



ABSTRACT & POWERPOINT PRESENTATION

Development of a Computer Model to Optimize Recharge Performance: Orange County Water District Recharge Facilities Model

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Symposium Organizers:

- National Water Research Institute
- Orange County Water District
- Water Research Foundation

www.nwri-usa.org/rechargesymposium2011.htm

Development of a Computer Model to Optimize Recharge Performance – OCWD Recharge Facilities Model

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Marcelo Reginato (CH2M HILL), Terry Foreman (CH2M HILL)**

The Orange County Water District (OCWD) developed a groundwater recharge operation model for the District's 1,100 acres of surface recharge facilities. The computer model was developed as a water resources planning tool to estimate the total water percolated through the spreading basins and to evaluate system performance under different future inflow scenarios and different system configurations.

The OCWD surface recharge facilities are located in the cities of Anaheim and Orange in southern California. The primary source of recharge water is the Santa Ana River (SAR) below Prado Dam in Riverside County. Other replenishment water sources include purified water from the Groundwater Replenishment System (GWRS) and water purchased from Metropolitan Water District of Southern California. The recharge facilities include over 20 recharge basins, two inflatable dams, pipelines to divert water from the SAR, pump stations to dewater basins, and conveyance systems.

Several factors influence the recharge rate on each recharge basin. The recharge rate decays through time mainly as a function of water quality, primarily the amount of fine-grained sediment in the water entering the basin. Different water sources and scheduled cleaning of the basins make a significant impact on the recharge capacity of the system and its operation. Other factors that impact the recharge capacity are the physical capabilities to divert, convey, and store water and a complex chain of operational rules through the system.

The model was constructed using Goldsim software, a general simulation software for dynamically modeling complex systems. The model runs on a desktop personal computer using a graphical user interface. It simulates Prado Dam operations, Santa Ana River flow, each recharge facility, and the District's pumping stations and pipelines that convey recharge water. The rate of percolation in each recharge facility and amount of water in storage is accounted for in the model using equations that define the change in percolation through time. The model also provides a complete water balance of the system. A time step of one day is used in the model.

One of the most challenging aspects in developing the model was capturing the logic for basin cleaning in the model. When the recharge rate in a particular basin declines to a certain minimum level, inflow to the basin is terminated and the water is pumped out to another basin to allow cleaning of the basin. The logic of where the pumped water is conveyed and subsequently percolated and properly accounting for these operational conditions required careful description of a series of operating

rules in the model. The model accounts for the cleaning time, maximum initial percolation, and recharge rate decline of each basin.

The model has been used successfully to evaluate potential changes in recharge that would occur if the District were to construct improvements to the recharge system, such as removing sediment from Santa Ana River water, new recharge facilities are constructed, existing facilities are improved, or increased storage is achieved at Prado Dam.

