Next Generation Artificial Intelligence Continuous Simulation Model of Cranes Roost

Integrated Surface Water-Reclaimed Water-Stormwater Storage & Retrieval System

ASCE EWRI EAST CENTRAL FLORIDA BRANCH
OCTOBER TECHNICAL LUNCHEON

When: Thursday, October 18, 2012
Where: Sheraton Downtown Orlando

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PRESENTATION OUTLINE

- **The Water Body:** *Its Location, Genesis, Geographic Coverage of it Basin, Function, & Goals [with helicopter tour - take your Dramamine]*
- **The Permitting & Environmental Constraints:** *Satisfying Many Masters*
- **The Model Conceptualization:** *Full Integration of Surface Water & Ground Water in a Land-locked Basin interconnected to a cascading series of upstream lakes*
- **The Challenges faced by the Modeler:** *he stood in his shoes and he wondered, and he wondered.*
- **The "Souped-Up" Software Which Was Coded to Meet the Challenge:** *PONDS 3.3 Next Generation Continuous Simulation Module*

PRESENTATION OUTLINE (CONTINUED)

- **The Raw Data:** *the drudgery of data mining is only exceeded by the drudgery of Quality Control checks [Rainfall, ET, Evaporation, Historic Pumping Records, Lake levels, Deep Aquifer Elevations, Shallow Aquifer Levels, etc.]*
- **The 21+ Year Model Calibration:** *the heavy lifting*
- **Predictive Simulations Using the Calibrated Model:** *Deep Blue's Chess Match with Kasparov--using the computer to seek out a real-world operating schedule which satisfies all Masters*
- **Historical Simulations:** *Discharges to Little Wekiva River with and without reclaimed water storage*
- **The Permit Submission & The Permit Issuance:** *doing it right with a full-blown pre-application presentation with all disciplines (stormwater, hydrogeologists, wetland ecologists, etc.)…the result = no R.A.I.*

WATERSHED & PUMPING FACILITIES

- **Cranes Roost is the principal drainage feature within the Central Business District of the City of Altamonte Springs. It is an internally drained 45± acre lake east of Interstate 4 and north of State Road 436. There is no natural surface outlet from Cranes Roost.**

- **The Cranes Roost water body is the terminal receiving lake for an approximately 1931± acre watershed that comprises a variety of urban land uses, and three other major upstream lakes which drain into Cranes Roost: Lake Mobile, Lake Florida, and Lake Adelaide.**

- **In 1977, the City constructed a 7,100 gpm 2-stage pump station (2 pumps) and force main system that discharges to the Little Wekiva River during periods of high water levels.**

- **Reclaimed water storage and recovery from Cranes Roost (2001 FDEP permit requires the retrieved water to be sent to the treatment plant prior to distribution via the reclaimed system).**

- **Let us now start a helicopter tour of the basin as it exists today.**

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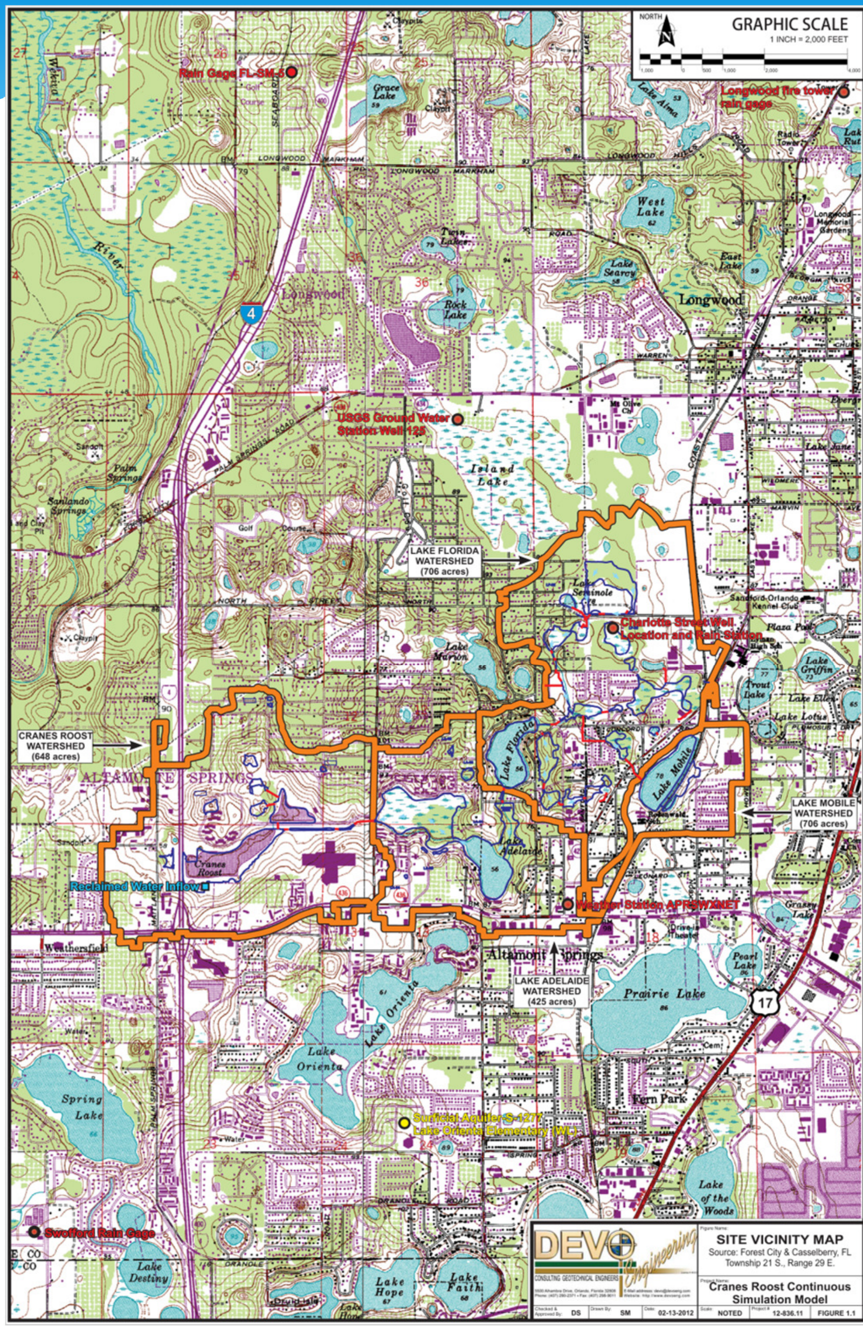
GOOGLE EARTH TOUR

CRANES ROOST HELICOPTER TOUR

Movie can be downloaded
from separate link on the website

WATERSHED & PUMPING FACILITIES ON GOOGLE EARTH ANIMATED MAP

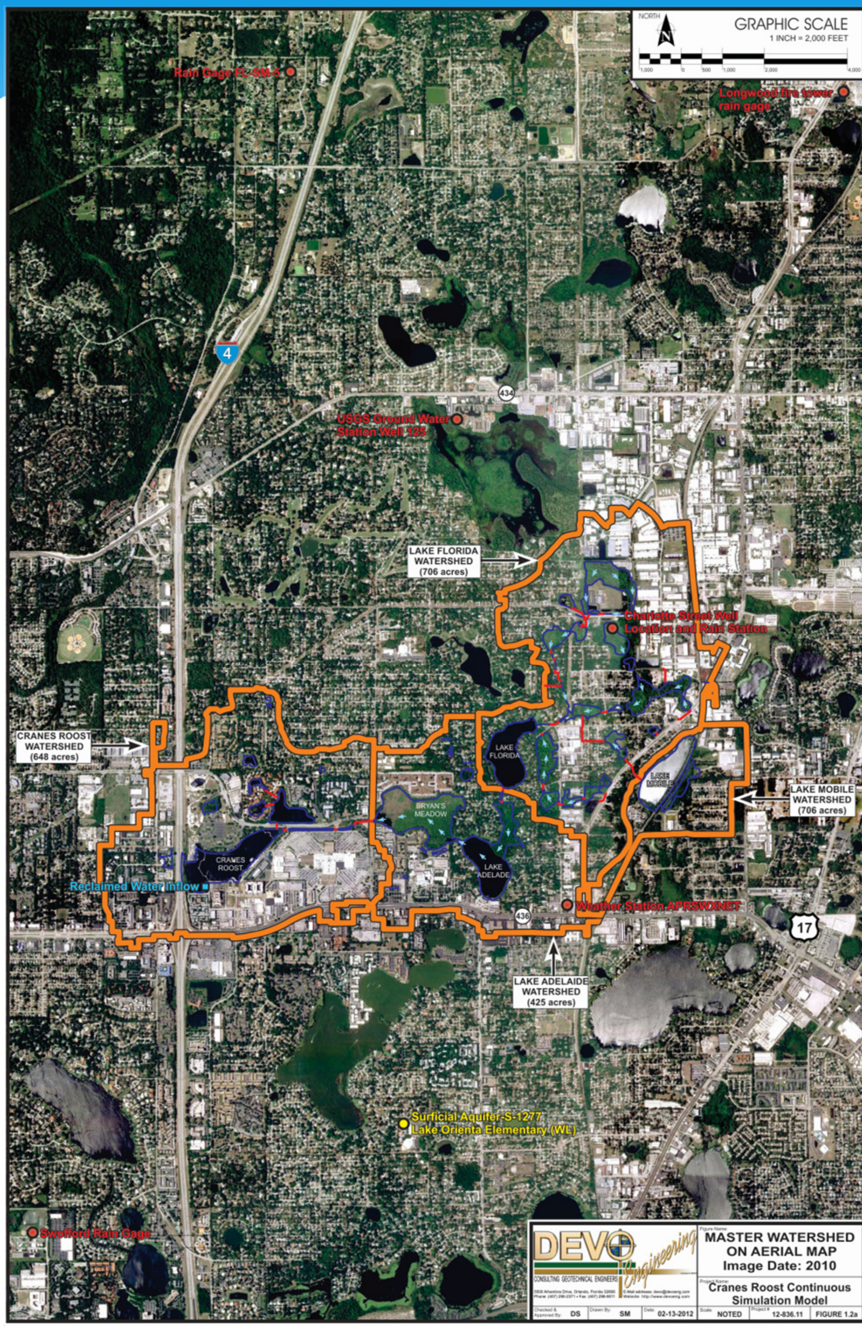
STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



WATERSHED ON SITE VICINITY MAP

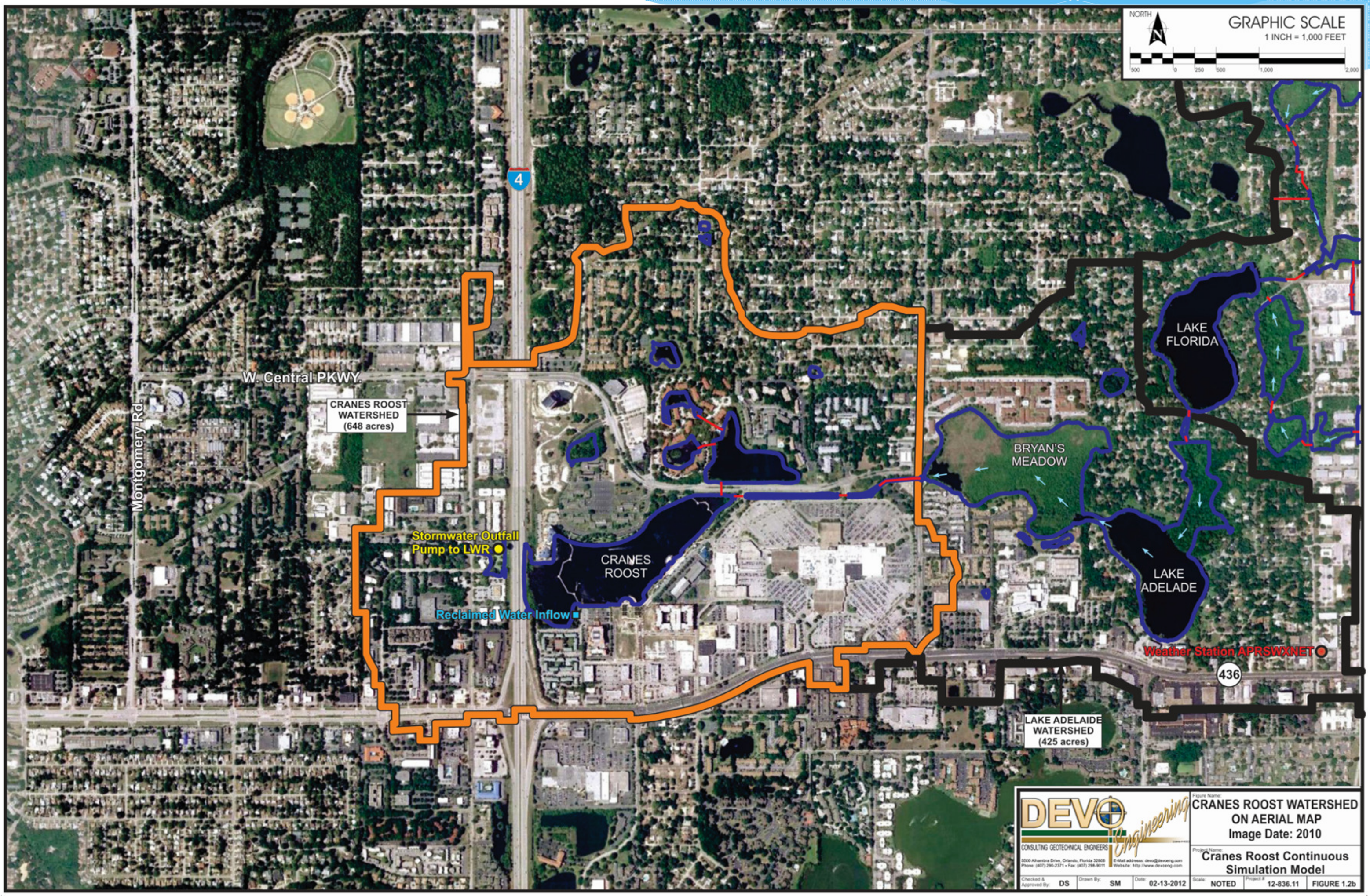
Forest City & Casselberry, Florida

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



WATERSHED ON 2010 AERIAL MAP

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



WATERSHED ON 2010 AERIAL MAP

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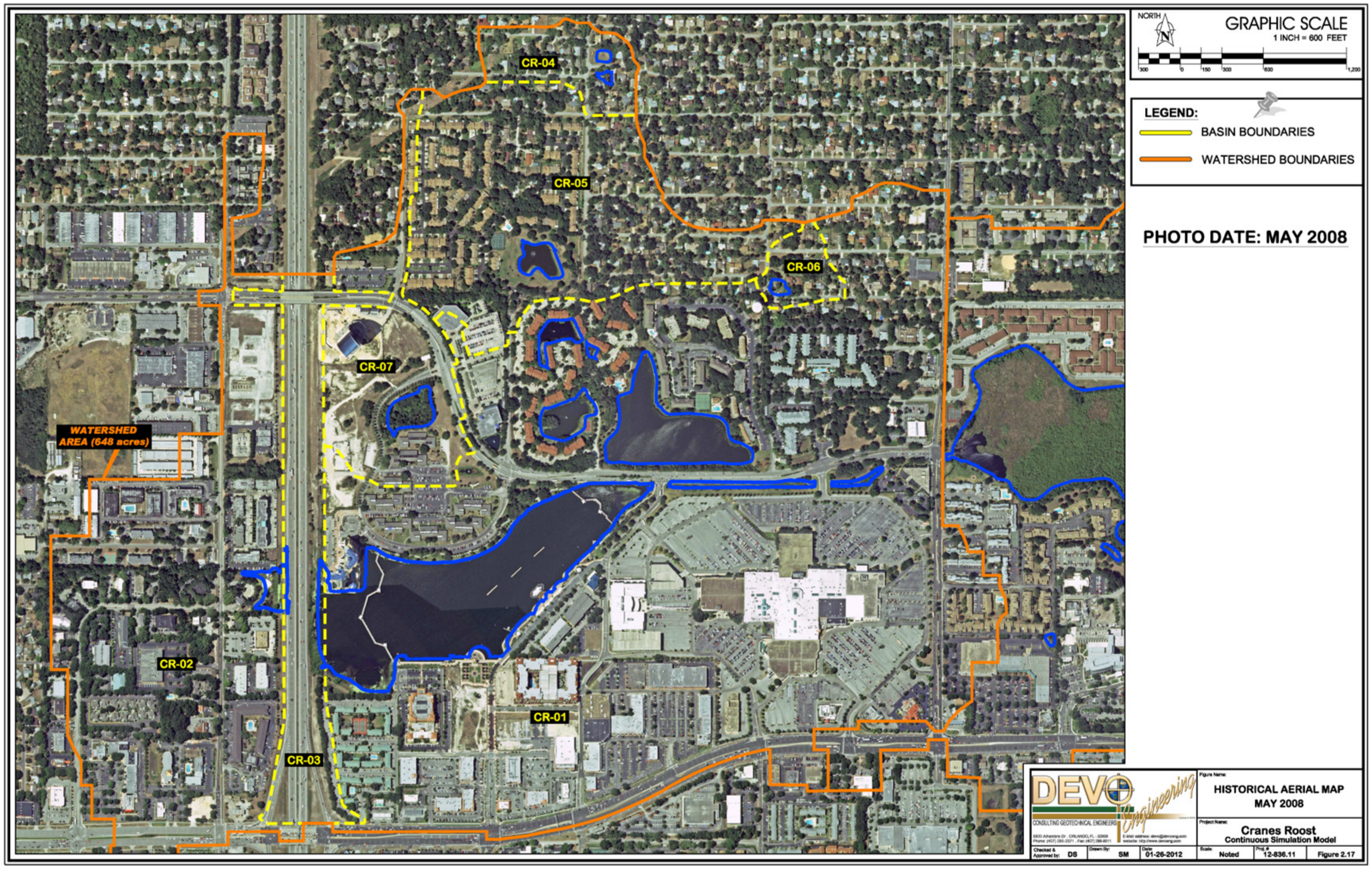
STORMWATER AND RECLAIMED WATER INTEGRATED PLANS

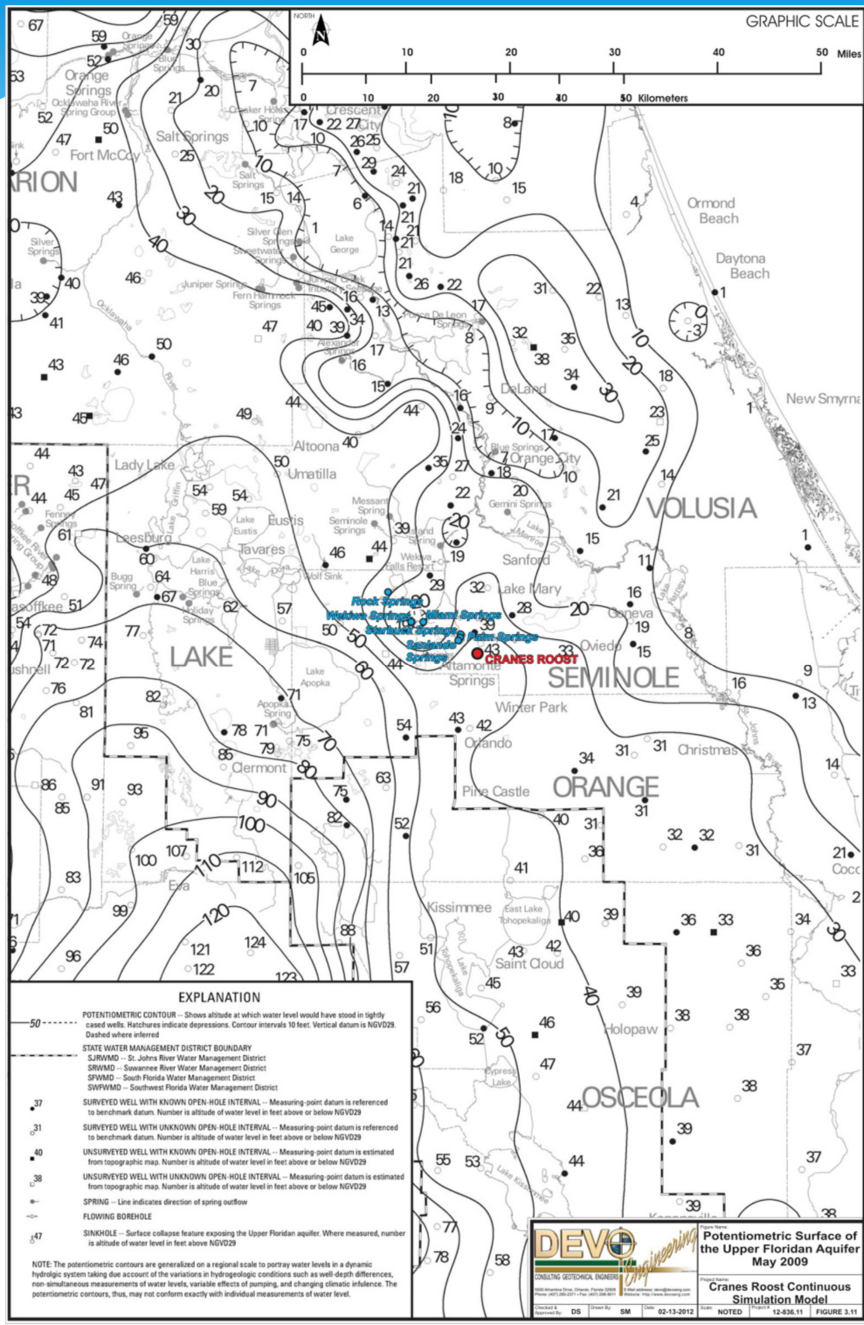


HISTORICAL AERIAL MAP MAY 2008

CRANES ROOST INTEGRATED STORMWATER

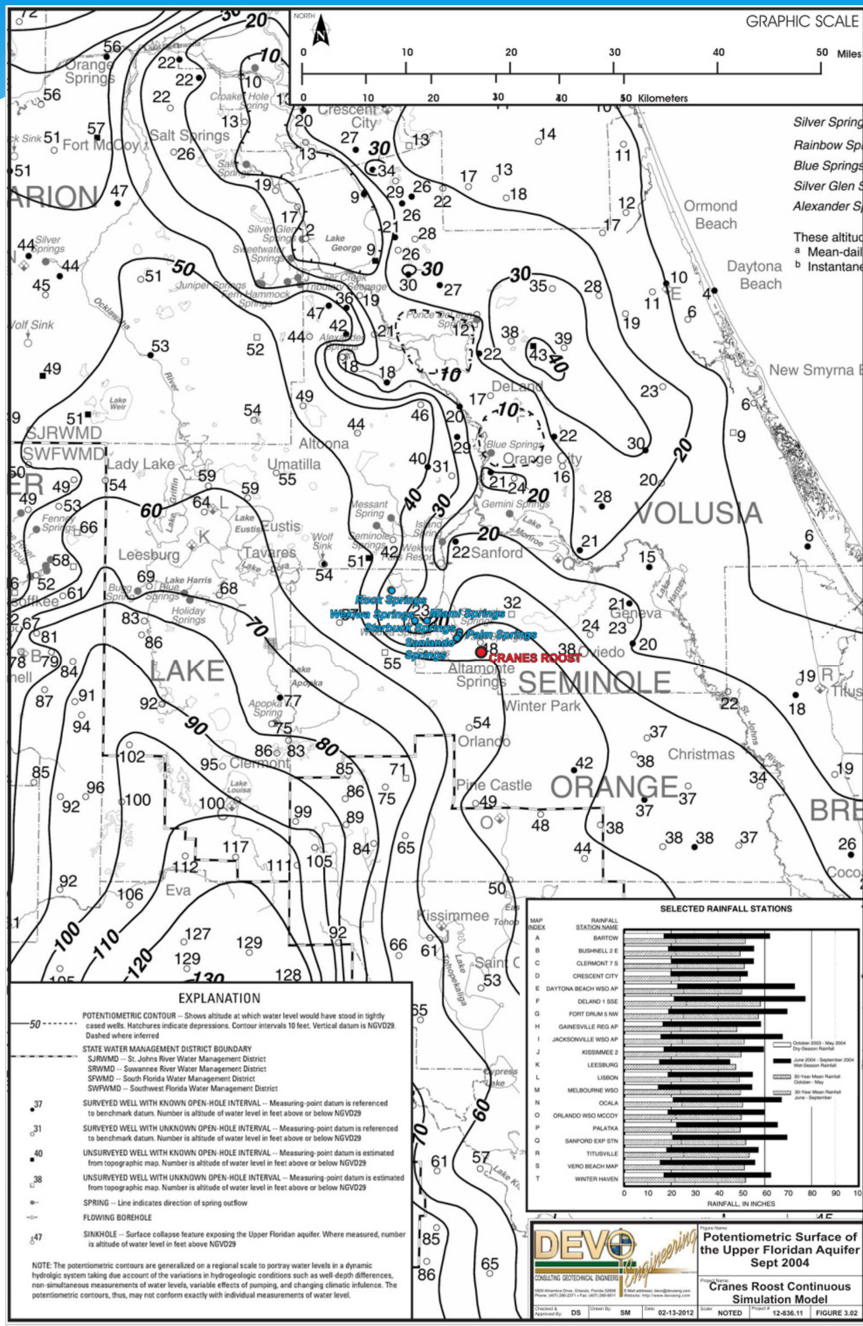
CRANES ROOST INTEGRATED STORMWATER/RECLAIMED WATER FACILITY

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER MAY 2009

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS

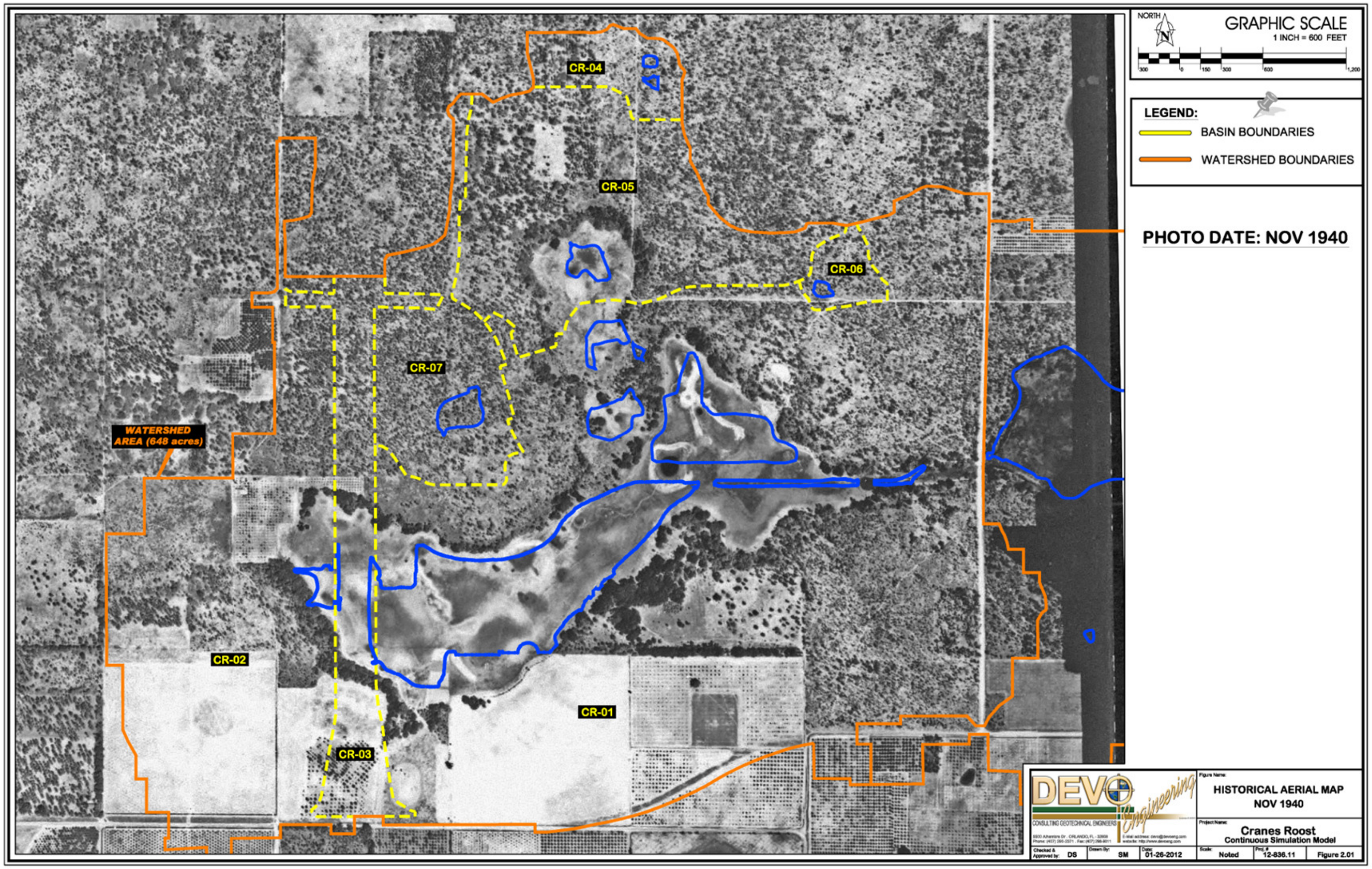


POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER SEPT.2004

THE EARLY YEARS
(NOVEMBER 1940 TO THE PRESENT)

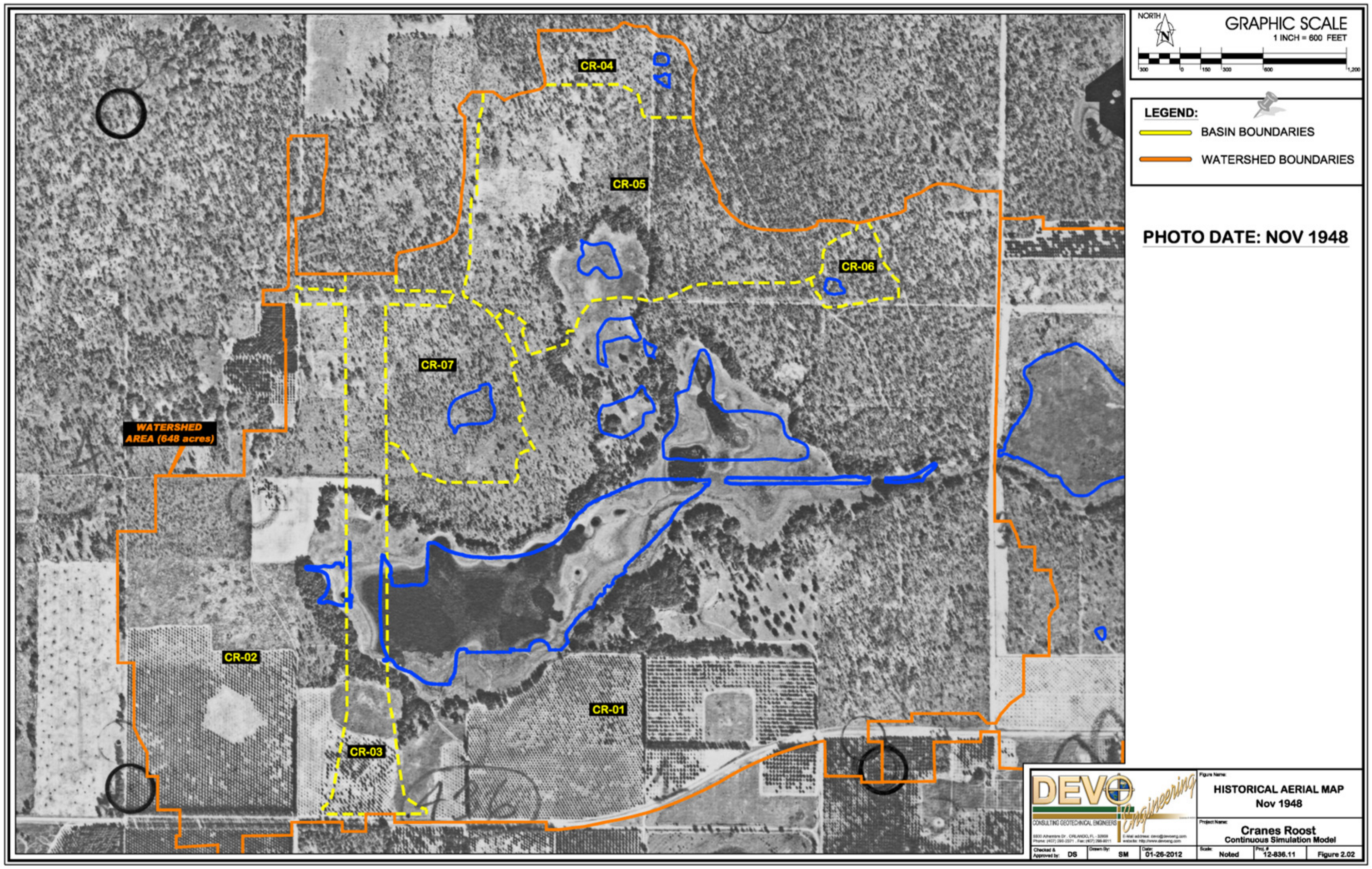
- Historical aerial photos of Cranes Roost dating back to as early as November 1940 are available.
- Cranes Roost is a former marsh and crane habitat that was dredged in the early 1960's as a source of fill material for use in the construction of Interstate Highway 4.
- October 1964 image: first one following the construction of Interstate 4.
- Photos of 1940, 1948, and 1957 show that Cranes Roost was seasonally inundated in some of the depressional features. The March 1957 aerial shows it being completely dry.
- It became a single large wet-bottom water body after its excavation in 1960, although it appears to have been dewatered and excavated again in 1972, possibly for the filling of the CenterPointe Office Park now on its north shoreline.
- Altamonte Mall is seen to be under construction in the February 1973 aerial.
- Land cover within the Cranes Roost direct and interconnected watershed is almost fully developed by the early 1980's, with a significant addition of impervious area.

