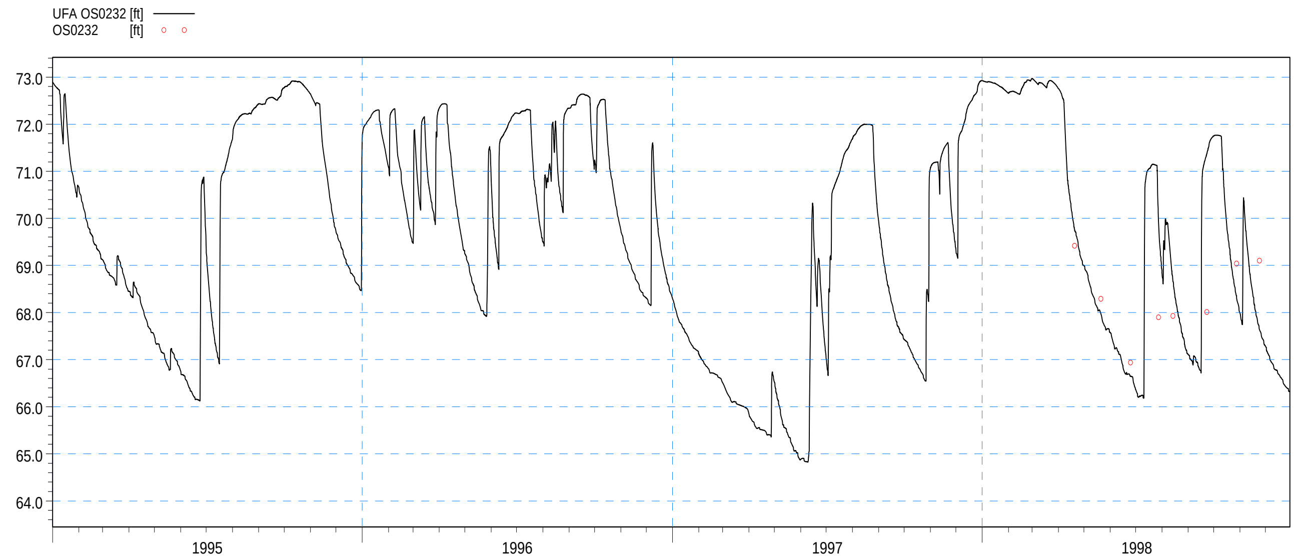
UFA WELLS



UFA - OSC022

UFA - OSC026

UFA WELLS



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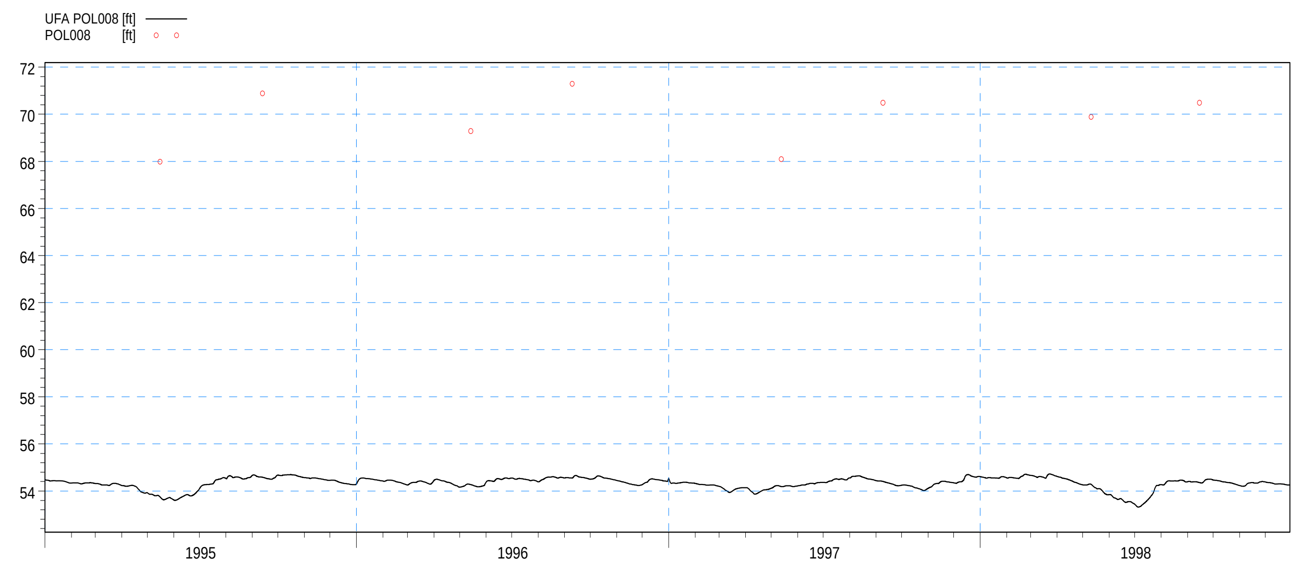

UFA -POL008

APPENDIX B

Description of Parameters in the MIKE SHE Water Budget

KBMOS AFET-W Water Budget Tables for the Re-Calibration Run

Description of Parameters in the MIKE SHE Water Budget

This Appendix will define the parameters, and relationship between the parameters, that are used to calculate the water budgets in MIKE SHE.

Definitions:

Inflows include all parameters that add water to the MIKE SHE model. These components include:

Rainfall (*Rai*)– This term represents an inflow to the model in the form of precipitation.

Irrigation (Irr) - This term represents an inflow to the model in the form of irrigation taken from river, groundwater, or external sources.

Overland boundary flows (olbc) – this term represents flow into and out of the overland flow module of the MIKE SHE model. Negative values represent flow out of the MIKE SHE model. Positive values represent flow into the MIKE SHE model**.**

SZ Boundary Flow (SZ_{BC}) – This term represents flow into and out of the saturated zone module of the MIKE SHE model. Negative values represent flow out of the MIKE SHE model. Positive values represent flow into the MIKE SHE model.

Outflows include all parameters that remove water from the MIKE SHE model. These components include:

Actual Evapotranspiration (*AET*) – This term represents an outflow from the model calculated as the sum of evaporation and transpiration.

PWS Pumpage (GW_p) - This term represents the volume of water removed from the groundwater component of the model for potable water supply. This volume is removed from the model.

Runoff (*ro*) – this term represents the volume of water moved to/from the MIKE 11 network from/to the overland flow component of MIKE SHE. Positive values represent contributions from the MIKE SHE overland flow module into the MIKE 11 model. Negative values represent contributions from MIKE 11 to the MIKE SHE overland flow module.

Baseflow (*bf*) - this term represents the volume of water moved between the MIKE SHE saturated zone and the MIKE 11 river network model. Positive values represent flow out of the saturated zone of the MIKE SHE model into the MIKE 11 model. Negative values represent flow from MIKE 11 in the saturated zone of the MIKE SHE model.

Drainage to River (*D*) – This term represented the volume of water moved between the MIKE SHE drainage module and the MIKE 11 river network model. Positive values represent flow from the MIKE SHE drainage module into the MIKE 11 model.

Storage Changes represent internal components of the model where water exchange occurs. These values represent the difference in volume of water stored within the module during the simulation.