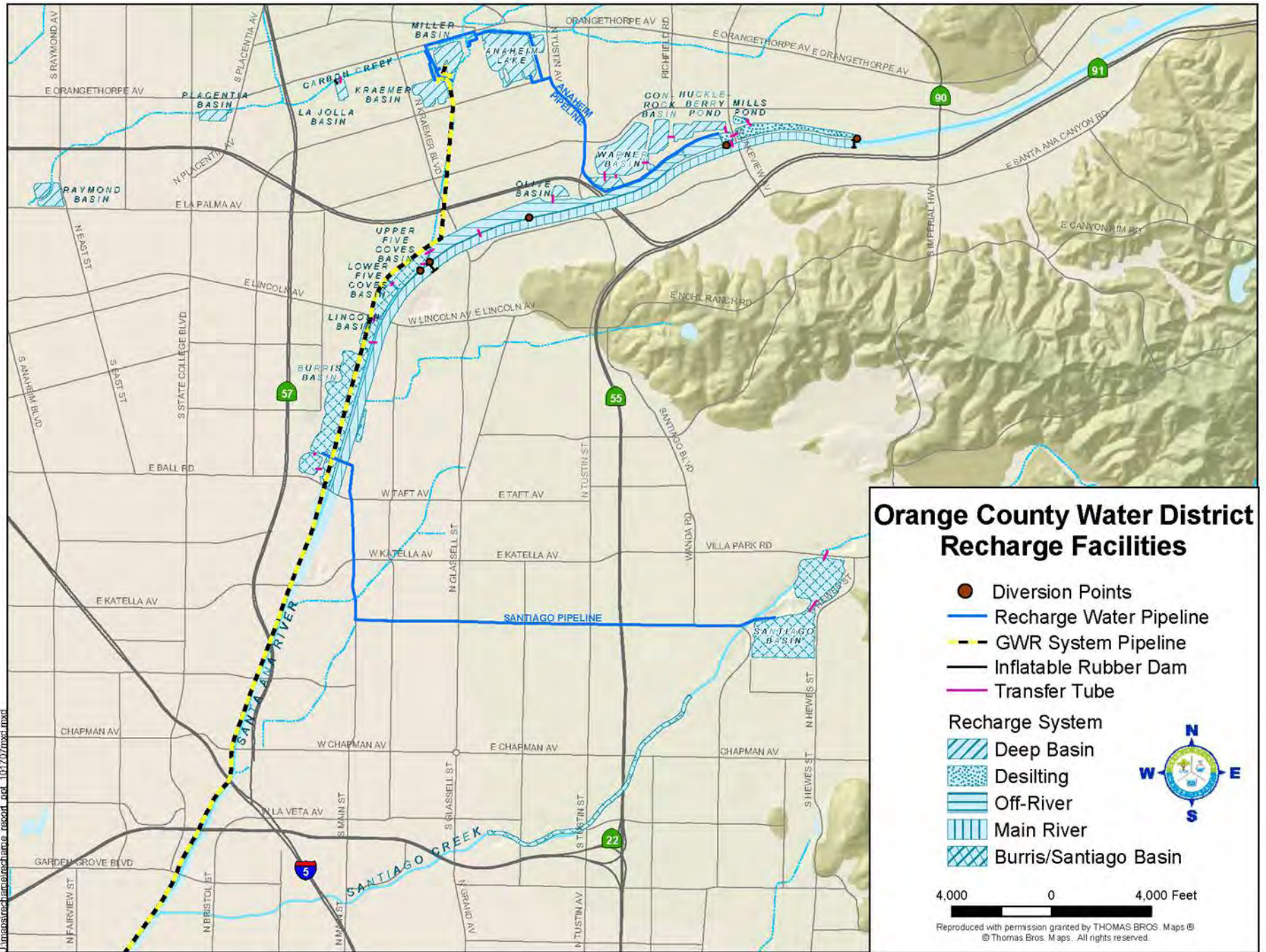


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Managed Aquifer Recharge Symposium




January 26, 2011



Orange County Water District Recharge Facilities

-  Diversion Points
-  Recharge Water Pipeline
-  GWR System Pipeline
-  Inflatable Rubber Dam
-  Transfer Tube

Recharge System

-  Deep Basin
-  Desilting
-  Off-River
-  Main River
-  Burris/Santiago Basin



4,000 0 4,000 Feet

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Summary of OCWD Recharge System in Anaheim and Orange

- ▶ **30 recharge facilities**
 - Approx. 1,100 wetted acres
- ▶ **5 points of diversion from SAR**
- ▶ **SAR water, local runoff, GWRS water, imported water**
- ▶ **5 pump stations to facilitate basin cleaning**
- ▶ **Pump station to pump water to Santiago Basins**
- ▶ **26,000 acre-feet of storage capacity**



Purpose of Model

- ▶ Optimization of recharge and cleaning activities
- ▶ Planning tool to determine how much additional water could be recharged if new facilities are built, existing facilities are improved, or Prado storage program is modified



Warner System



Warner Basin

Little Warner

Conrock

Huckleberry

Weir Pond #4