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



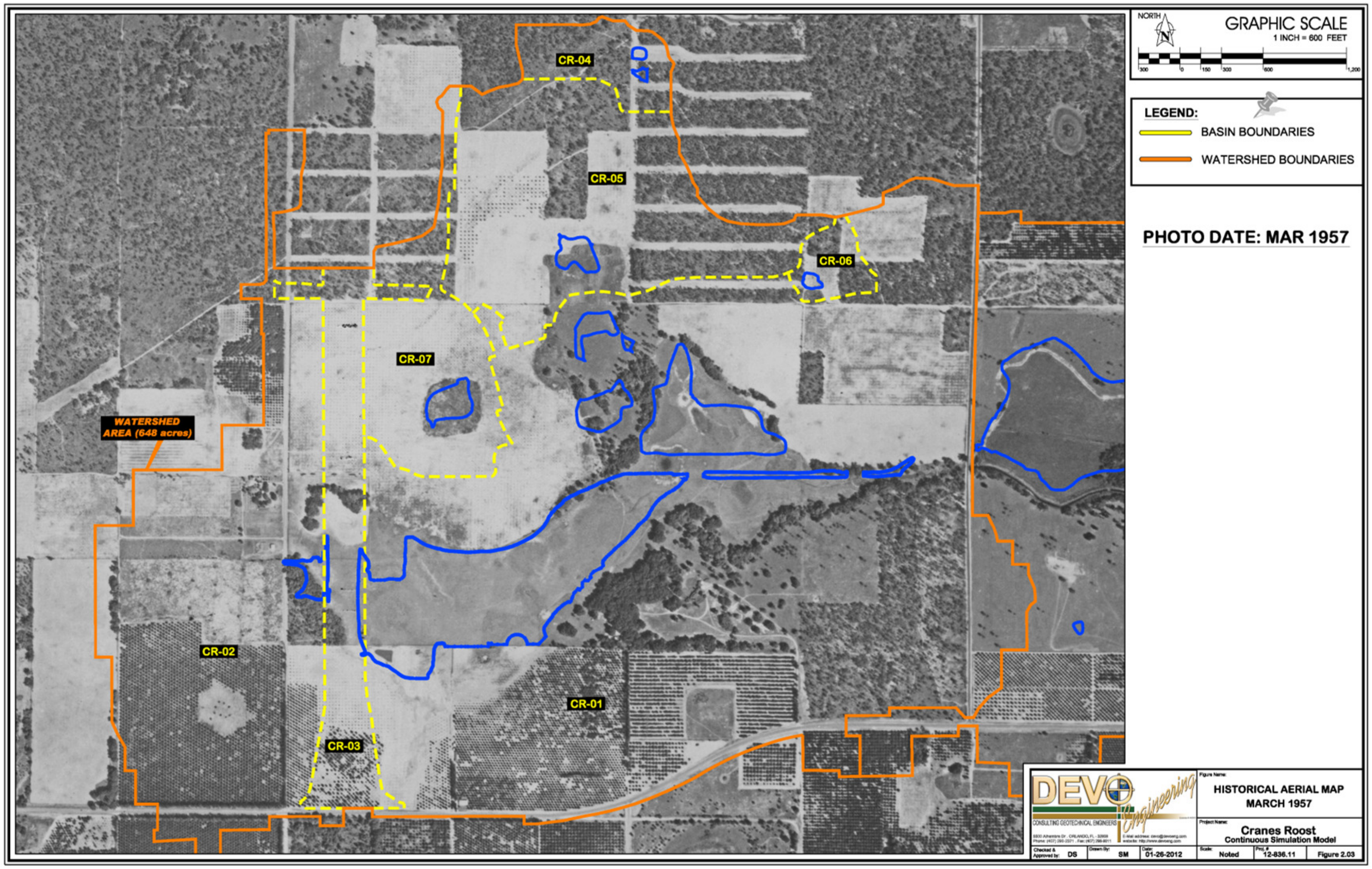
HISTORICAL AERIAL MAP NOV. 1940

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



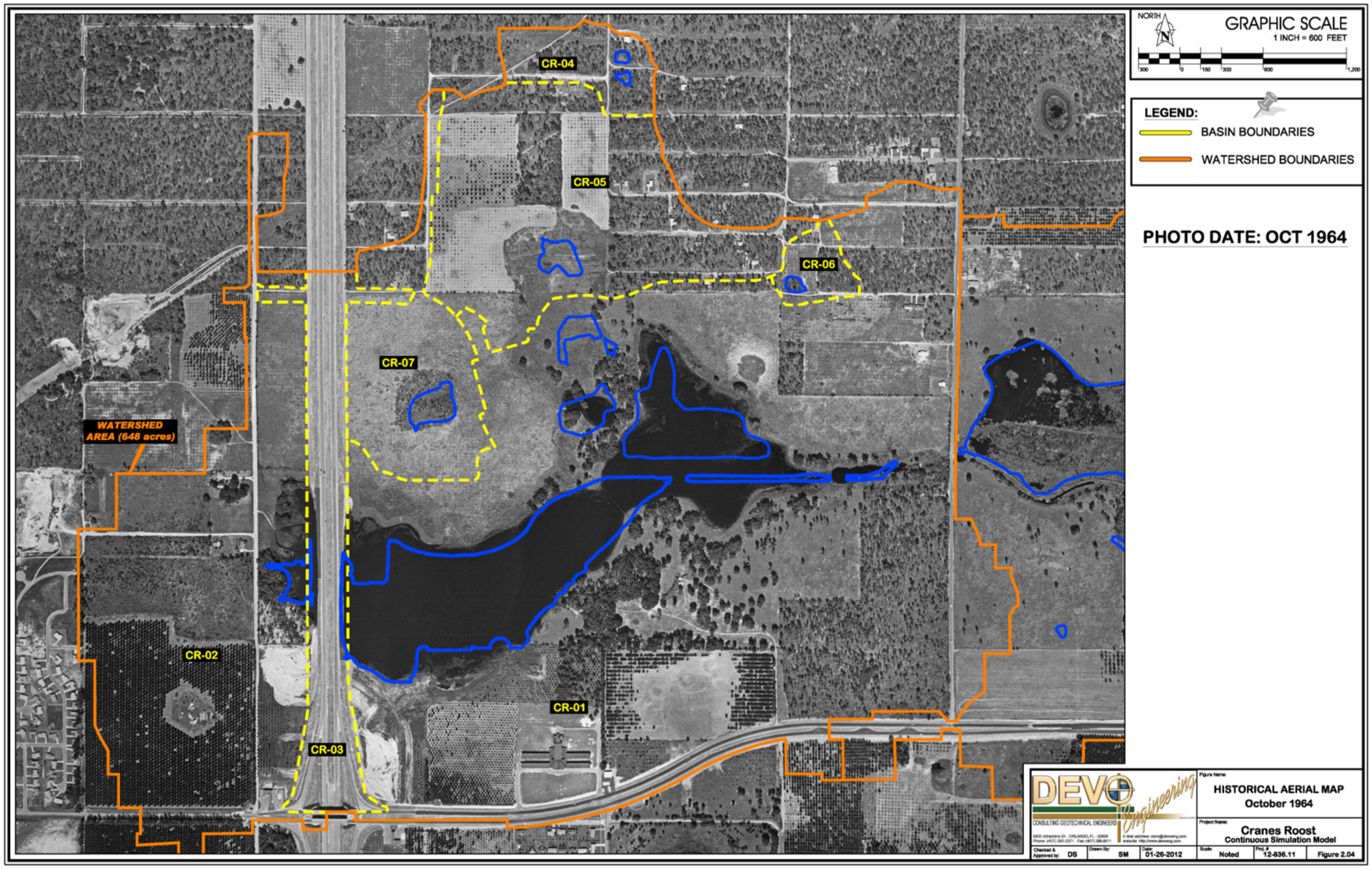
HISTORICAL AERIAL MAP NOV. 1948

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



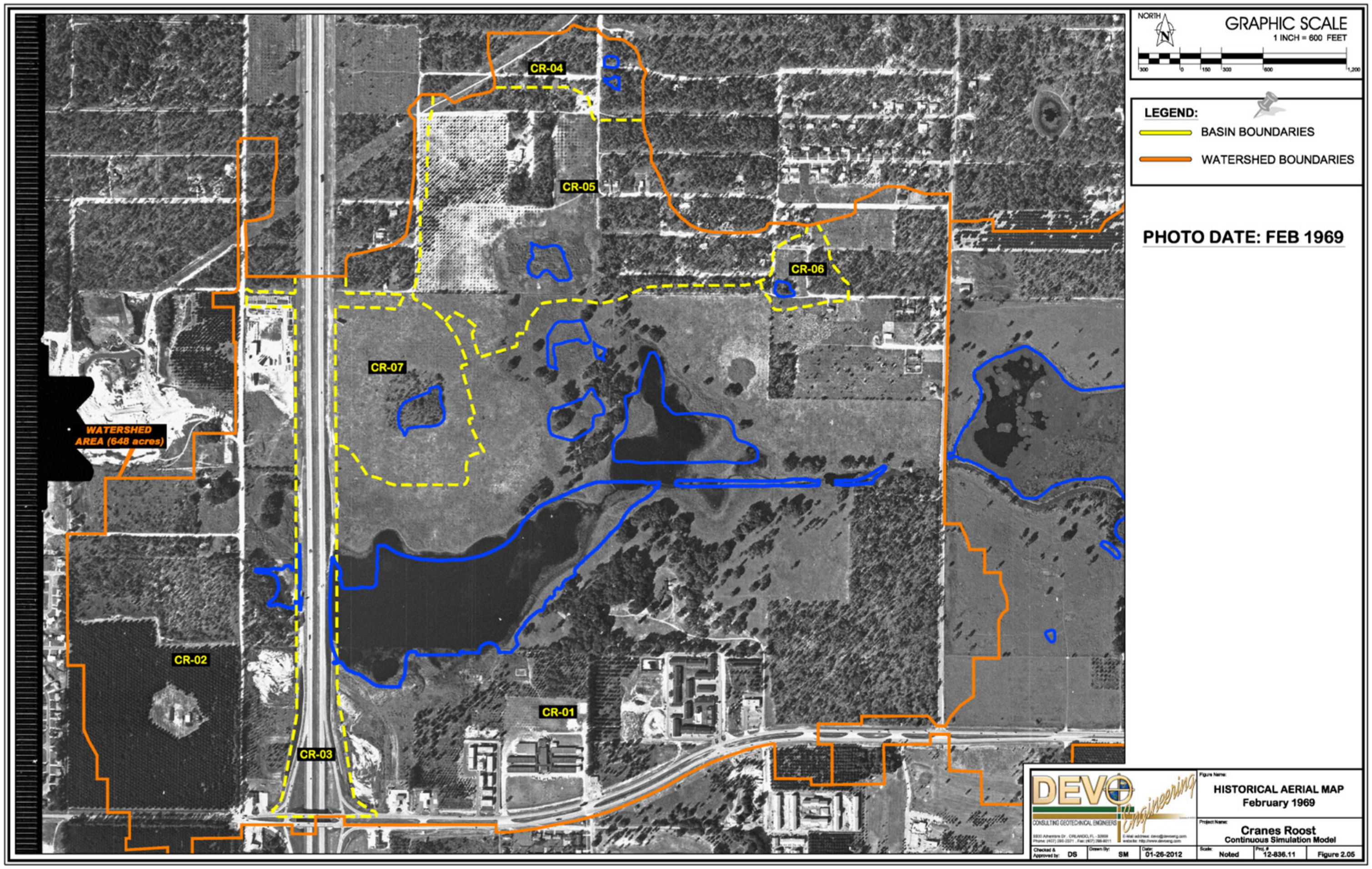
HISTORICAL AERIAL MAP MAR. 1957

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



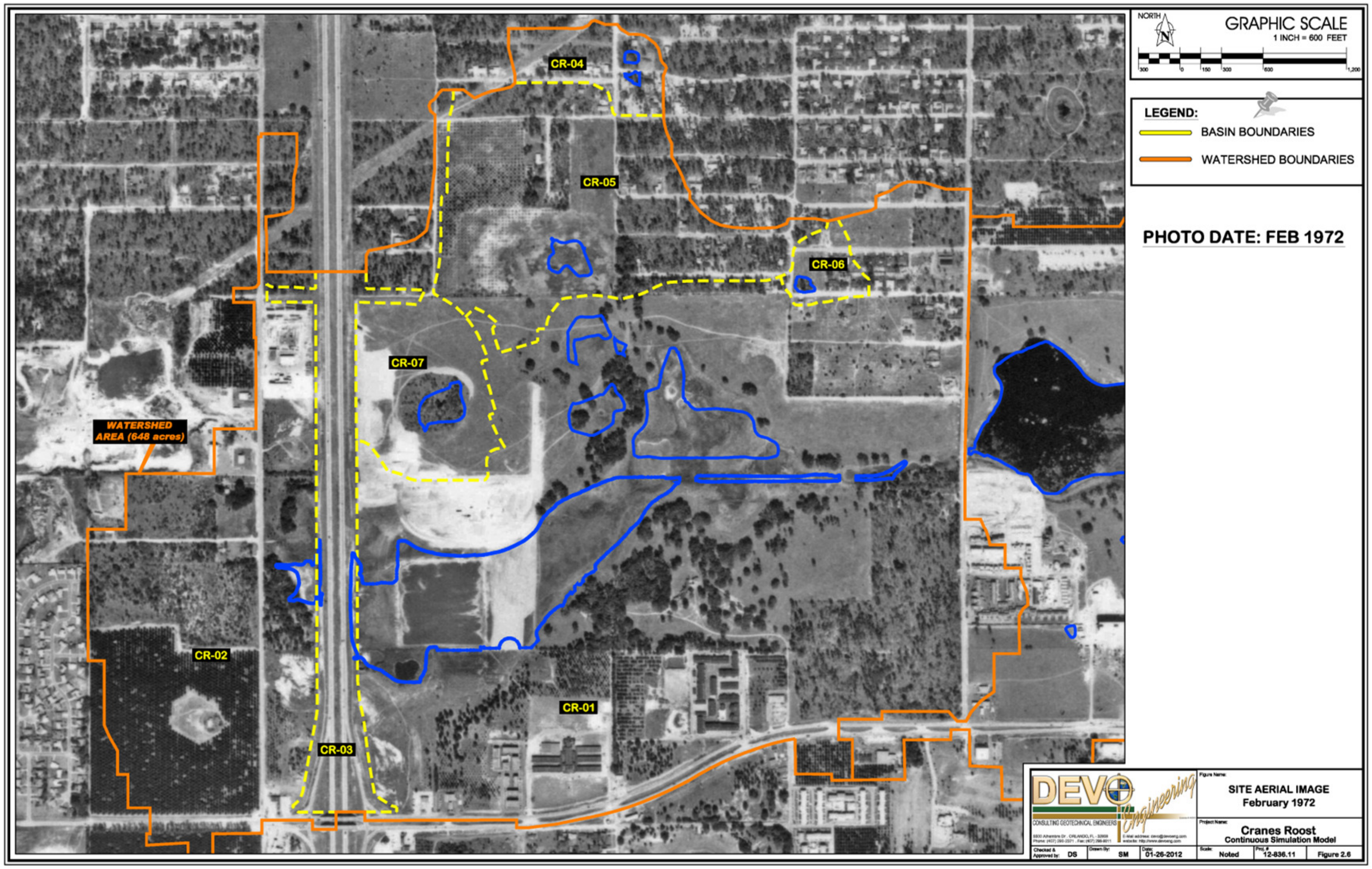
HISTORICAL AERIAL MAP OCT. 1964

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



HISTORICAL AERIAL MAP FEB. 1969

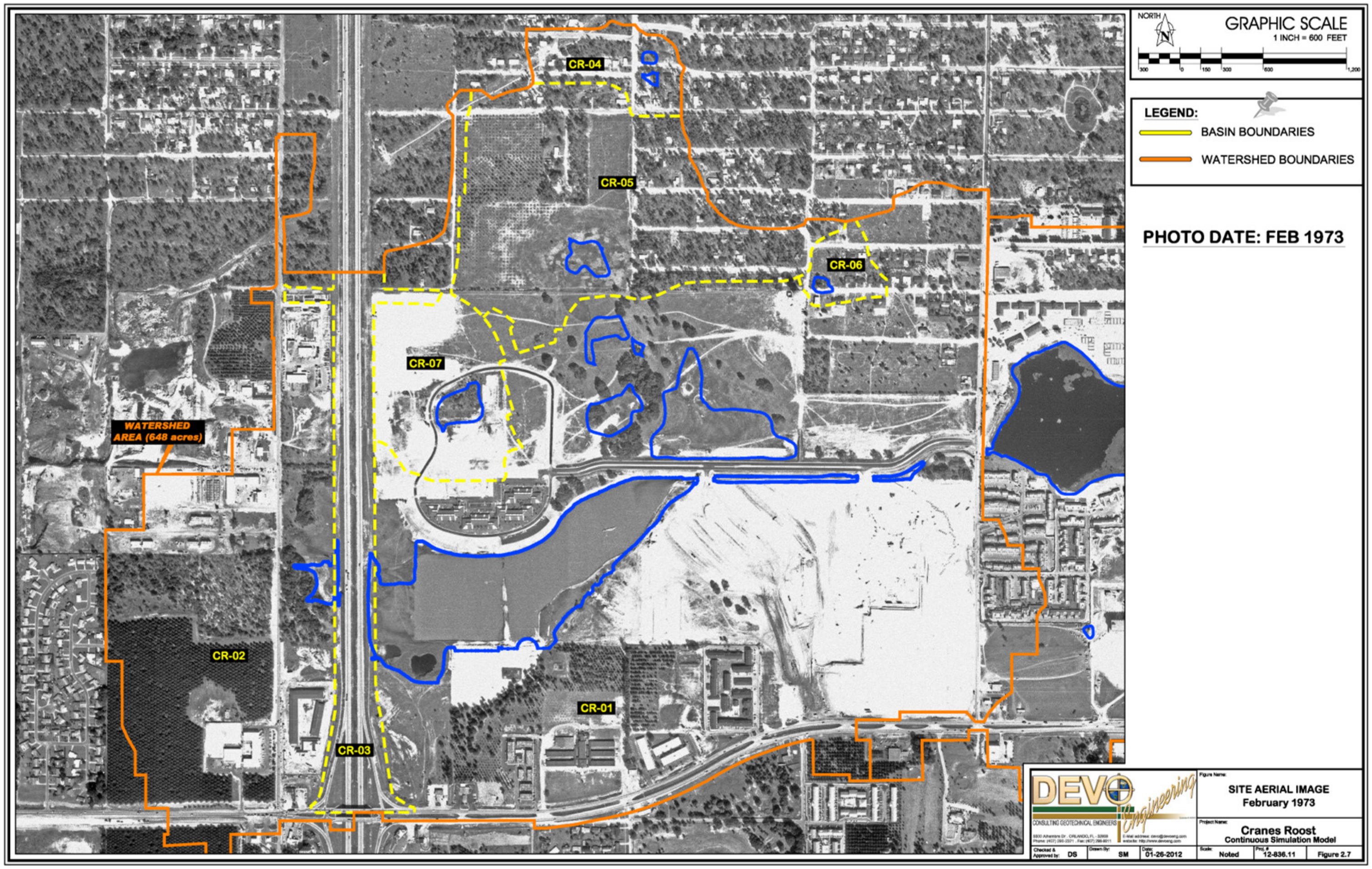
STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



HISTORICAL AERIAL MAP FEB. 1972

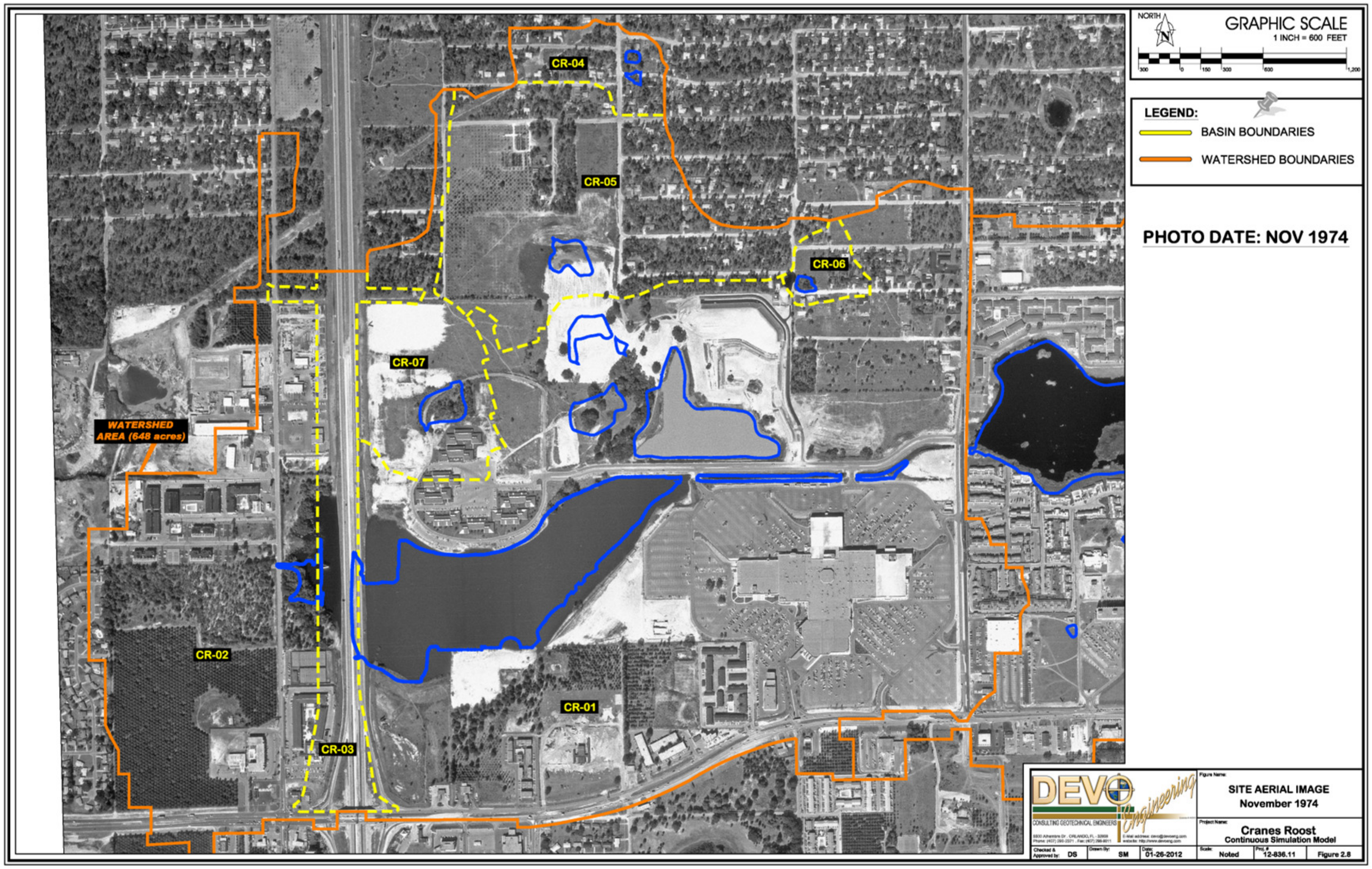
CRANES ROOST INTEGRATED STORMWATER
CRANES ROOST INTEGRATED STORMWATER/RECLAIMED WATER FACILITY

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



HISTORICAL AERIAL MAP FEB. 1973

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



HISTORICAL AERIAL MAP NOV. 1974

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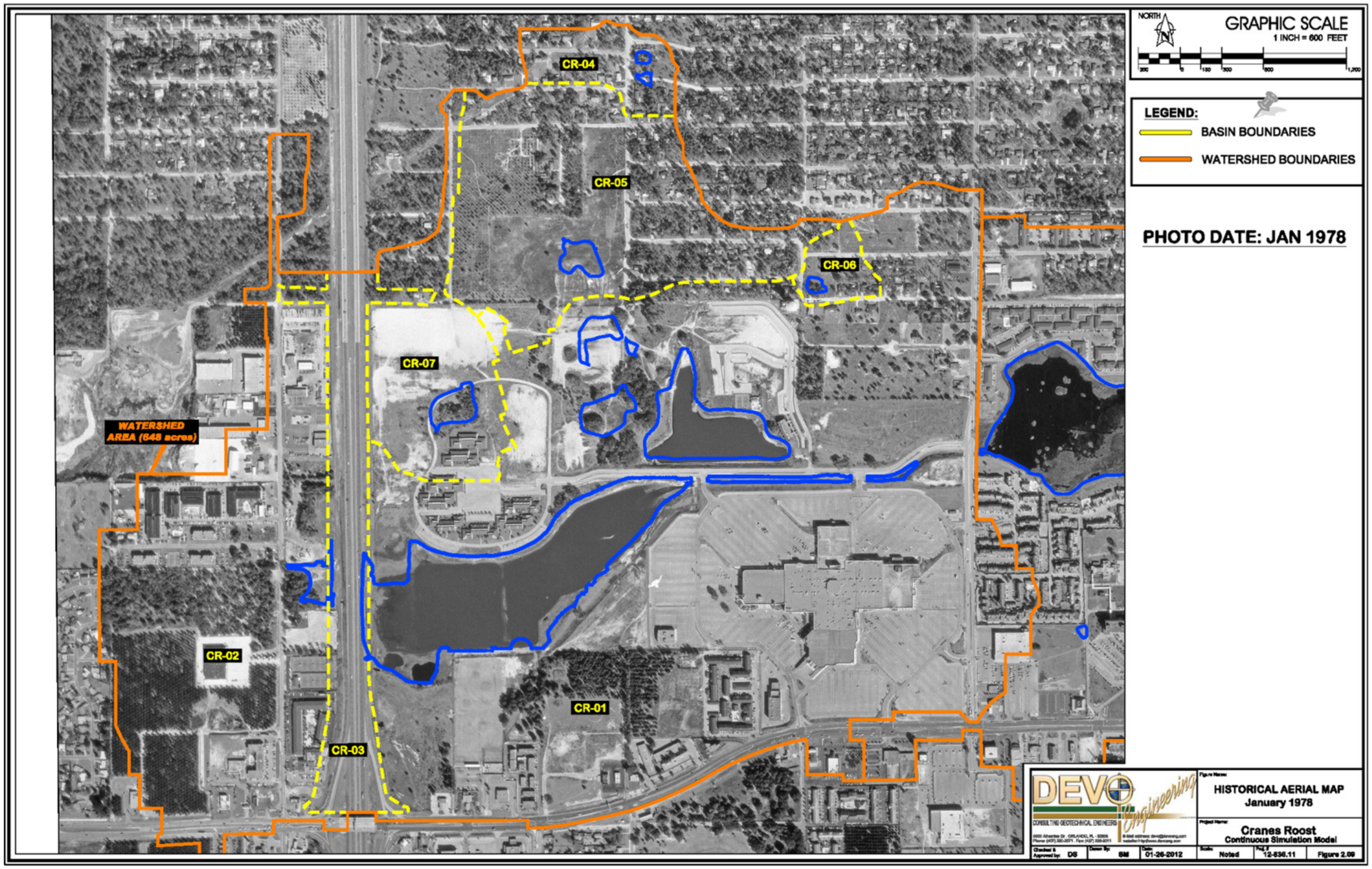
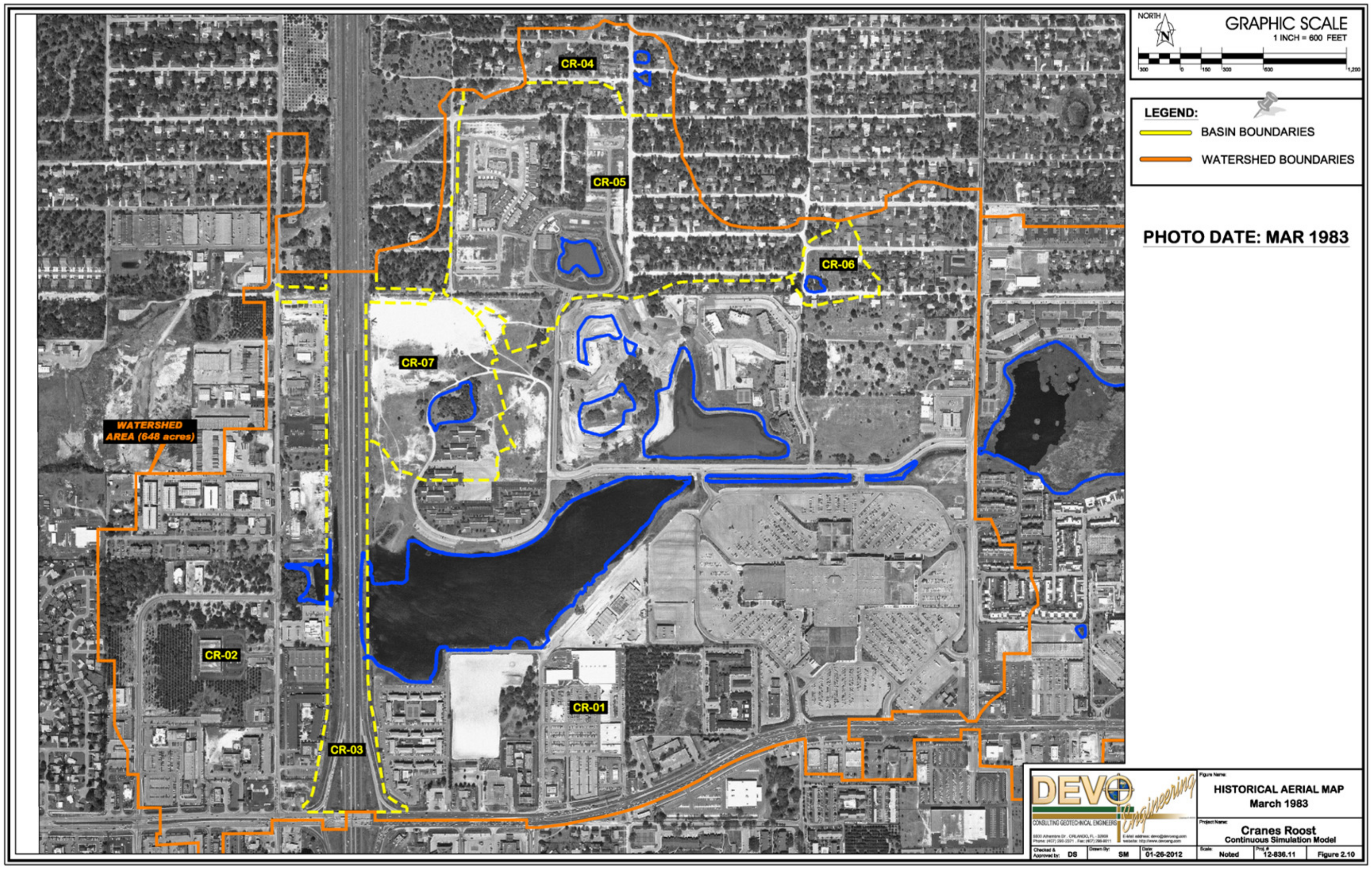
STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