UZ Storage Change (*ΔUZ*) - This is an internal computation within the MIKE SHE model used to represent change in volume stored within the unsaturated zone of the model. Negative values represent a loss in stored volume. Positive values represent an increase in stored volume.

Canopy-Overland Storage Change (*ΔOL*) – This is an internal computation within the MIKE SHE model used to represent change in volume stored within the vegetative canopy or in the overland flow plain. Negative values represent a loss in stored volume. Positive values represent an increase in stored volume.

SZ Storage Change (*ΔSZ*) - This is an internal computation within the MIKE SHE model used to represent change in volume stored within the saturated zone of the model. Negative values represent a loss in stored volume. Positive values represent an increase in stored volume.

Other Parameters

Irrigation Pumpage (Gw_i) - This term represents a volume of water removed from the groundwater component of the model and applied as irrigation. This component is not included in water budget calculations.

Total Error (Err) – This term represents the computation error that occurs during the simulation period.

CALCULATING THE WATER BUDGET

In general, the balanced water budget is expressed in the following fashion:

Total Error = Inflows – Outflows – Change in Storage

Using the parameters described above, the MIKE SHE water budget would be written as:

$$ERR = (Rai + Irr + OL_{BC} + SZ_{BC}) - (AET + R_o + BF + D + GW_P) - (\Delta OL + \Delta UZ + \Delta SZ)$$

KBMOS AFET-W Water Budget tables for the Re-Calibration Run

Table B-1 Seasonal MIKE SHE water budget (inches) for 29 defined sub-watersheds during the Re-Calibration period

Sub-Watershed	ID	Rain (*Rai*)	Actual ET (*AET*)	Canopy-OL Storage Change ΔOL	Runoff (*Ro*)	OL Boundary Flows (OL_{BC})	Baseflow (*BF*)	Drainage To River (*D*)	Irrigation (*Irr*)	PWS Pump (GW_P)	Irrigation Pump (GW_I)	SZ Boundary Flow (SZ_{BC})	Subsurface Storage Change ($\Delta SZ+\Delta UZ$)	Total Error (*Err*)
Upper Reedy Cr.	1	50.13	37.82	-1.05	2.43	0.00	0.41	7.78	0.63	0.00	0.00	-3.97	-0.60	0.01
Shingle Creek	2	49.56	35.13	-0.88	4.23	0.00	0.70	7.84	0.13	0.00	0.00	-3.29	-0.65	0.01
Boggy Creek	3	50.35	35.47	-0.98	4.51	0.00	0.24	10.61	0.28	0.00	0.00	-1.27	-0.49	0.01
Lake Hart	4	52.59	43.42	-1.67	0.86	0.08	0.09	9.88	0.34	0.00	0.00	-0.39	-0.16	0.01
Horse Creek	5	50.65	36.15	2.85	7.02	0.03	1.79	0.00	2.96	0.00	0.00	-5.35	0.40	-0.01
Lower Reedy Cr.	6	49.24	40.47	-1.56	1.11	0.00	0.79	8.04	0.35	0.00	0.00	-0.94	-0.18	0.01
Lake Toho	7	50.24	41.79	-0.65	0.17	0.00	0.20	9.12	0.36	0.00	0.00	-0.43	-0.47	0.02
East Lake Toho	8	50.73	43.86	-0.79	-0.27	0.01	0.41	8.09	0.17	0.00	0.00	-0.01	-0.42	0.01
Alligator Lake	9	52.71	42.98	-1.20	1.06	0.00	0.15	10.87	0.75	0.00	0.00	-0.08	-0.48	0.02
Lake Mrytle	10	52.35	43.84	-2.35	3.33	0.12	0.64	5.70	0.00	0.00	0.00	-1.24	-0.16	0.01
Lake Conlin	11	51.67	42.13	-1.33	0.00	0.05	0.00	11.19	0.03	0.00	0.00	-0.15	-0.43	0.06
Lake Marion	12	50.16	38.17	-0.59	0.51	-0.05	0.05	12.30	4.39	0.00	0.00	-4.51	-0.34	0.01
Marion Creek	13	48.83	40.29	-1.85	1.09	0.06	0.64	7.91	0.02	0.00	0.00	-1.04	-0.30	0.01
Lake Cypress	14	50.58	41.63	-0.88	-0.59	0.01	0.75	10.17	0.00	0.00	0.00	0.22	-0.26	0.02
S63A	15	51.20	39.01	-0.78	0.28	0.02	0.25	12.65	0.28	0.00	0.00	-0.46	-0.37	0.03
Lake Gentry	16	51.33	41.33	-1.02	-0.02	0.00	0.21	12.88	2.32	0.00	0.00	-0.62	-0.31	0.05
Lake Pierce	17	50.73	37.75	0.00	1.93	0.03	0.00	11.97	6.61	0.00	0.00	-5.89	-0.28	0.01
Catfish Creek	18	51.41	37.81	-0.50	1.92	0.02	2.25	10.89	1.11	0.00	0.00	-0.38	-0.23	0.01
Lake Hatch	19	50.10	46.37	-0.59	-2.11	-0.09	0.98	5.57	0.02	0.00	0.00	-0.06	-0.07	0.01
Lk Weohyakapaka	20	52.55	38.85	0.02	1.28	0.01	0.03	14.11	3.49	0.00	0.00	-1.84	-0.09	0.00
Lake Rosalie	21	51.98	41.29	-0.14	2.44	0.03	0.26	7.77	1.39	0.00	0.00	-1.80	-0.09	0.00
Tiger Lake	22	52.29	43.64	-0.32	0.02	0.01	0.18	9.14	0.03	0.00	0.00	0.26	-0.07	0.01
Lake Kissimmee	23	53.30	47.06	-0.25	-1.76	0.01	0.10	8.38	0.11	0.00	0.00	0.05	-0.09	0.01
Lake Jackson	24	54.11	41.56	-0.49	-0.13	0.01	0.06	11.88	0.01	0.00	0.00	-1.26	-0.02	0.01
Lake Marian	25	59.72	44.00	-0.19	0.54	0.00	0.01	15.63	0.00	0.00	0.00	0.15	-0.11	0.01
S-65A	26	55.49	38.59	0.64	1.72	0.06	0.80	13.05	0.16	0.00	0.00	-0.54	0.27	0.01
S-65BC	27	54.89	38.39	0.35	1.16	-0.01	1.12	14.16	0.19	0.00	0.00	-0.01	-0.09	0.01
S-65D	28	52.89	37.75	-0.16	2.38	0.05	0.99	12.81	1.16	0.00	0.00	-0.40	-0.17	0.01
S-65E	29	50.07	37.35	-0.96	0.18	0.69	2.56	12.29	0.89	0.00	0.00	0.92	-0.21	0.02

Table B-2 Seasonal MIKE SHE water budget (inches) for 29 defined sub-watersheds for 1995