An aerial photograph showing a large water treatment facility. The facility consists of several basins: a small rectangular Kraemer Basin at the top, a larger irregular Miller Basin to its right, and a very large, irregular Anaheim Lake in the center. A multi-lane highway runs along the right side of the basins. The surrounding area is a mix of industrial buildings, parking lots, and residential neighborhoods. The water in the basins is a dark blue-green color, while the surrounding land is mostly brown and sandy, indicating recent construction or excavation.

Kraemer Basin

Miller Basin

Anaheim Lake



Model Approach

- ▶ Define operational rules
- ▶ Specify SAR, GWR System, MWD, local inflows
- ▶ Demand driven model
 - Demand = percolation capacity
- ▶ Model based on GoldSim software
 - GoldSim originally developed by Golder Inc
 - Now owned by GoldSim Technology Group
- ▶ Route water based on percolation capacity and available supply
 - Includes pipeline and pumping system capacities



Model Approach (cont.)

► Percolation primarily defined by equations:

- Exponential percolation decay as function of previous accumulated percolation (Q_t) with a Depth/MaxDepth coefficient (developed for basins with sufficient historical data)

$$Q = \frac{Depth}{Depth_{Max}} (d \times e^{(-Q_t \times b)} + c)$$

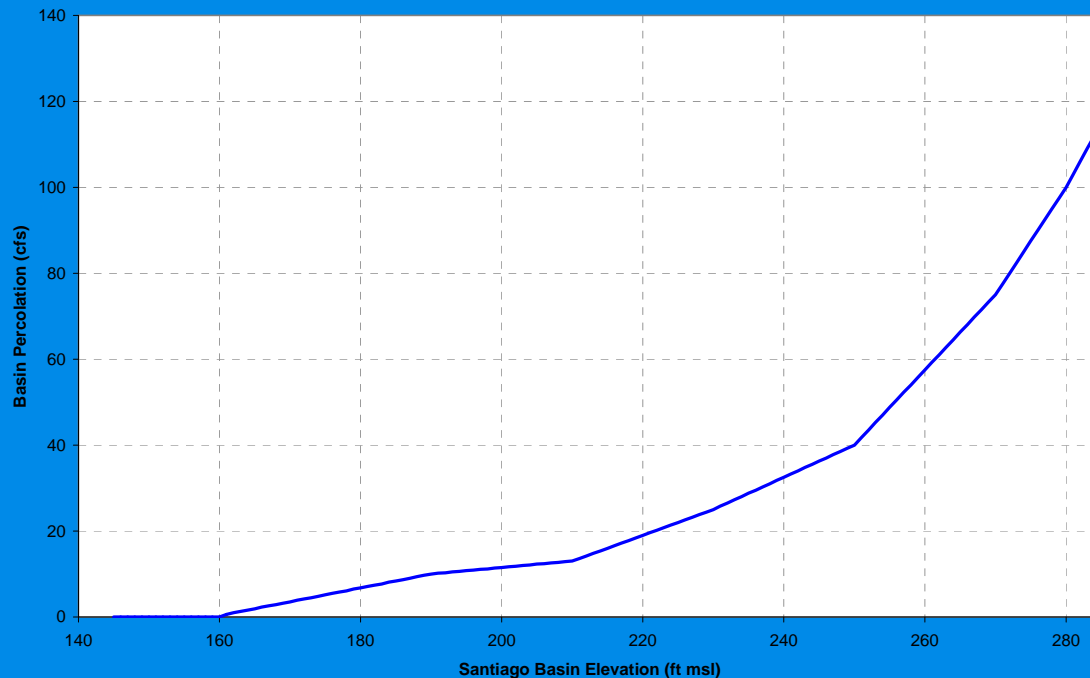
- Linear percolation decay as a function of days since last cleaning