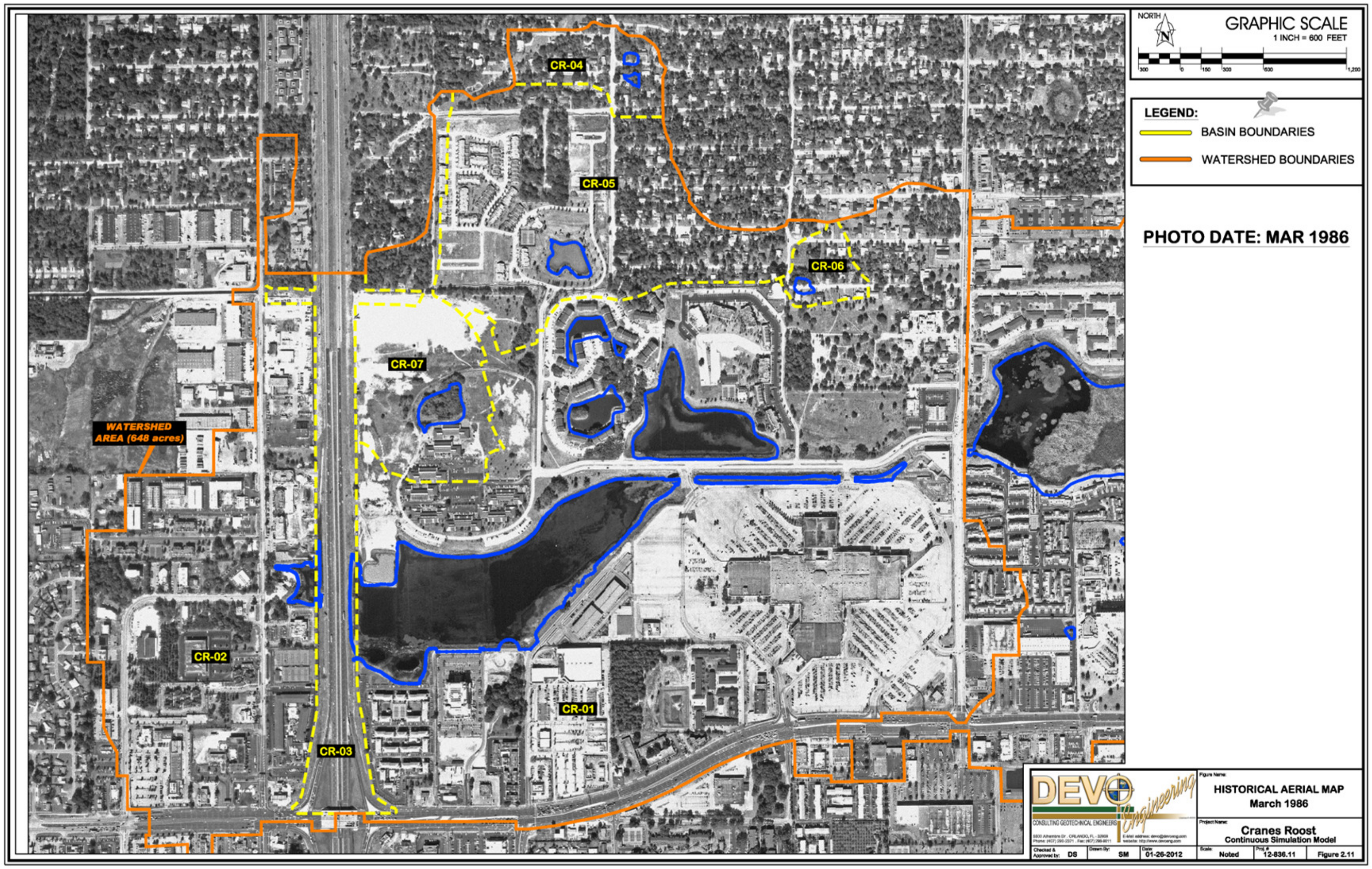
HISTORICAL AERIAL MAP JAN. 1978

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



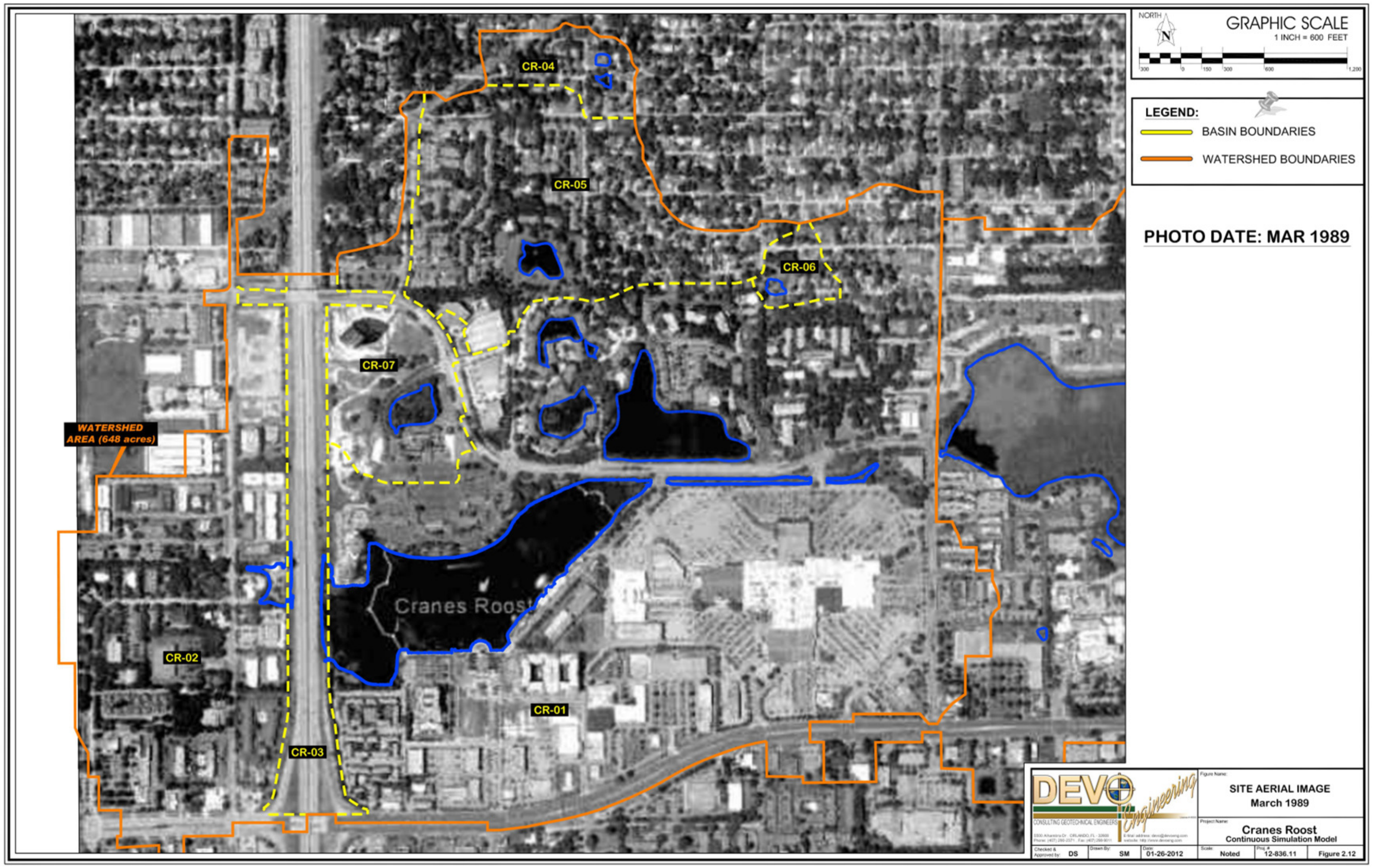
HISTORICAL AERIAL MAP MAR. 1983

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



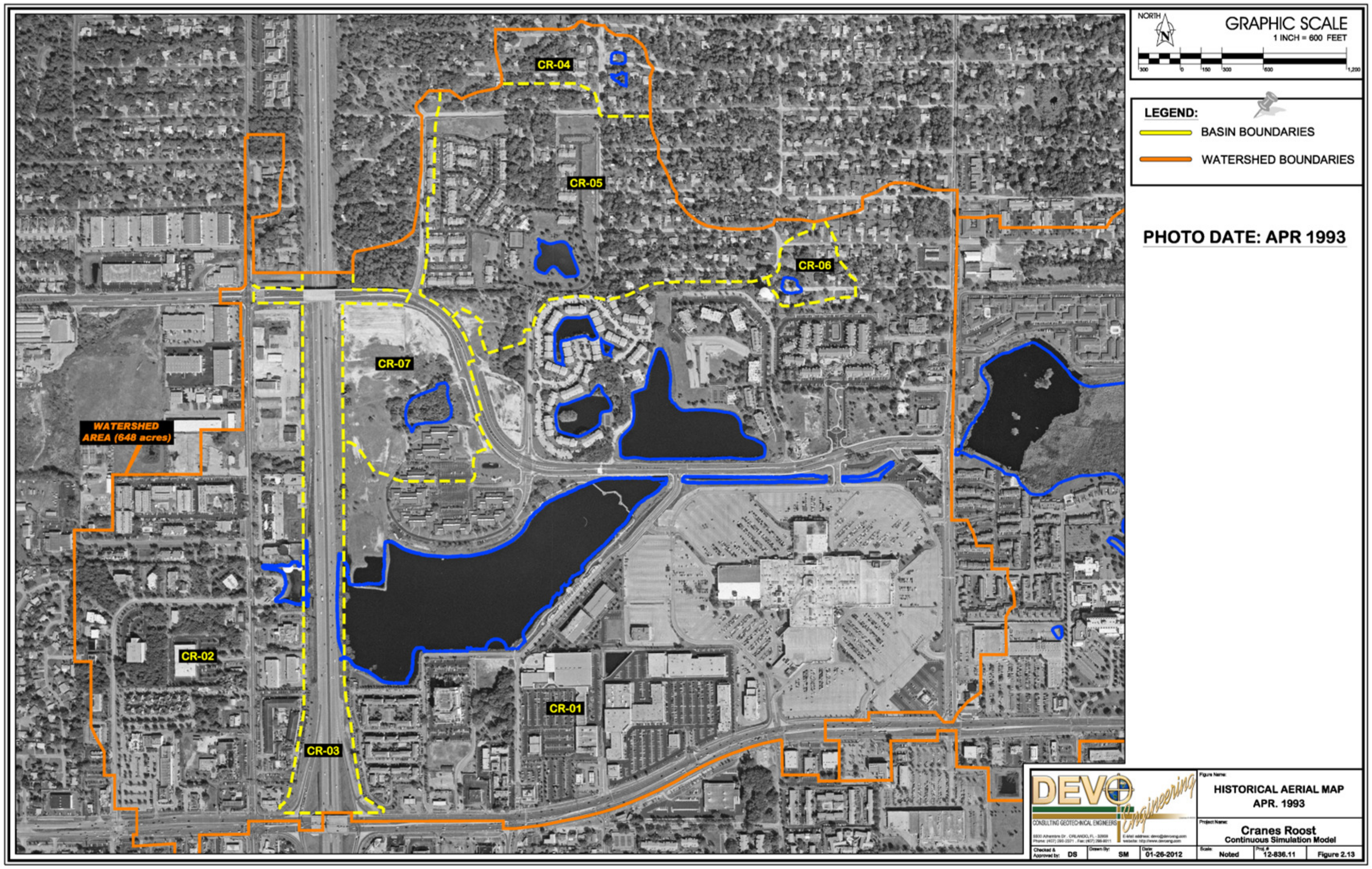
HISTORICAL AERIAL MAP MAR. 1986

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



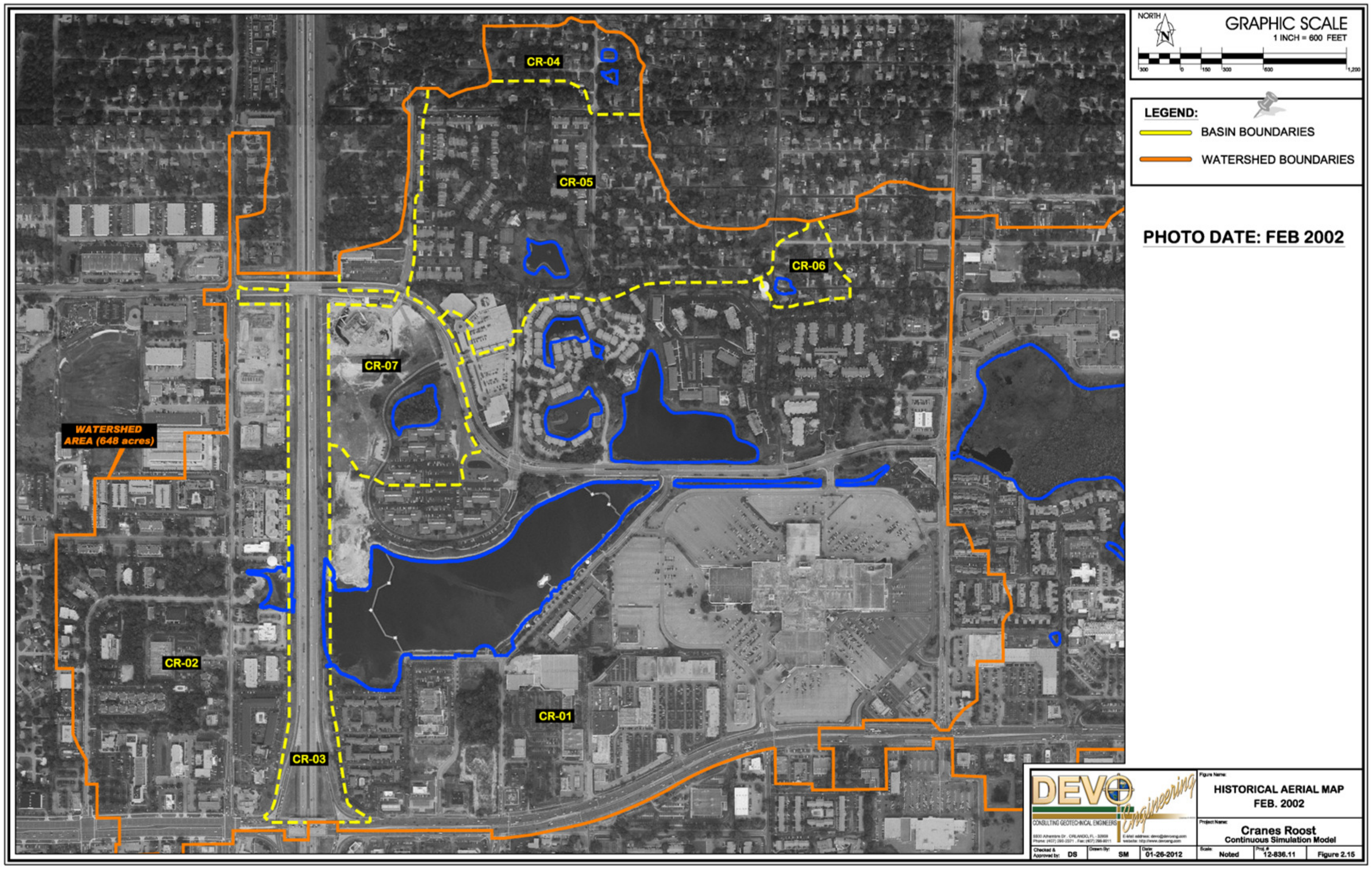
HISTORICAL AERIAL MAP MAR. 1989

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



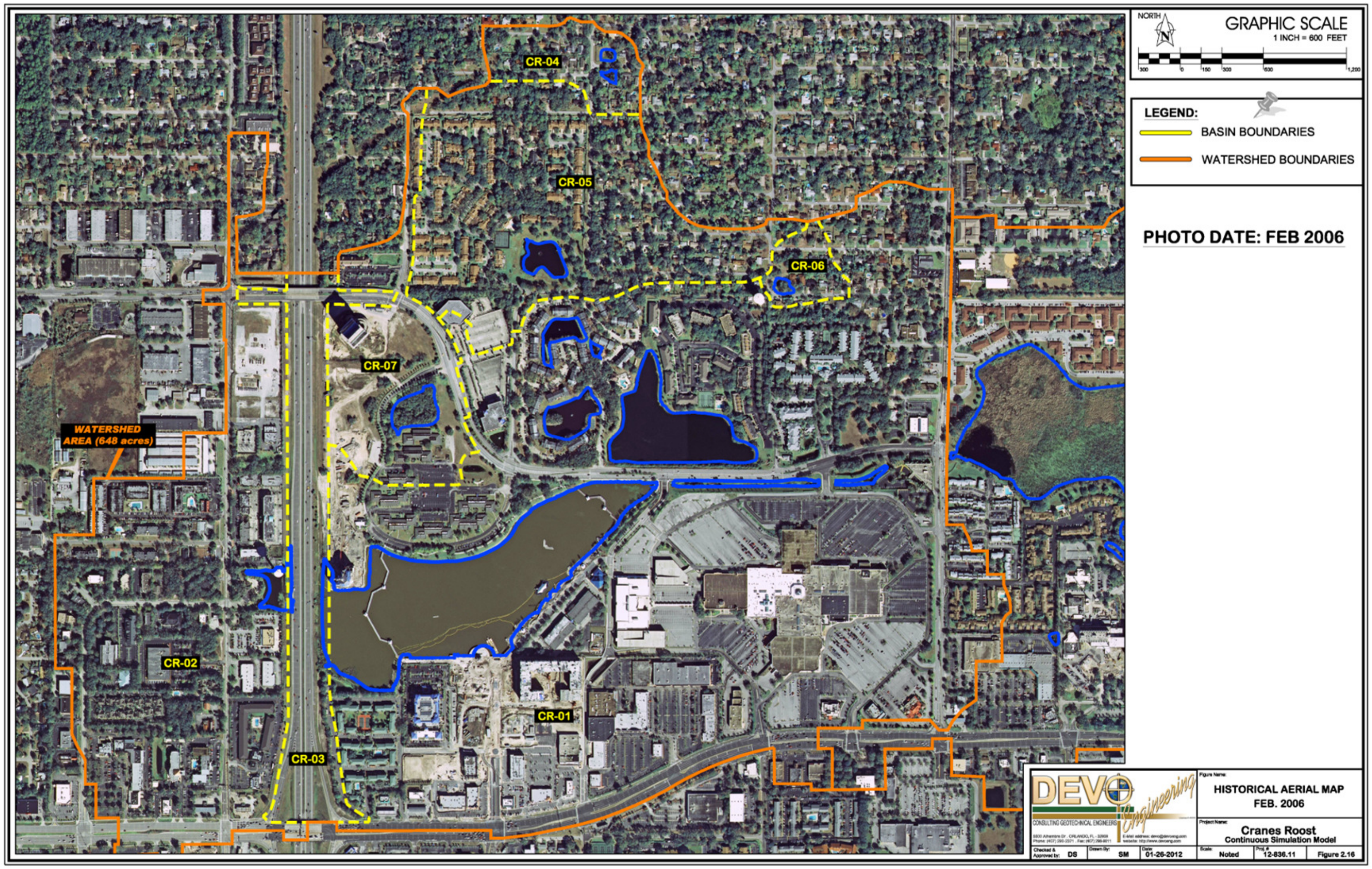
HISTORICAL AERIAL MAP APR. 1993

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



HISTORICAL AERIAL MAP FEB 2002

STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



HISTORICAL AERIAL MAP FEB 2006

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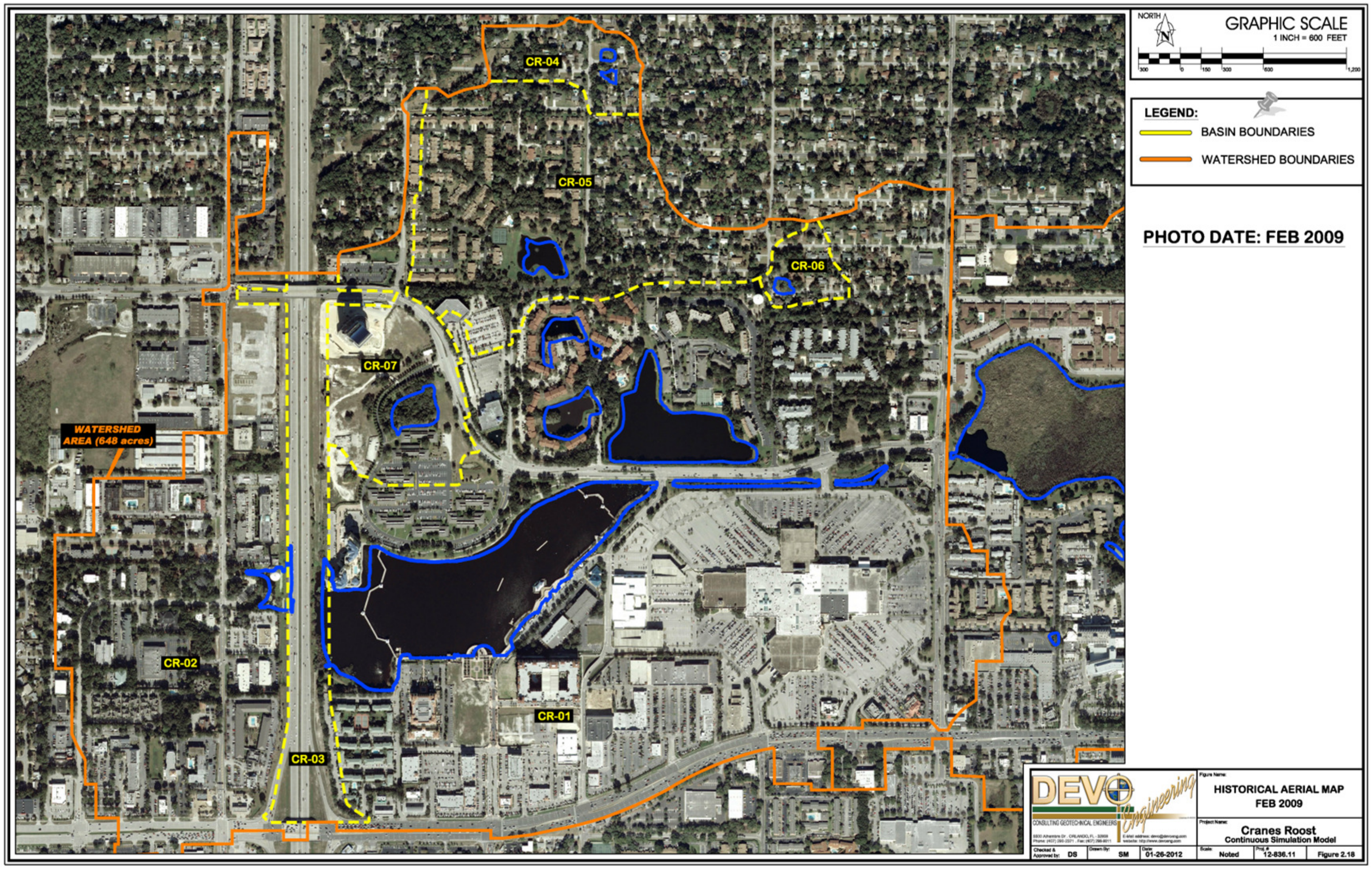
STORMWATER AND RECLAIMED WATER INTEGRATED PLANS



HISTORICAL AERIAL MAP FEB. 2009

STORMWATER PUMP STATION PERMIT

SJRWMD limits on the operation of this stormwater discharge system are as follows:

1. **Pumping may not begin until the water surface elevation in Cranes Roost is above +52.66 ft NAVD**
2. **Once pumping has started, the water surface elevation may not be lowered below +50.63 ft NAVD**
3. **No pump operations will occur when the water level in the Little Wekiva River is at or above elevation +51.85 ft NAVD at the former Seminole County stream gauge located approximately 0.2 miles downstream from the State Road 436 bridge.**
4. **There shall be no reduction in the storage capacity of the Cranes Roost Basin below +52.66 ft NAVD.**

STORMWATER PUMP STATION

PUMP STATION

PROJECT GOALS

1. Currently estimated that approximately 210 million gallons of treated wastewater is discharged directly to the Little Wekiva River during an average year for periods of low irrigation demand. Provide storage capacity in Cranes Roost to reduce the discharge of treated wastewater to the Little Wekiva River from the Swofford Regional WRF. This discharge (nutrient load) reduction is required as part of the Wekiva Parkway and Protection Act.

2. Reduce the city's reliance on groundwater (Floridan aquifer) augmentation during periods when irrigation demand exceeds the supply of reclaimed water. At present, groundwater augmentation is approximately 180 million gallons at present for an average rainfall year.

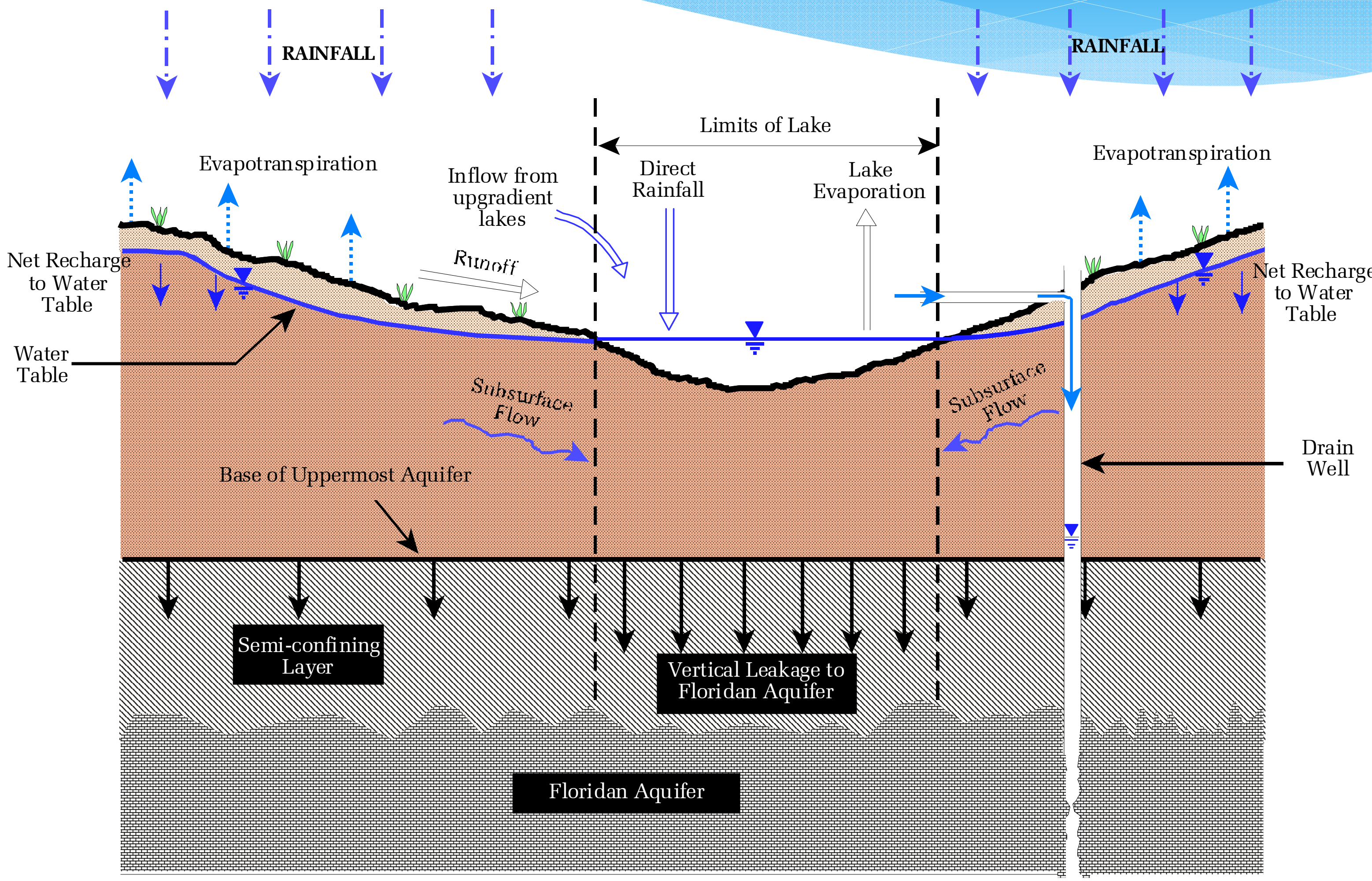
3. Reduce the direct pumped stormwater discharge volume from Cranes Roost to the Little Wekiva River during periods of high water.

4. Since this lake serves as the waterfront feature for the city's central business district, the lake's hydroperiod cannot be altered too significantly in either direction.

THE TASK

In order for the city to gage the available transient storage capacity in Cranes Roost for various scenarios of rainfall, an integrated continuous simulation hydrologic/hydrogeologic model has to be developed to simulate the flow rates into and out of the system for key design and planning scenarios.

CONCEPTUAL MODEL



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NEW FEATURES INTRODUCED IN PONDS 3.3's REFINED METHOD MODULE
CONTINUOUS SIMULATION HYDROGRAPH

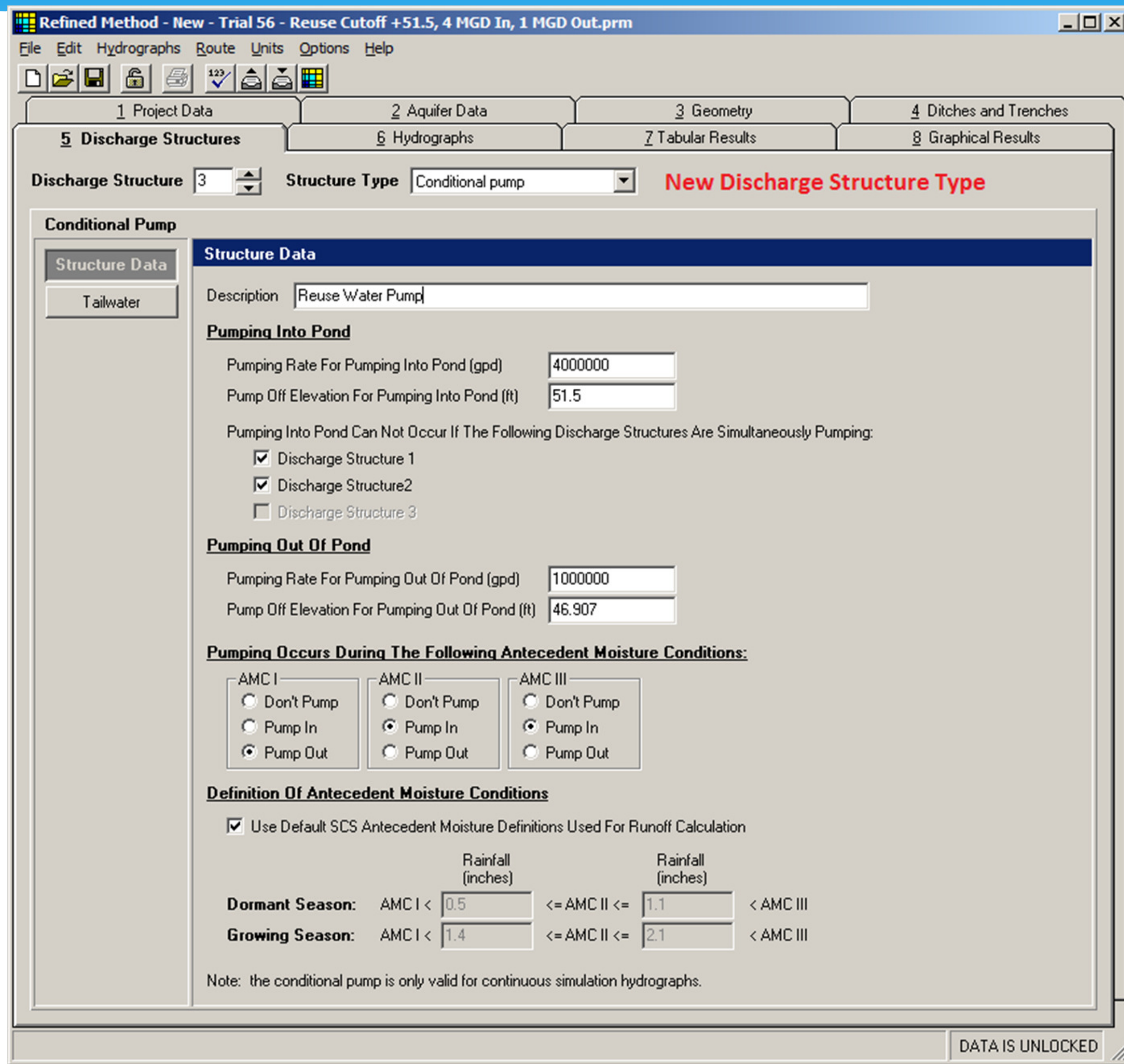
FEATURE #1

The addition of a new type of discharge structure called a "conditional pump" which is a pump with the ability to do the following:

1. **turn on/off,**
2. **change flow direction, and/or**
3. **change flow rate based on instantaneous values for parameters such as:**
   a) **5-day antecedent rainfall (a.k.a Antecedent Moisture Condition),**
   b) **stage in Cranes Roost,**
   c) **status of stormwater pump (on/off), etc.**

Exhibit on next page shows the level of sophistication with this the new type of pump and the project-specific list of conditional parameters applicable to the Cranes Roost project.