Sub-Watershed	ID	Rain (*Rai*)	Actual ET (*AET*)	Canopy-OL Storage Change *ΔOL*	Runoff (*Ro*)	OL Boundary Flows (OL_{BC})	Baseflow (*BF*)	Drainage To River (*D*)	Irrigation (*Irr*)	PWS Pump (GW_P)	Irrigation Pump (GW_I)	SZ Boundary Flow (SZ_{BC})	Subsurface Storage Change (*ΔSZ+ΔUZ*)	Total Error (*Err*)
Upper Reedy Cr.	1	46.29	38.09	-3.29	1.77	-0.001	0.43	7.57	0.59	0.00	0.00	-3.84	-1.52	0.01
Shingle Creek	2	44.93	35.45	-2.86	2.74	0.001	0.76	7.49	0.12	0.00	0.00	-3.18	-1.72	0.02
Boggy Creek	3	43.95	35.45	-3.27	2.15	0.000	0.27	9.41	0.27	0.00	0.00	-1.32	-1.10	0.03
Lake Hart	4	47.88	42.62	-4.49	0.38	0.072	0.09	9.43	0.36	0.00	0.00	-0.39	-0.29	0.01
Horse Creek	5	47.48	34.38	3.38	4.35	0.042	1.36	0.00	3.61	0.00	0.00	-6.02	1.53	-0.03
Lower Reedy Cr.	6	49.52	39.71	-2.65	1.31	-0.012	1.01	9.26	0.44	0.00	0.00	-1.21	0.13	0.01
Lake Toho	7	52.94	41.54	-1.67	2.08	-0.002	0.20	11.71	0.33	0.00	0.00	-0.38	-0.98	0.02
East Lake Toho	8	52.04	43.35	-1.85	1.94	0.001	0.43	8.97	0.16	0.00	0.00	-0.01	-0.66	0.02
Alligator Lake	9	55.18	42.31	-2.21	2.55	-0.006	0.15	13.64	0.71	0.00	0.00	-0.11	-0.66	0.02
Lake Mrytle	10	52.92	43.03	-3.31	4.46	0.133	0.64	6.83	0.00	0.00	0.00	-1.28	-0.15	0.01
Lake Conlin	11	54.72	41.38	-4.47	0.00	0.078	0.00	17.93	0.02	0.00	0.00	-0.09	-0.19	0.08
Lake Marion	12	45.45	36.92	-1.57	-0.10	-0.051	0.05	11.60	4.29	0.00	0.00	-4.04	-1.12	0.02
Marion Creek	13	47.54	39.33	-3.85	1.48	0.088	0.68	9.39	0.02	0.00	0.00	-1.02	-0.58	0.00
Lake Cypress	14	53.61	41.04	-2.24	0.49	0.026	0.93	14.77	0.00	0.00	0.00	0.21	-1.17	0.03
S63A	15	53.41	38.49	-2.09	0.44	0.018	0.34	17.30	0.26	0.00	0.00	-0.36	-1.17	0.03
Lake Gentry	16	54.54	40.60	-2.72	0.46	-0.007	0.22	18.32	2.18	0.00	0.00	-0.55	-0.65	0.05
Lake Pierce	17	48.74	36.25	0.56	2.17	0.031	0.00	11.46	6.44	0.00	0.00	-5.74	-1.06	0.01
Catfish Creek	18	51.48	36.85	-0.54	2.06	0.037	2.21	12.19	1.07	0.00	0.00	-0.54	-0.78	0.01
Lake Hatch	19	51.30	45.21	-0.11	-1.06	-0.094	0.93	6.71	0.01	0.00	0.00	0.02	-0.24	0.01
Lk Weohyakapaka	20	51.56	37.68	0.46	1.36	0.004	0.03	14.01	3.37	0.00	0.00	-1.82	-0.45	0.01
Lake Rosalie	21	52.10	40.13	0.06	3.15	0.032	0.25	8.25	1.33	0.00	0.00	-1.76	-0.20	0.00
Tiger Lake	22	51.76	42.42	-0.19	0.52	0.020	0.18	9.37	0.03	0.00	0.00	0.15	-0.36	0.02
Lake Kissimmee	23	52.00	46.21	-0.63	-1.90	0.011	0.11	8.96	0.10	0.00	0.00	0.04	-0.62	0.01
Lake Jackson	24	54.14	40.63	-1.39	0.00	0.025	0.06	13.82	0.01	0.00	0.00	-1.20	-0.18	0.01
Lake Marian	25	62.96	43.25	0.17	1.15	0.001	0.01	19.11	0.00	0.00	0.00	0.15	-0.57	0.01
S-65A	26	50.97	37.52	-1.09	1.48	0.045	0.75	11.72	0.12	0.00	0.00	-0.44	0.23	0.01
S-65BC	27	53.57	37.81	-0.72	1.19	-0.004	1.12	14.87	0.17	0.00	0.00	-0.09	-0.59	0.02
S-65D	28	55.46	37.53	-0.68	3.01	0.075	1.05	16.04	1.07	0.00	0.00	-0.43	-0.89	0.02
S-65E	29	56.38	37.03	-1.65	1.40	0.895	3.01	18.02	0.74	0.00	0.00	0.88	-0.68	0.02

Table B-3 Seasonal MIKE SHE water budget (inches) for 29 defined sub-watersheds for 1996