Santiago Basin

- ▶ Percolation defined as function of water surface elevation

Santiago Basins Percolation Lookup Table



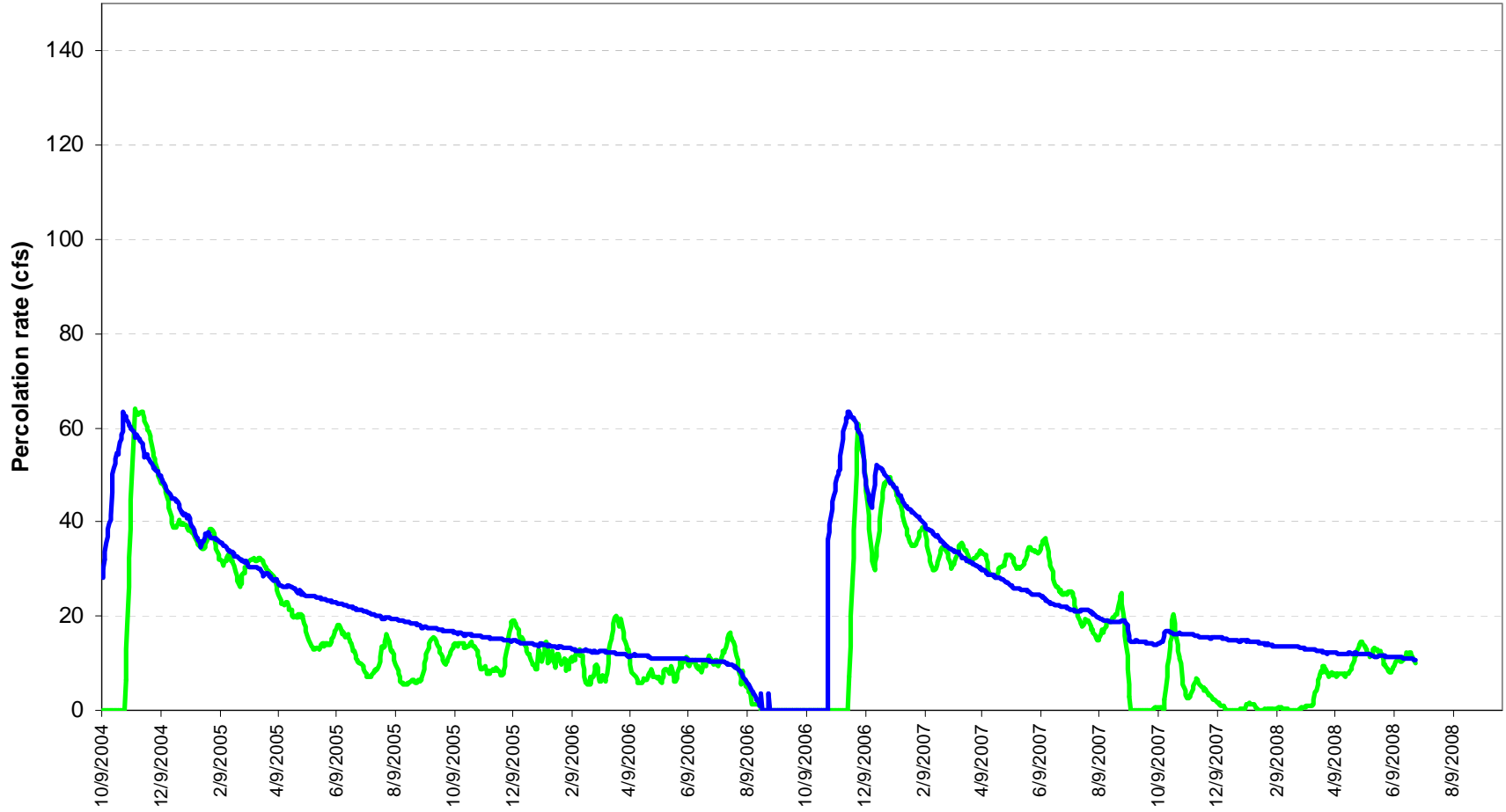


Review of Model Results

- ▶ Compare model results to historical data
- ▶ Good comparison of model results to historical data indicates model can replicate past performance
- ▶ Helps determine validity of model