CONDITIONAL PUMP INPUT DATA



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CRANES ROOST INTEGRATED STORMWATER
CRANES ROOST INTEGRATED STORMWATER/RECLAIMED WATER FACILITY

NEW FEATURES INTRODUCED IN PONDS 3.3's REFINED METHOD MODULE
CONTINUOUS SIMULATION HYDROGRAPH

FEATURE #2

The ability to model at computational time steps of less than 1 day (such as 15 minutes, 30 minutes, 60 minutes, etc.). This additional precision was found to be necessary to allow the pumps to activate/deactivate and not cause an unacceptable water budget error during the solution process.

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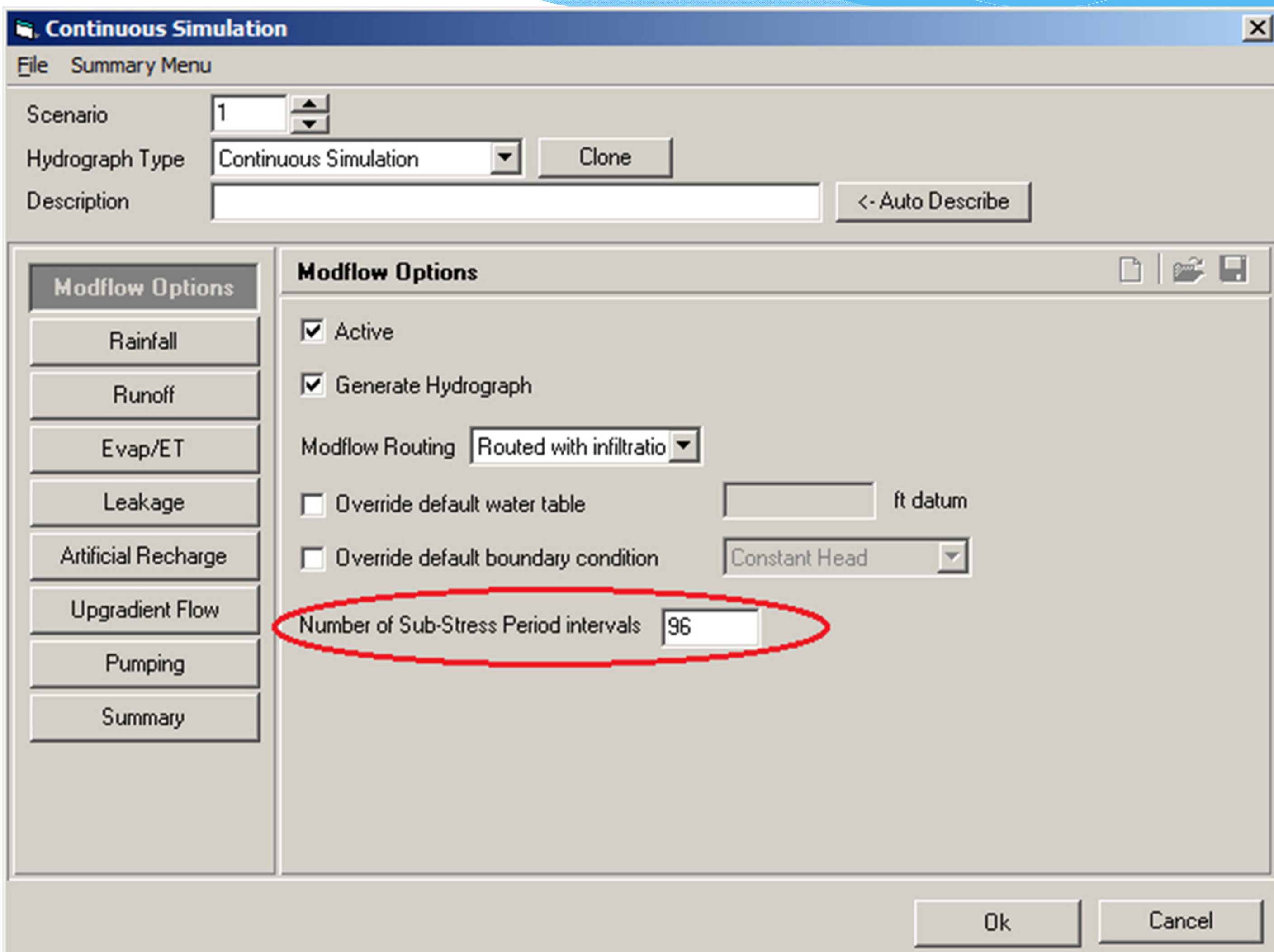
CONTINUOUS SIMULATION
HYDROGRAPH – MODFLOW OPTIONS

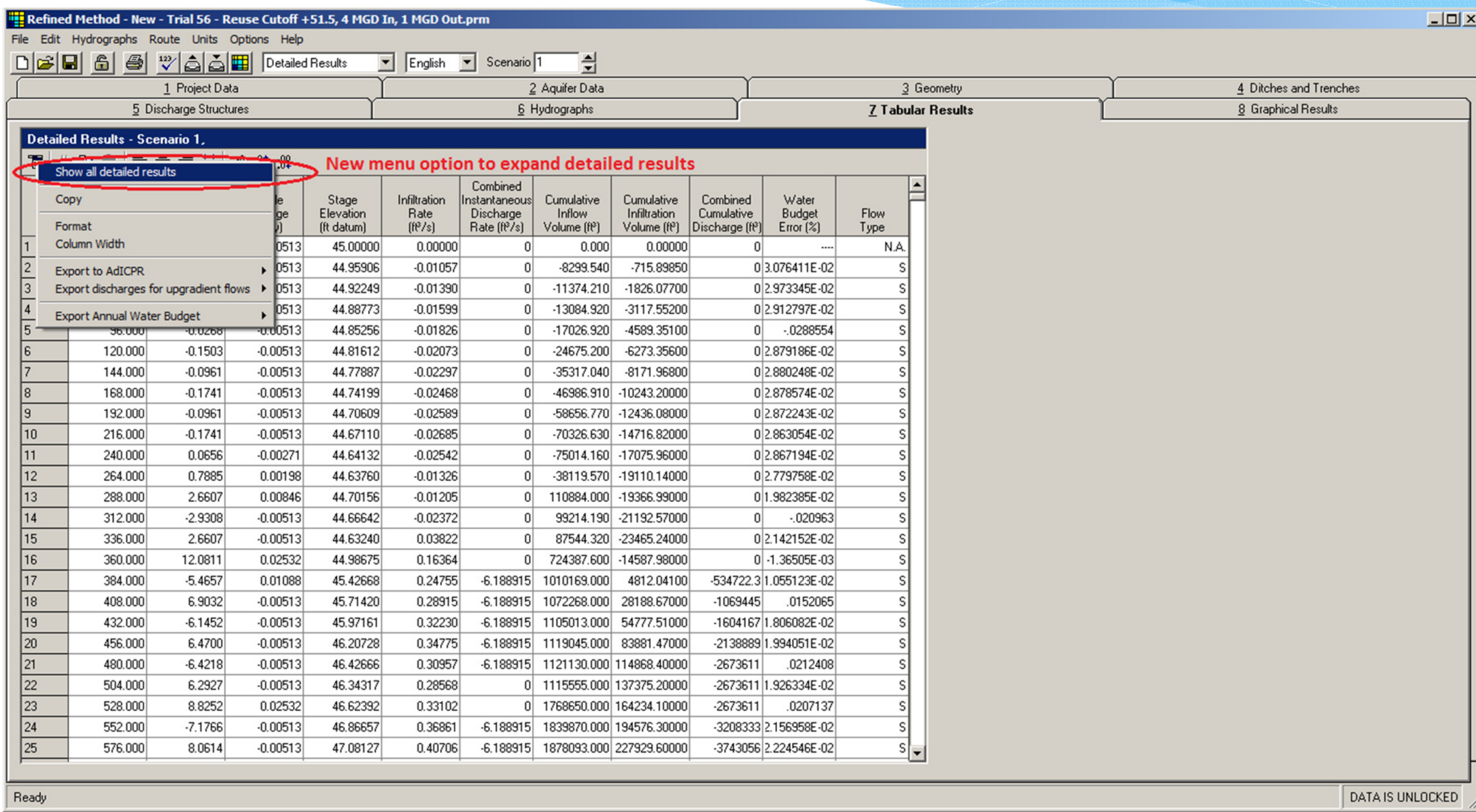


NEW FEATURES INTRODUCED IN PONDS 3.3's REFINED METHOD MODULE
CONTINUOUS SIMULATION HYDROGRAPH

FEATURE #3

The expansion of the model output to display individual discharges for each structure and aquifer leakages.

DETAILED RESULTS VIEW

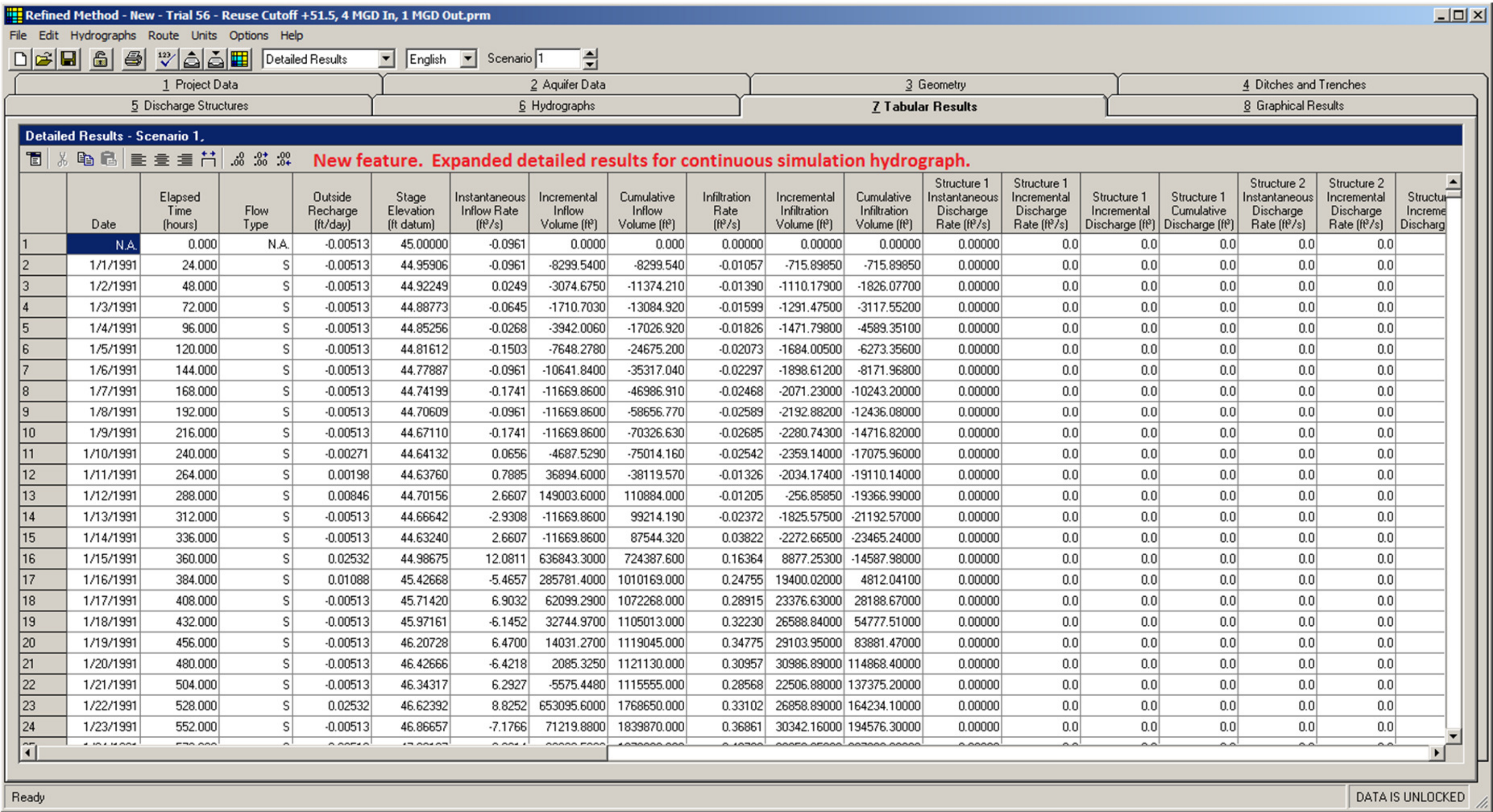


			...e ...ge ...)	Stage Elevation (ft datum)	Infiltration Rate (ft³/s)	Combined Instantaneous Discharge Rate (ft³/s)	Cumulative Inflow Volume (ft³)	Cumulative Infiltration Volume (ft³)	Combined Cumulative Discharge (ft³)	Water Budget Error (%)	Flow Type
1			0513	45.00000	0.00000	0	0.000	0.00000	0	----	N.A.
2			0513	44.95906	-0.01057	0	-8299.540	-715.89850	0	3.076411E-02	S
3			0513	44.92249	-0.01390	0	-11374.210	-1826.07700	0	2.973345E-02	S
4			0513	44.88773	-0.01599	0	-13084.920	-3117.55200	0	2.912797E-02	S
5	96.000	-0.0268	-0.00513	44.85256	-0.01826	0	-17026.920	-4589.35100	0	-.0288554	S
6	120.000	-0.1503	-0.00513	44.81612	-0.02073	0	-24675.200	-6273.35600	0	2.879186E-02	S
7	144.000	-0.0961	-0.00513	44.77887	-0.02297	0	-35317.040	-8171.96800	0	2.880248E-02	S
8	168.000	-0.1741	-0.00513	44.74199	-0.02468	0	-46986.910	-10243.20000	0	2.878574E-02	S
9	192.000	-0.0961	-0.00513	44.70609	-0.02589	0	-58656.770	-12436.08000	0	2.872243E-02	S
10	216.000	-0.1741	-0.00513	44.67110	-0.02685	0	-70326.630	-14716.82000	0	2.863054E-02	S
11	240.000	0.0656	-0.00271	44.64132	-0.02542	0	-75014.160	-17075.96000	0	2.867194E-02	S
12	264.000	0.7885	0.00198	44.63760	-0.01326	0	-38119.570	-19110.14000	0	2.779758E-02	S
13	288.000	2.6607	0.00846	44.70156	-0.01205	0	110884.000	-19366.99000	0	1.982385E-02	S
14	312.000	-2.9308	-0.00513	44.66642	-0.02372	0	99214.190	-21192.57000	0	-.020963	S
15	336.000	2.6607	-0.00513	44.63240	0.03822	0	87544.320	-23465.24000	0	2.142152E-02	S
16	360.000	12.0811	0.02532	44.98675	0.16364	0	724387.600	-14587.98000	0	-1.36505E-03	S
17	384.000	-5.4657	0.01088	45.42668	0.24755	-6.188915	1010169.000	4812.04100	-534722.3	1.055123E-02	S
18	408.000	6.9032	-0.00513	45.71420	0.28915	-6.188915	1072268.000	28188.67000	-1069445	.0152065	S
19	432.000	-6.1452	-0.00513	45.97161	0.32230	-6.188915	1105013.000	54777.51000	-1604167	1.806082E-02	S
20	456.000	6.4700	-0.00513	46.20728	0.34775	-6.188915	1119045.000	83881.47000	-2138889	1.994051E-02	S
21	480.000	-6.4218	-0.00513	46.42666	0.30957	-6.188915	1121130.000	114868.40000	-2673611	.0212408	S
22	504.000	6.2927	-0.00513	46.34317	0.28568	0	1115555.000	137375.20000	-2673611	1.926334E-02	S
23	528.000	8.8252	0.02532	46.62392	0.33102	0	1768650.000	164234.10000	-2673611	.0207137	S
24	552.000	-7.1766	-0.00513	46.86657	0.36861	-6.188915	1839870.000	194576.30000	-3208333	2.156958E-02	S
25	576.000	8.0614	-0.00513	47.08127	0.40706	-6.188915	1878093.000	227929.60000	-3743056	2.224546E-02	S

CRANES ROOST INTEGRATED STORMWATER

CRANES ROOST INTEGRATED STORMWATER/RECLAIMED WATER FACILITY

DETAILED RESULTS VIEW



	Date	Elapsed Time (hours)	Flow Type	Outside Recharge (ft/day)	Stage Elevation (ft datum)	Instantaneous Inflow Rate (ft³/s)	Incremental Inflow Volume (ft³)	Cumulative Inflow Volume (ft³)	Infiltration Rate (ft³/s)	Incremental Infiltration Volume (ft³)	Cumulative Infiltration Volume (ft³)	Structure 1 Instantaneous Discharge Rate (ft³/s)	Structure 1 Incremental Discharge Rate (ft³/s)	Structure 1 Incremental Discharge (ft³)	Structure 1 Cumulative Discharge (ft³)	Structure 2 Instantaneous Discharge Rate (ft³/s)	Structure 2 Incremental Discharge Rate (ft³/s)	Structu Increme Discharg
1	N.A.	0.000	N.A.	-0.00513	45.00000	-0.0961	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	
2	1/1/1991	24.000	S	-0.00513	44.95906	-0.0961	-8299.5400	-8299.540	-0.01057	-715.89850	-715.89850	0.00000	0.0	0.0	0.0	0.0	0.0	
3	1/2/1991	48.000	S	-0.00513	44.92249	0.0249	-3074.6750	-11374.210	-0.01390	-1110.17900	-1826.07700	0.00000	0.0	0.0	0.0	0.0	0.0	
4	1/3/1991	72.000	S	-0.00513	44.88773	-0.0645	-1710.7030	-13084.920	-0.01599	-1291.47500	-3117.55200	0.00000	0.0	0.0	0.0	0.0	0.0	
5	1/4/1991	96.000	S	-0.00513	44.85256	-0.0268	-3942.0060	-17026.920	-0.01826	-1471.79800	-4589.35100	0.00000	0.0	0.0	0.0	0.0	0.0	
6	1/5/1991	120.000	S	-0.00513	44.81612	-0.1503	-7648.2780	-24675.200	-0.02073	-1684.00500	-6273.35600	0.00000	0.0	0.0	0.0	0.0	0.0	
7	1/6/1991	144.000	S	-0.00513	44.77887	-0.0961	-10641.8400	-35317.040	-0.02297	-1898.61200	-8171.96800	0.00000	0.0	0.0	0.0	0.0	0.0	
8	1/7/1991	168.000	S	-0.00513	44.74199	-0.1741	-11669.8600	-46986.910	-0.02468	-2071.23000	-10243.20000	0.00000	0.0	0.0	0.0	0.0	0.0	
9	1/8/1991	192.000	S	-0.00513	44.70609	-0.0961	-11669.8600	-58656.770	-0.02589	-2192.88200	-12436.08000	0.00000	0.0	0.0	0.0	0.0	0.0	
10	1/9/1991	216.000	S	-0.00513	44.67110	-0.1741	-11669.8600	-70326.630	-0.02685	-2280.74300	-14716.82000	0.00000	0.0	0.0	0.0	0.0	0.0	
11	1/10/1991	240.000	S	-0.00271	44.64132	0.0656	-4687.5290	-75014.160	-0.02542	-2359.14000	-17075.96000	0.00000	0.0	0.0	0.0	0.0	0.0	
12	1/11/1991	264.000	S	0.00198	44.63760	0.7885	36894.6000	-38119.570	-0.01326	-2034.17400	-19110.14000	0.00000	0.0	0.0	0.0	0.0	0.0	
13	1/12/1991	288.000	S	0.00846	44.70156	2.6607	149003.6000	110884.000	-0.01205	-256.85850	-19366.99000	0.00000	0.0	0.0	0.0	0.0	0.0	
14	1/13/1991	312.000	S	-0.00513	44.66642	-2.9308	-11669.8600	99214.190	-0.02372	-1825.57500	-21192.57000	0.00000	0.0	0.0	0.0	0.0	0.0	
15	1/14/1991	336.000	S	-0.00513	44.63240	2.6607	-11669.8600	87544.320	0.03822	-2272.66500	-23465.24000	0.00000	0.0	0.0	0.0	0.0	0.0	
16	1/15/1991	360.000	S	0.02532	44.98675	12.0811	636843.3000	724387.600	0.16364	8877.25300	-14587.98000	0.00000	0.0	0.0	0.0	0.0	0.0	
17	1/16/1991	384.000	S	0.01088	45.42668	-5.4657	285781.4000	1010169.000	0.24755	19400.02000	4812.04100	0.00000	0.0	0.0	0.0	0.0	0.0	
18	1/17/1991	408.000	S	-0.00513	45.71420	6.9032	62099.2900	1072268.000	0.28915	23376.63000	28188.67000	0.00000	0.0	0.0	0.0	0.0	0.0	
19	1/18/1991	432.000	S	-0.00513	45.97161	-6.1452	32744.9700	1105013.000	0.32230	26588.84000	54777.51000	0.00000	0.0	0.0	0.0	0.0	0.0	
20	1/19/1991	456.000	S	-0.00513	46.20728	6.4700	14031.2700	1119045.000	0.34775	29103.95000	83881.47000	0.00000	0.0	0.0	0.0	0.0	0.0	
21	1/20/1991	480.000	S	-0.00513	46.42666	-6.4218	2085.3250	1121130.000	0.30957	30986.89000	114868.40000	0.00000	0.0	0.0	0.0	0.0	0.0	
22	1/21/1991	504.000	S	-0.00513	46.34317	6.2927	-5575.4480	1115555.000	0.28568	22506.88000	137375.20000	0.00000	0.0	0.0	0.0	0.0	0.0	
23	1/22/1991	528.000	S	0.02532	46.62392	8.8252	653095.6000	1768650.000	0.33102	26858.89000	164234.10000	0.00000	0.0	0.0	0.0	0.0	0.0	
24	1/23/1991	552.000	S	-0.00513	46.86657	-7.1766	71219.8800	1839870.000	0.36861	30342.16000	194576.30000	0.00000	0.0	0.0	0.0	0.0	0.0	

MODELING TASK #1 - CALIBRATION

The development of a reasonably calibrated, interconnected, continuous simulation model of the four (4) individual lakes (at daily reporting time steps) for the 21-year period Jan 1, 1991 to Dec 31, 2011 using the as-operated scenario with the actual reclaimed water transfers.

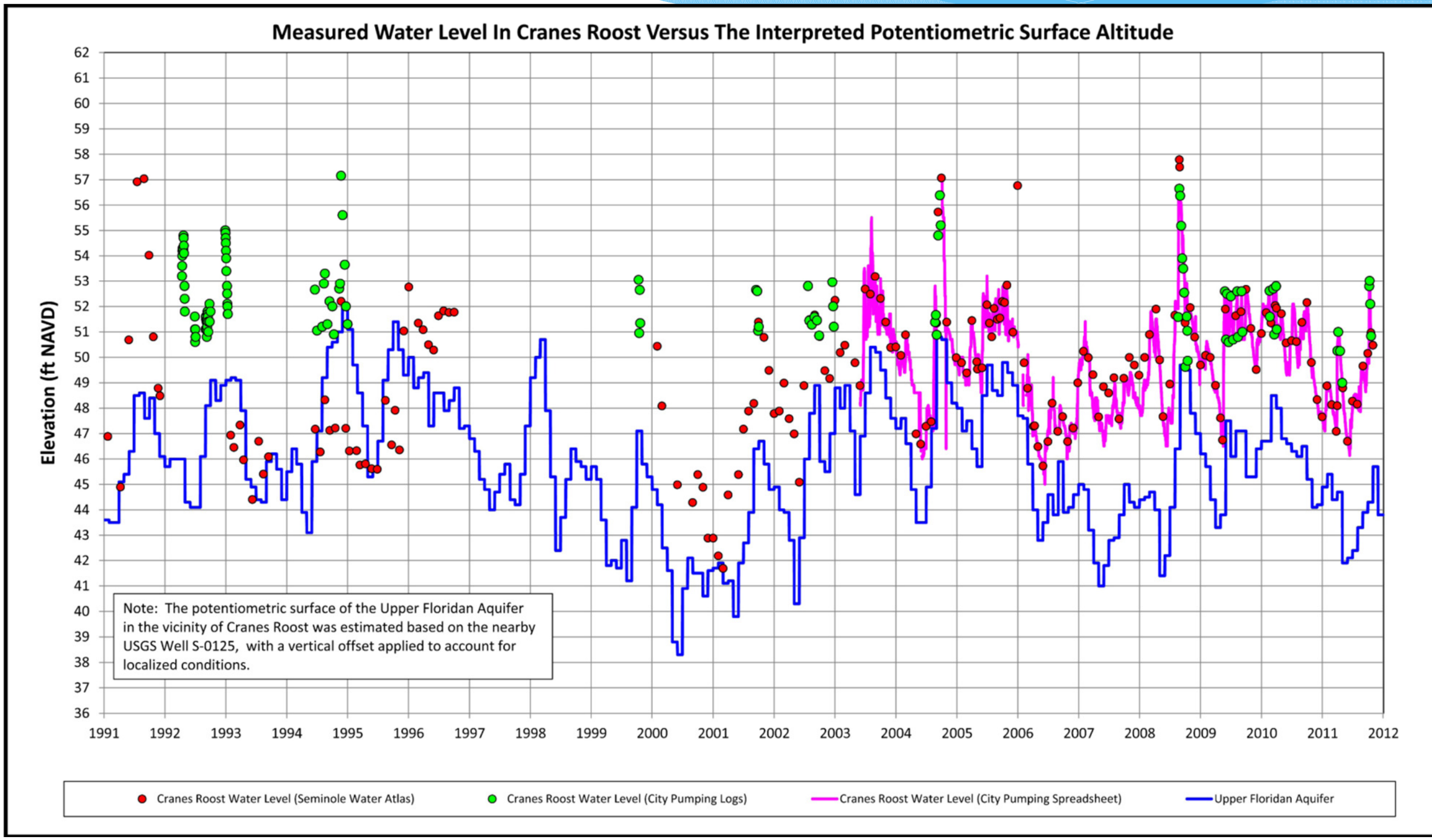
MODEL CALIBRATION
BASIN PARAMETERS

Comparison of Runoff Basin Parameters and Calibrated Leakance For Initial Calibration Comapared to 1996 Devo Model and 2011 Pegasus Estimates

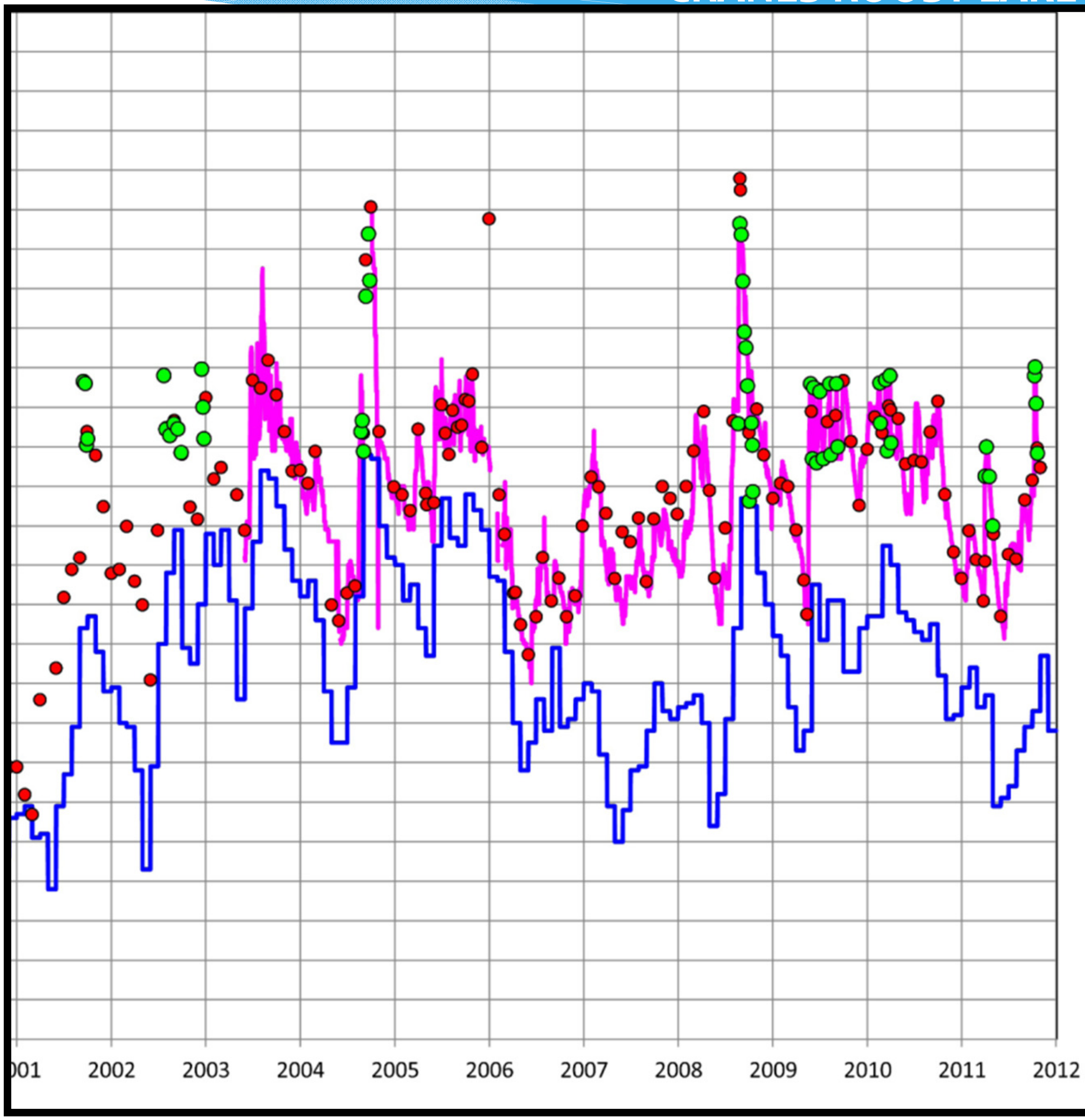
Parameter	Units	Cranes Roost			Lake Adelaide			Lake Florida			Lake Mobile		
		Current Calibration	1996 Model	2011 Pegasus	Current Calibration	1996 Model	2011 Pegasus	Current Calibration	1996 Model	2011 Pegasus	Current Calibration	1996 Model	2011 Pegasus
Base of Aquifer Elevation	ft NAVD	0	0	-	41	41	-	41	41	-	65	65	-
Horizontal Conductivity	ft/day	3	3	-	3	3	-	2	2	-	1	1	-
Fillable Porosity	%	25	25	-	25	25	-	25	25	-	25	25	-
Total Area of Drainage Basin	acres	647.7	640.7	647.7	424.9	433.3	424.9	706.1	717.4	706.1	152.4	170	152.4
Lake Area	acres	45.3	43.3	45.3	74	79.2	23.3	28.5	83.2	28.5	26.7	33.1	26.7
DCIA	acres	322.5	167.4	322.5	150	111.4	199	10	2.4	274.8	10	0.9	41.5
Impervious Area With no ET Losses	acres	388.9		-	176.1		-	308.5			47.5		-
Weighted Average non-DCIA Curve Number	-	58.6	85.9	58.6	49.4	76.5	49.4	72.3	77.6	53.8	67	71.6	55.4
Leakage Below Pond	in/yr	-	-	-	10	25	-	28	25	-	14	8	-
Leakage Outside Pond	in/yr	11	6	-	6	6	-	18	6	-	14	4	-
Potentiometric Leakage Coefficient	cfs/ft/ft	0.5	0.25	-	-	-	-	-	-	-	-	-	-
Yearly Lake Evaporation	in/yr	50.9	50.9	-	50.9	50.9	-	50.9	50.9	-	50.9	50.9	-
Yearly ET	in/yr	55	39.4	-	55	39.4	-	55	39.4	-	55	39.4	-

