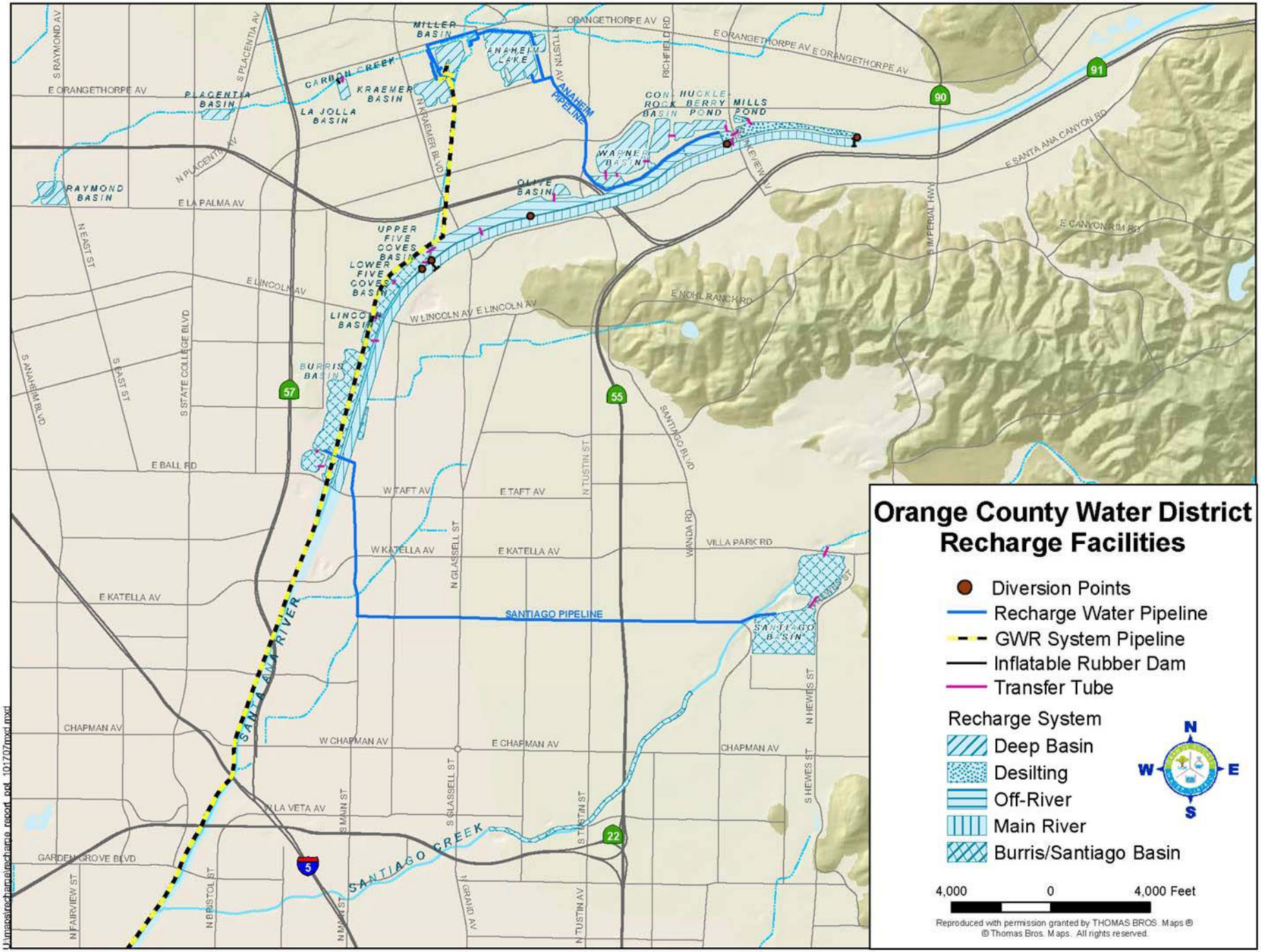
Recharge Facilities Model of OCWD's Recharge System