Sub-Watershed	ID	Rain (*Rai*)	Actual ET (*AET*)	Canopy-OL Storage Change ΔOL	Runoff (*Ro*)	OL Boundary Flows (OL_{BC})	Baseflow (*BF*)	Drainage To River (*D*)	Irrigation (*Irr*)	PWS Pump (GW_P)	Irrigation Pump (GW_I)	SZ Boundary Flow (SZ_{BC})	Subsurface Storage Change ($\Delta SZ+\Delta UZ$)	Total Error (*Err*)
Upper Reedy Cr.	1	53.89	38.38	0.26	2.33	0.003	0.43	9.13	0.58	0.00	0.00	-3.94	0.01	0.01
Shingle Creek	2	53.49	36.02	0.14	3.98	0.002	0.75	9.20	0.11	0.00	0.00	-3.29	0.18	0.01
Boggy Creek	3	52.28	35.82	-0.18	4.05	0.000	0.24	11.40	0.26	0.00	0.00	-1.25	-0.05	0.01
Lake Hart	4	56.74	43.16	0.06	1.83	0.099	0.09	11.37	0.29	0.00	0.00	-0.37	0.01	0.00
Horse Creek	5	52.11	36.64	4.38	5.76	0.024	1.94	0.00	2.62	0.00	0.00	-5.45	0.54	0.00
Lower Reedy Cr.	6	51.16	41.16	-1.03	0.70	0.008	0.92	8.55	0.30	0.00	0.00	-0.93	0.23	0.02
Lake Toho	7	53.49	36.02	0.14	3.98	0.002	0.75	9.20	0.11	0.00	0.00	-3.29	0.18	0.01
East Lake Toho	8	52.70	44.35	-0.52	-0.13	0.008	0.42	8.73	0.16	0.00	0.00	0.00	-0.01	0.01
Alligator Lake	9	51.12	43.60	-1.71	-0.02	0.000	0.15	9.94	0.73	0.00	0.00	-0.07	-0.17	0.03
Lake Mrytle	10	53.25	43.68	-1.83	3.36	0.132	0.70	6.05	0.00	0.00	0.00	-1.30	-0.12	0.02
Lake Conlin	11	47.74	43.02	-0.87	0.00	0.015	0.00	6.16	0.02	0.00	0.00	-0.14	-0.59	0.12
Lake Marion	12	51.15	38.81	0.16	-0.26	-0.040	0.05	11.40	4.28	0.00	0.00	-4.73	0.60	0.01
Marion Creek	13	50.45	40.92	-0.70	0.48	0.064	0.64	7.63	0.02	0.00	0.00	-1.05	0.40	0.01
Lake Cypress	14	49.35	42.73	-0.74	-0.92	-0.001	0.74	7.31	0.00	0.00	0.00	0.21	0.47	0.03
S63A	15	47.04	39.90	-1.11	0.14	0.014	0.28	7.50	0.29	0.00	0.00	-0.49	0.19	0.05
Lake Gentry	16	46.08	41.63	-1.22	-0.44	-0.007	0.20	7.77	2.32	0.00	0.00	-0.66	-0.12	0.08
Lake Pierce	17	54.37	38.51	0.94	1.76	0.025	0.00	12.98	6.45	0.00	0.00	-5.90	0.64	0.01
Catfish Creek	18	56.21	38.40	0.21	2.33	0.024	2.43	12.99	1.08	0.00	0.00	-0.37	0.53	0.00
Lake Hatch	19	53.33	46.72	0.34	-1.10	-0.133	1.08	6.20	0.02	0.00	0.00	-0.07	0.18	0.00
Lk Weohyakapaka	20	53.40	39.16	0.15	0.76	0.006	0.03	14.62	3.41	0.00	0.00	-1.78	0.30	0.01
Lake Rosalie	21	56.23	41.57	0.48	3.85	0.037	0.27	9.17	1.37	0.00	0.00	-1.86	0.34	0.00
Tiger Lake	22	51.47	43.71	-0.82	0.29	0.004	0.19	8.23	0.03	0.00	0.00	0.26	0.16	0.00
Lake Kissimmee	23	47.57	47.10	-1.09	-3.34	0.012	0.11	4.77	0.12	0.00	0.00	0.08	0.22	0.01
Lake Jackson	24	46.97	41.54	-2.95	-0.73	0.008	0.05	7.82	0.01	0.00	0.00	-1.30	-0.03	0.03
Lake Marian	25	52.61	44.20	-1.37	-0.88	0.000	0.01	10.62	0.00	0.00	0.00	0.15	0.19	0.02
S-65A	26	44.65	38.43	-2.50	0.55	0.042	0.96	7.13	0.20	0.00	0.00	-0.50	-0.22	0.03
S-65BC	27	44.29	38.15	-3.34	0.61	-0.009	1.06	8.73	0.22	0.00	0.00	0.03	-0.66	0.02
S-65D	28	43.90	37.77	-2.24	1.08	0.043	0.93	7.99	1.24	0.00	0.00	-0.41	-0.81	0.02
S-65E	29	43.27	37.61	-2.62	-0.48	0.644	2.34	8.60	0.96	0.00	0.00	0.98	-0.84	0.03

Table B-4 Seasonal MIKE SHE water budget (inches) for 29 defined sub-watersheds for 1997

Sub-Watershed	ID	Rain (*Rai*)	Actual ET (*AET*)	Canopy-OL Storage Change ΔOL	Runoff (*Ro*)	OL Boundary Flows (OL_{BC})	Baseflow (*BF*)	Drainage To River (*D*)	Irrigation (*Irr*)	PWS Pump (GW_P)	Irrigation Pump (GW_I)	SZ Boundary Flow (SZ_{BC})	Subsurface Storage Change ($\Delta SZ+\Delta UZ$)	Total Error (*Err*)
Upper Reedy Cr.	1	58.16	35.96	7.78	3.03	0.000	0.34	5.81	0.63	0.00	0.00	-4.11	1.71	-0.04
Shingle Creek	2	58.44	33.85	6.10	6.57	0.003	0.55	6.28	0.13	0.00	0.00	-3.33	1.79	-0.05
Boggy Creek	3	61.57	34.65	6.09	7.86	0.004	0.20	10.25	0.27	0.00	0.00	-1.24	1.46	-0.06
Lake Hart	4	57.44	41.61	5.70	1.11	0.069	0.09	8.36	0.35	0.00	0.00	-0.37	0.41	-0.04
Horse Creek	5	59.33	35.08	10.82	7.04	0.049	1.77	0.00	2.67	0.00	0.00	-5.01	2.19	-0.03
Lower Reedy Cr.	6	54.52	38.37	6.87	1.54	-0.002	0.52	5.65	0.33	0.00	0.00	-0.88	0.97	-0.04
Lake Toho	7	54.45	39.63	3.74	2.14	0.004	0.17	7.39	0.36	0.00	0.00	-0.44	1.22	-0.06
East Lake Toho	8	56.48	41.85	3.90	2.43	0.011	0.35	7.04	0.16	0.00	0.00	-0.04	0.94	-0.06
Alligator Lake	9	58.10	40.74	5.14	2.36	-0.001	0.13	9.15	0.74	0.00	0.00	-0.05	1.20	-0.07
Lake Mrytle	10	57.49	41.91	5.62	3.65	0.102	0.58	4.21	0.00	0.00	0.00	-1.07	0.31	-0.02
Lake Conlin	11	56.99	39.45	8.12	0.00	0.039	0.00	7.88	0.06	0.00	0.00	-0.25	1.13	-0.16
Lake Marion	12	60.63	37.01	4.83	3.38	-0.054	0.04	13.03	4.12	0.00	0.00	-4.92	1.57	-0.02
Marion Creek	13	55.57	38.52	6.52	1.66	0.026	0.58	6.56	0.03	0.00	0.00	-1.00	0.71	-0.03
Lake Cypress	14	52.60	39.65	3.13	-0.23	-0.001	0.56	8.52	0.00	0.00	0.00	0.23	1.13	-0.06
S63A	15	55.52	36.80	4.24	0.28	0.016	0.14	12.09	0.28	0.00	0.00	-0.59	1.56	-0.08
Lake Gentry	16	55.98	39.16	5.46	0.29	0.010	0.19	11.22	2.30	0.00	0.00	-0.67	1.18	-0.10
Lake Pierce	17	53.17	36.26	2.78	2.21	0.034	0.00	10.81	6.36	0.00	0.00	-5.78	1.60	-0.01
Catfish Creek	18	48.84	36.32	1.87	1.36	0.014	1.98	7.20	1.08	0.00	0.00	-0.26	0.91	0.00
Lake Hatch	19	49.22	44.49	1.86	-2.19	-0.044	0.86	3.97	0.01	0.00	0.00	-0.12	0.16	-0.01
Lk Weohyakapaka	20	52.55	37.42	2.20	1.62	0.005	0.03	11.70	3.42	0.00	0.00	-1.88	1.08	-0.01
Lake Rosalie	21	48.65	39.50	1.47	1.00	0.022	0.26	5.47	1.36	0.00	0.00	-1.68	0.58	-0.01
Tiger Lake	22	53.75	42.12	3.60	-0.11	-0.001	0.16	7.91	0.03	0.00	0.00	0.29	0.37	-0.02
Lake Kissimmee	23	59.96	45.62	4.08	0.74	0.004	0.09	8.84	0.10	0.00	0.00	-0.02	0.63	-0.03
Lake Jackson	24	61.62	39.82	8.37	0.59	0.006	0.05	11.05	0.01	0.00	0.00	-1.27	0.41	-0.06
Lake Marian	25	68.43	42.30	6.20	2.48	0.001	0.01	16.65	0.00	0.00	0.00	0.09	0.79	-0.08
S-65A	26	64.66	37.07	11.26	1.52	0.045	0.69	11.73	0.14	0.00	0.00	-0.54	1.90	-0.04
S-65BC	27	59.06	36.46	7.96	0.10	-0.008	1.02	12.00	0.20	0.00	0.00	0.01	1.70	-0.02
S-65D	28	52.98	35.46	3.33	1.92	0.032	0.87	10.30	1.21	0.00	0.00	-0.37	1.88	-0.02
S-65E	29	50.83	35.33	2.72	-0.17	0.601	2.28	10.04	0.91	0.00	0.00	0.91	1.81	-0.04