DEVO Engineering

POTENTIOMETRIC SURFACE VS. CRANES ROOST LAKE LEVEL



POTENTIOMETRIC SURFACE VS. CRANES ROOST LAKE LEVEL



ZOOM IN

GENERAL TREND BETWEEN ANNUAL RAINFALL AND STORMWATER DISCHARGE PUMPING

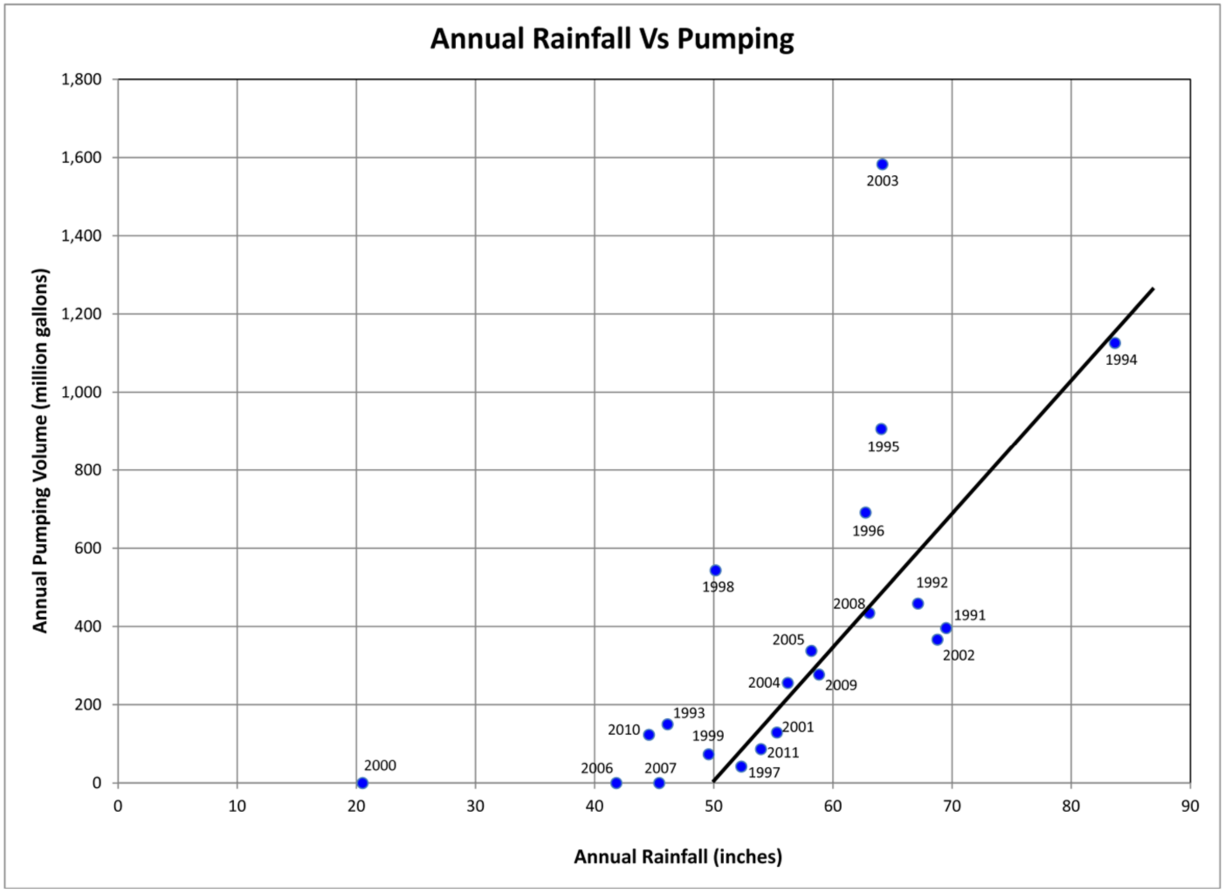


Figure A-8

HISTORICAL STORMWATER PUMPING RATES

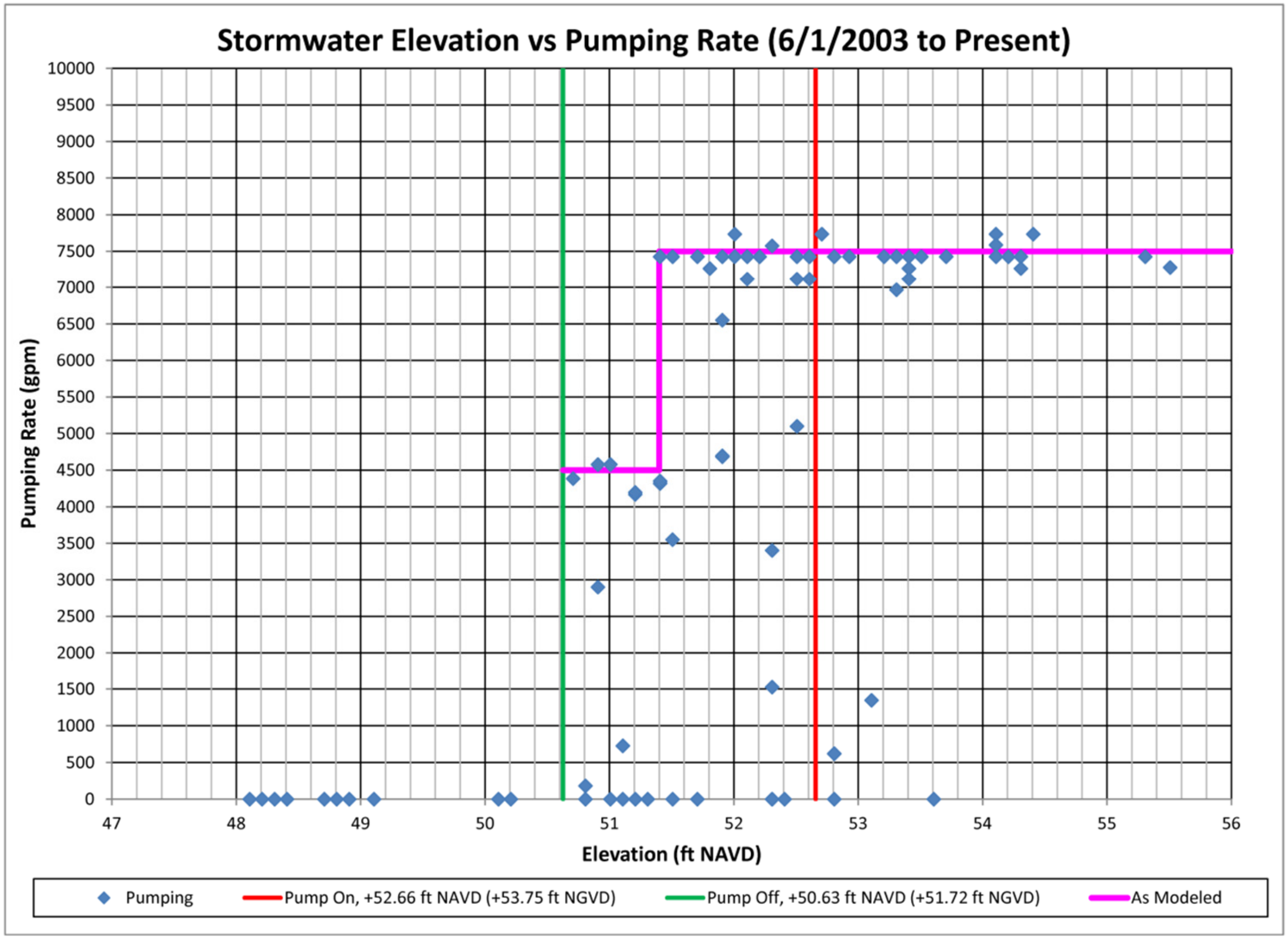


Figure B-2

HISTORICAL RECLAIMED INFLOWS & OUTFLOWS

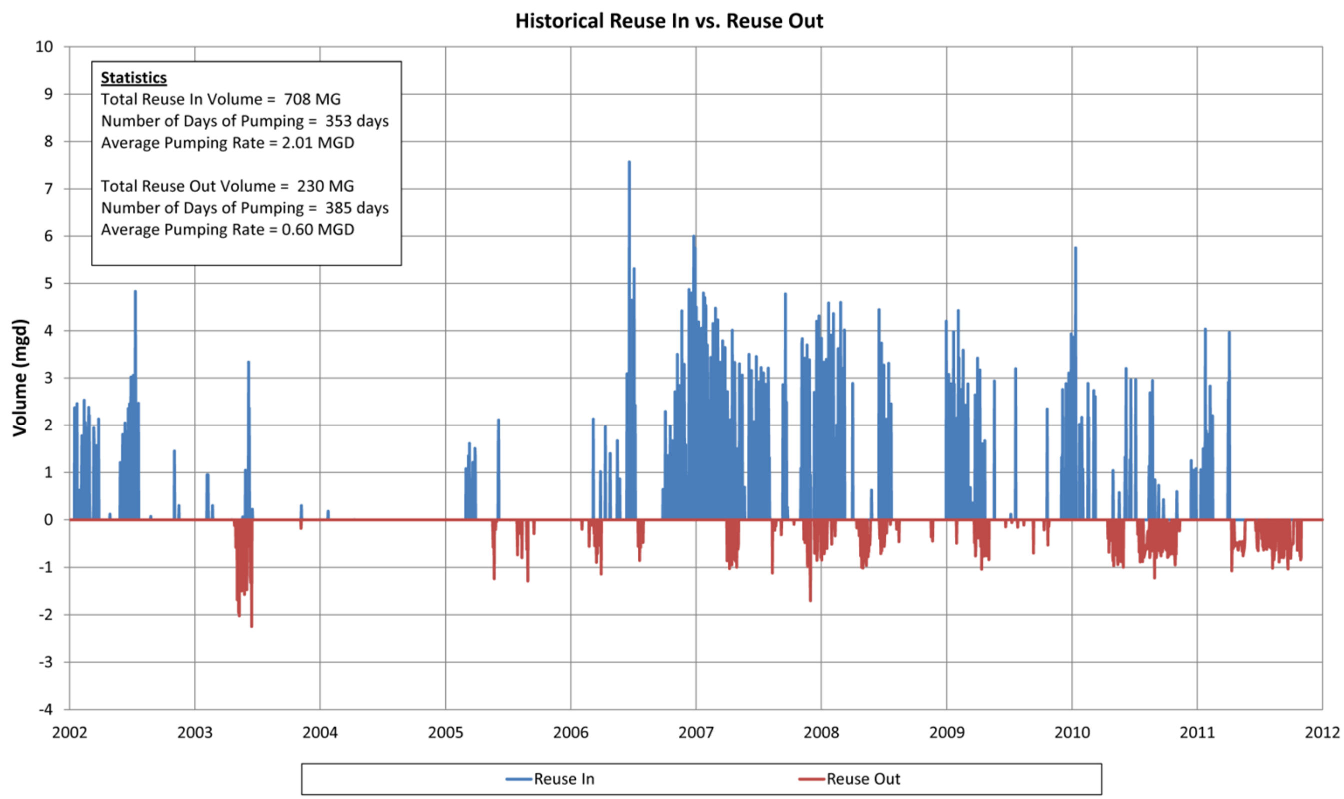


Figure B-1

DEVO Engineering

CALIBRATION FOR LAKE MOBILE

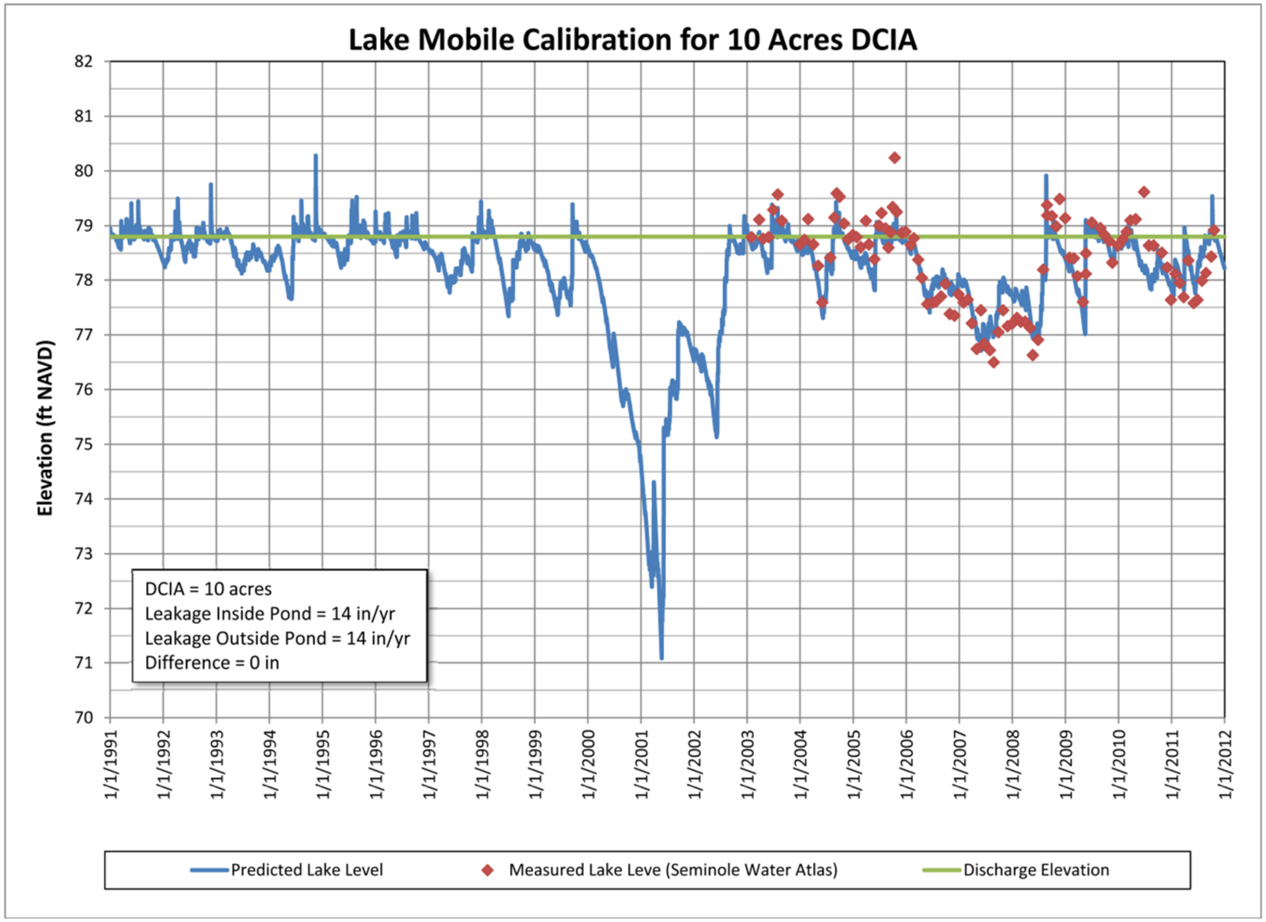


Figure A-1

DEVO Engineering

CALIBRATION FOR LAKE FLORIDA

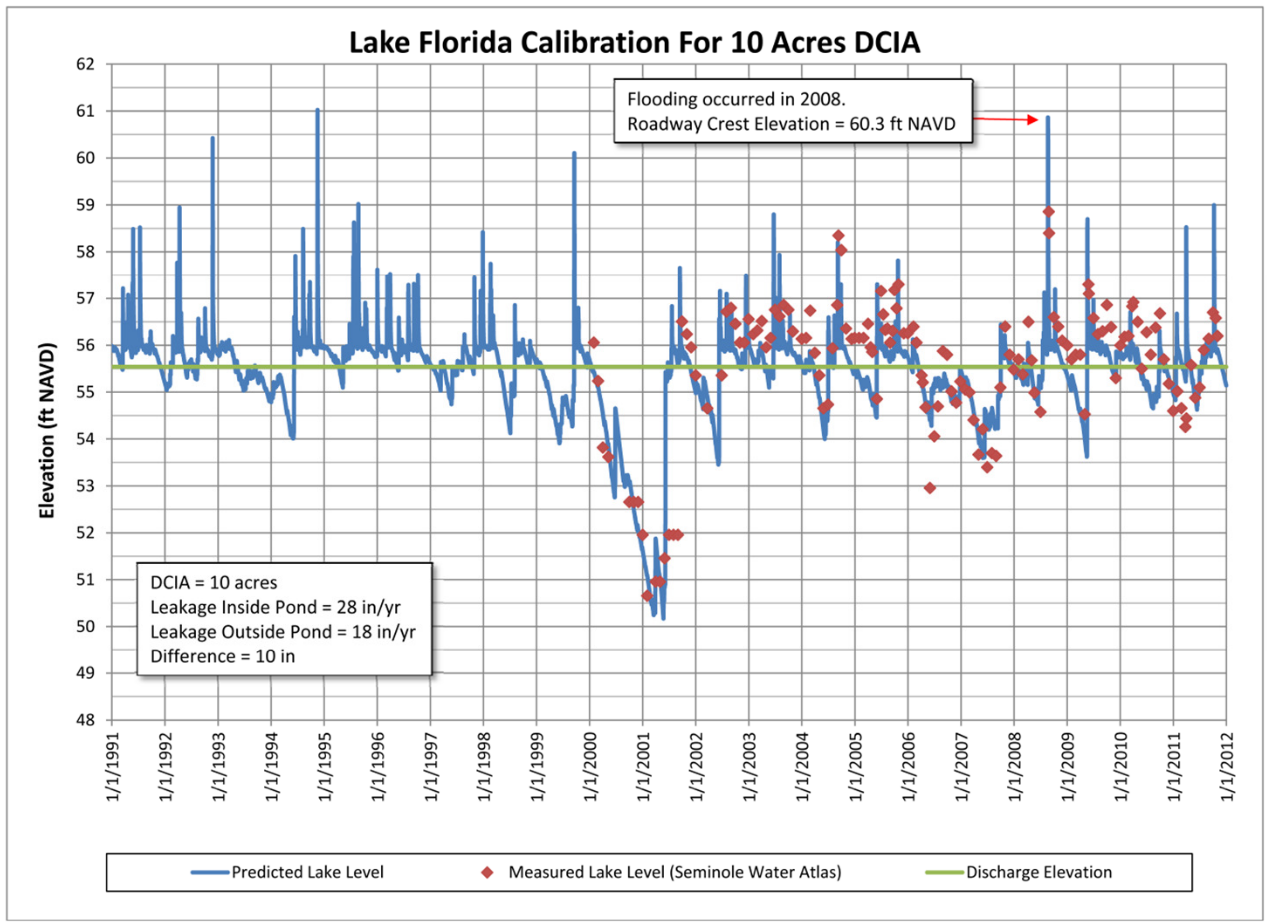


Figure A-3

CALIBRATION FOR LAKE ADELAIDE

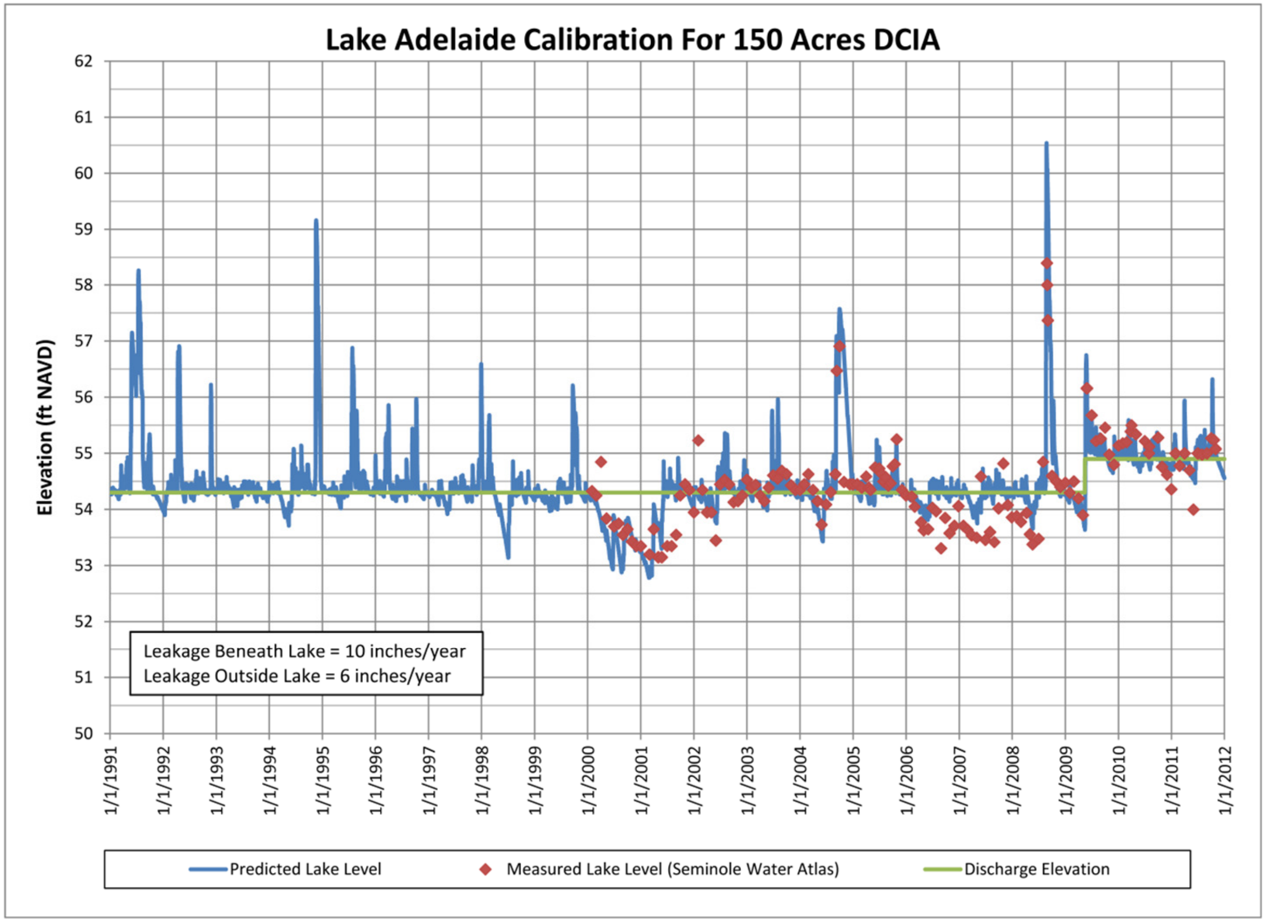


Figure A-5

CALIBRATION FOR CRANES ROOST

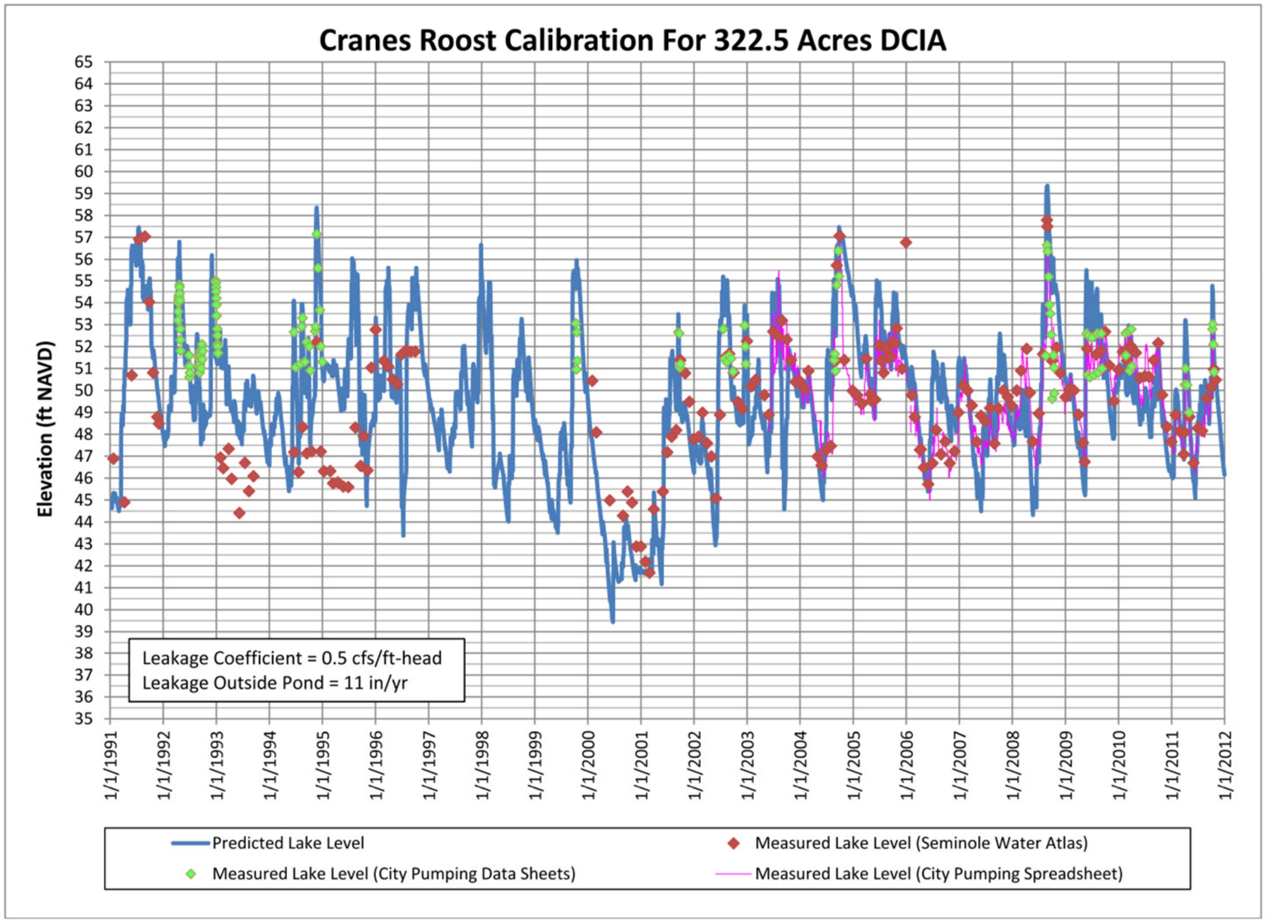
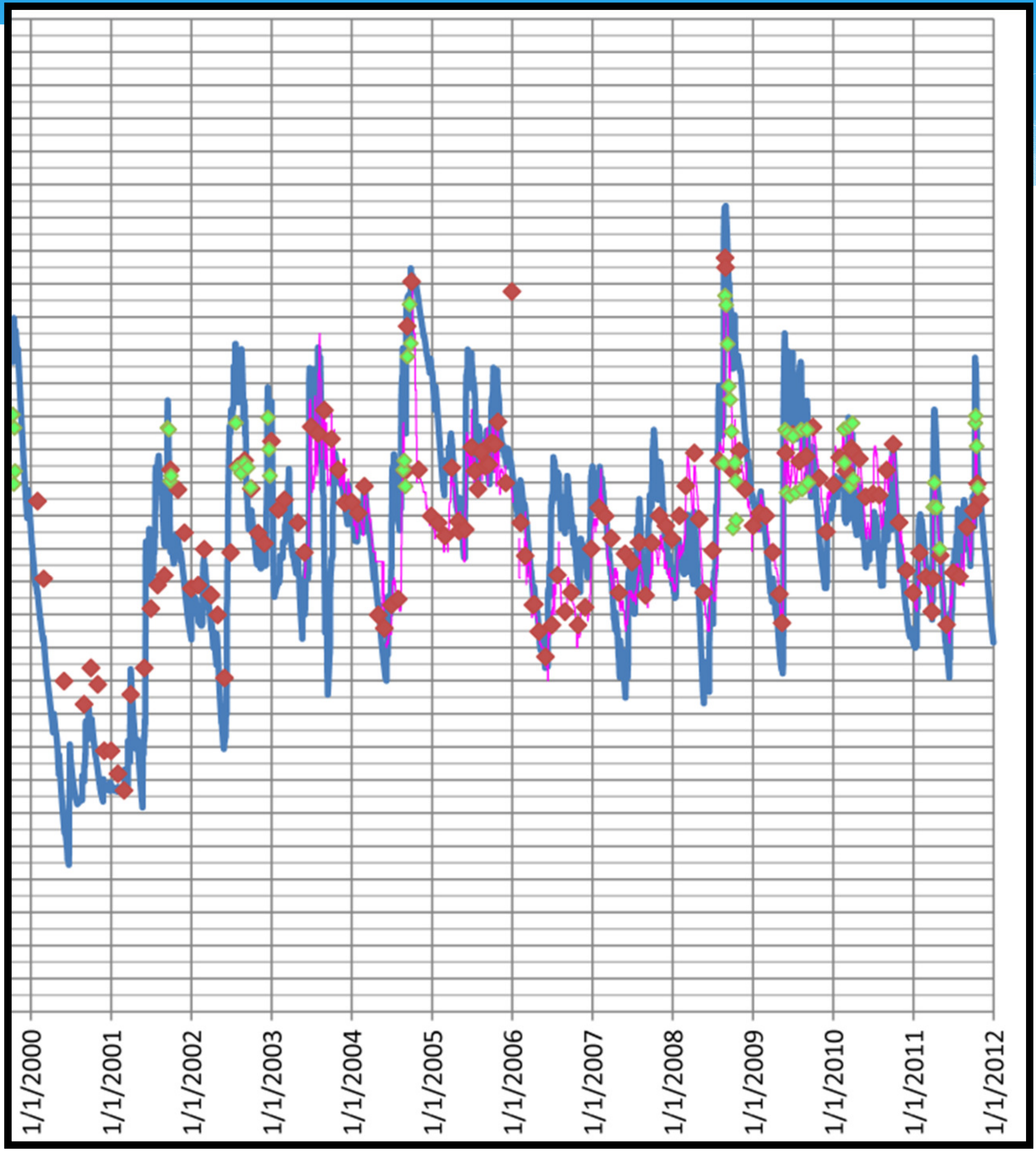


Figure A-7

DEVO Engineering

CALIBRATION FOR CRANES ROOST



ZOOM IN

MODELING TASK #2 - OPERATIONAL SCENARIOS FOR REUSE

Use of this calibrated 21-year duration model to seek a realistic operating scenario for reclaimed water storage and recovery in Cranes Roost which simultaneously accomplishes the following triad of environmental benefits:

1. **reducing the average long term stormwater discharge volume to the Little Wekiva River;**
2. **increasing recharge to the Upper Floridan aquifer within the springshed of Sanlando Springs, Palm Springs, and Starbuck Springs; and**
3. **reducing current levels of groundwater withdrawals used to augment the city's reuse system.**

MODELING TASK #2 - OPERATIONAL SCENARIOS FOR REUSE (continue)

Reuse Pumping Into Cranes Roost

1. Allowed if the stage in Cranes Roost was below a specified cutoff elevation. Model predictions were run for cutoff elevations of: +51.0 ft NAVD, +51.5 ft NAVD, and +52.0 ft NAVD.
2. Reuse pumping in occur when the antecedent moisture conditions are represented by AMC II or AMC III (wet conditions).
3. Prohibited if stormwater pumps are running.

Reuse Pumping Out Of Cranes Roost

1. May not occur if the water level in Cranes Roost falls below an elevation of 46.91 ft NAVD (per permit).
2. Assumed to occur when the antecedent moisture conditions are represented by AMC I, i.e., prevailing dry conditions with a high demand for irrigation water coupled by a reduced supply at the reuse plant.
3. May occur simultaneously with stormwater pumping out of Cranes Roost.

CONCEPTUAL PUMPING SCHEMATIC

Pumping Schematic For Predictive Scenarios

STORMWATER PUMP OUTFALL TO LITTLE WEKIVA RIVER

1. Both stormwater pumps activate if water level exceeds +52.66 ft NAVD (by permit).
2. If active, stormwater pump 2 (3,000 gpm) turns off when water level drops below +51.4 ft NAVD (historical).
3. If active, stormwater pump 1 (4,500 gpm) turns off when water level drops below +50.63 ft NAVD (by permit).
4. Stormwater pump 1 pumps at a rate of 4,500 gpm above elevation +50.63 ft NAVD.
5. Stormwater pump 2 pumps at a rate of 3,000 gpm, above elevation +51.4 ft NAVD.
6. Combined pumping rate above elevation +51.4 ft NAVD is 7,500 gpm.
7. Stormwater pump permit threshold: 11.5 mgd maximum.

RECLAIMED WATER PUMPED INFLOW INTO CRANES ROOST

1. Reuse in pumping occurs when water level is below +51, 51.5, or 52 ft NAVD (depending on model assumption).
2. Pump is on if Antecedent Moisture Condition (AMC) is AMC II or AMC III.
3. However, this pump is off if the stormwater pumps are actively discharging to Little Wekiva River.

REUSE WATER PUMPED OUT OF CRANES ROOST

1. Reuse pumping out only occurs if the water level in Cranes Roost is greater than +46.91 ft NAVD (by permit).
2. Reuse pumping out only occurs if Antecedent Moisture Condition is AMC I.
3. Reuse pumping out may occur concurrently with stormwater pumping (unlike reclaimed pumping in).
4. Maximum annual net reuse withdrawals must not exceed 200 million gallons (by permit).
5. Maximum daily net reuse withdrawals must not exceed 2.0 million gallons (by permit).
6. Withdrawals are prohibited when lake level elevation is at or below +46.907 ft NAVD (+48 ft NGVD).