SAWPA Basin Monitoring Program Task Force

May 17, 2011

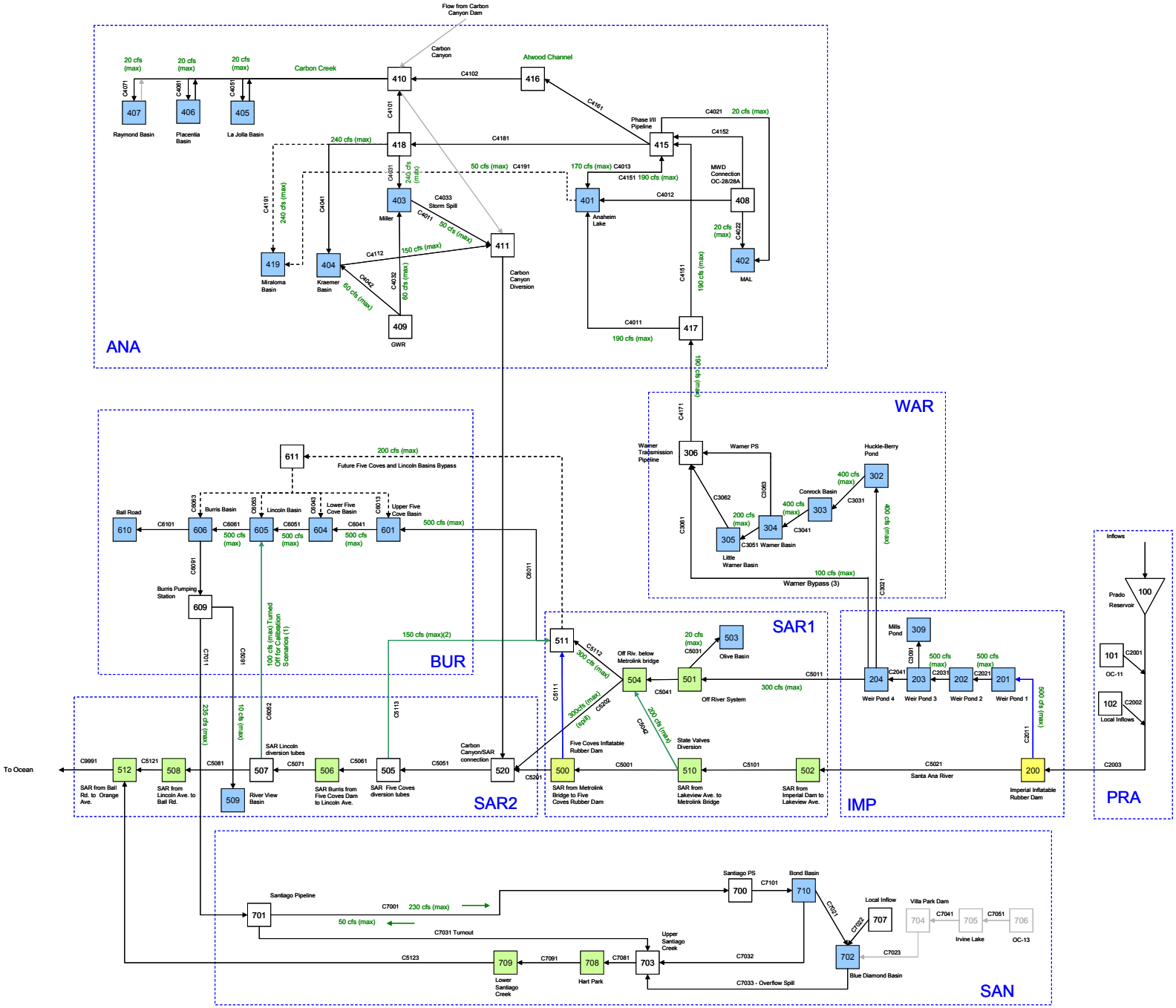

Orange County Water District
Recharge Facilities
Diversion Points
Recharge Water Pipeline
GWR System Pipeline
Inflatable Rubber Dam
Transfer Tube
Recharge System
Deep Basin
Desilting
Off-River
Main River
Burris/Santiago Basin
N
W
E
S
4,000
0
4,000 Feet
Reproduced with permission granted by THOMAS BROS. Maps ®
© Thomas Bros. Maps. All rights reserved.
MILLER BASIN
ANAHEIM LAKE
ANAHEIM PIPELINE
CARBON CREEK
KRAEMER BASIN
LA JOLLA BASIN
PLACENTIA BASIN
RAYMOND BASIN
OLIVE BASIN
WARNER BASIN
CON. HUCKLE-BERRY POND
MILLS POND
UPPER FIVE COVES BASIN
LOWER FIVE COVES BASIN
LINCOLN BASIN
BURRIS BASIN
SANTIAGO BASIN
SANTIAGO PIPELINE
SANTA ANA RIVER
SANTIAGO CREEK
ORANGETHORPE AV
E ORANGETHORPE AV
E LA PALMA AV
E LINCOLN AV
W LINCOLN AV
E NOHL RANCH RD
E BALL RD
W TAFT AV
E TAFT AV
W KATELLA AV
E KATELLA AV
VILLA PARK RD
CHAPMAN AV
W CHAPMAN AV
E CHAPMAN AV
LA VETA AV
GARDEN GROVE BLVD
E SANTA ANA CANYON RD
E CANYON RIM RD
S RAYMOND AV
S PLACENTIA AV
N PLACENTIA AV
N KRAEMER BLVD
N TUSTIN AV
RICHFIELD RD
N RAMONA AV
S IMPERIAL HWY
N EAST ST
S EAST ST
S STATE COLLEGE BLVD
S ANAHEIM BLVD
N GLASSELL ST
S GLASSELL ST
N TUSTIN ST
S TUSTIN ST
SANTIAGO BLVD
WANDA RD
N HEWES ST
S HEWES ST
S MAIN ST
N MAIN ST
N GRAND AV
N BRISTOL ST
N FAIRVIEW ST
91
90
57
55
22
5

Summary of OCWD Recharge System in Anaheim and Orange

- 30 recharge basins
  - Approx. 1,100 acres
- 5 points of diversion from SAR
- Flow to basins primarily gravity driven
- 6 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


Flow from Carbon Canyon Dam
Carbon Canyon
Carbon Creek
Atwood Channel
20 cfs (max)
20 cfs (max)
20 cfs (max)
C4071
C4081
C4051
410
416
C4102
C4161
407
406
405
Raymond Basin
Placentia Basin
La Jolla Basin
C4101
418
C4181
415
Phase I/II Pipeline
C4021
20 cfs (max)
C4152
240 cfs (max)
C4131
240 cfs (max)
50 cfs (max)
C4191
170 cfs (max)
C4013
C4151
190 cfs (max)
MWD Connection OC-28/28A
403
401
408
C4012
C4033 Storm Spill
Miller
Anaheim Lake
C4191
240 cfs (max)
C4041
C4401
50 cfs (max)
20 cfs (max)
C4022
411
419
404
402
C4112
150 cfs (max)
C4042
60 cfs (max)
C4032
60 cfs (max)
Miraloma Basin
Kraemer Basin
Carbon Canyon Diversion
MAL
C4151
190 cfs (max)
409
GWR
C4011
190 cfs (max)
417
190 cfs (max)
ANA
WAR
C4171
Warner Transmission Pipeline
306
Warner PS
Huckle-Berry Pond
302
400 cfs (max)
C3062
C3063
Conrock Basin
303
C3031
400 cfs (max)
C3061
200 cfs (max)
304
C3041
305
C3051 Warner Basin
Little Warner Basin
400 cfs (max)
100 cfs (max)
Warner Bypass (3)
C3021
611
200 cfs (max)
Future Five Coves and Lincoln Basins Bypass
Ball Road
Burris Basin
Lincoln Basin
Lower Five Cove Basin
Upper Five Cove Basin
C6063
C6053
C6043
C6013
610
C6101
606
C6061
605
C6051
604
C6041
601
500 cfs (max)
500 cfs (max)
500 cfs (max)
500 cfs (max)
C6091
C6011
Burris Pumping Station
609
100 cfs (max) Turned Off for Calibration Scenarios (1)
C7071
C6091
150 cfs (max)(2)
BUR
511
SAR1
C5112
300 cfs (max)
Off Riv. below Metrolink bridge
20 cfs (max)
C5031
503
Olive Basin
504
501
C5041
C5011
300 cfs (max)
Off River System
Mills Pond
309
C3091
500 cfs (max)
500 cfs (max)
204
C2041
203
C2031
202
C2021
201
Weir Pond 4
Weir Pond 3
Weir Pond 2
Weir Pond 1
C5111
300cfs (max) (goal)
C5002
200 cfs (max)
C5042
State Valves Diversion
C5113
C6052
235 cfs (max)
10 cfs (max)
Five Coves Inflatable Rubber Dam
500 cfs (max)
C2011
Inflows
Prado Reservoir
100
101
C2001
OC-11
102
C2002
Local Inflows
C9991
512
C5121
508
C5081
507
C5071
506
C5061
505
C5051
520
C5201
Carbon Canyon/SAR connection
SAR Lincoln diversion tubes
To Ocean
SAR from Ball Rd. to Orange Ave.
SAR from Lincoln Ave. to Ball Rd.
River View Basin
SAR Burris from Five Coves Dam to Lincoln Ave.
SAR Five Coves diversion tubes
SAR2
500
C5001
510
C5101
502
SAR from Metrolink Bridge to Five Coves Rubber Dam
SAR from Lakeview Ave. to Metrolink Bridge
SAR from Imperial Dam to Lakeview Ave.
IMP
C5021
Santa Ana River
200
Imperial Inflatable Rubber Dam
C2003
PRA
Santiago Pipeline
701
C7001
230 cfs (max)
50 cfs (max)
C7031 Turnout
Santiago PS
700
C7101
Bond Basin
710
C7021
C7022
Local Inflow
707
Villa Park Dam
704
C7041
705
C7051
706
Irvine Lake
OC-13
Upper Santiago Creek
C5123
709
Lower Santiago Creek
C7091
708
Hart Park
C7081
703
C7032
702
C7023
Blue Diamond Basin
C7033 - Overflow Spill
SAN

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 separate company GoldSim Technology Group
- Route water based on percolation capacity and available supply
  - Includes pipeline and pumping system capacities

Model Approach (cont.)