Warner Basin Percolation Equation Development

Historical 10 day moving Average Model Equation



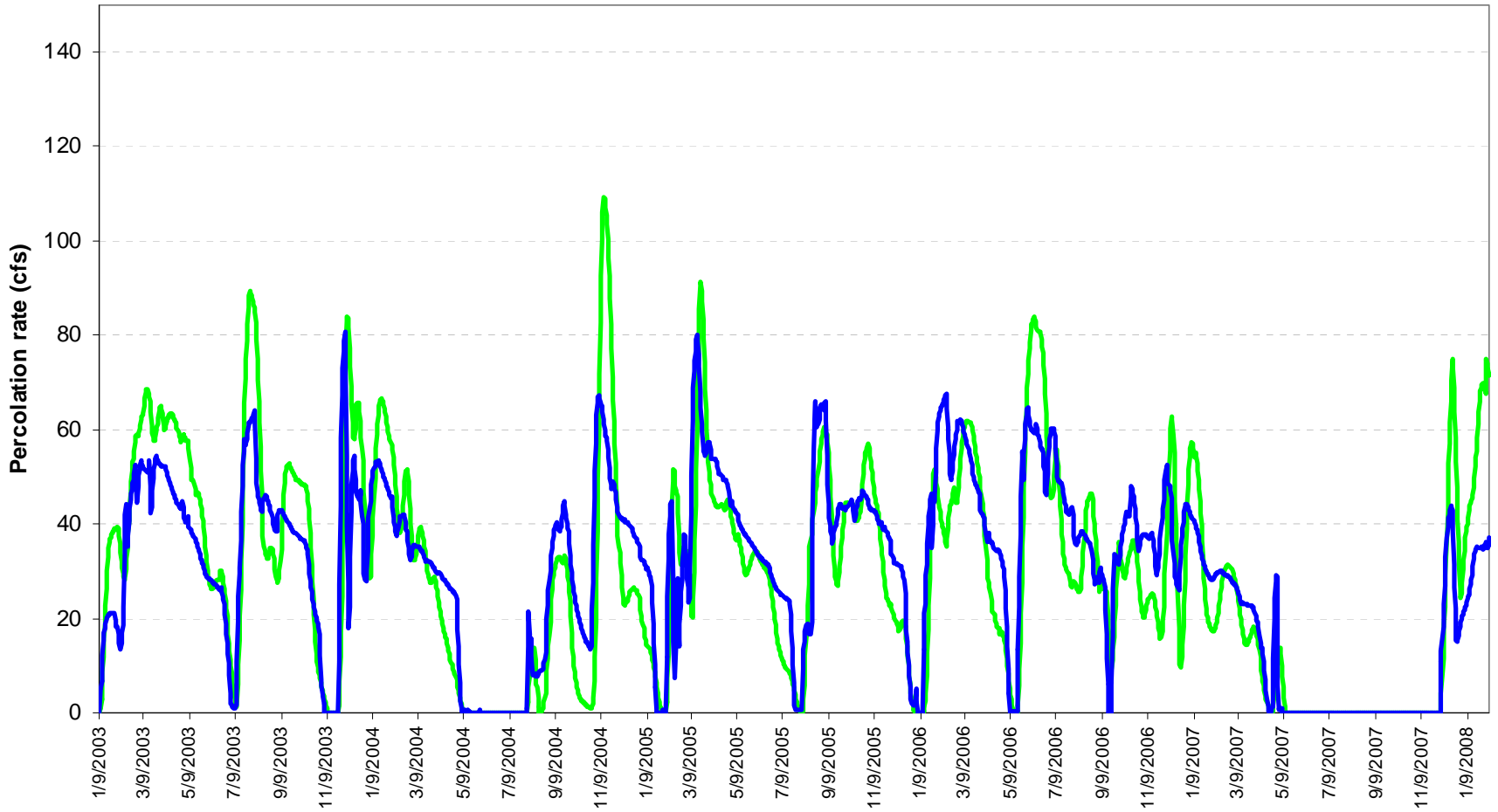
Anaheim Lake Percolation Equation Development