Table B-5 Seasonal MIKE SHE water budget (inches) for 29 defined sub-watersheds for 1998

Sub-Watershed	ID	Rain (*Rai*)	Actual ET (*AET*)	Canopy-OL Storage Change ΔOL	Runoff (*Ro*)	OL Boundary Flows (OL_{BC})	Baseflow (*BF*)	Drainage To River (*D*)	Irrigation (*Irr*)	PWS Pump (GW_P)	Irrigation Pump (GW_I)	SZ Boundary Flow (SZ_{BC})	Subsurface Storage Change ($\Delta SZ+\Delta UZ$)	Total Error (*Err*)
Upper Reedy Cr.	1	41.91	38.08	-7.32	2.16	0.004	0.41	7.79	0.70	0.00	0.00	-3.84	-2.32	0.04
Shingle Creek	2	41.09	34.50	-5.07	2.87	0.000	0.73	7.61	0.15	0.00	0.00	-3.23	-2.61	0.05
Boggy Creek	3	42.99	35.32	-4.98	3.16	0.006	0.25	10.43	0.32	0.00	0.00	-1.23	-2.07	0.05
Lake Hart	4	47.91	45.37	-6.72	0.01	0.093	0.09	9.67	0.36	0.00	0.00	-0.40	-0.67	0.02
Horse Creek	5	43.41	37.69	-6.05	10.17	0.017	2.01	0.00	2.88	0.00	0.00	-4.70	-2.23	0.03
Lower Reedy Cr.	6	41.34	41.76	-8.24	0.72	0.002	0.67	7.95	0.32	0.00	0.00	-0.70	-1.86	0.05
Lake Toho	7	41.42	42.24	-3.12	-3.44	0.000	0.20	7.52	0.39	0.00	0.00	-0.46	-2.00	0.05
East Lake Toho	8	41.21	44.93	-3.62	-5.41	0.003	0.42	6.85	0.18	0.00	0.00	-0.01	-1.76	0.05
Alligator Lake	9	45.77	44.36	-5.14	-0.74	-0.003	0.16	9.93	0.81	0.00	0.00	-0.08	-2.03	0.06
Lake Mrytle	10	45.23	45.81	-8.97	1.72	0.118	0.63	5.35	0.00	0.00	0.00	-1.25	-0.63	0.05
Lake Conlin	11	46.96	43.80	-7.06	0.00	0.053	0.00	11.98	0.02	0.00	0.00	-0.12	-1.74	0.18
Lake Marion	12	43.23	39.06	-4.59	-0.98	-0.061	0.05	12.33	4.79	0.00	0.00	-4.17	-1.93	0.03
Marion Creek	13	41.44	41.47	-8.20	0.62	0.065	0.65	7.42	0.03	0.00	0.00	-1.04	-1.57	0.03
Lake Cypress	14	46.25	42.18	-3.17	-1.63	0.005	0.75	9.44	0.00	0.00	0.00	0.22	-1.08	0.04
S63A	15	48.51	39.98	-3.46	0.25	0.024	0.24	12.95	0.29	0.00	0.00	-0.37	-1.50	0.05
Lake Gentry	16	48.47	43.06	-4.69	-0.36	0.000	0.23	13.46	2.43	0.00	0.00	-0.57	-1.27	0.11
Lake Pierce	17	46.28	39.14	-3.59	1.52	0.026	0.00	12.07	7.05	0.00	0.00	-5.90	-1.78	0.02
Catfish Creek	18	48.58	38.82	-2.96	1.88	0.025	2.26	10.74	1.19	0.00	0.00	-0.34	-1.32	0.02
Lake Hatch	19	46.23	48.04	-3.84	-3.78	-0.099	1.01	5.14	0.02	0.00	0.00	-0.08	-0.29	0.01
Lk Weohyakapaka	20	52.06	40.26	-2.25	1.37	0.008	0.03	15.51	3.69	0.00	0.00	-1.81	-0.98	0.02
Lake Rosalie	21	50.36	43.03	-2.10	1.75	0.040	0.26	7.86	1.46	0.00	0.00	-1.84	-0.86	0.01
Tiger Lake	22	51.61	45.35	-3.34	-0.43	0.005	0.18	10.56	0.03	0.00	0.00	0.32	-0.33	0.03
Lake Kissimmee	23	53.15	48.26	-2.88	-2.26	0.004	0.11	10.52	0.12	0.00	0.00	0.08	-0.37	0.01
Lake Jackson	24	53.55	43.36	-4.93	-0.35	0.020	0.06	14.29	0.01	0.00	0.00	-1.25	-0.12	0.03
Lake Marian	25	54.65	45.30	-4.84	-0.46	0.000	0.01	15.45	0.00	0.00	0.00	0.20	-0.55	0.05
S-65A	26	61.00	40.52	-4.55	3.33	0.090	0.77	20.96	0.17	0.00	0.00	-0.65	-0.59	0.02
S-65BC	27	62.23	40.36	-1.97	2.89	-0.014	1.25	20.49	0.17	0.00	0.00	0.00	-0.58	0.02
S-65D	28	58.71	39.44	-0.53	3.47	0.061	1.09	16.56	1.08	0.00	0.00	-0.38	-0.66	0.02
S-65E	29	49.17	38.60	-1.92	-0.01	0.583	2.51	12.05	0.92	0.00	0.00	0.86	-0.83	0.03

APPENDIX C

Electronic Copy of the Calibration Log

ELECTRONIC COPY OF THE CALIBRATION LOG

		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
Run 99	Base Files	Topography	Pre-P1_Topography_36.dfs2			
		Precipitation	KBMOS_DailyRainfall.dfs2			
		Vegetation	00Lu_46.dfs2			
		Irrigation command areas	ica-merg-dis_50.dfs2			
		Evapotranspiration	Reference Evapotranspiration.dfs0			
		Network	KBMOS_PrePH_1K_99.nwk11			
		Cross Section	KBMOS_99.xns			
		Boundary	KBMOS_PrePh1_63.bnd11			
		Hydrodynamic	KBMOS_PrePh1_82.HD11			
		Mannings Overland	Kb_00lu_man_56.dfs2			
		Detention	Kb_00lu_ds_46.dfs2			
		Initial overland depth	OL_IC_1K_46.dfs2			
		Overland-groundwater leakage	OverlandLeakageCoefficients_77.dfs2			
		UZ Soil	Krb_soils_37.dfs2			
		SAS Lower Level	ICTOP.dfs2			
		SAS Kh	physio_sas_Kh_82.dfs2			
		SAS Kv	physio_sas_Kv_82.dfs2			
		SAS SS	physio_sas_Sy_078.dfs2			
		ICU Lower Level	uftop.dfs2			
		ICU Kh	icu_megapoly_kh_82.dfs2			