- **Percolation at basins is driven 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)**

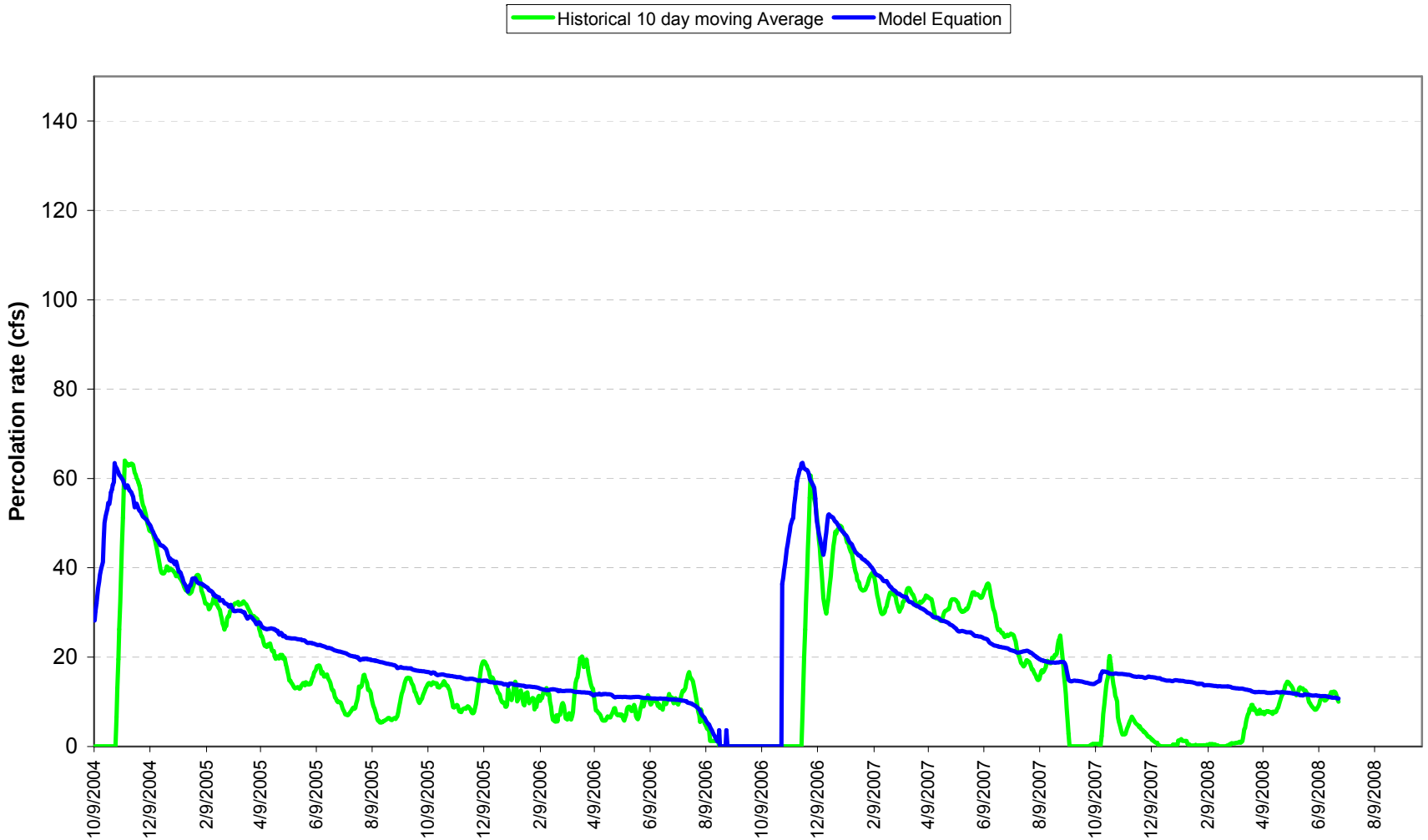
$$Q = \frac{Depth}{Depth_{Max}}(d \times e^{(-Q_t \times b)} + c)$$