Historical 10 day moving Average Model Equation



Kraemer Basin Percolation Equation Development

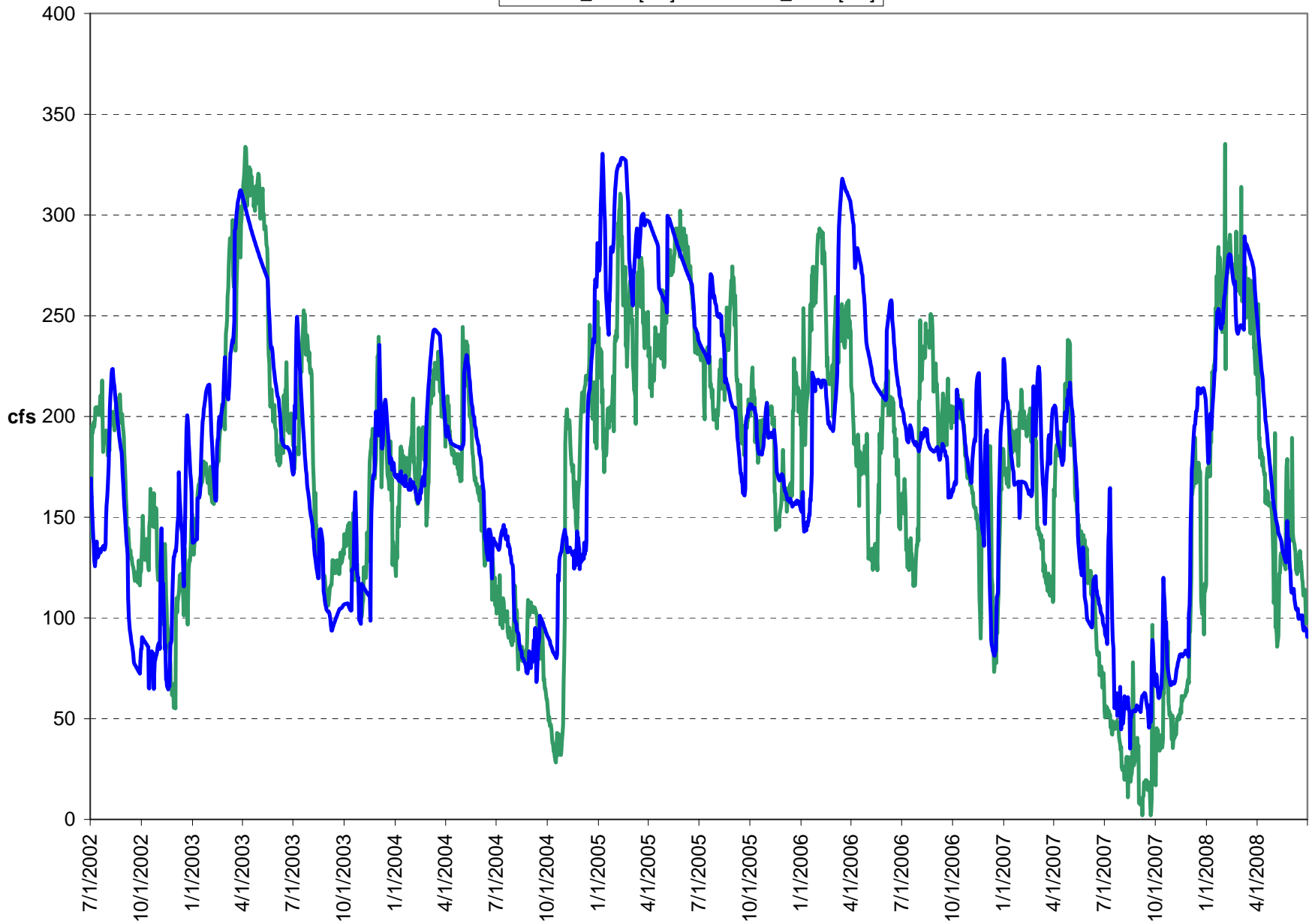
Historical 10 day moving avg Equation1



Model vs. Historical Percolation

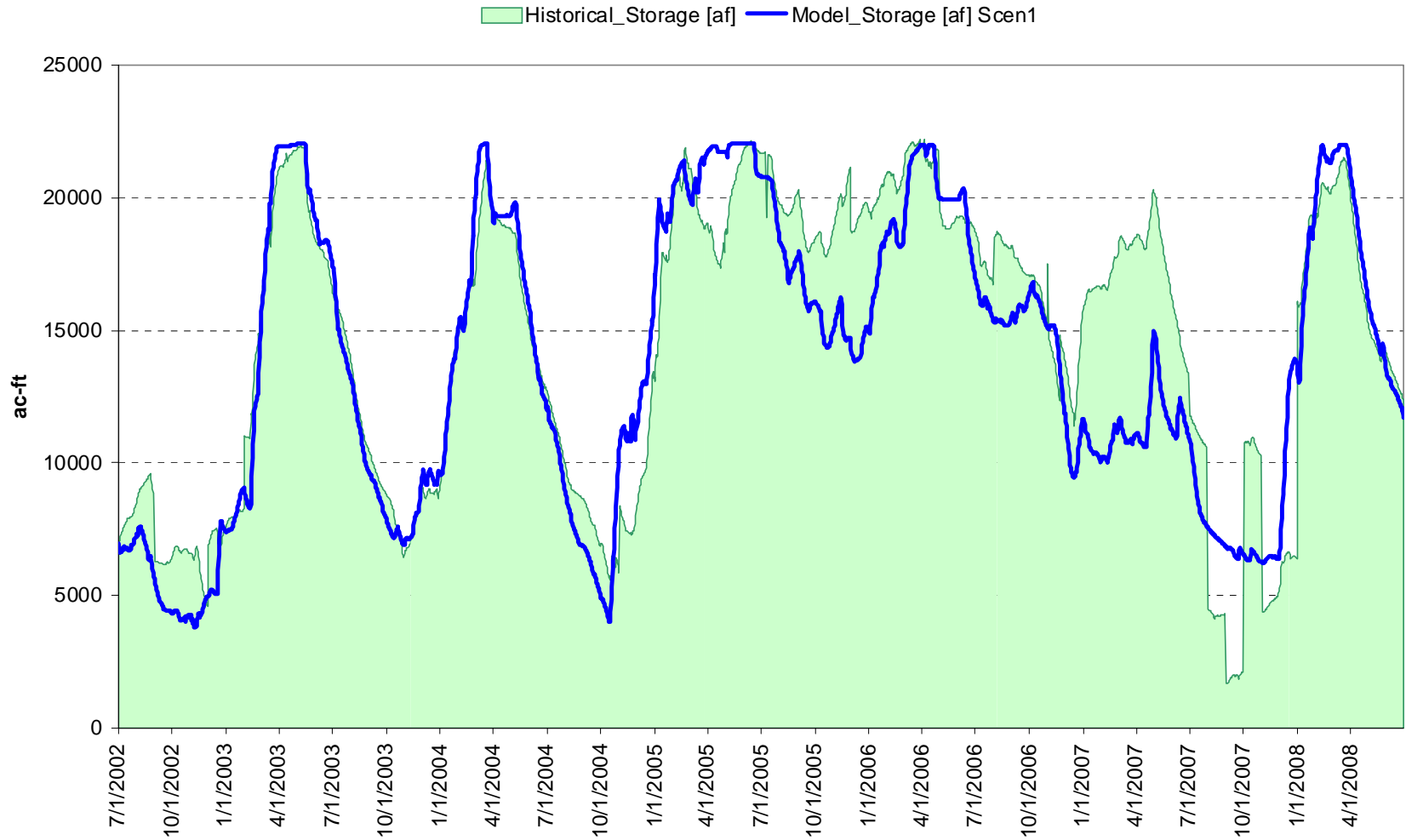
(Warner, Anaheim, Kraemer, Miller, Burris and Santiago Basins)