		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
		ICU Kv	icu_megapoly_kv_82.dfs2			
		UFA Lower Level	mctop			
		UFA Kh	ufa_Kh_04			
		UFA Kv	ufa_Kv_04			
		UFA Storage Coefficient	0.0009144			
		SAS Initial heads	SAS_ic_3K_75.dfs2			
		ICU Initial heads	icu_ic_73.dfs2			
		UFA Initial heads	SS_ic-3K_40			
		Drainage Level	Kb_00lu_dl_82.dfs2			
		Time Constant	Kb_00lu_tc_82.dfs2			
		Drain codes	KBMOS)DrainCodes_1K_82			
		Specific drainage option	KBMOS)_specificDrainageOptions_3K_82			
		Pumping wells	UFA_wells.wel			
1K Base Run	Files Changed	None				
1K Base Run Modified PET	Files Changed	Evapotranspiration	Kissimmee_PETin_per_hr.dfs2	.txt files Sent from ET 6/13/08. Spatially Distributed PET file created		

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		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
Run00	Files Changed	None				
Run 0		Evapotranspiration	Kissimmee_PETin_per_hr.dfs2	.txt files Sent from ET 6/13/08. Spatially Distributed PET file created		See report
ADA file name:						
KBMOS_PrePH1_3K_99_modPET_ADDwells						
Run 01						
ADA file name:						
KBMOS_PrePH1_3K_99_modPET_OLleak_ADDwells	Files Changed	Evapotranspiration	Kissimmee_PETin_per_hr.dfs2	.txt files Sent from ET 6/13/08. Spatially Distributed PET file created	District provides PET file	
		Overland-groundwater leakage	OverlandLeakageCoefficients_77_calib.dfs2	Selected areas that were 'blank' or had 'delete values' and inserted a value of 1.51e-006	Test sensitivity to overland leakage	

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		File Type	File Name	Description of Modilfcation	Reason for modification	Outcome of modification
Run 02	Files Changed	Evapotranspiration	PET_65_05_in_per_hr.dfs2	.txt files Sent from ET 6/30/08. Spatially Distributed PET file created	Newest PET file from District	
		Overland-groundwater leakage	OverlandLeakageCoefficients_77_calib.dfs2	Selected areas that were 'blank' or had 'delete values' and inserted a value of 1.51e-006		Model seemed unresponsive to change
		UFA Kh	AFET_ECFT_ufa_kh_04.dfs2	Combined original KBMOS Kh with ECFT Kh	It was suggested to use ECFT K values	Heads showed little variation
		UFA Kv	AFET_ECFT_ufa_kv_04.dfs2	Combined original KBMOS Kh with ECFT Kh and divided by 10 to create Kv	It was suggested to use ECFT K values	
Run 03	Files Changed	UFA Kh	AFET_ECFT_ufa_kh_x_2.dfs2	Combined original KBMOS Kh with ECFT Kh and multiplying entire area by 2	Test sensitivity to K variation	Some variation in heads (again not appreciable) some got higher (KISSFS) some remained the same
		UFA Kv	AFET_ECFT_ufa_kv_x_2.dfs2	Combined original KBMOS Kh with ECFT Kh and divided by 10 to create Kv; then multiplied entire area by 2	Test sensitivity to K variation	
Run 04	Files Changed	UFA Kh	UFA\AFET_ECFT_ufa_kh_div_2.dfs2	Combined original KBMOS Kh with ECFT Kh and divided entire area by 2	Test sensitivity to K variation	Little variation in heads in SAS
		UFA Kv	AFET_ECFT_ufa_kv_div_2.dfs2	Combined original KBMOS Kh with ECFT Kh and divided by 10 to create Kv; then divided entire area by 2	Test sensitivity to K variation	
Run 05	Files Changed	Overland-groundwater leakage	OverlandLeakageCoefficients_77.dfs2	Original KBMOS OL leakage file		
		UFA Kh	AFET_ECFT_ufa_kh_04.dfs2	Combined original KBMOS Kh with ECFT Kh	Test sensitivity to K variation	Same as above
		UFA Kv	AFET_ECFT_ufa_kv_04.dfs2	Combined original KBMOS Kh with ECFT Kh and divided by 10 to create Kv	Test sensitivity to K variation	

		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
Run 06	Files Changed	Overland-groundwater leakage	OverlandLeakageCoefficients_77_calib_ver_2.dfs2	Took 'OverlandLeakageCoefficients_77_calib.dfs2' where, selected areas that were 'blank' or had 'delete values' and inserted a value of 1.51e-006; then divided entire area by 10	Test sensitivity to OL variation	Noticed little to no difference in leakge to SAS
		UFA Kh	AFET_ECFT_ufa_kh_04.dfs2	Combined original KBMOS Kh with ECFT Kh	Test sensitivity to K variation	Same as above
		UFA Kv	AFET_ECFT_ufa_kv_04.dfs2	Combined original KBMOS Kh with ECFT Kh and divided by 10 to create Kv	Test sensitivity to K variation	
Run 07	Files Changed	UFA Kh	AFET_ECFT_ufa_kh_04.dfs2	Combined original KBMOS Kh with ECFT Kh	Test sensitivity to K variation	SAS was same as previous run with same K files
		UFA Kv	AFET_ECFT_ufa_kv_04.dfs2	Combined original KBMOS Kh with ECFT Kh and divided by 10 to create Kv	Test sensitivity to K variation	
		UFA Initial heads	UF_IC_3K_40_data_based.dfs2	From original file, looked at observed data, and in areas with wells that had poor initial heads, drew polygons around an area and set the value to what the observed data dictated	Tried to improve initial conditions	Some intial conditions got better, some worse
Run 08	Files Changed					
		ICU Kh	icu_megapoly_kv_82_kh_div_10.dfs2	Divided original file by 10	Test K sensitivity	
		SAS Initial heads	SAS_IC-1KH_99_for_3K.dfs2	Used SAS initial conditions file from 1K model, used the interpolate feature to allow grid cell differences to be overcome (from 1K to 3K)	Test Initial Conditions sesitivity	File was deemed inappropriate
		ICU Initial heads	UF_IC_3K_40_data_based.dfs2	Same file as UFA		
		UFA Initial heads	UF_IC_3K_40_data_based.dfs2	From original file, looked at observed data, and in areas with wells that had poor initial heads, drew polygons around an area and set the value to what the observed data dictated		IC results were highly variable
Run 09	Files Changed					
		ICU Kh	icu_megapoly_kv_82_kh_div_10.dfs2	Divided original file by 10	Allow water to build in ICU	Water levels inappropriate