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

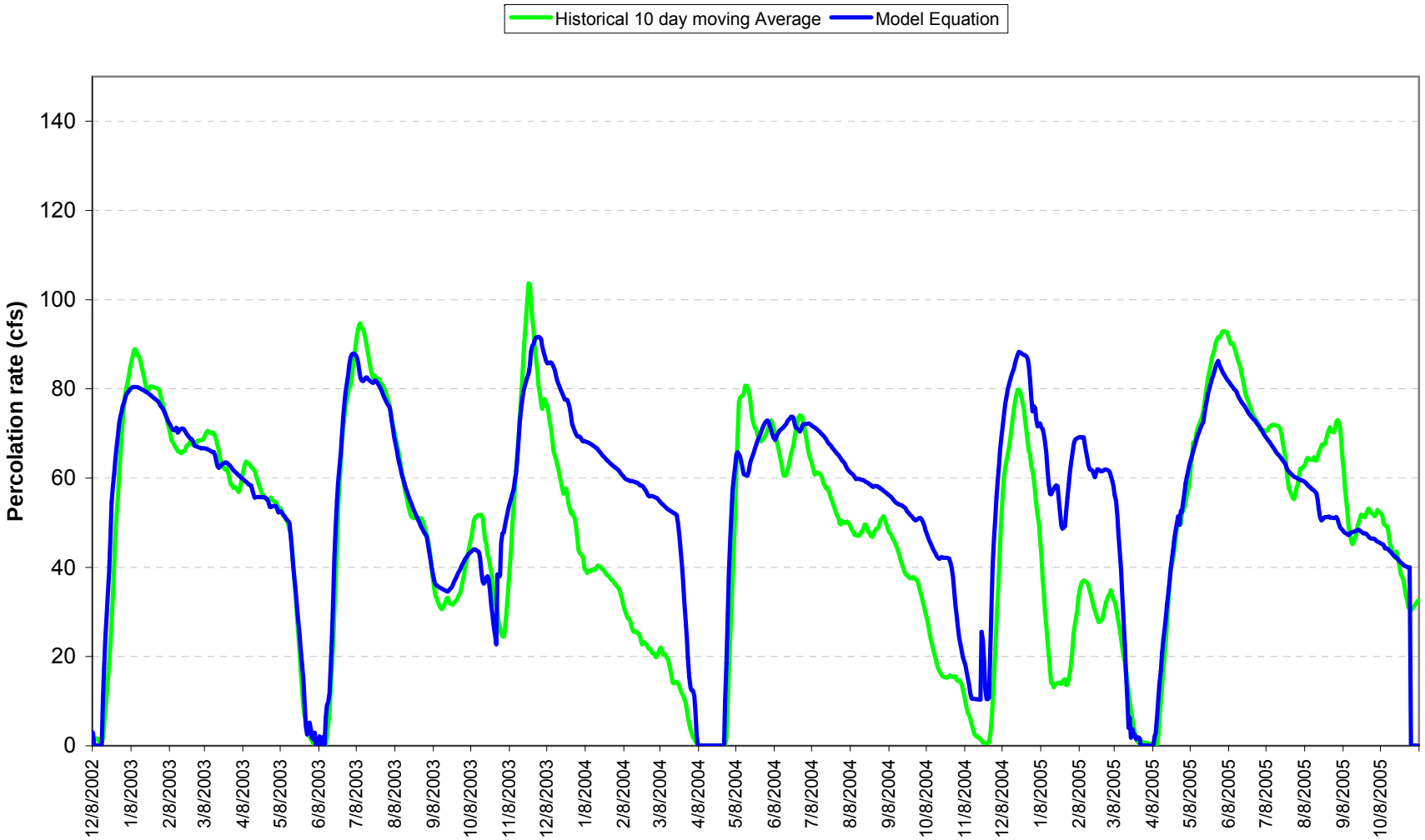
Review of Model Results

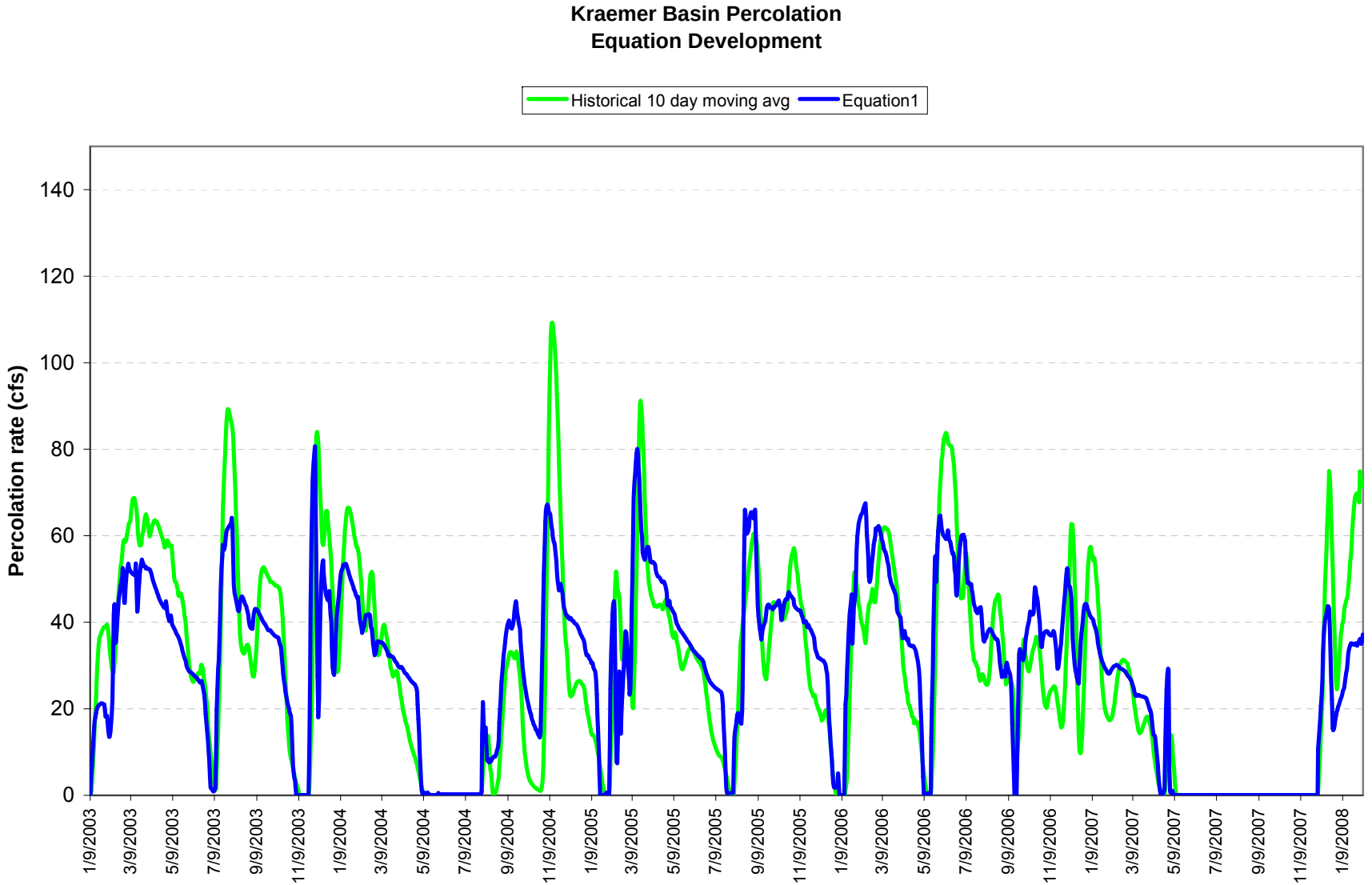
- Compare model results to historical data
- Good comparison of model results to historical data indicates model can replicate past performance
- Helps determine validity of model

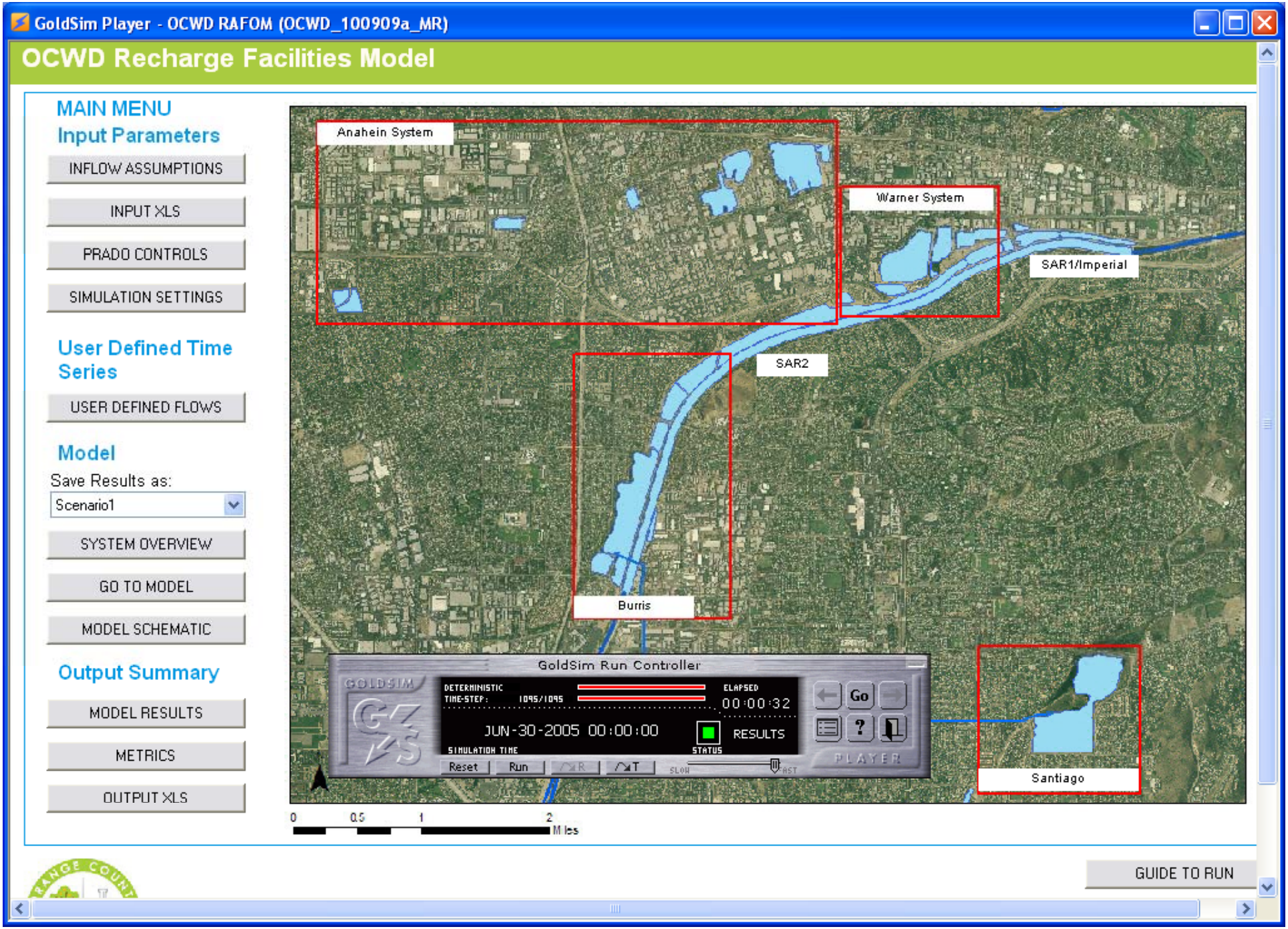
Warner Basin Percolation
Equation Development