Hist_Perc [cfs] Model_Perc [cfs]



Model vs. Historical Storage

Includes only Warner, Anaheim, Kraemer, Miller, Burris and Santiago Basins



OCWD Recharge Facilities Model

MAIN MENU

Input Parameters

- INFLOW ASSUMPTIONS
- INPUT XLS
- PRADO CONTROLS
- SIMULATION SETTINGS

User Defined Time Series

- USER DEFINED FLOWS

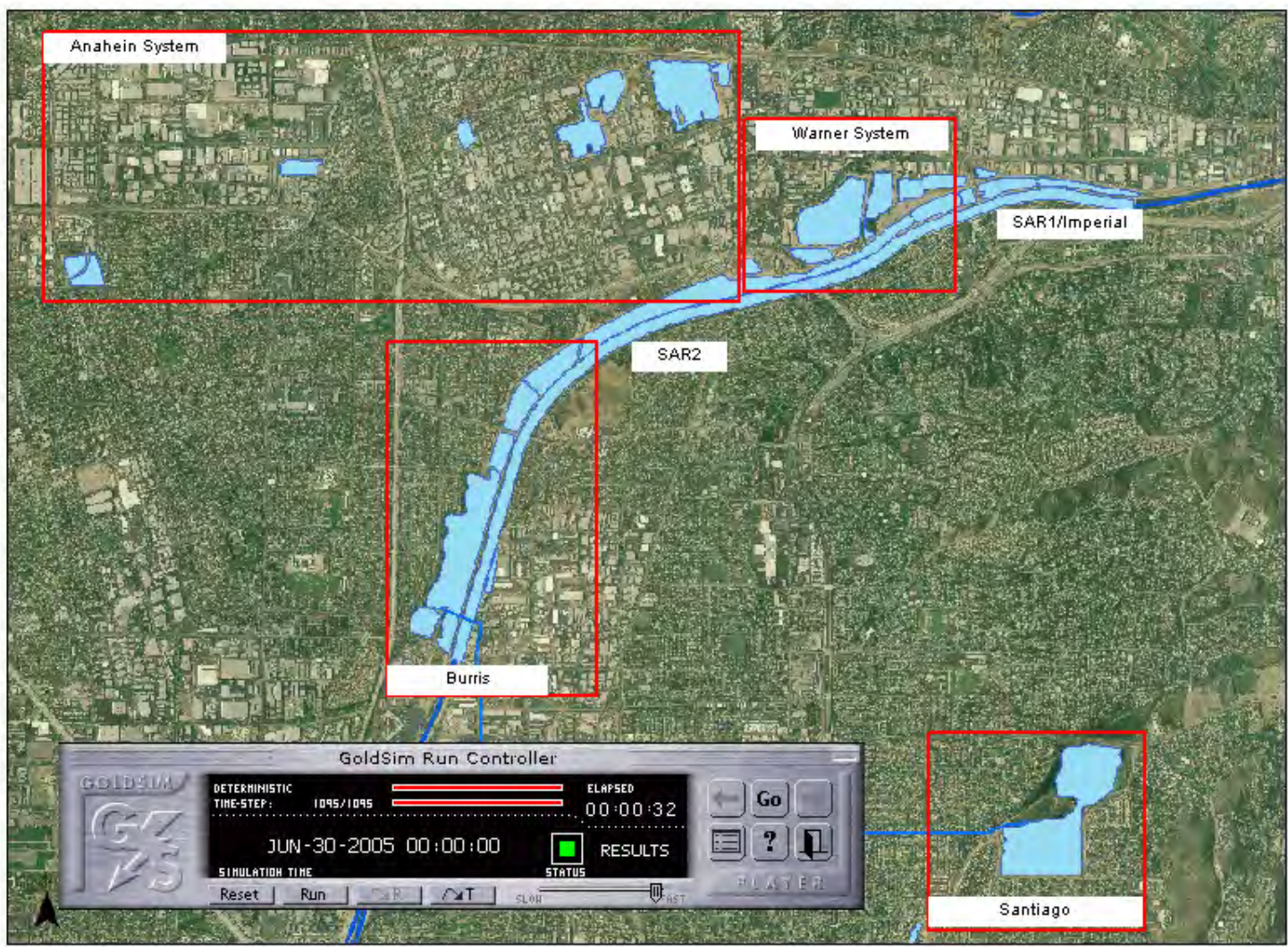
Model

Save Results as:

- SYSTEM OVERVIEW
- GO TO MODEL
- MODEL SCHEMATIC

Output Summary

- MODEL RESULTS
- METRICS
- OUTPUT XLS



OCWD Recharge Basins Model - Inflow Assumptions

Inflow Assumptions

Model Inflows Assumption
 Historical Prado Releases

0 1000 5000
 Fixed Inflow (cfs)

Downstream Prado Local Flows
 Off

Storage/Percolation Initial Conditions
 Option3

Minimum Demand to run through the system (cfs)
 0.5

Storage fraction that can be used for SAR flows
 0.95

Warner-Anaheim Throttle Switch(3)

Five Coves Lincoln Bypass

Calibration Mode(2)

Rubber Dam Controls

Imperial Max Diversion (cfs)
 500

Five Coves Max Diversion (cfs)
 500

Diversion Reduction (cfs)
 250

Changing the max div capacity to >500cfs will not be effective if pipe capacities are not changed. Pipe capacities are changed in the MSEExcel Control XLS file

GWR Controls (1)

Historical GWR

GWR Switch (ON/OFF)

Miller Demand (cfs) 35

Kraemer Demand (cfs) 0

Miraloma Demand (cfs) 0

Santiago Fraction Full Prado Elev. (ft)
 0.9 494

SAR water has Priority over GWR

Santiago Assumptions

Santiago to Burris Pumping Options
 Existing Pumps (max25cfs)

Burris to Santiago Pumping
 Pump Burris to Santiago

Do not pump BUR->SAN if SAN fraction full is greater than 0.7

Santiago Local Flows
 Off

MWD Inflows Assumption

Off

Options for User Specified

Max Inflow [cfs]	0
MWD_fromMon	JAN
MWD_toMon	JAN

- Back to Main Menu
- Back to Guide
- Model Overview

Notes:
 (1) Select either the Historical OR GWR Switch. The model trigger for shutting down GWRs water will be as for feet and it is before March 15 then turn off GWRs, otherwise leave GWRs flow on. Make these trigger values