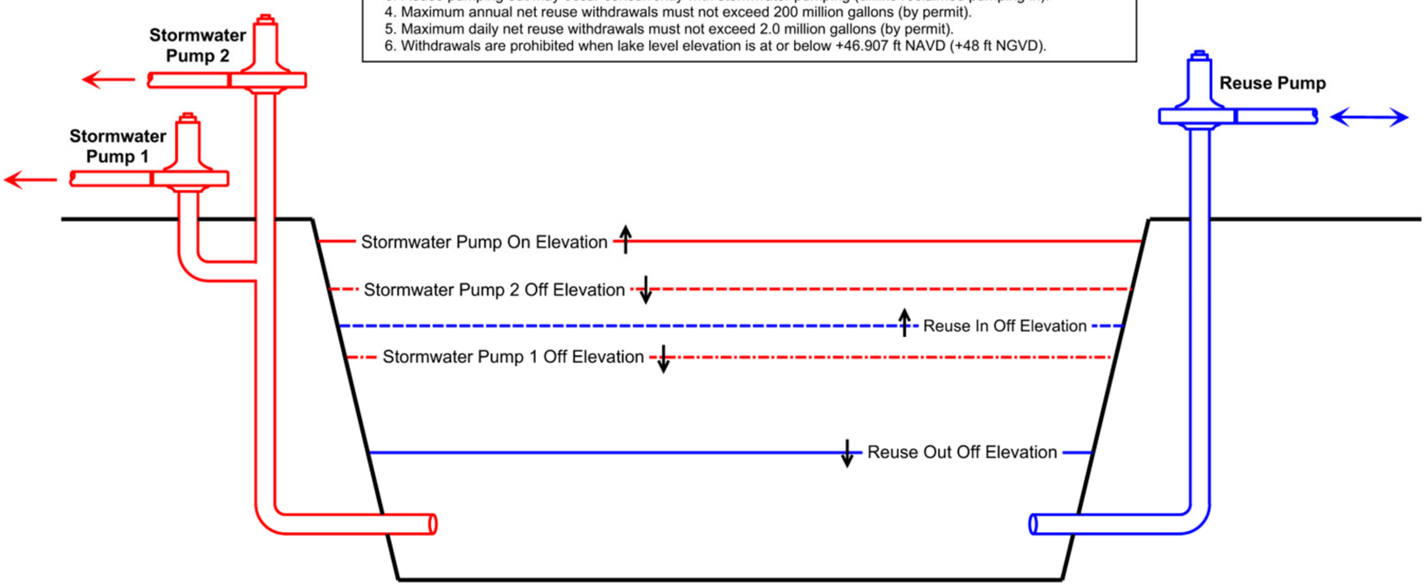


Figure B-4

CONCEPTUAL PUMPING SCHEMATIC

ZOOM IN

Pumping Schematic For Predictive Scenarios

STORMWATER PUMP OUTFALL TO LITTLE WEKIVA RIVER

1. Both stormwater pumps activate if water level exceeds +52.66 ft NAVD (by permit).
2. If active, stormwater pump 2 (3,000 gpm) turns off when water level drops below +51.4 ft NAVD (historical).
3. If active, stormwater pump 1 (4,500 gpm) turns off when water level drops below +50.63 ft NAVD (by permit).
4. Stormwater pump 1 pumps at a rate of 4,500 gpm above elevation +50.63 ft NAVD.
5. Stormwater pump 2 pumps at a rate of 3,000 gpm, above elevation +51.4 ft NAVD.
6. Combined pumping rate above elevation +51.4 ft NAVD is 7,500 gpm.
7. Stormwater pump permit threshold: 11.5 mgd maximum.

RECLAIMED WATER PUMPED INFLOW INTO CRANES ROOST

1. Reuse in pumping occurs when water level is below +51, 51.5, or 52 ft NAVD (depending on model assumption).
2. Pump is on if Antecedent Moisture Condition (AMC) is AMC II or AMC III.
3. However, this pump is off if the stormwater pumps are actively discharging to Little Wekiva River.

REUSE WATER PUMPED OUT OF CRANES ROOST

1. Reuse pumping out only occurs if the water level in Cranes Roost is greater than +46.91 ft NAVD (by permit).
2. Reuse pumping out only occurs if Antecedent Moisture Condition is AMC I.
3. Reuse pumping out may occur concurrently with stormwater pumping (unlike reclaimed pumping in).
4. Maximum annual net reuse withdrawals must not exceed 200 million gallons (by permit).
5. Maximum daily net reuse withdrawals must not exceed 2.0 million gallons (by permit).
6. Withdrawals are prohibited when lake level elevation is at or below +46.907 ft NAVD (+48 ft NGVD).

MODELING TASK #2 - OPERATIONAL SCENARIOS FOR REUSE (continue)

The historic reuse pumping rates were analyzed to determine the typical/average pumping rates which have been relied upon in the past. Model was seeded with the average past pumping rate for reuse water entering the pond is approximately 2.06 MGD, and the average past pumping rate for reuse water withdrawals is approximately 0.6 MGD.

MODEL RECALIBRATION FOR IDEALIZED STORMWATER PUMP CONFIGURATION

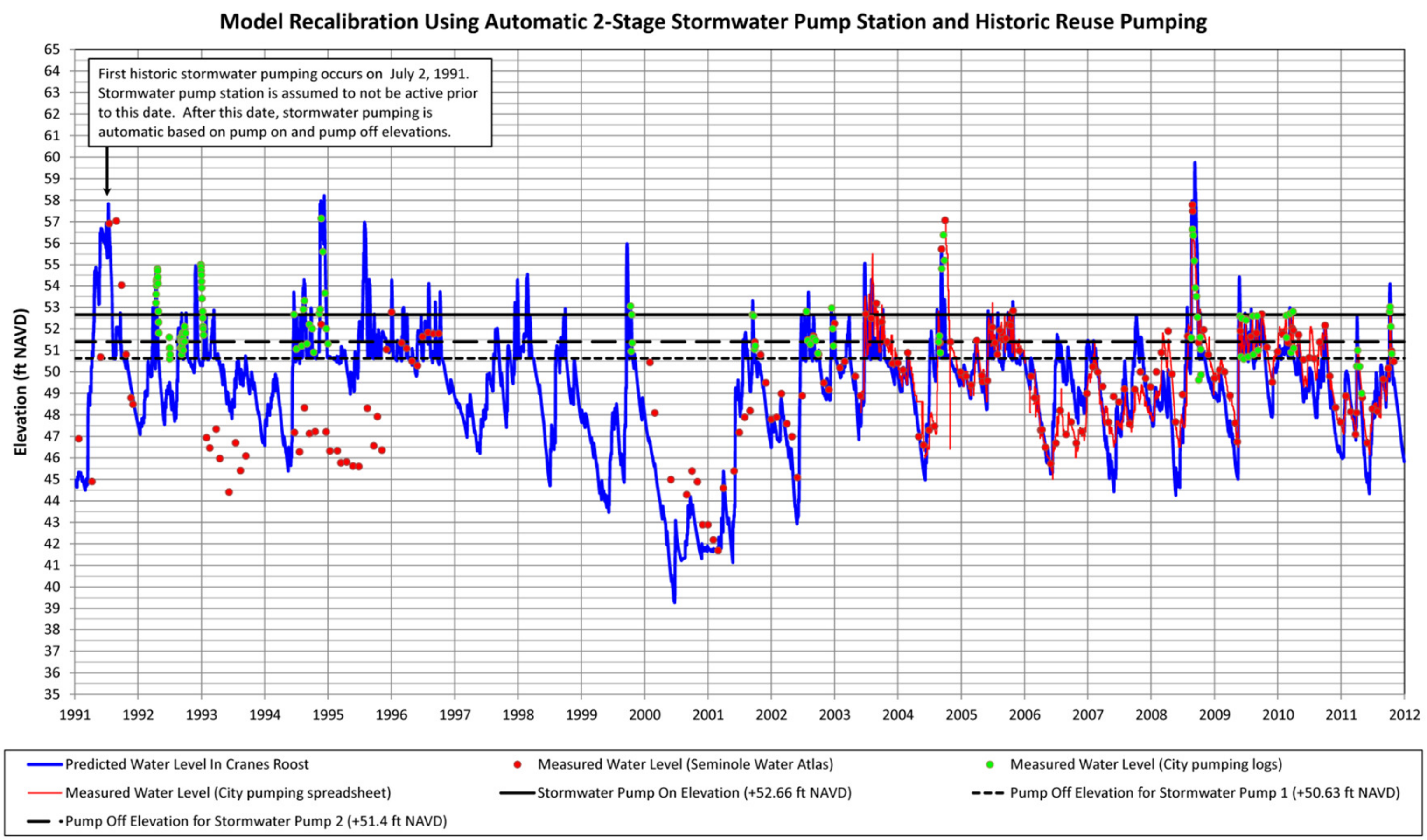
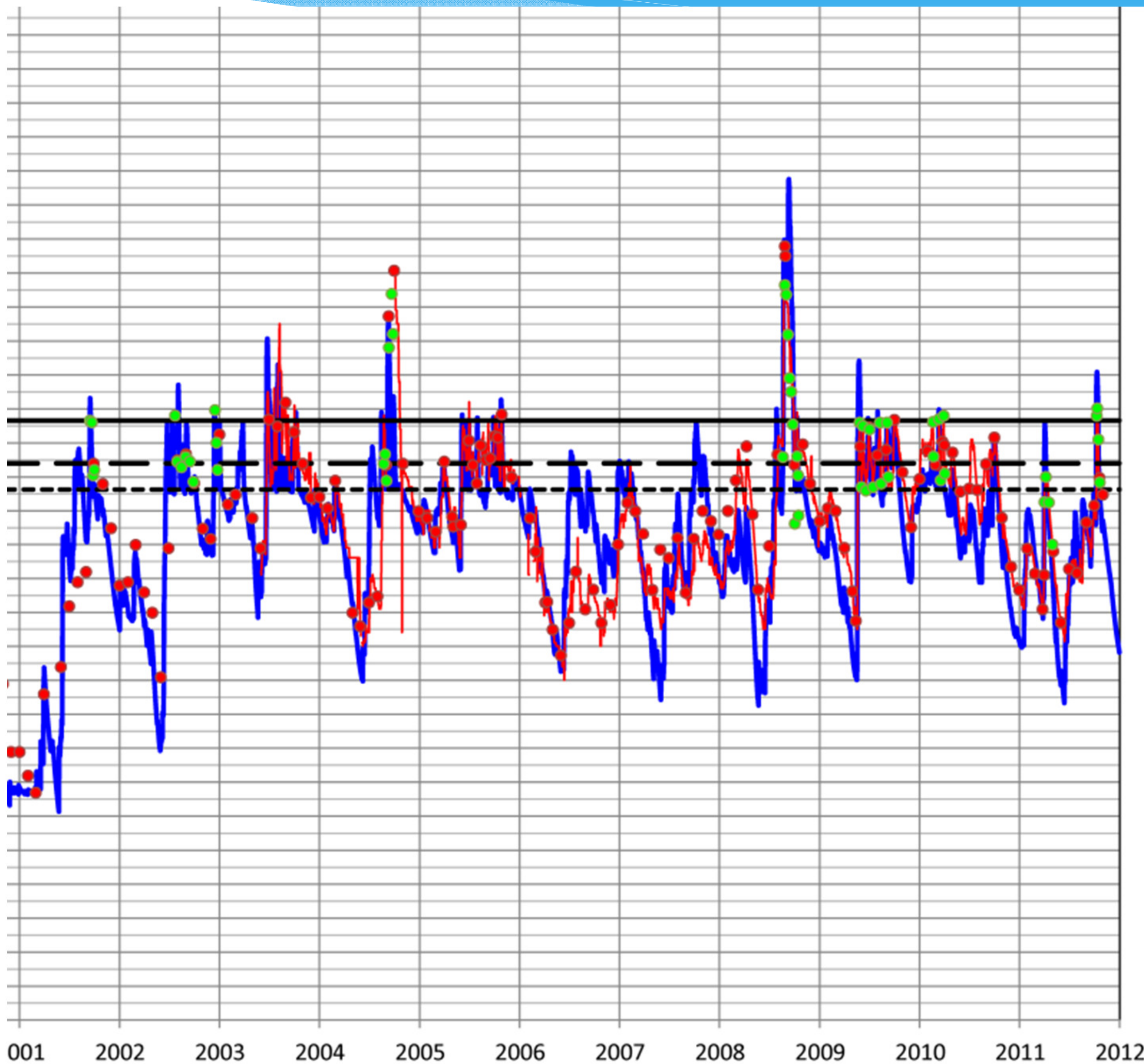


Figure B-3

DEVO Engineering

MODEL RECALIBRATION FOR IDEALIZED STORMWATER PUMP CONFIGURATION



ZOOM IN

KEY RESULTS - THE SWEET SPOT DETECTED BY MODEL

Modeling indicates that the ideal ratio of *REUSE PUMPING IN* versus *REUSE PUMPING OUT* is approximately 4 to 1. Therefore, for example, a reuse in pumping rate of 4 MGD on days with antecedent moisture conditions of AMC II or AMC III, and a reuse out pumping rate of 1 MGD on days with antecedent moisture condition of AMC I, with a reuse in pump-off threshold of up to approximately +51.5 ft NAVD.

This protocol results in a 3.4% reduction in discharge volume to the Little Wekiva River and a 3.8% increase in leakage to the Sanlando Springs. There is no perceptible change to the hydroperiod of Cranes Roost so its aesthetic value is not compromised.

KEY RESULTS FOR SELECTED OPERATIONAL SCENARIO

"Trial 56"

Reuse-In Cutoff Elevation = +51.5 ft NAVD
Reuse-Out Cutoff Elevation = +46.91 ft NAVD
Reuse-In Pumping Rate = 4 MGD
Reuse-Out Pumping Rate = 1 MGD

Compared to baseline case with no reuse pumping:

- **Average annual stormwater discharge decreased by 3.4%, from 1,117 to 1,079 ac-ft/yr**
- **Average annual leakage to the Upper Floridan aquifer increased by 3.8%, from 1,160 to 1,318 ac-ft/yr**
- **The average net reuse water pumping represents a net disposal of 39.4 MGY (lost to aquifer, etc.)**
- **The maximum annual reuse pumping withdrawal from the lake for the 21-year model period is 160.1 MGY, which is less than the permitted 200 MGY.**
- **The average percentage of days on which stormwater discharge pumping occurs decreases from 14.9% to 12.2%.**
- **Reuse pumping into the lake is predicted to occur for 18.0% of days.**
- **Reuse pumping out of the lake is predicted to occur for 54.2% of days.**
- **No pumping (reuse or stormwater) is predicted for 19.6% of days.**

MODELING RESULTS

Summary of Model Results For Various Combinations of Reuse In and Reuse Out

Trial Number	Baseline No Reuse Pumping	Baseline Historic Reuse Pumping	Trial 49 2 MGD in 0.6 MGD out	Trial 51 3MGD In 1 MGD Out	Trial 52 4 MGD in 1 MGD out	Preferred Option Trial 56 4 MGD in 1 MGD out	Trial 57 4 MGD in 1 MGD out
Reuse In Cutoff Elevation (ft NAVD)	N.A.	N.A.	51	51	51	51.5	52
Reuse Out Cutoff Elevation (ft NAVD)	N.A.	N.A.	46.91	46.91	46.91	46.91	46.91
Reuse In Nominal Pumping Rate (MGD)	0	2.01	2	3	4	4	4
Reuse Out Nominal Pumping Rate (MGD)	0	0.60	0.6	1	1	1	1
Ratio of Reuse In / Reuse Out		3.36	3.33	3	4	4	4
Stormwater Pumping							
Cumulative Discharge For 21 Year Model Period (ac-ft)	23,461	23,626	22,266	21,119	21,778	22,669	23,994
Long Term Average Annual Stormwater Discharge (ac-ft/yr)	1,117	1,125	1,060	1,006	1,037	1,079	1,143
Change in Stormwater Pumping Compared to Baseline (%)		0.7	-5.1	-10.0	-7.2	-3.4	**2.3**
Leakage							
Average Long Term Annual Leakage (ac-ft)	1,160	1,222	1,231	1,227	1,284	1,318	1,344
Change in Leakage From Baseline Conditions (%)		5.3	6.1	**-0.4**	12.5	3.8	5.0
Reuse Pumping							
Effective Long Term Net Pumping Rate (gpd)		131,113	12,463	-40,449	39,191	107,925	186,583
Long Term Average Net Reuse Pumping (MGY)		47.9	4.6	-14.8	14.3	39.4	68.1
Worst Case Year Net Reuse Out Pumping (MGY)		-32.9	-123.4	**-200.7**	-184.7	-160.1	-136.2
Note: Negative values represent pumping out of Cranes Roost. Positive values represent pumping into Cranes Roost							
Days Pumping							
Total Days In Model Period	7670	3650	7670	7670	7670	7670	7670
Days with Stormwater Discharge Pumping (days)	1,142	472	947	853	902	938	993
Days with Stormwater Discharge Pumping (%)	14.9	12.9	**12.3**	**11.1**	**11.8**	**12.2**	**12.9**
Days With Reuse In Pumping (days)		353	1315	1313	1254	1380	1511
Days With Reuse In Pumping (%)		9.7	**17.1**	**17.1**	**16.3**	**18.0**	**19.7**
Days With Reuse Out Pumping (days)		385	4033	3958	4124	4154	4167
Days With Reuse Out Pumping (%)		10.5	**52.6**	**51.6**	**53.8**	**54.2**	**54.3**
Days with No Pumping (days)		2466	1702	1835	1684	1504	1325
Days with No Pumping (%)		67.6	**22.2**	**23.9**	**22.0**	**19.6**	**17.3**

PRE VS. POST HYDROPERIOD FOR TRIAL 56

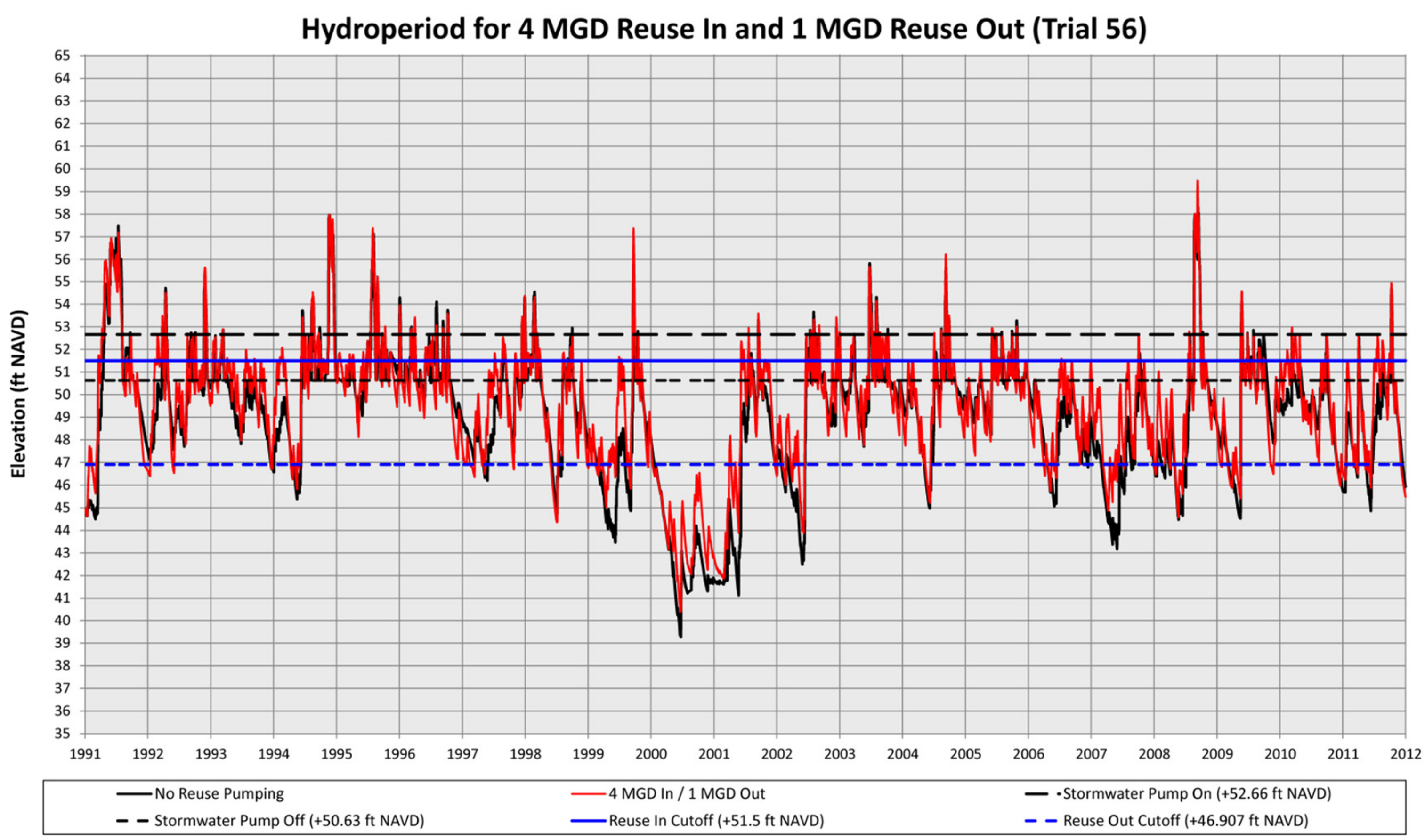


Figure B-12

MODELING TASK #3 – REVIEW OF HISTORICAL OPERATIONS

Modification of the as-operated, calibration scenario to exclude the reuse water component entirely and create an alternate baseline scenario with no reclaimed pumpage. Comparison of these two scenarios to assess the impact of the historical use of Cranes Roost for reclaimed water storage, with focus on the following key parameters:

1. **changes in stormwater pumpage volume to the Little Wekiva River**
2. **change in vertical leakage to the Floridan aquifer, and**
3. **frequency/duration of stormwater pumping to the river.**

KEY RESULT FOR TASK #3 - HISTORIC OPERATION

SJRWMD requested a model simulation to gage the historical effect of pumping reuse water into and out of Cranes Roost for the period 2002 to 2011.

- **The calibrated model which includes reuse transfers was re-run with the reuse component zeroed out.**

- **The results of this simulation when compared to the baseline (no reuse pumping) scenario indicate that the historic reuse pumping would have resulted in a deminimis increase in stormwater pumping discharge from Cranes Roost of about 0.7% (8 acre-feet) and an increase in recharge to the Upper Floridan aquifer is estimated to be 5.3% (62 acre-feet).**

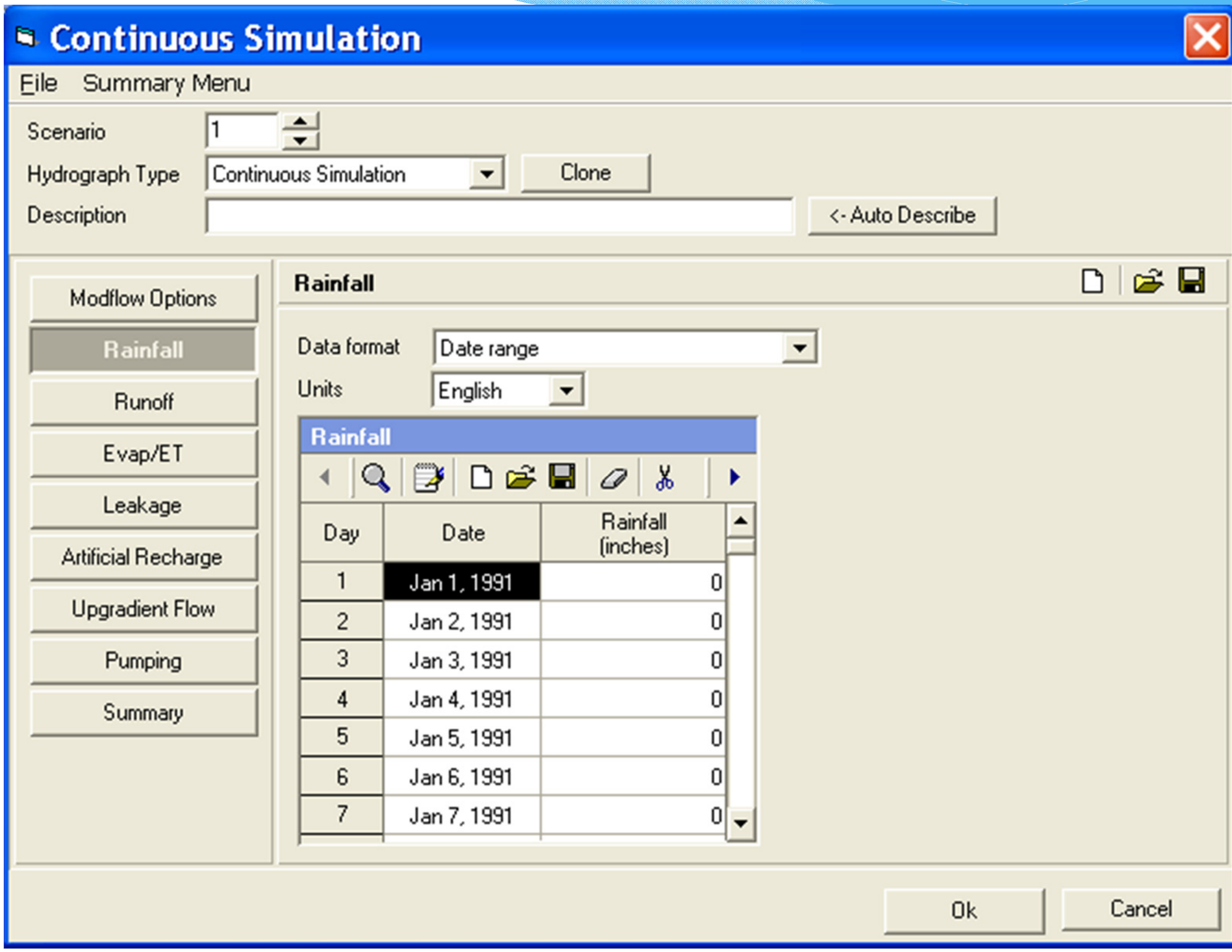
FLOODING OF CRANES ROOST DURING TS FAY (AUGUST 2008)

FLOODING OF CRANES ROOST DURING TS FAY (AUGUST 2008)

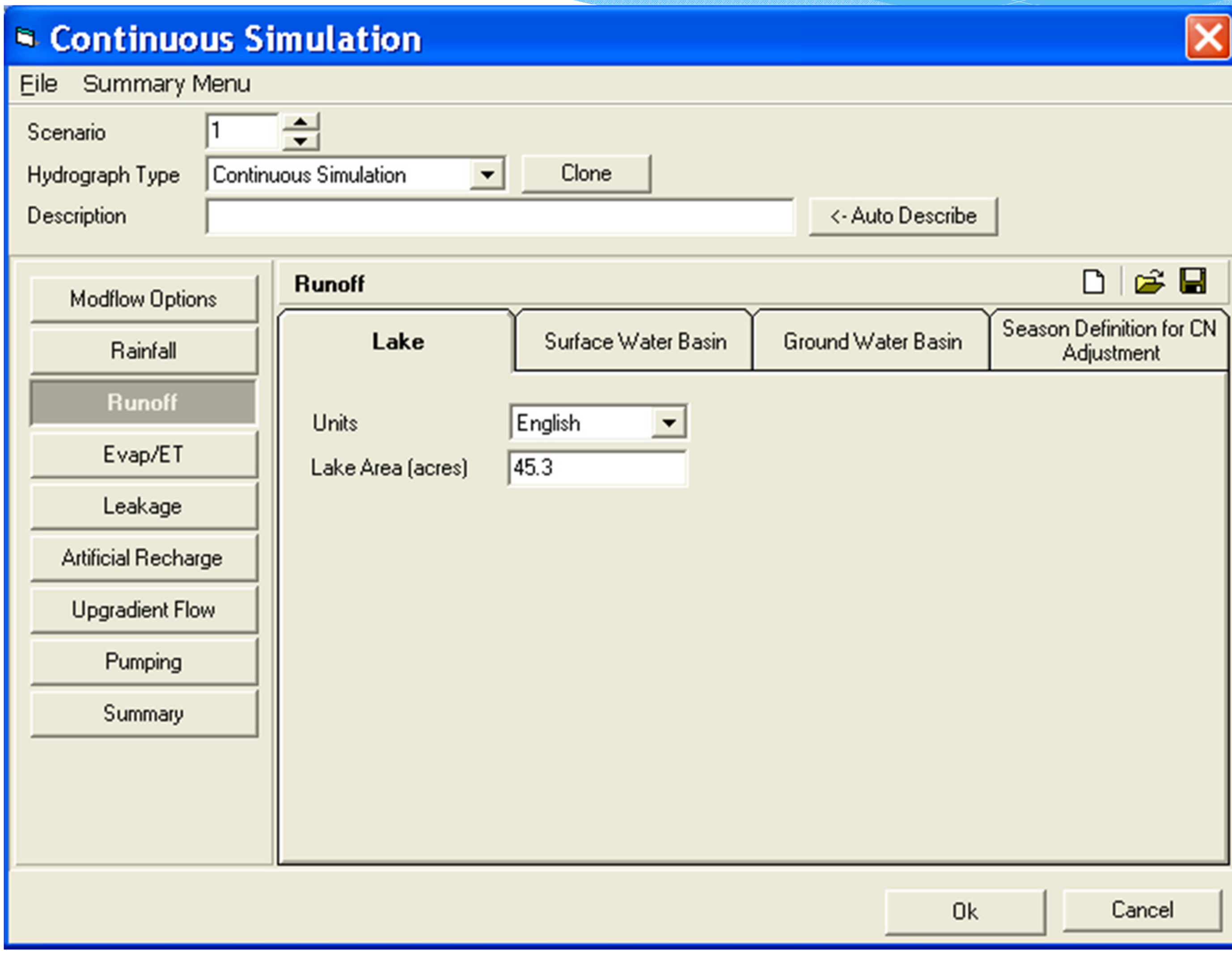
FLOODING OF CRANES ROOST DURING TS FAY (AUGUST 2008)

FLOODING OF CRANES ROOST DURING TS FAY (AUGUST 2008)