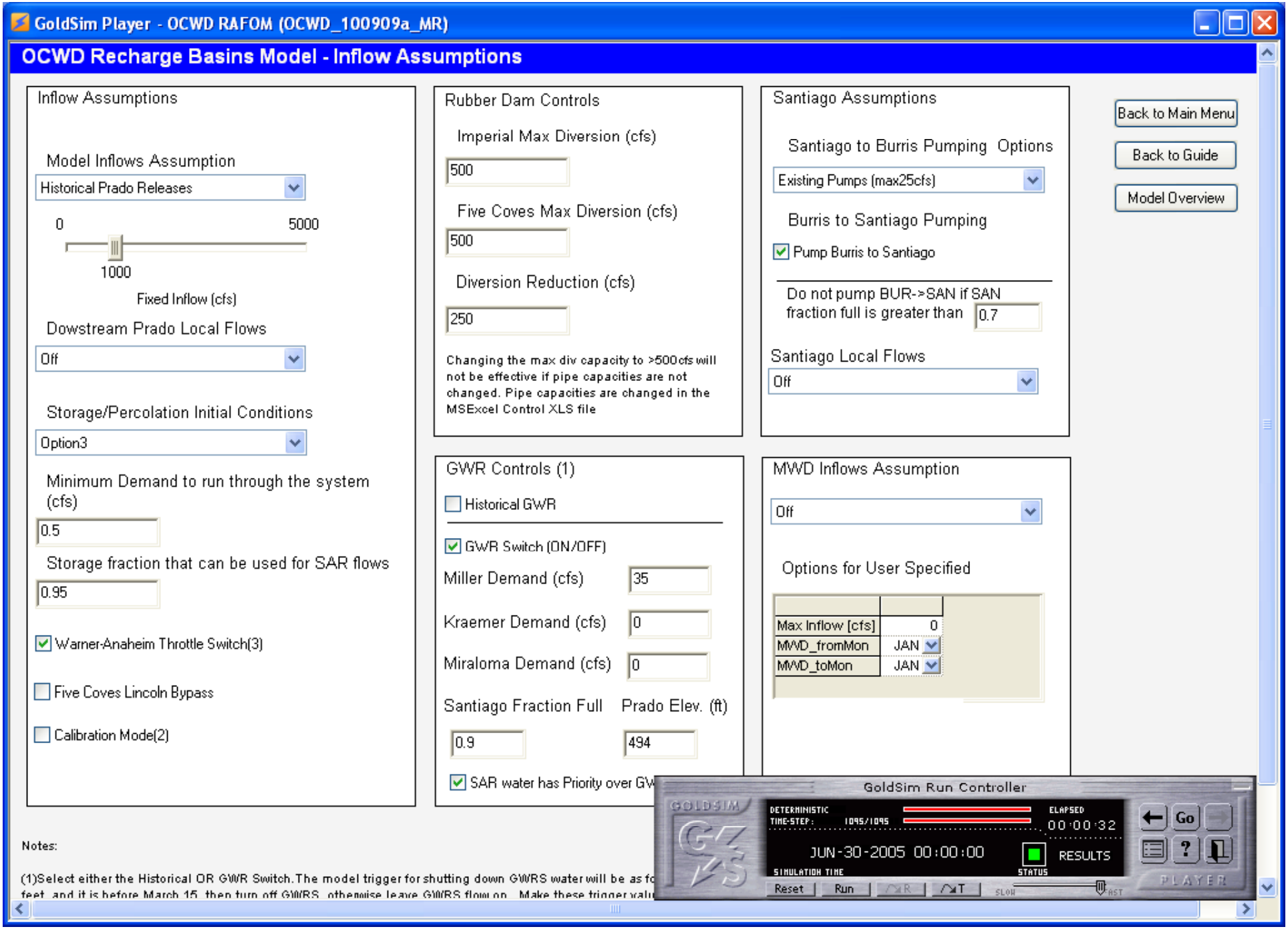


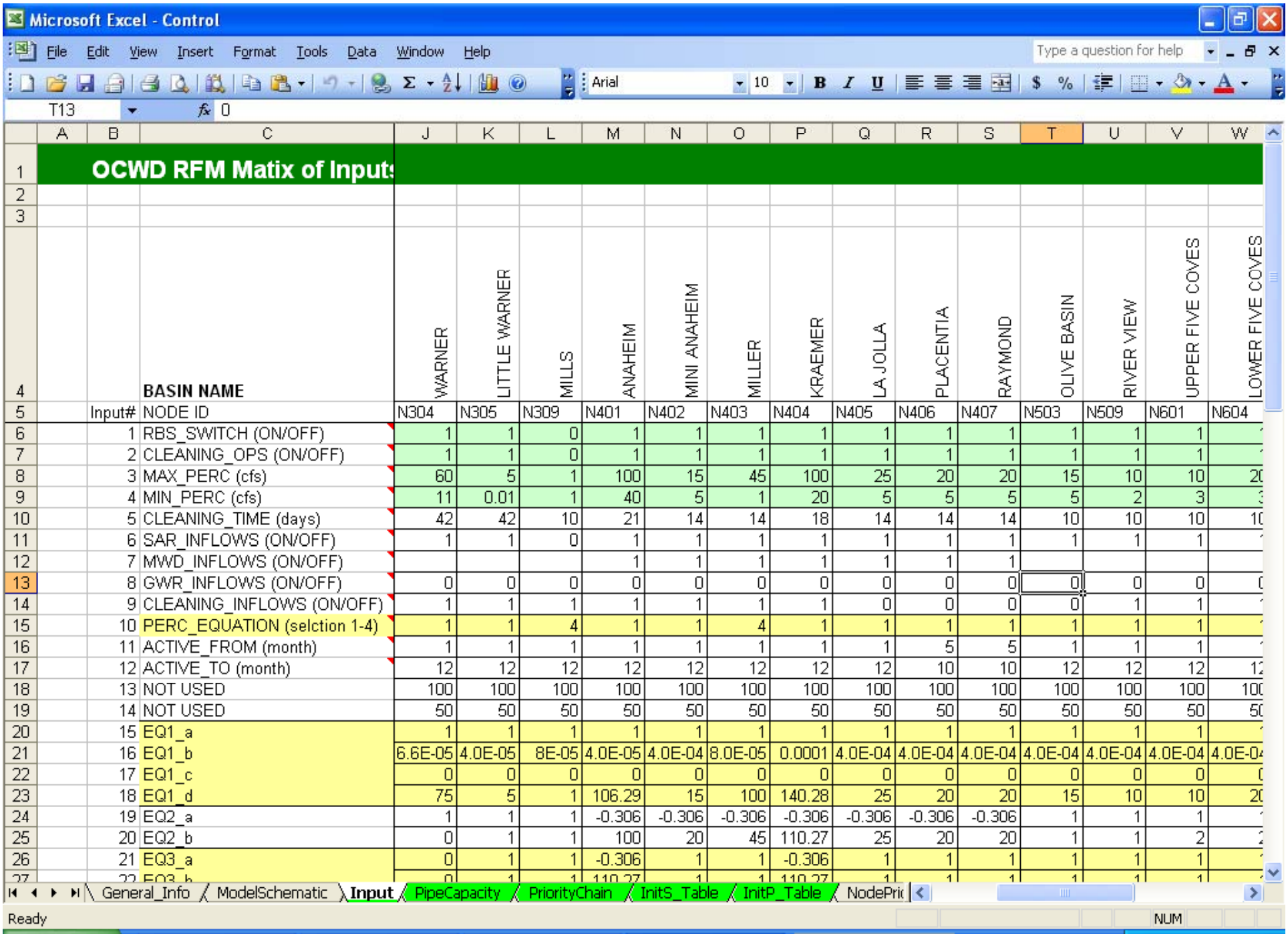
Anaheim Lake Percolation
Equation Development