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		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
		ICU Kh	icu_megapoly_kv_82_kh_div_10.dfs2	Divided original file by 10		
Run 10	Files Changed	SAS Kh	physio_sas_kh_82_x_10.dfs2	Original KBMOS Kh multiplied by 10	Increase Flux within and out of SAS	h too high in some areas too low in others
		SAS Kv	physio_sas_kh_82_x_10.dfs2	Original KBMOS Kh multiplied by 10		
		ICU Kh	icu_megapoly_kh_82.dfs2	Original KBMOS Kh	Go back to original KBMOS ICU	h too high in some areas too low in others
		ICU Kv	icu_megapoly_kh_82.dfs2	Original KBMOS Kh		
Run 11	Files Changed					
		ICU Kh	icu_megapoly_kh_82_x_10.dfs2	Original KBMOS Kh X 10	Increase flux to UFA	h too high overall (results still variable)

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		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
		ICU Kv	icu_megapoly_kh_82_x_10.dfs2	Original KBMOS Kh X 10		
		SAS Initial heads	SAS_IC-1KH_99_for_3K_ft.dfs2	Used SAS initial conditions file for this 3K model, used the interpolate feature to allow grid cell differences to be overcome UNITS now in ft	Corrected error in units	Initial heads got more reasonable
Run 12	Files Changed	SAS Kh	physio_sas_kh_82.dfs2	Original KBMOS Kh	Increase h in SAS	h in SAS not as low when increased ICU in Run 10, still variable
		SAS Kv	physio_sas_kv_82.dfs2	Original KBMOS Kv		
Run 13	Files Changed					
		ICU Kh	icu_megapoly_kh_82_x_100.dfs2	Original KBMOS Kh X 100	Increase flux to UFA	Flux increased
		ICU Kv	icu_megapoly_kh_82_x_100.dfs2	Original KBMOS Kh X 100		

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		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
Run 14	Files Changed					
		ICU Kh	icu_megapoly_kh_82_x_10.dfs2	Original KBMOS Kh X 10	Increase flux to UFA within tolerance of reasonable range	Flux increased
		ICU Kv	icu_megapoly_kh_82_x_10.dfs2	Original KBMOS Kh X 10		
Run 15	Files Changed					
Run 12 Base						
		UFA Kh	AFET_ECFT_ufa_kh_div_2.dfs2	Combined original KBMOS Kh with ECFT Kh and divided by 2	Decrease flux through UFA	Flux decreased and some variation of hydrographs in UFA was lost

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		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
Run 16	Files Changed	SAS Kh	physio_sas_kh_82_south_x_p3.dfs2	Original KBMOS Kh selected southern area and x 0.3	Decrease losses from SAS	Some wells showed too high h, some still too low
		SAS Kv	physio_sas_kv_82_south_div_2.dfs2	Original KBMOS Kv with south / 2	Noticed wells in south much lower than observed data	Wells in south were still variable in relation to h vs. observed data
		ICU Kh	icu_megapoly_kh_82_x_5.dfs2	Original KBMOS Kh x5	Increase Flux through ICU	More water flowed to UFA
		ICU Kv	icu_megapoly_kv_82.dfs2	Original KBMOS Kv		
		UFA Kh	AFET_div_4_ECFT_ufa_kh_04.dfs2	Combined original KBMOS Kh divided by 4 with ECFT Kh	Noticed UFA wells in south too low when compared with observed data	Some wells were responsive while others stayed the same
		UFA Kv	AFET_div_4_ECFT_ufa_kv_04.dfs2	Combined original KBMOS Kv / 4 with ECFT Kv	Same as above	
		SAS Initial heads	layer1mshe.dfs2	Updated from ECFT initial conditions	Initial condition problems with some wells	Some wells start out at the right elevation, others still not correct
		ICU Initial heads	layer3MSHE.dfs2	Updated from ECFT initial conditions		
		UFA Initial heads	layer3MSHE.dfs2	Updated from ECFT initial conditions		
		UFA Storage Coefficient	0.00008	Increased Storage Coeff of UFA	Testing sensitivity to Stor. Coeff	Increased fluctuation in UFA
Run 17	Files Changed	UFA Storage Coefficient	0.0009144	Original KBMOS Storage coefficient	Testing sensitivity to Stor. Coeff	Fluctuations in UFA same as Run 15

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		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
Run 18	Files Changed	SAS Kh	physio_sas_kh_82_south_x_p3.dfs2	Original KBMOS Kh selected southern area and x 0.3	Decrease losses from SAS	Some wells showed too high h, some still too low
		SAS Kv	physio_sas_kv_82_south_div_2.dfs2	Original KBMOS Kv with south / 2	Noticed wells in south much lower than observed data	Wells in south were still variable in relation to h vs. observed data
		ICU Kh	icu_megapoly_kh_82_x_5.dfs2	Original KBMOS Kh x5	Increase Flux through ICU	More water flowed to UFA
		ICU Kv	icu_megapoly_kv_82_south_X_10.dfs2	Multiplied area in southern portion of the model by 10	Noticed some wells in south SAS too much h UFA too little, with small fluctuations compared to observed data	Increased amount of water in UFA, SAS wells, some lost water
		UFA Kh	AFET_div_4_ECFT_ufa_kh_04_all_div_2.dfs2	Combined KBMOS with ECFT Kh, divided AFET by 4 and entire area divided by 2	Trying to increase water in UFA	Increased some UFA elevations, others the same
		UFA Kv	AFET_div_4_ECFT_ufa_kv_04.dfs2	Combined original KBMOS Kv / 4 with ECFT Kv	Same as above	
		UFA Storage Coefficient	0.00008			
Run 19	Files Changed	SAS Kh	physio_sas_kh_82_south_x_p5.dfs2	Original KBMOS Kh selected southern area and x 0.5	Decrease losses from SAS	Some wells showed too high h, some still too low
		SAS Kv	physio_sas_kv_82_south_div_2.dfs2	Original KBMOS Kv with south / 2	Noticed wells in south much lower than observed data	Wells in south were still variable in relation to h vs. observed data
		ICU Kh	icu_megapoly_kh_82_x_5.dfs2	Original KBMOS Kh x5	Increase Flux through ICU	More water flowed to UFA
		ICU Kv	icu_megapoly_kv_82_south_X_10.dfs2	Multiplied area in southern portion of the model by 10	Noticed some wells in south SAS too much h UFA too little, with small fluctuations compared to observed data	Increased amount of water in UFA, SAS wells, some lost water
		UFA Kh	AFET_div_4_ECFT_ufa_kh_04_all_div_2.dfs2	Combined KBMOS with ECFT Kh, divided AFET by 4 and entire area divided by 2	Trying to increase water in UFA	Increased some UFA elevations, others the same
		UFA Kv	AFET_div_4_ECFT_ufa_kv_04.dfs2	Combined original KBMOS Kv / 4 with ECFT Kv	Same as above	
		SAS Initial heads	SAS_initial_elev_interpol.dfs2	Used well locations in model set up and assigned starting heads from observed data, and interpolated values to create a grid file	Initial conditions still off for some wells	Some wells started out right, others still too low or high
		ICU Initial heads	UFA_initial_elev_interpol.dfs2	Used well locations in model set up and assigned starting heads from observed data, and interpolated values to create a grid file	Initial conditions still off for some wells	Some wells started out right, others still too low or high
		UFA Initial heads	UFA_initial_elev_interpol.dfs2	Used well locations in model set up and assigned starting heads from observed data, and interpolated values to create a grid file	Initial conditions still off for some wells	Some wells started out right, others still too low or high
		UFA Storage Coefficient	0.00008			