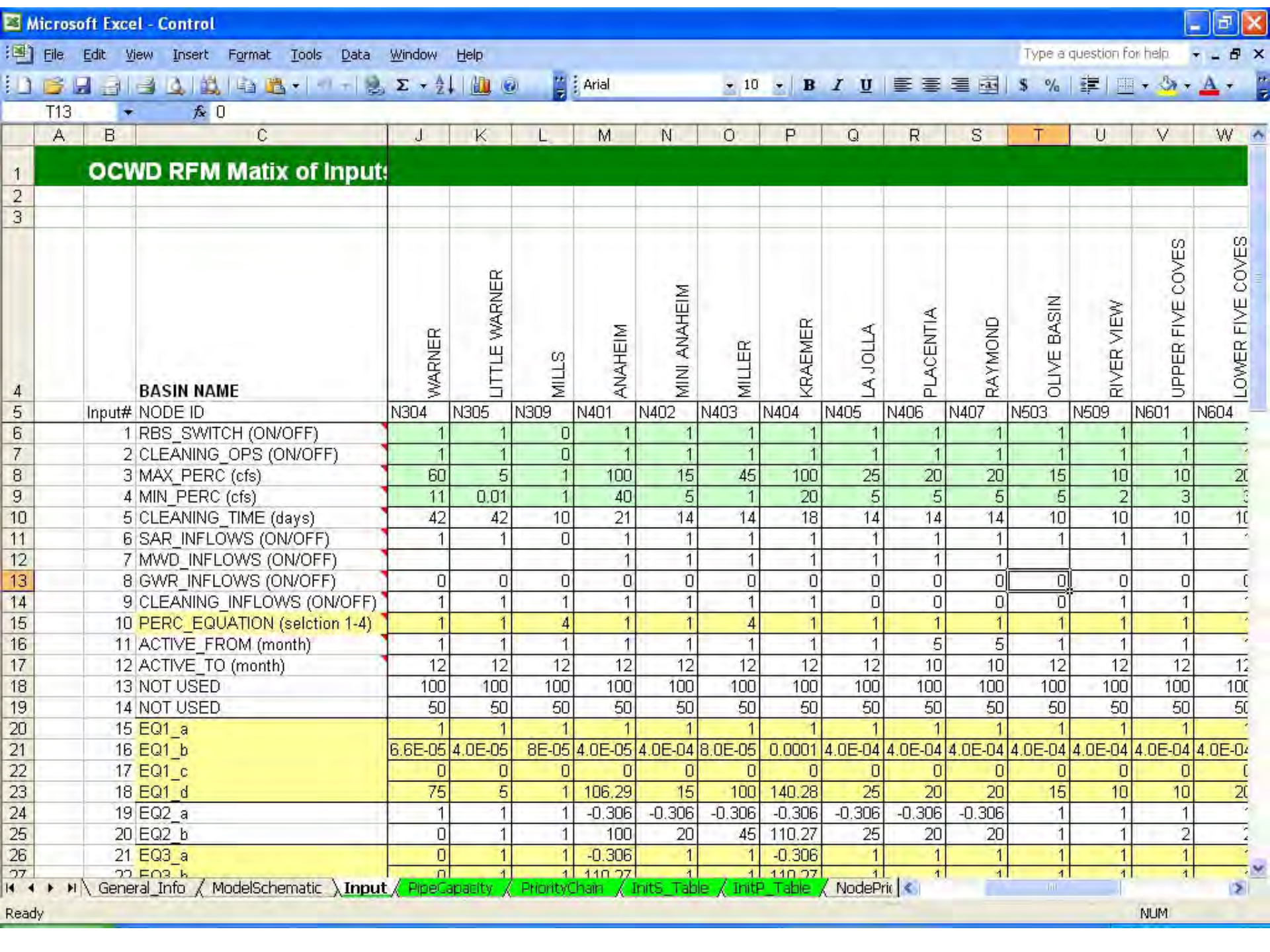
GoldSim Run Controller

DETERMINISTIC TIME-STEP: 1095/1095 ELAPSED 00:00:32

JUN-30-2005 00:00:00 RESULTS

STATUS

Reset Run



	A	B	C	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	OCWD RFM Matix of Input																
2																	
3																	
4	BASIN NAME			WARNER	LITTLE WARNER	MILLS	ANAHEIM	MINI ANAHEIM	MILLER	KRAEMER	LA JOLLA	PLACENTIA	RAYMOND	OLIVE BASIN	RIVER VIEW	UPPER FIVE COVES	LOWER FIVE COVES
5	Input#	NODE ID	N304	N305	N309	N401	N402	N403	N404	N405	N406	N407	N503	N509	N601	N604	
6	1	RBS_SWITCH (ON/OFF)	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
7	2	CLEANING_OPS (ON/OFF)	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
8	3	MAX_PERC (cfs)	60	5	1	100	15	45	100	25	20	20	15	10	10	20	20
9	4	MIN_PERC (cfs)	11	0.01	1	40	5	1	20	5	5	5	5	2	3	3	3
10	5	CLEANING_TIME (days)	42	42	10	21	14	14	18	14	14	14	10	10	10	10	10
11	6	SAR_INFLOWS (ON/OFF)	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
12	7	MWD_INFLOWS (ON/OFF)				1	1	1	1	1	1	1					
13	8	GWR_INFLOWS (ON/OFF)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	9	CLEANING_INFLOWS (ON/OFF)	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1
15	10	PERC_EQUATION (selction 1-4)	1	1	4	1	1	4	1	1	1	1	1	1	1	1	1
16	11	ACTIVE_FROM (month)	1	1	1	1	1	1	1	1	5	5	1	1	1	1	1
17	12	ACTIVE_TO (month)	12	12	12	12	12	12	12	12	10	10	12	12	12	12	12
18	13	NOT USED	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
19	14	NOT USED	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
20	15	EQ1_a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	16	EQ1_b	6.6E-05	4.0E-05	8E-05	4.0E-05	4.0E-04	8.0E-05	0.0001	4.0E-04	4.0E-04	4.0E-04	4.0E-04	4.0E-04	4.0E-04	4.0E-04	4.0E-04
22	17	EQ1_c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	18	EQ1_d	75	5	1	106.29	15	100	140.28	25	20	20	15	10	10	20	20
24	19	EQ2_a	1	1	1	-0.306	-0.306	-0.306	-0.306	-0.306	-0.306	-0.306	1	1	1	1	1
25	20	EQ2_b	0	1	1	100	20	45	110.27	25	20	20	1	1	2	2	2
26	21	EQ3_a	0	1	1	-0.306	1	1	-0.306	1	1	1	1	1	1	1	1
27	22	EQ3_b	0	1	1	110.27	1	1	110.27	1	1	1	1	1	1	1	1

Simulation Settings...



Time **Monte Carlo** Globals Information



Specify model start time and duration, and define global time steps for model calculations and result plotting.

Basic Time Settings

Time Display Units:

Duration:

Start-time:

End-time:

Time Phase Settings

Time Range	#Steps	Length [day]	Plot Every	Fv
7/1/2002 - 6/30/2005	1095	1	1	<input checked="" type="checkbox"/>

Add...

Remove

Advanced...

OK

Cancel

Help



On-Going Use of Model

- ▶ **Evaluation of benefits of sediment removal**
 - Increased percolation performance with sediment removal
 - Evaluate increased stormwater capture and recharge
- ▶ **Evaluation of benefits of potential new recharge facilities**
- ▶ **Potential incorporation of optimization module**