Kraemer Basin Percolation
Equation Development
Historical 10 day moving avg
Equation1
Percolation rate (cfs)
0
20
40
60
80
100
120
140
1/9/2003
3/9/2003
5/9/2003
7/9/2003
9/9/2003
11/9/2003
1/9/2004
3/9/2004
5/9/2004
7/9/2004
9/9/2004
11/9/2004
1/9/2005
3/9/2005
5/9/2005
7/9/2005
9/9/2005
11/9/2005
1/9/2006
3/9/2006
5/9/2006
7/9/2006
9/9/2006
11/9/2006
1/9/2007
3/9/2007
5/9/2007
7/9/2007
9/9/2007
11/9/2007
1/9/2008


GoldSim Player - OCWD RAFOM (OCWD_100909a_MR)
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:
Scenario1
SYSTEM OVERVIEW
GO TO MODEL
MODEL SCHEMATIC
Output Summary
MODEL RESULTS
METRICS
OUTPUT XLS
Anahein System
Warner System
SAR1/Imperial
SAR2
Burris
Santiago
GoldSim Run Controller
DETERMINISTIC
TIME-STEP:
1095/1095
ELAPSED
00:00:32
JUN-30-2005 00:00:00
SIMULATION TIME
RESULTS
STATUS
Go
Reset
Run
PLAYER
0
0.5
1
2
Miles
GUIDE TO RUN


GoldSim Player - OCWD RAFOM (OCWD_100909a_MR)
OCWD Recharge Basins Model - Inflow Assumptions
Inflow Assumptions
Model Inflows Assumption
Historical Prado Releases
0
5000
1000
Fixed Inflow (cfs)
Dowstream 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 MSExcel 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 GW
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
GoldSim Run Controller
DETERMINISTIC
TIME-STEP:
1095/1095
ELAPSED
00:00:32
JUN-30-2005 00:00:00
SIMULATION TIME
RESULTS
STATUS
Reset
Run
Go
PLAYER
Notes:
(1)Select either the Historical OR GWR Switch.The model trigger for shutting down GWRS water will be as fo
feet, and it is before March 15, then turn off GWRS, otherwise leave GWRS flow on. Make these trigger valu



Microsoft Excel - Control

File Edit View Insert Format Tools Data Window Help

Type a question for help

Arial 10

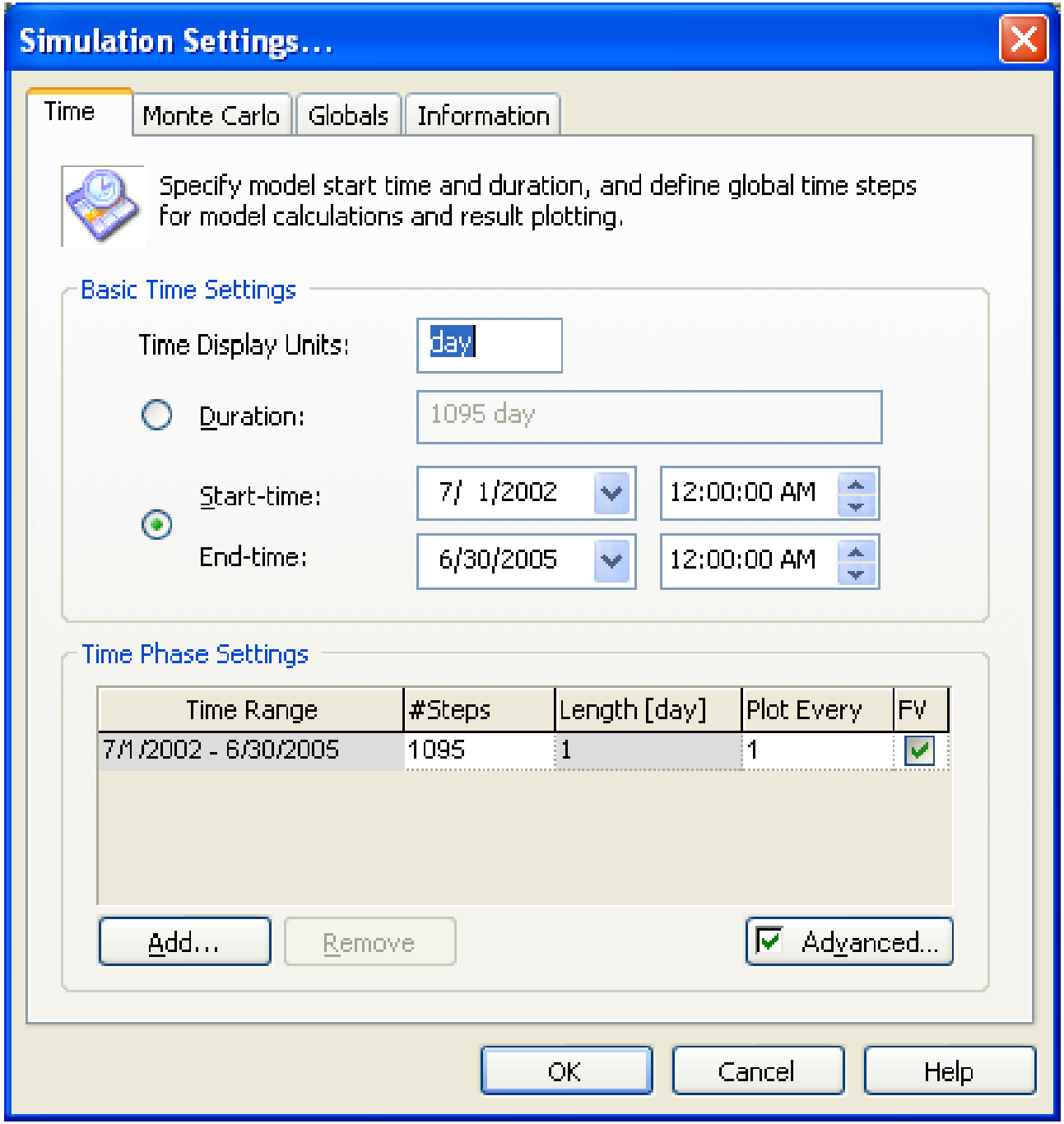
T13 0

	A	B	C	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1		OCWD RFM Matix of Inputs															
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	
7		2	CLEANING_OPS (ON/OFF)	1	1	0	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
9		4	MIN_PERC (cfs)	11	0.01	1	40	5	1	20	5	5	5	5	2	3	
10		5	CLEANING_TIME (days)	42	42	10	21	14	14	18	14	14	14	10	10	10	10
11		6	SAR_INFLOWS (ON/OFF)	1	1	0	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
14		9	CLEANING_INFLOWS (ON/OFF)	1	1	1	1	1	1	1	0	0	0	0	1	1	
15		10	PERC_EQUATION (selction 1-4)	1	1	4	1	1	4	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	
17		12	ACTIVE_TO (month)	12	12	12	12	12	12	12	12	10	10	12	12	12	12
18		13	NOT USED	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
20		15	EQ1_a	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
22		17	EQ1_c	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
24		19	EQ2_a	1	1	1	-0.306	-0.306	-0.306	-0.306	-0.306	-0.306	-0.306	1	1	1	
25		20	EQ2_b	0	1	1	100	20	45	110.27	25	20	20	1	1	2	
26		21	EQ3_a	0	1	1	-0.306	1	1	-0.306	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	