		File Type	File Name	Description of Modilfcation	Reason for modification	Outcome of modification
Run 20	Files Changed	SAS Kh	physio_sas_kh_82_south_x_p7.dfs2	Original KBMOS Kh selected southern area and x 0.7	Decrease losses from SAS	Some wells showed too high h, some still too low
Run 21	Files Changed	SAS Kh	physio_sas_kh_82_south_x_p5.dfs2	Same as Run 19	Testing 1K model to determine effects of changes in subsurface geologic layers to surface water sensitivity	Some SAS wells better, some worse, some M11 stations ok, some better, some a little worse
1K model uses run 19 as base		SAS Kv	physio_sas_kv_82_south_div_2.dfs2	Same as Run 19		
		SAS Initial heads	SAS_IC_PrePH1_3K_82.dfs2	Same as Run 19		
	Internal BC	SAS to ICU GHB	KBMOS_PH1_3K_99_ICU_from3K_run19.dfs2	Same as Run 19		
Run 22	Files Changed	SAS Kh	physio_sas_kh_82.dfs2	From original KBMOS	Testing sensitivity of ICU Kh with original paramaters as described in model files	
Uses Run 03 as base		SAS Kv	physio_sas_kv_82.dfs2	From original KBMOS	Testing sensitivity of ICU Kh with original paramaters as described in model files	
		ICU Kh	icu_megapoly_kh_82.dfs2	From original KBMOS	Testing sensitivity of ICU Kh with original paramaters as described in model files	
		ICU Kv	icu_megapoly_kv_82.dfs2	From original KBMOS	Testing sensitivity of ICU Kh with original paramaters as described in model files	
		UFA Kh	AFET_div_4_ECFT_ufa_kh_04_all_div_20.dfs2	Combined KBMOS with ECFT Kh, divided AFET by 4 and entire area divided by 2 then divided entire area by 10 again	Testing sensitivity of ICU Kh with original paramaters as described in model files	Some wells responsive, some got worse, some better, some the same
		SAS Initial heads	SAS_IC-3K_75.dfs2			
		ICU Initial heads	ICU_IC_73.dfs2			
		UFA Initial heads	UFA_initial_elev_interpol.dfs2	Used well locations in model set up and assigned starting heads from observed data, and interpolated values to create a grid file	Initial conditions still off for some wells	Some wells started out right, others still too low or high

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		File Type	File Name	Description of Modilfcation	Reason for modification	Outcome of modification
		UFA Storage Coefficient	0.00008			
Run 23	Files Changed	SAS Kh	physio_sas_kh_82.dfs2	Went back to KBMOS parameters	Testing sensitivity of ICU Kh with original paramaters as described in model files	
Run 22 as base		SAS Kv	physio_sas_kv_82.dfs2	Went back to KBMOS parameters	Testing sensitivity of ICU Kh with original paramaters as described in model files	
		ICU Kh	icu_megapoly_kh_82.dfs2	Went back to KBMOS parameters	Testing sensitivity of ICU Kh with original paramaters as described in model files	
		ICU Kv	icu_megapoly_kv_82.dfs2	Went back to KBMOS parameters	Testing sensitivity of ICU Kh with original paramaters as described in model files	
		UFA Kh	AFET_div_4_ECFT_ufa_kh_04_all_div_20_north_div_2.dfs2	Combined KBMOS with ECFT Kh, divided AFET by 4 and entire area divided by 2 then divided entire area by 10 again and northern area by 2	Testing UFA Kh sensitivity noticed some wells in northern area with too low h	Some wells responded and increased h, some too high, others no response
		SAS Initial heads	SAS_IC-3K_75.dfs2			
		ICU Initial heads	ICU_IC_73.dfs2			
		UFA Initial heads	UFA_initial_elev_interpol.dfs2	Used well locations in model set up and assigned starting heads from observed data, and interpolated values to create a grid file	Initial conditions still off for some wells	Some wells started out right, others still too low or high
		UFA Storage Coefficient	0.00008			
Run 24	Files Changed	SAS Kh	physio_sas_kh_82_south_x_p5.dfs2	Original KBMOS Kh selected southern area and x 0.5	Decrease losses from SAS	Some wells showed too high h, some still too low
Run 19 as Base		SAS Kv	physio_sas_kv_82_south_div_2.dfs2	Original KBMOS Kv with south / 2	Noticed wells in south much lower than observed data	Wells in south were still variable in relation to h vs. observed data
		ICU Kh	icu_megapoly_kh_82_x_5.dfs2	Original KBMOS Kh x5	Increase Flux through ICU	More water flowed to UFA
		ICU Kv	icu_megapoly_kv_82_POL012_x_10_rest_x_5.dfs2	KBMOS original file and multiplied area around POL012 by 10 the rest of domain by 5 (exluding POL012)	Increase flux through POL012 (decrease water levels) and maintain observed h gradient from west to east	POL012 still built up h throughout simulation
		UFA Kh	AFET_div_4_ECFT_ufa_kh_04_all_div_2_POL012_x_10.dfs2			

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		File Type	File Name	Description of Modlifcation	Reason for modification	Outcome of modification
		SAS Initial heads	SAS_initial.dfs2	From ECFT starting heads	File was updated to remove extraneous values outside of model domain	Intial heads got much better
		ICU Initial heads	UFA_initial.dfs2	From ECFT starting heads	File was updated to remove extraneous values outside of model domain	Intial heads got much better
		UFA Initial heads	UFA_initial.dfs2	From ECFT starting heads	File was updated to remove extraneous values outside of model domain	Intial heads got much better
		UFA Storage Coefficient	0.00008			
Run 25	Files Changed	UFA Heads (Outer Boundary Condition)	UFA_BC_03_min_5p5ft.dfs2	Subtracted 5.5 ft from model domain BC, noticed very high values in northwest/west portion of model	Increase flux through POL012 (decrease water levels) and maintain observed h gradient from west to east	Some response in POL012, uniform as to be expected, but still not viable for POL012
Run 26	Files Changed	SAS Kh	physio_sas_kh_82_south_x_p5.dfs2	Original KBMOS Kh selected southern area and x 0.5	Decrease losses from SAS	
1K model uses run 24 as base		SAS Kv	physio_sas_kv_82_south_div_2.dfs2	Original KBMOS Kv with south / 2	Noticed wells in south much lower than observed data	
		SAS Initial heads	SAS_initial.dfs2	From ECFT starting heads	File was updated to remove extraneous values outside of model domain	Intial heads got much better
	Internal BC	SAS to ICU GHB	KBMOS_PH1_3K_99_ICU_from3K_run24.dfs2			