THE CONTINUOUS SIMULATION HYDROGRAPH
Rainfall Data

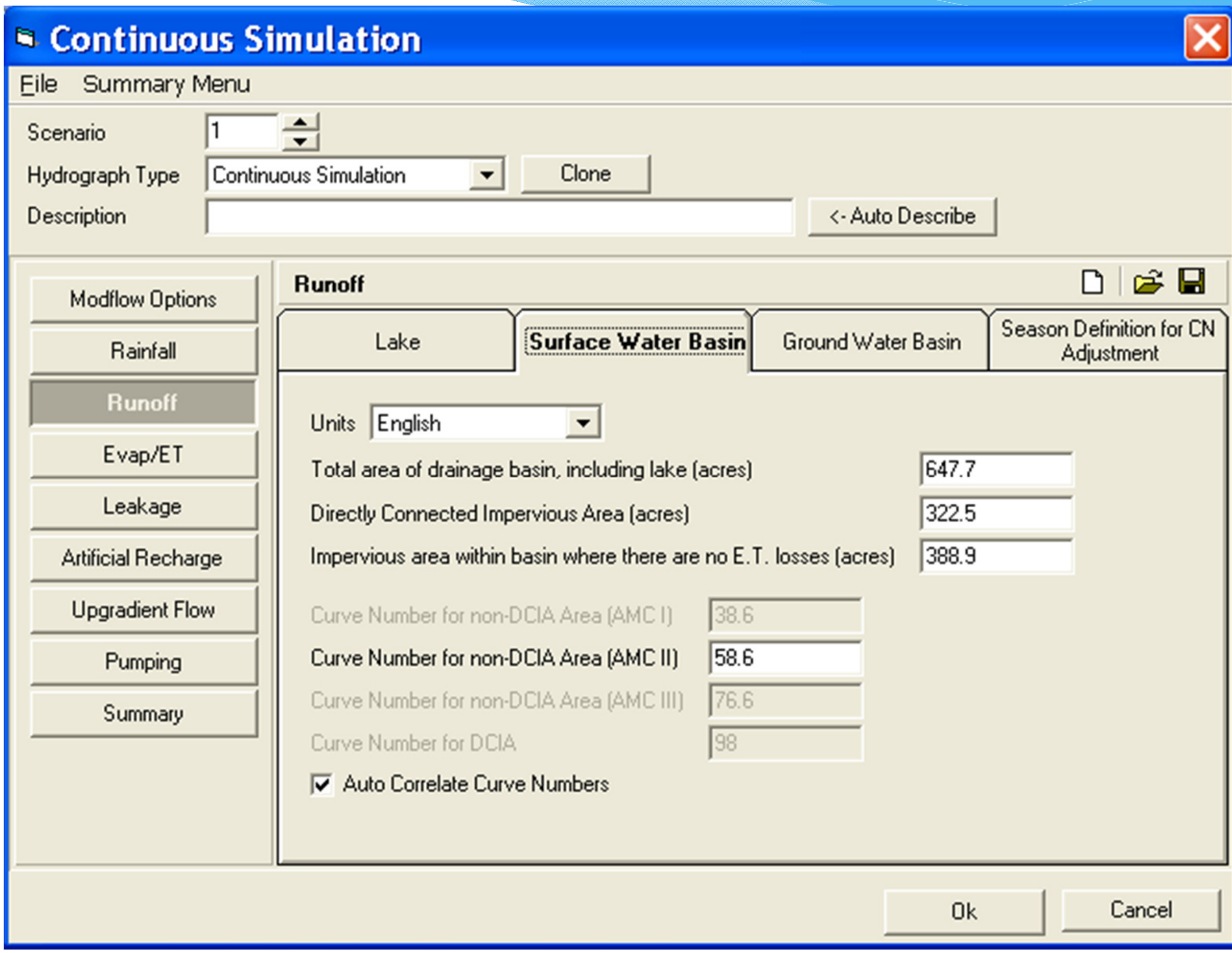


THE CONTINUOUS SIMULATION HYDROGRAPH
Lake Area

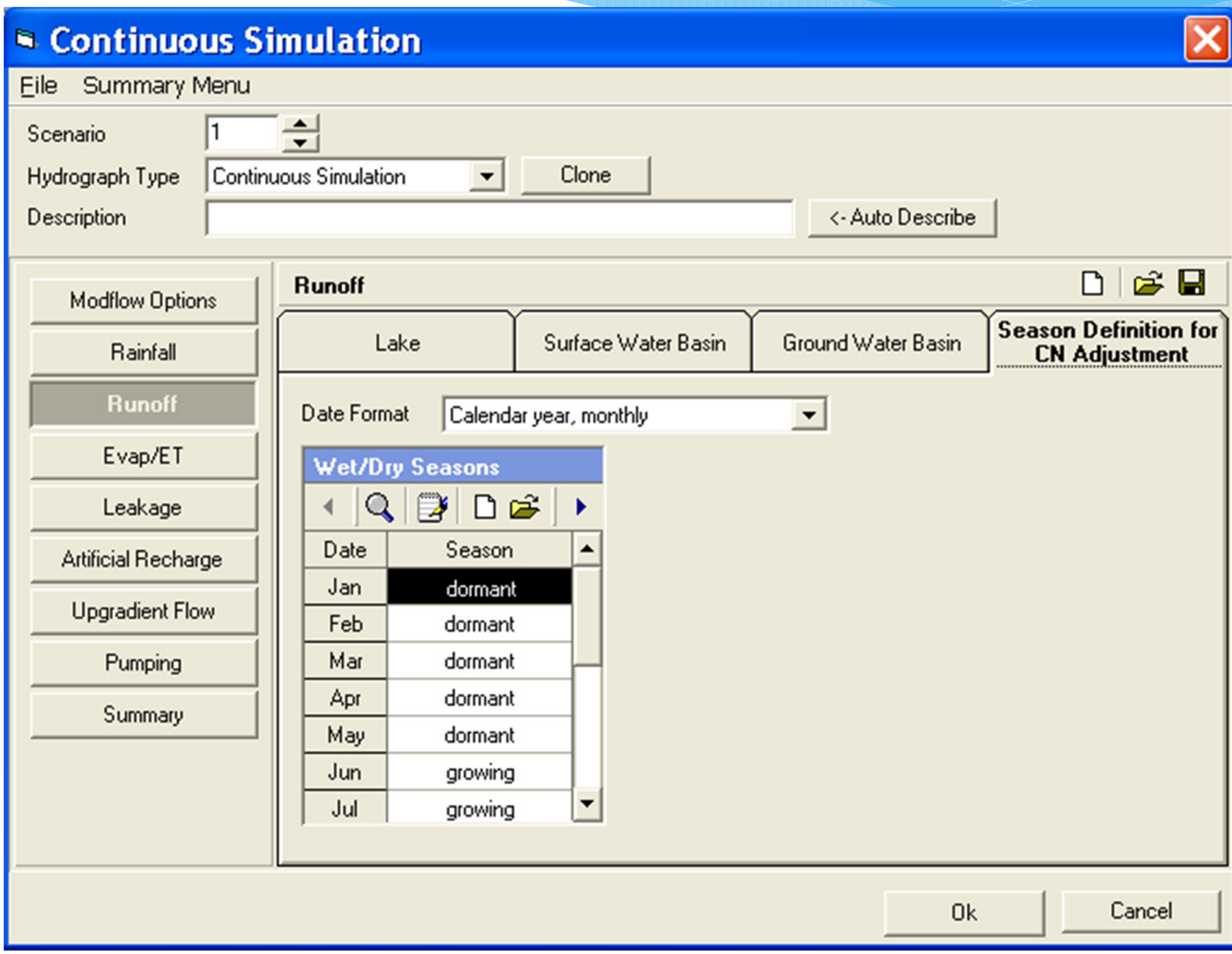


THE CONTINUOUS SIMULATION HYDROGRAPH

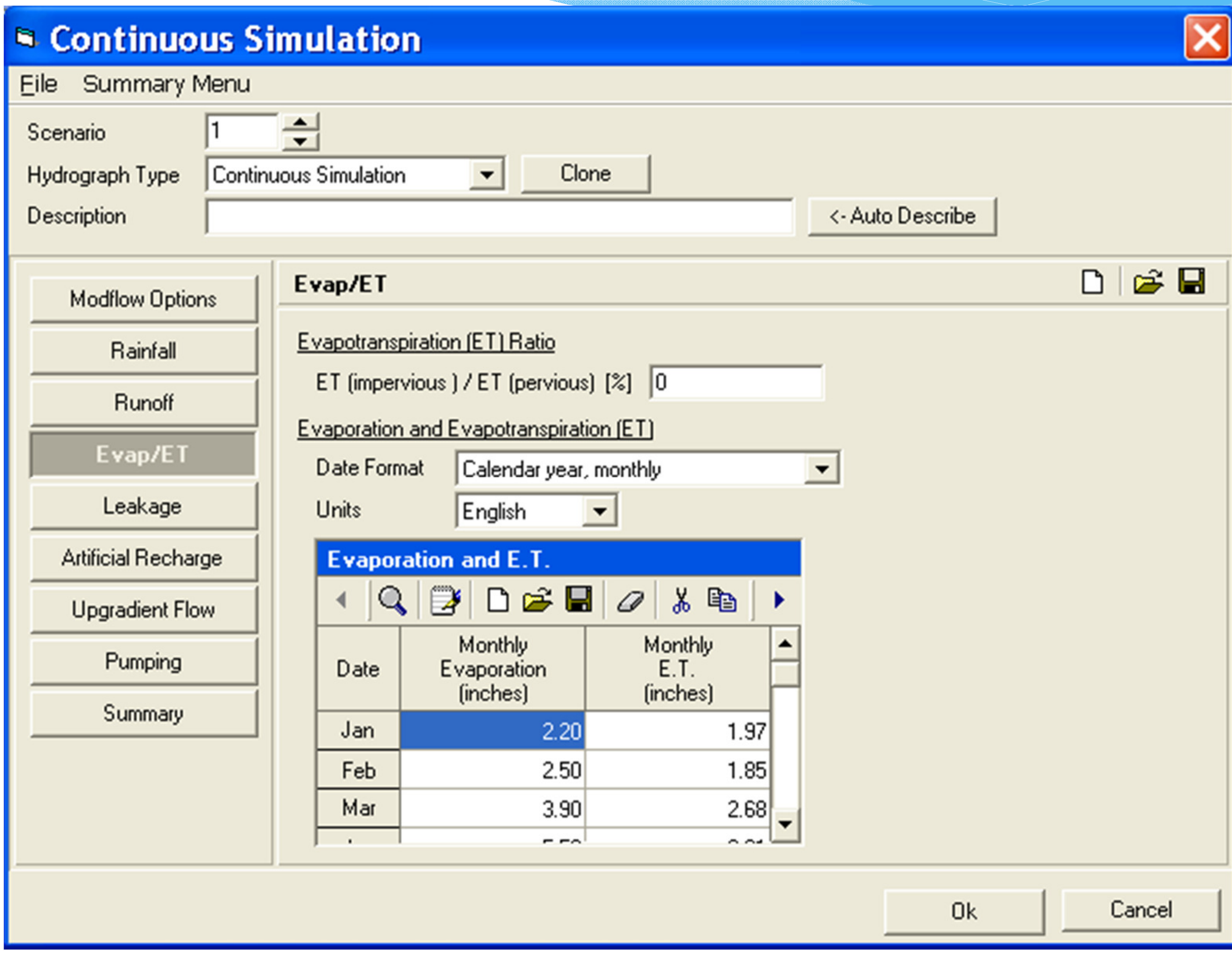
Surface Water Basin Runoff Parameters



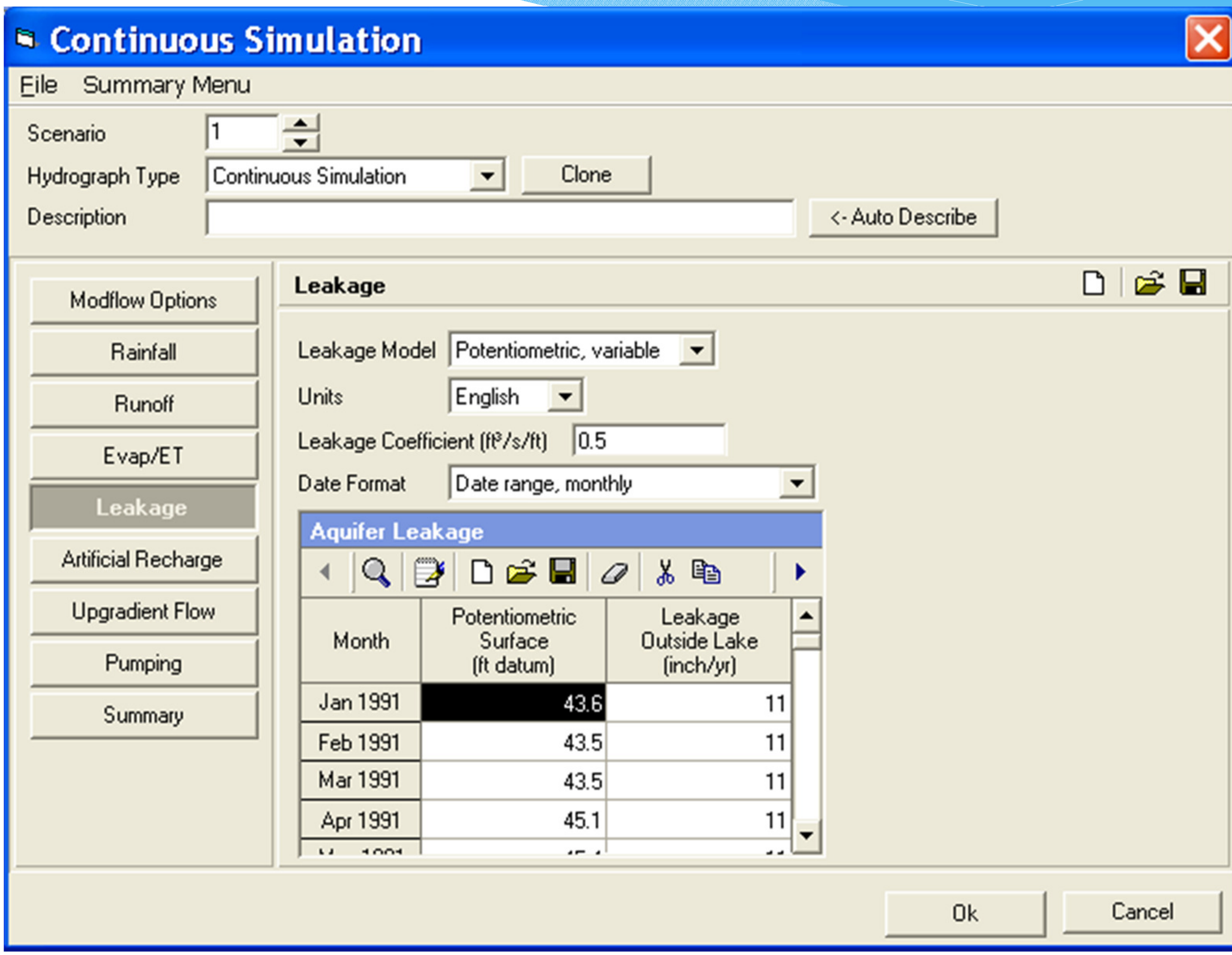
THE CONTINUOUS SIMULATION HYDROGRAPH
Growing Season



THE CONTINUOUS SIMULATION HYDROGRAPH
Evaporation & Evapotranspiration



THE CONTINUOUS SIMULATION HYDROGRAPH
Leakage



DEVO Engineering

ESTIMATED POTENTIOMETRIC SURFACE FOR CRANES ROOST WATER BODY

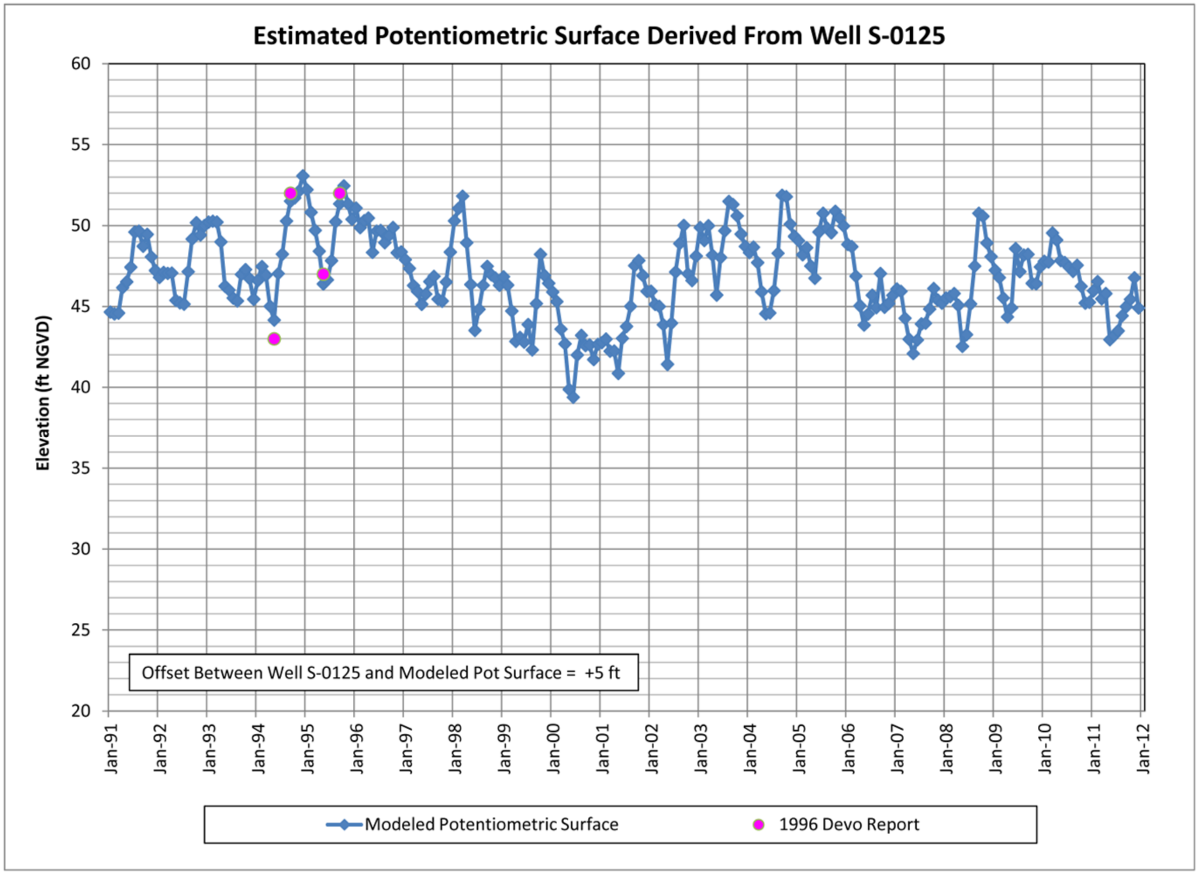


Figure A-6

CRANES ROOST INTEGRATED STORMWATER

CRANES ROOST INTEGRATED STORMWATER/RECLAIMED WATER FACILITY

CALIBRATION FOR LAKE MOBILE

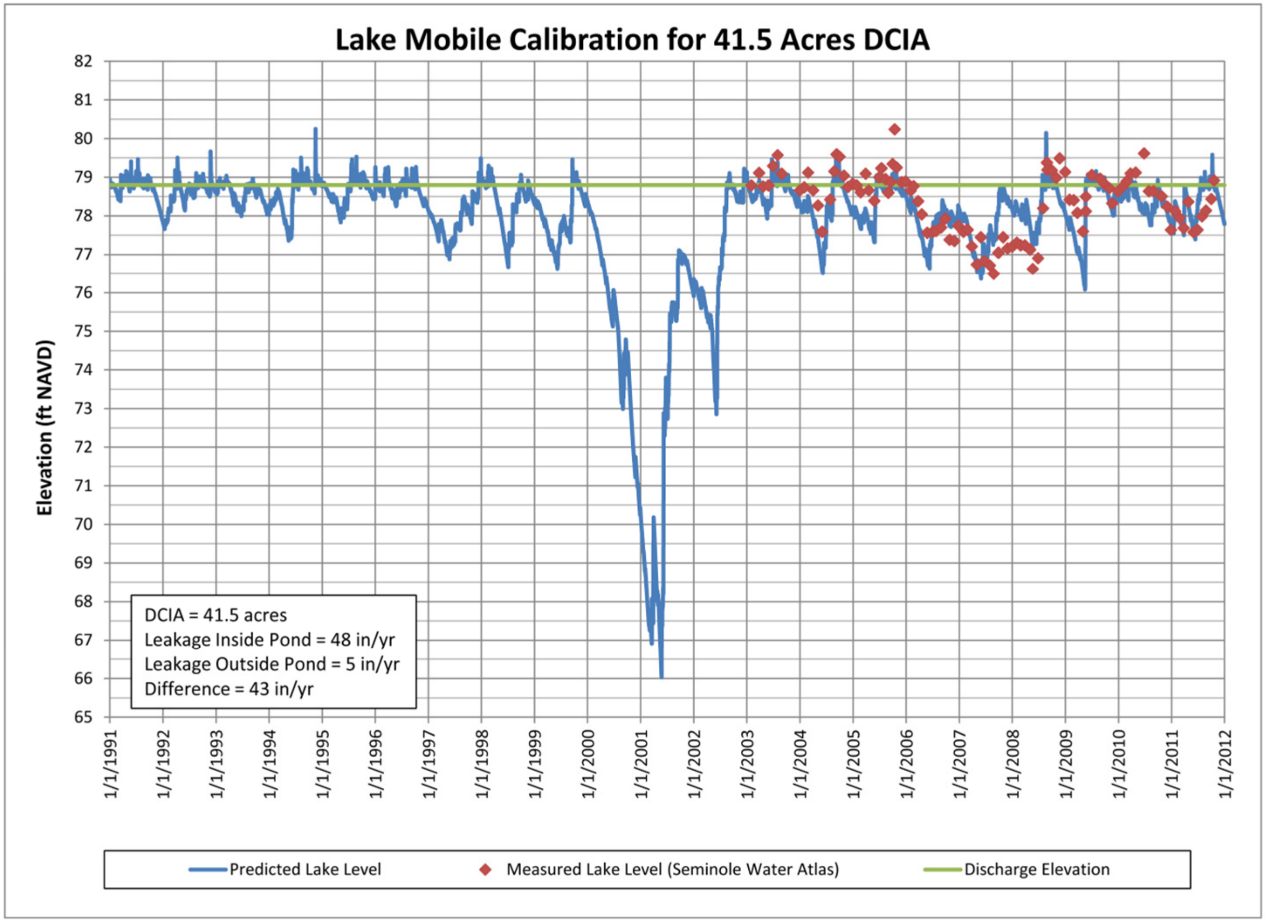


Figure A-2

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CALIBRATION FOR LAKE FLORIDA

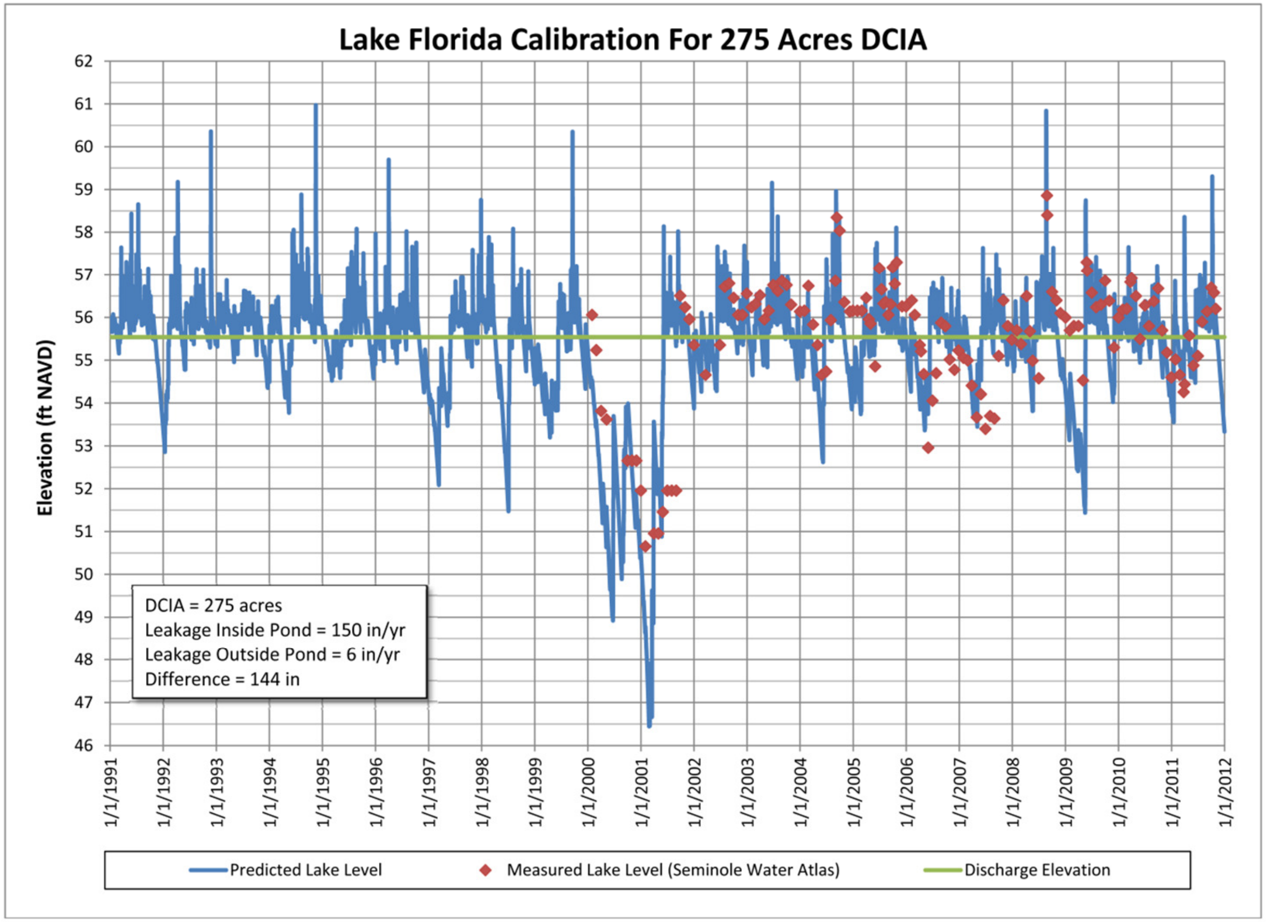

Figure A-4

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PRE VS. POST HYDROPERIOD FOR TRIAL 49

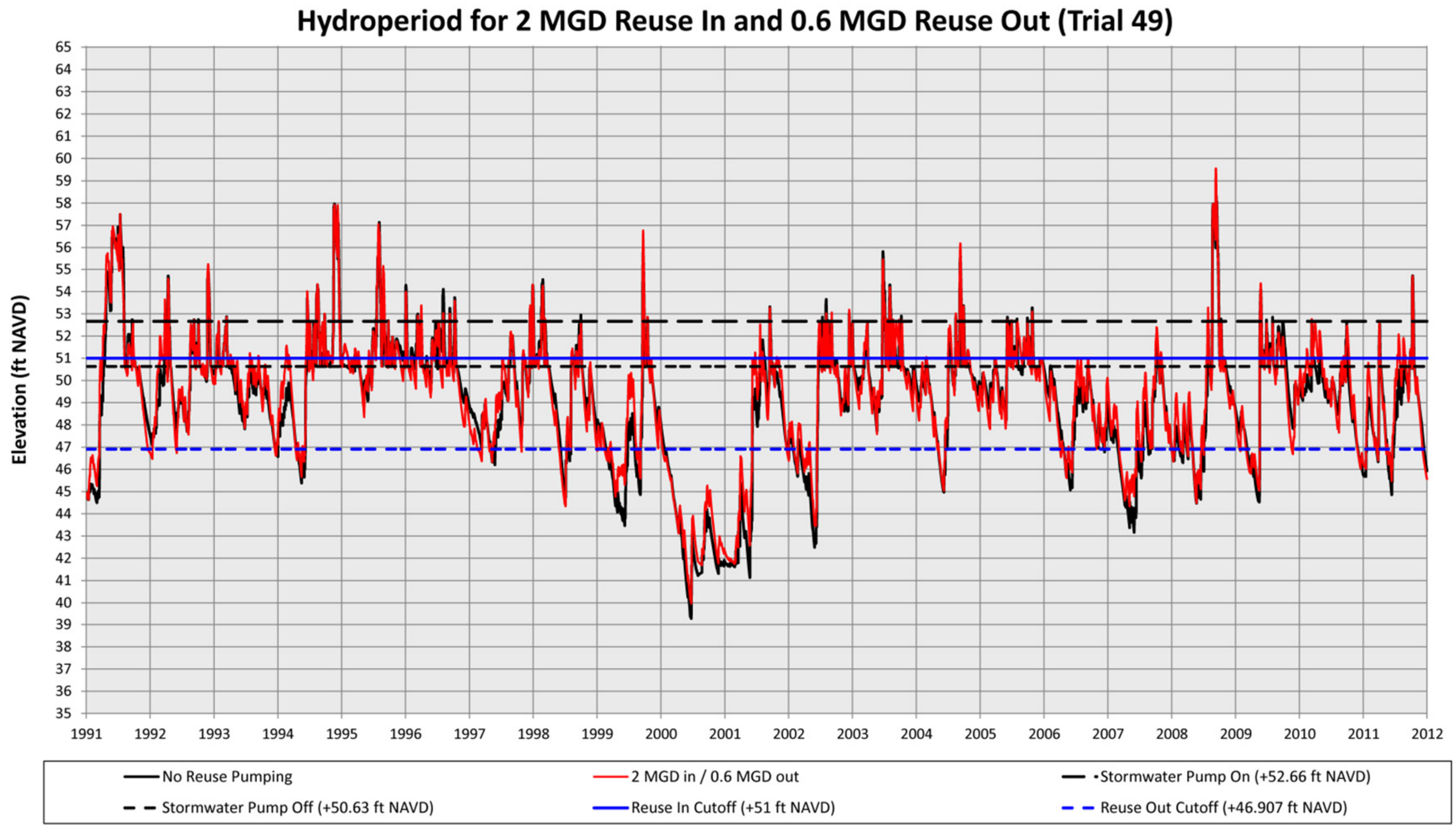

Figure B-5

CRANES ROOST INTEGRATED STORMWATER

CRANES ROOST INTEGRATED STORMWATER/RECLAIMED WATER FACILITY

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PRE VS. POST HYDROPERIOD FOR TRIAL 50