General_Info | ModelSchematic | Input | PipeCapacity | PriorityChain | InitS_Table | InitP_Table | NodePric

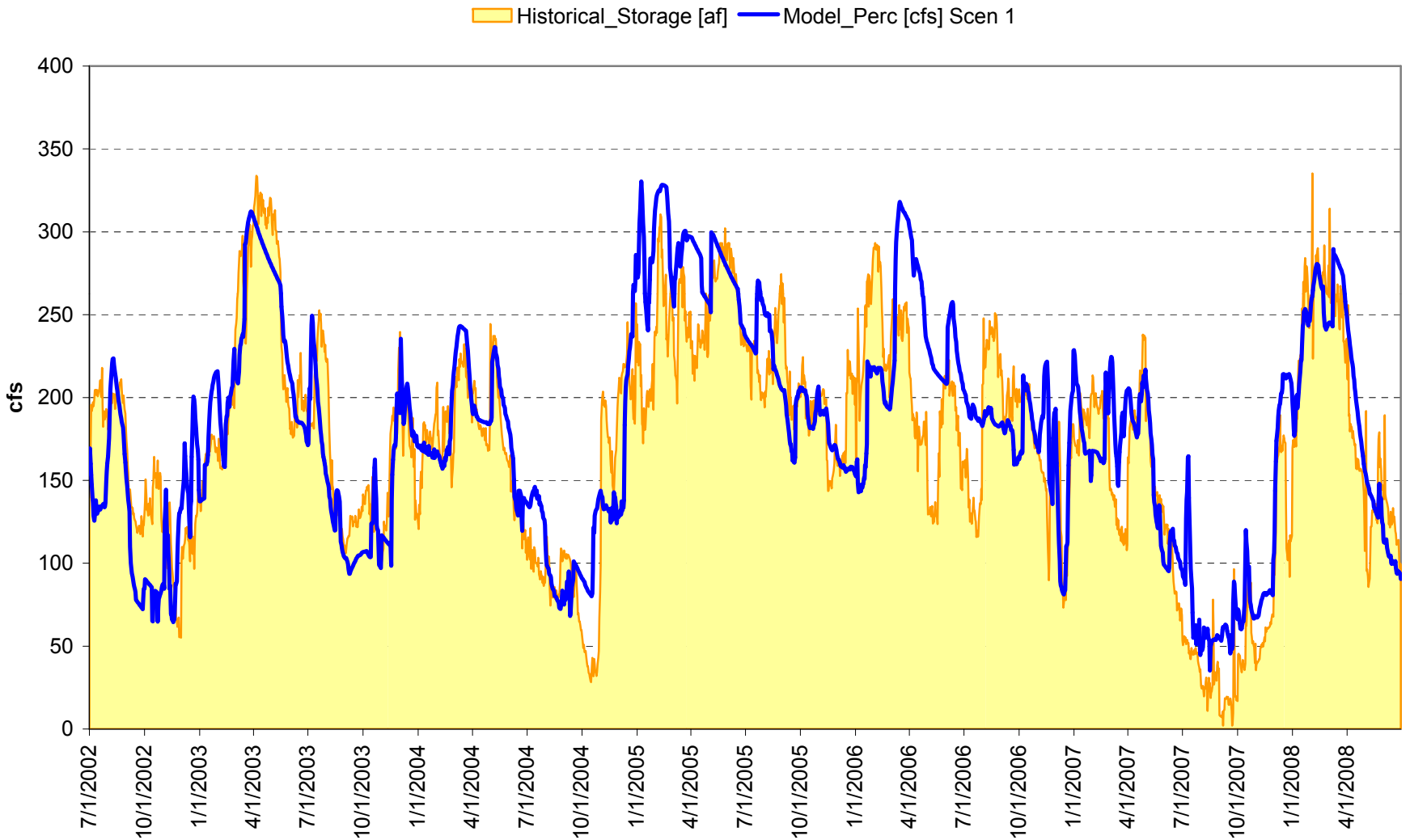
Ready

NUM


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:
day
Duration:
1095 day
Start-time:
7/ 1/2002
12:00:00 AM
End-time:
6/30/2005
12:00:00 AM
Time Phase Settings
Time Range
#Steps
Length [day]
Plot Every
FV
7/1/2002 - 6/30/2005
1095
1
1
Add...
Remove
Advanced...
OK
Cancel
Help

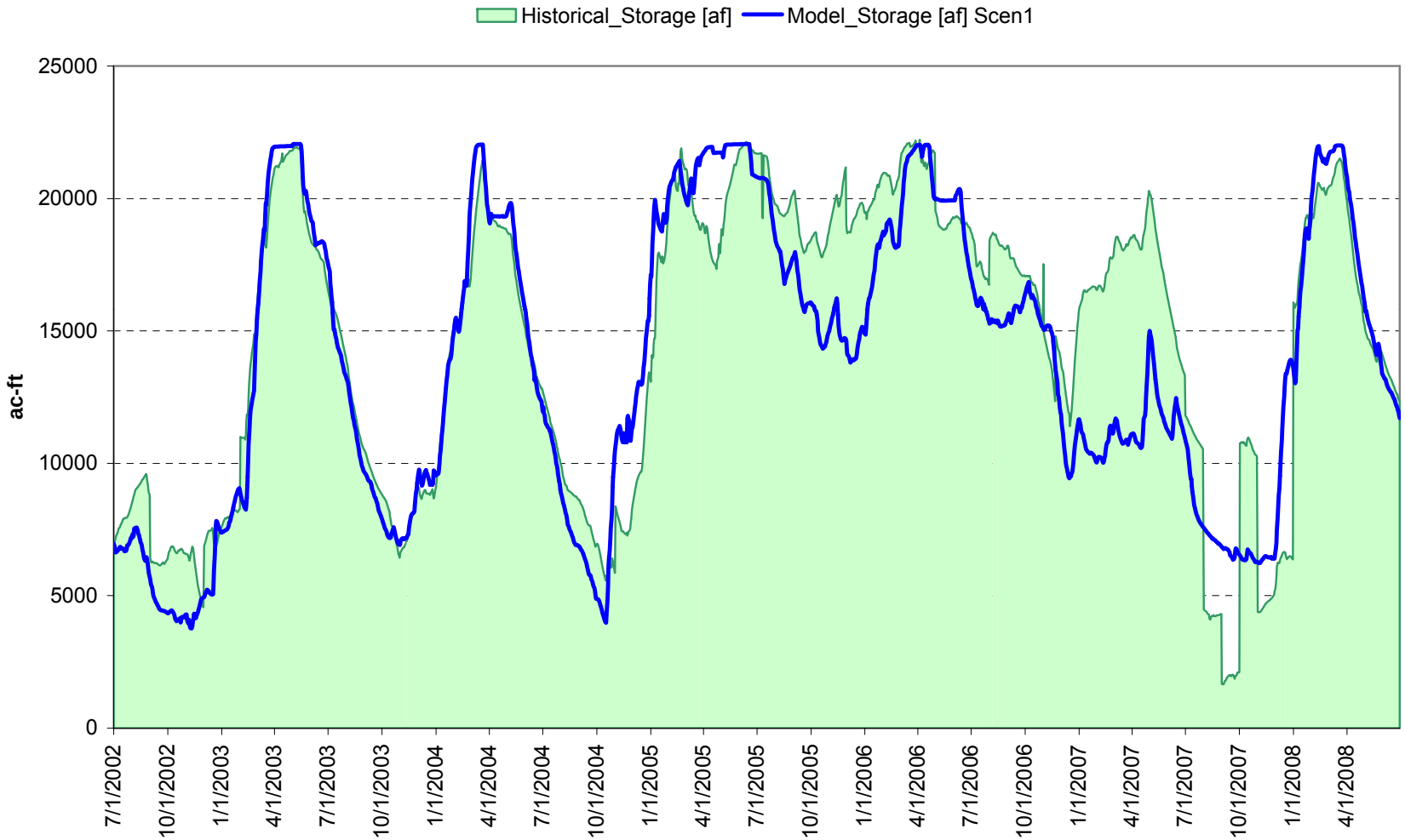
Model vs. Historical Percolation

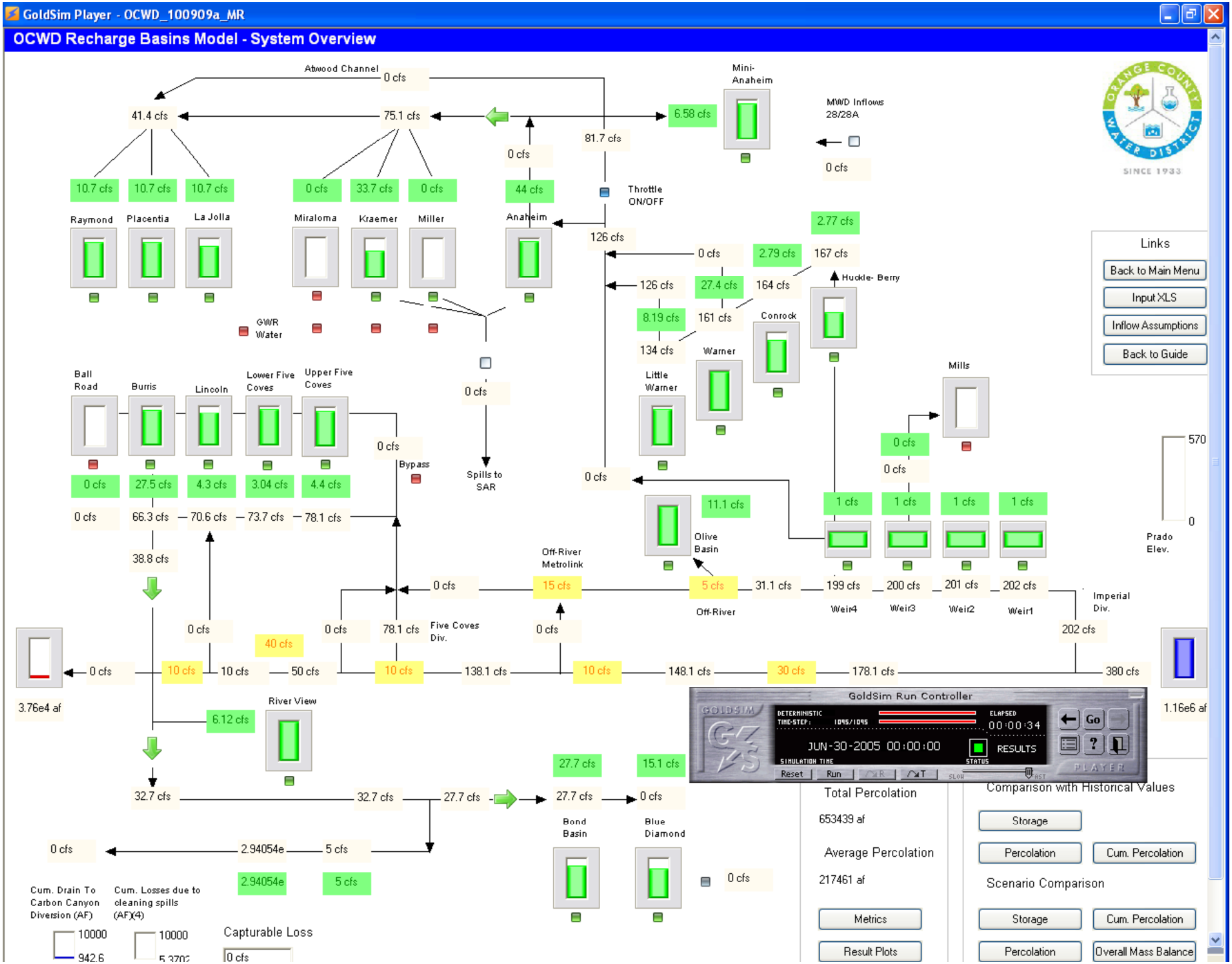
Includes only Warner, Anaheim, Kraemer, Miller, Burris and Santiago Basins



Model vs. Historical Storage

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




GoldSim Player - OCWD_100909a_MR
OCWD Recharge Basins Model - System Overview
Atwood Channel
0 cfs
41.4 cfs
75.1 cfs
81.7 cfs
6.58 cfs
Mini-Anaheim
MWD Inflows 28/28A
0 cfs
10.7 cfs
10.7 cfs
10.7 cfs
0 cfs
33.7 cfs
0 cfs
44 cfs
Throttle ON/OFF
Raymond
Placentia
La Jolla
Miraloma
Kraemer
Miller
Anaheim
126 cfs
2.77 cfs
0 cfs
2.79 cfs
167 cfs
126 cfs
27.4 cfs
164 cfs
Huckle- Berry
8.19 cfs
161 cfs
Conrock
GWR Water
134 cfs
Warner
Little Warner
Mills
Ball Road
Burris
Lincoln
Lower Five Coves
Upper Five Coves
0 cfs
Bypass
Spills to SAR
0 cfs
0 cfs
0 cfs
0 cfs
27.5 cfs
4.3 cfs
3.04 cfs
4.4 cfs
0 cfs
66.3 cfs
70.6 cfs
73.7 cfs
78.1 cfs
38.8 cfs
11.1 cfs
Olive Basin
1 cfs
1 cfs
1 cfs
1 cfs
570
0
Prado Elev.
Off-River Metrolink
0 cfs
15 cfs
5 cfs
31.1 cfs
199 cfs
200 cfs
201 cfs
202 cfs
Off-River
Weir4
Weir3
Weir2
Weir1
Imperial Div.
0 cfs
78.1 cfs
Five Coves Div.
0 cfs
202 cfs
40 cfs
0 cfs
10 cfs
10 cfs
50 cfs
10 cfs
138.1 cfs
10 cfs
148.1 cfs
30 cfs
178.1 cfs
380 cfs
3.76e4 af
1.16e6 af
River View
6.12 cfs
27.7 cfs
15.1 cfs
32.7 cfs
32.7 cfs
27.7 cfs
27.7 cfs
0 cfs
Bond Basin
Blue Diamond
0 cfs
2.94054e
5 cfs
2.94054e
5 cfs
0 cfs
Cum. Drain To Carbon Canyon Diversion (AF)
Cum. Losses due to cleaning spills (AF)(4)
10000
942.6
10000
Capturable Loss
0 cfs
GoldSim Run Controller
DETERMINISTIC
TIME-STEP:
1095/1095
ELAPSED
00:00:34
JUN-30-2005 00:00:00
SIMULATION TIME
STATUS
RESULTS
Go
Reset
Run
PLAYER
Links
Back to Main Menu
Input XLS
Inflow Assumptions
Back to Guide
Total Percolation
653439 af
Average Percolation
217461 af
Metrics
Result Plots
Comparison with Historical Values
Storage
Percolation
Cum. Percolation
Scenario Comparison
Storage
Cum. Percolation
Percolation
Overall Mass Balance
ORANGE COUNTY WATER DISTRICT
SINCE 1933