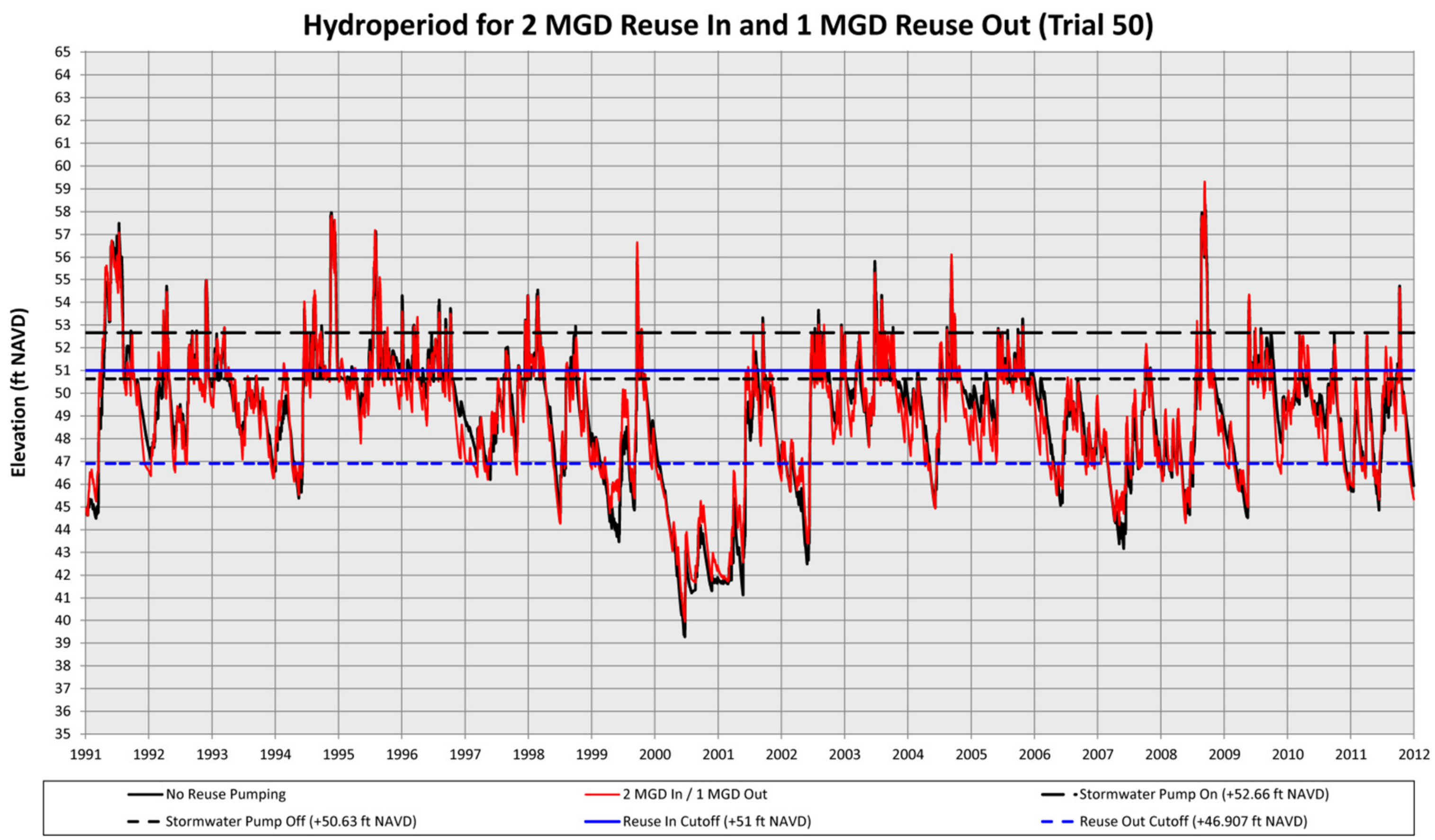

Figure B-6

PRE VS. POST HYDROPERIOD FOR TRIAL 51

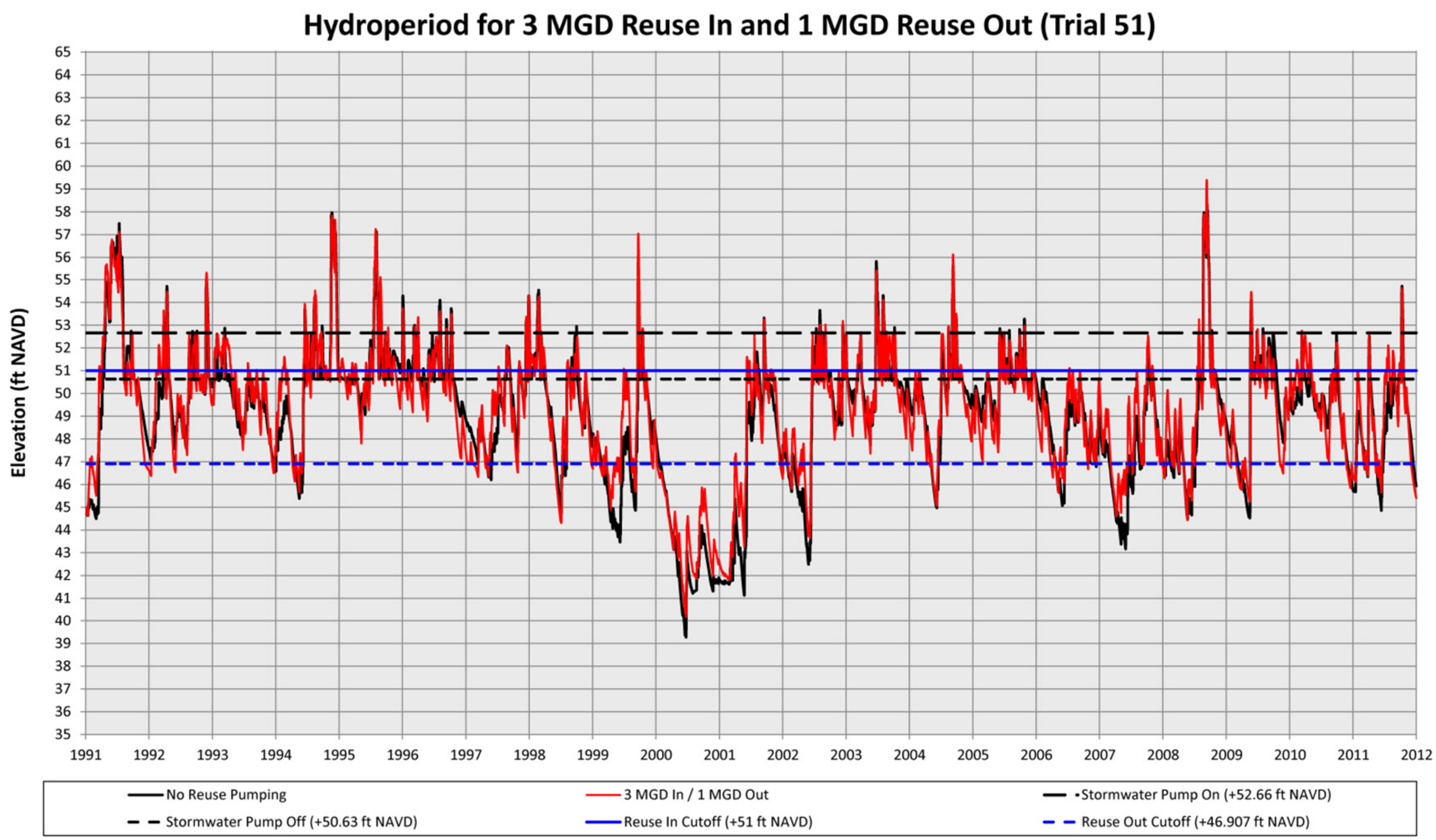

Figure B-7

PRE VS. POST HYDROPERIOD FOR TRIAL 52

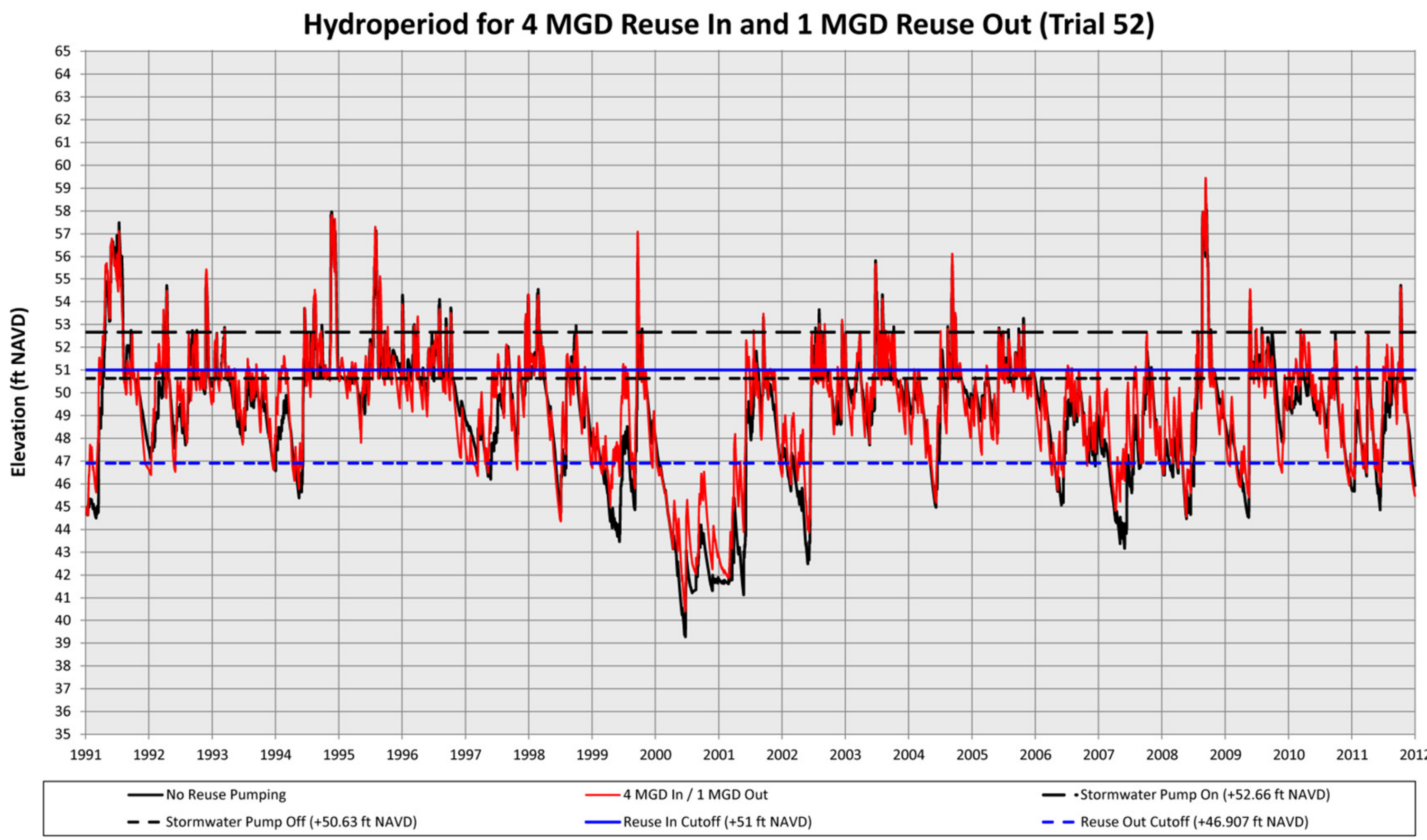

Figure B-8

PRE VS. POST HYDROPERIOD FOR TRIAL 53

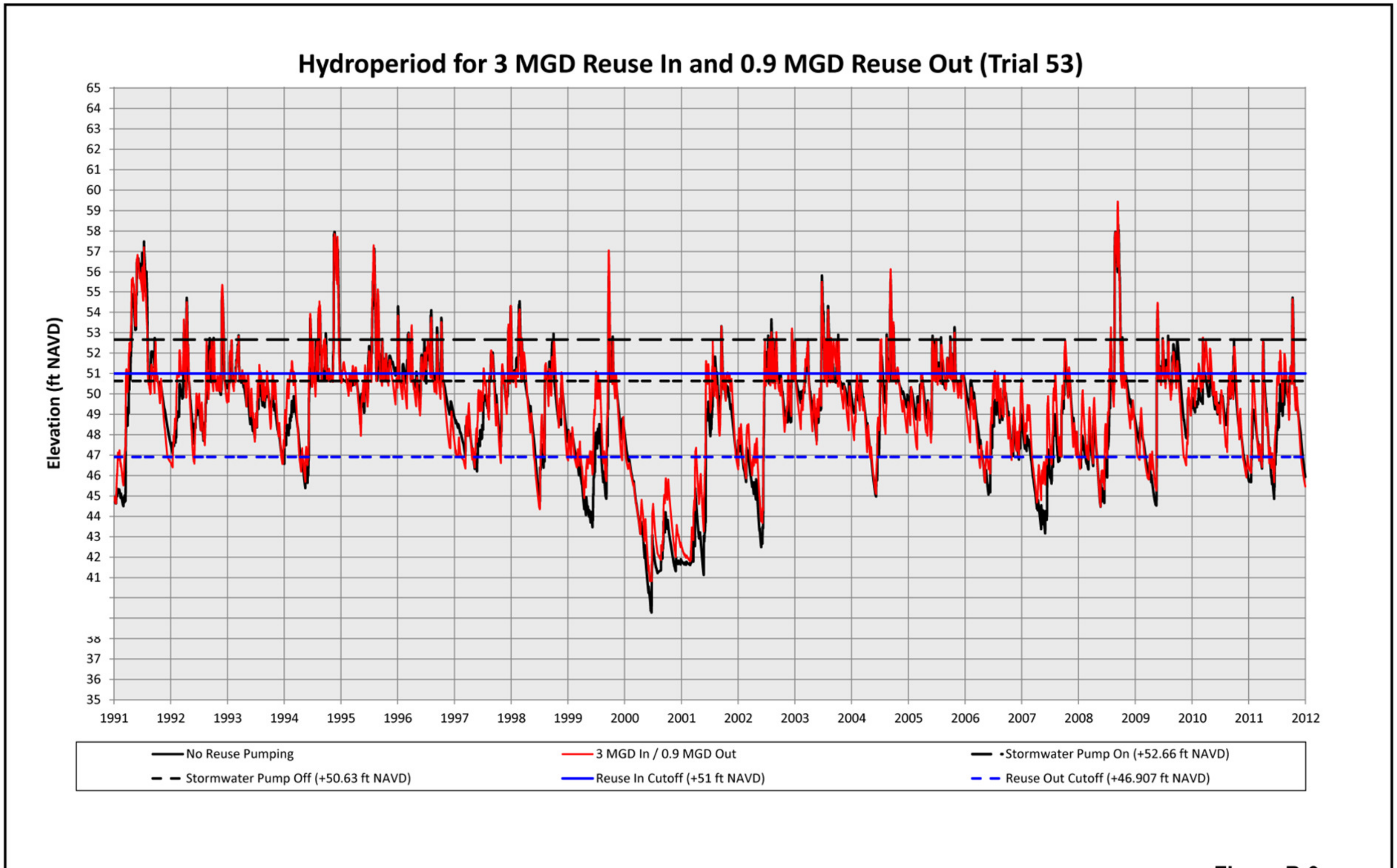

Figure B-9

PRE VS. POST HYDROPERIOD FOR TRIAL 54

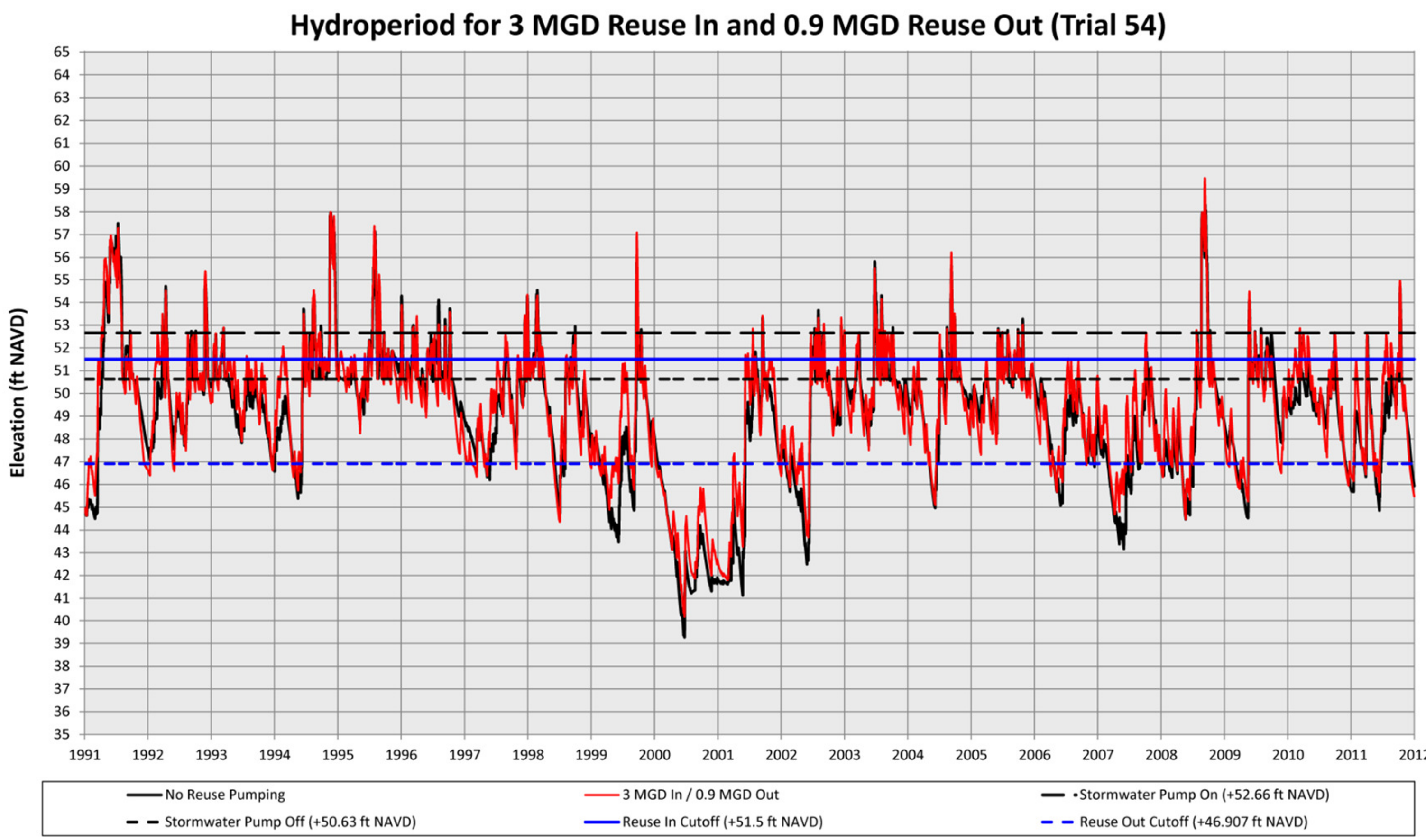

Figure B-10

PRE VS. POST HYDROPERIOD FOR TRIAL 55

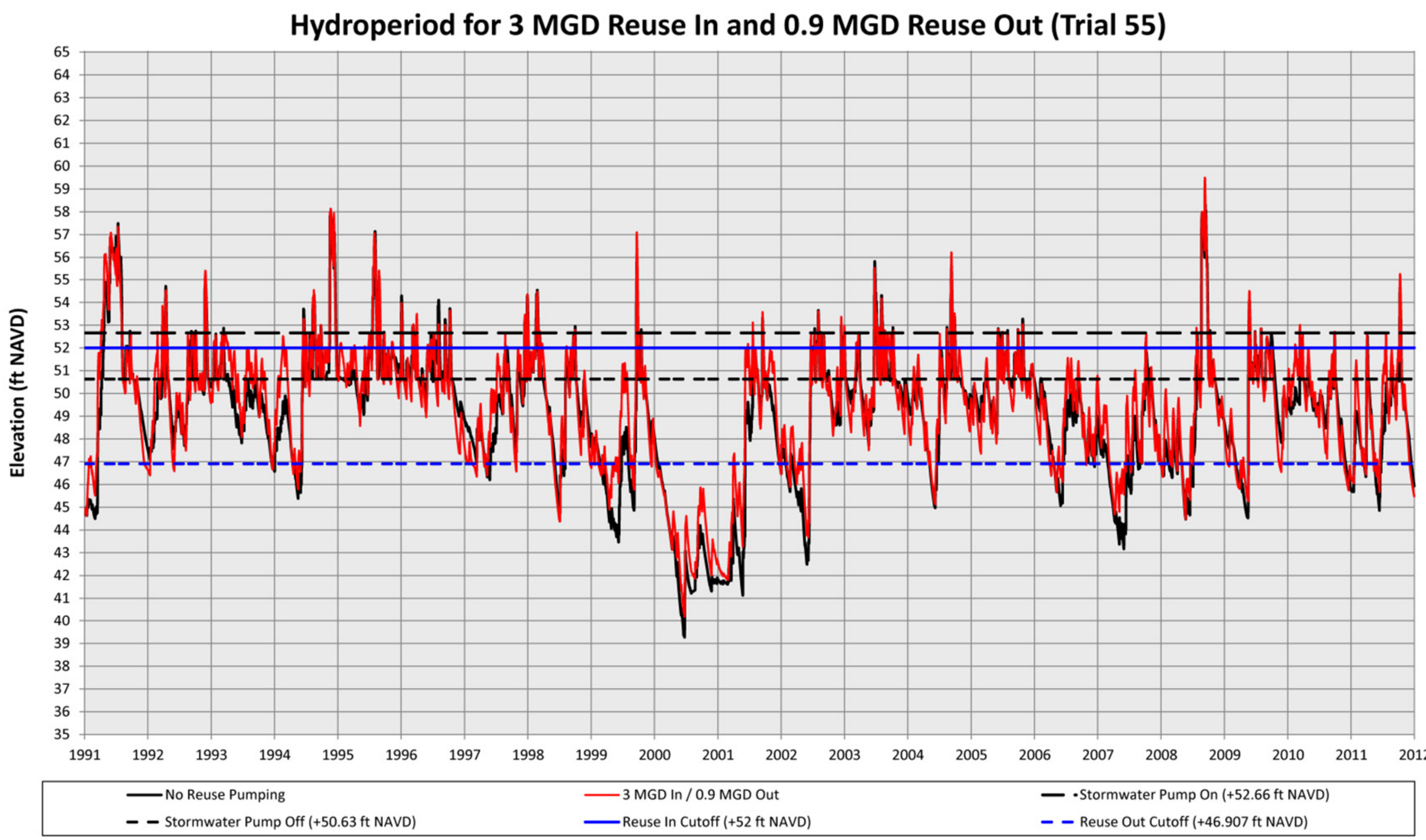

Figure B-11

PRE VS. POST HYDROPERIOD FOR TRIAL 57

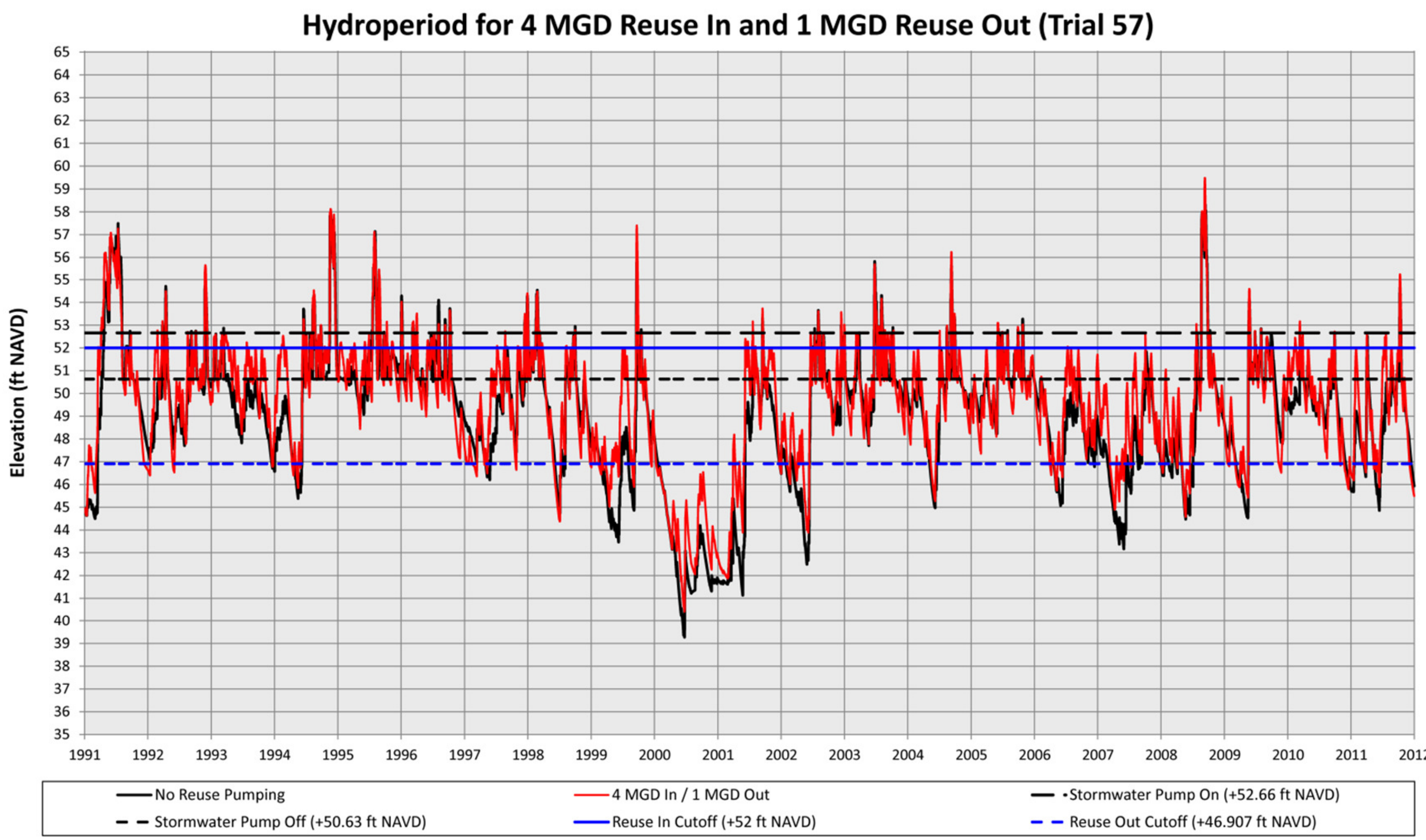

Figure B-13

PRE VS. POST HYDROPERIOD FOR TRIAL 58

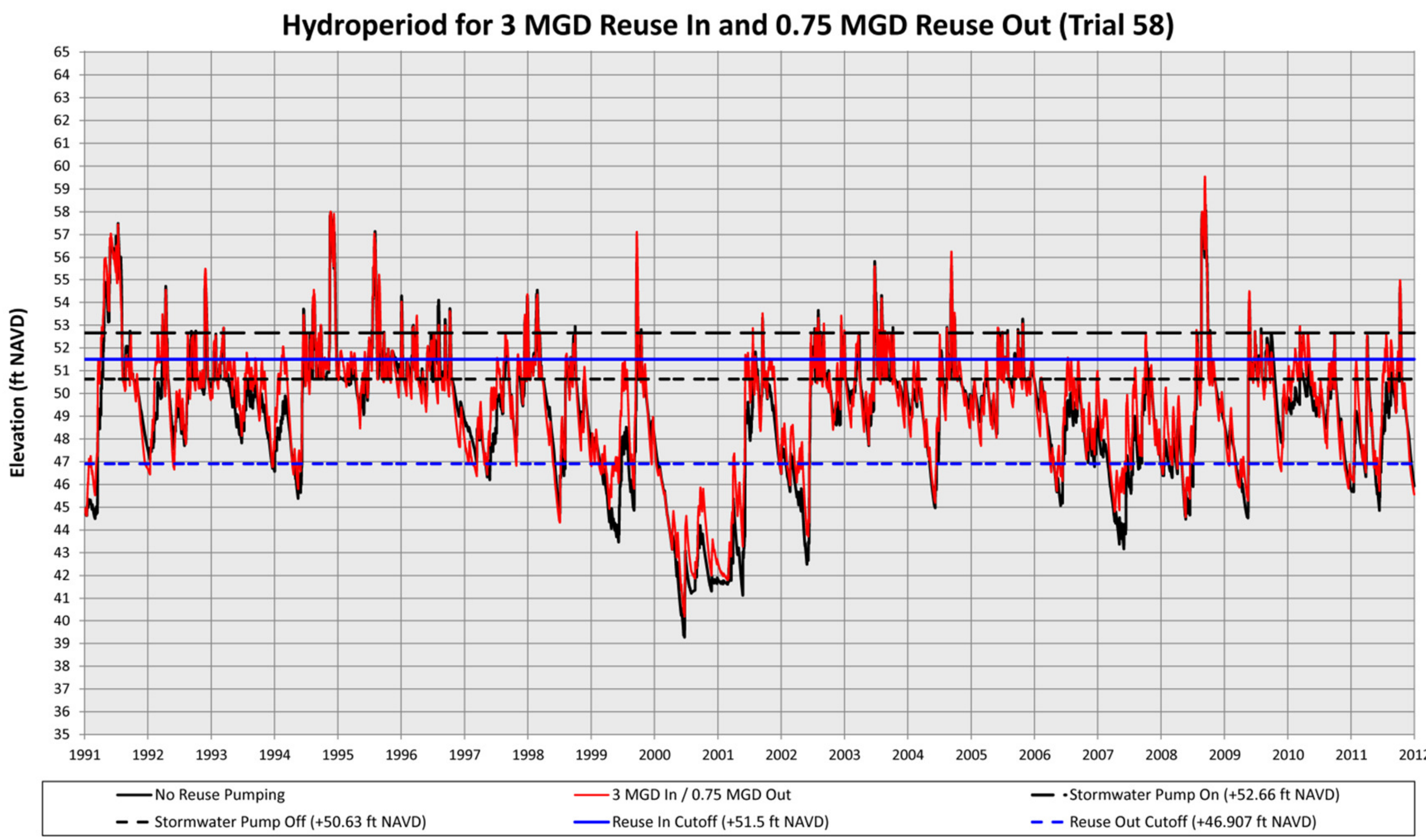

Figure B-14

PRE VS. POST HYDROPERIOD FOR TRIAL 59

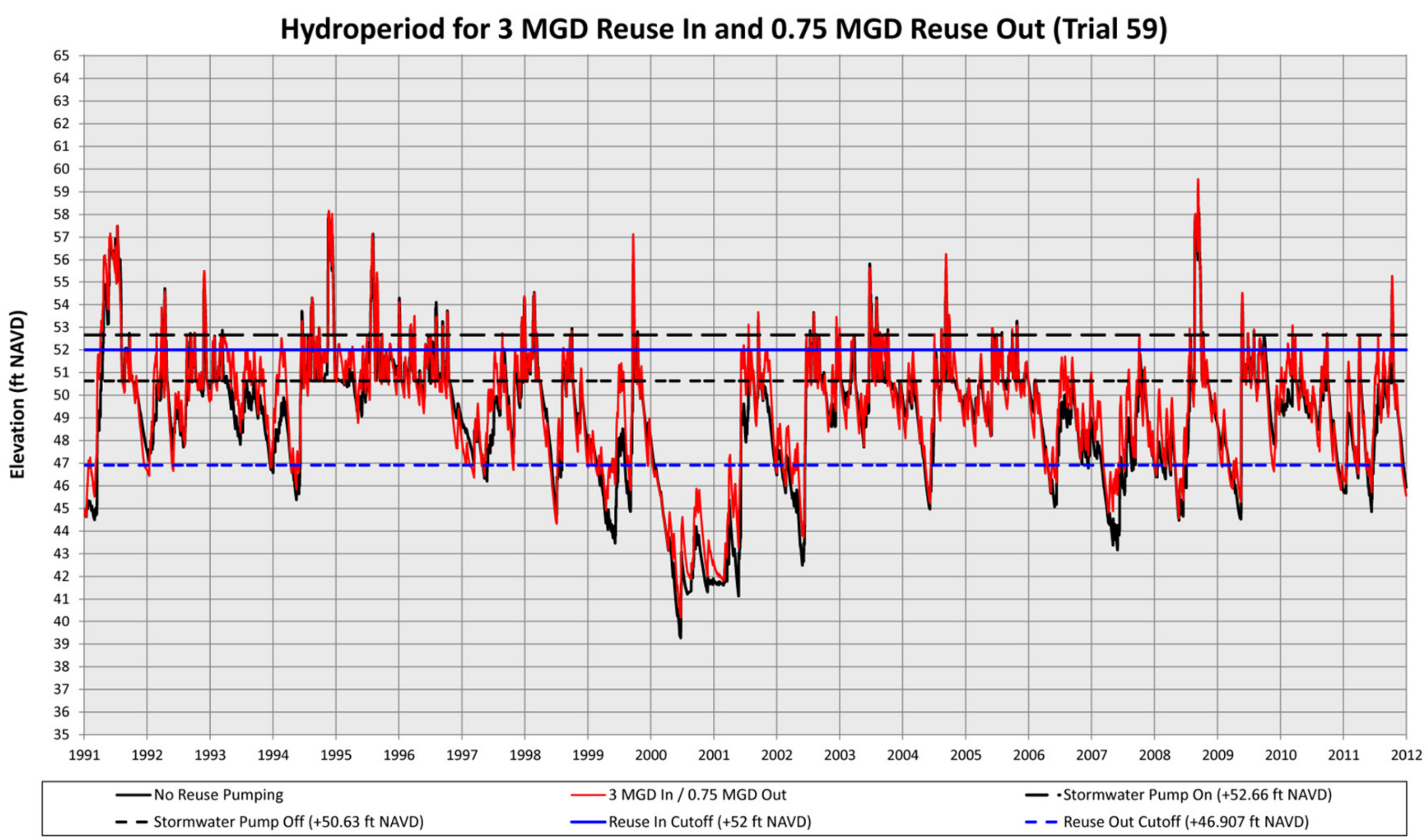

Figure B-15

PRE VS. POST HYDROPERIOD FOR TRIAL 60

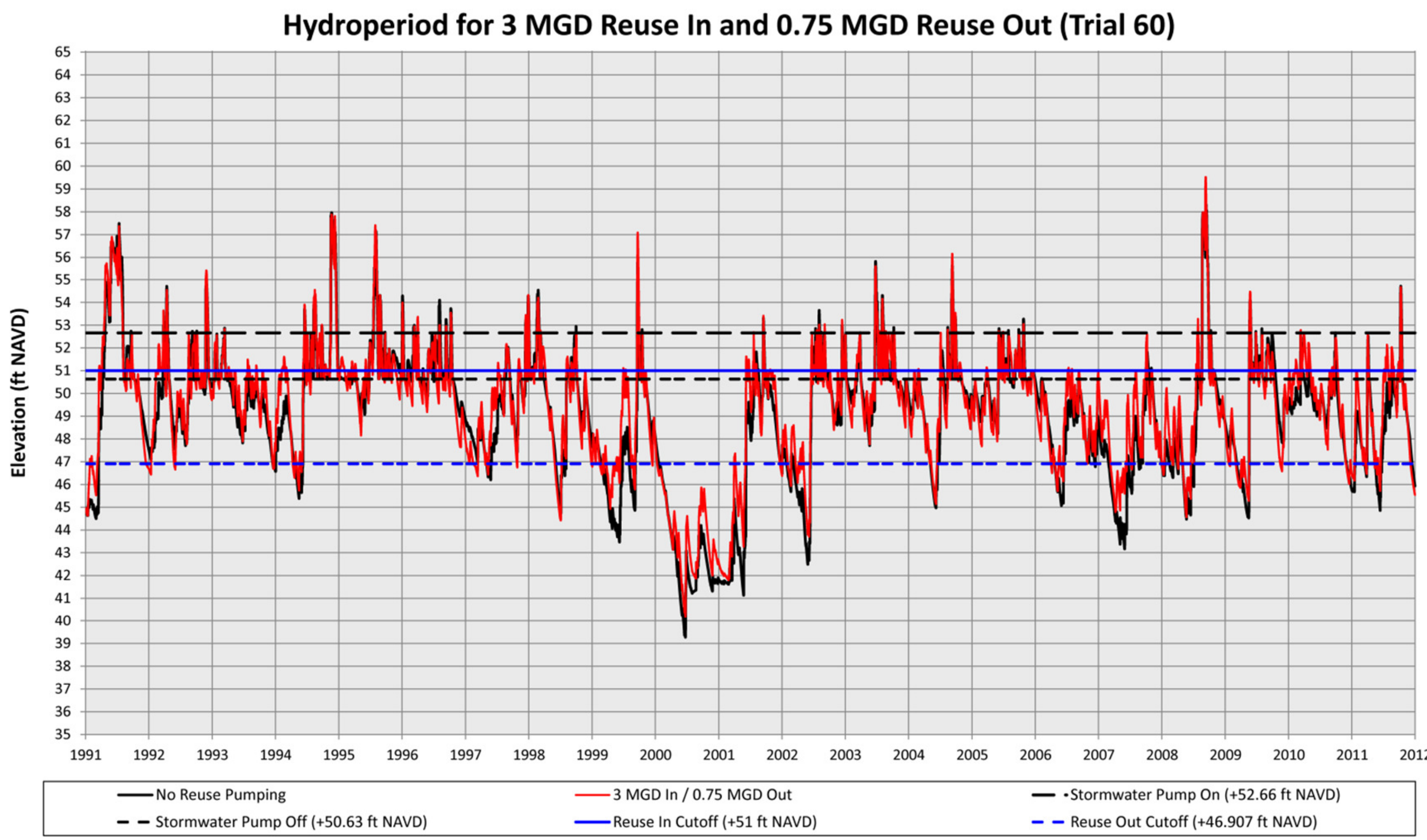

Figure B-16

PRE VS. POST HYDROPERIOD FOR TRIAL 61

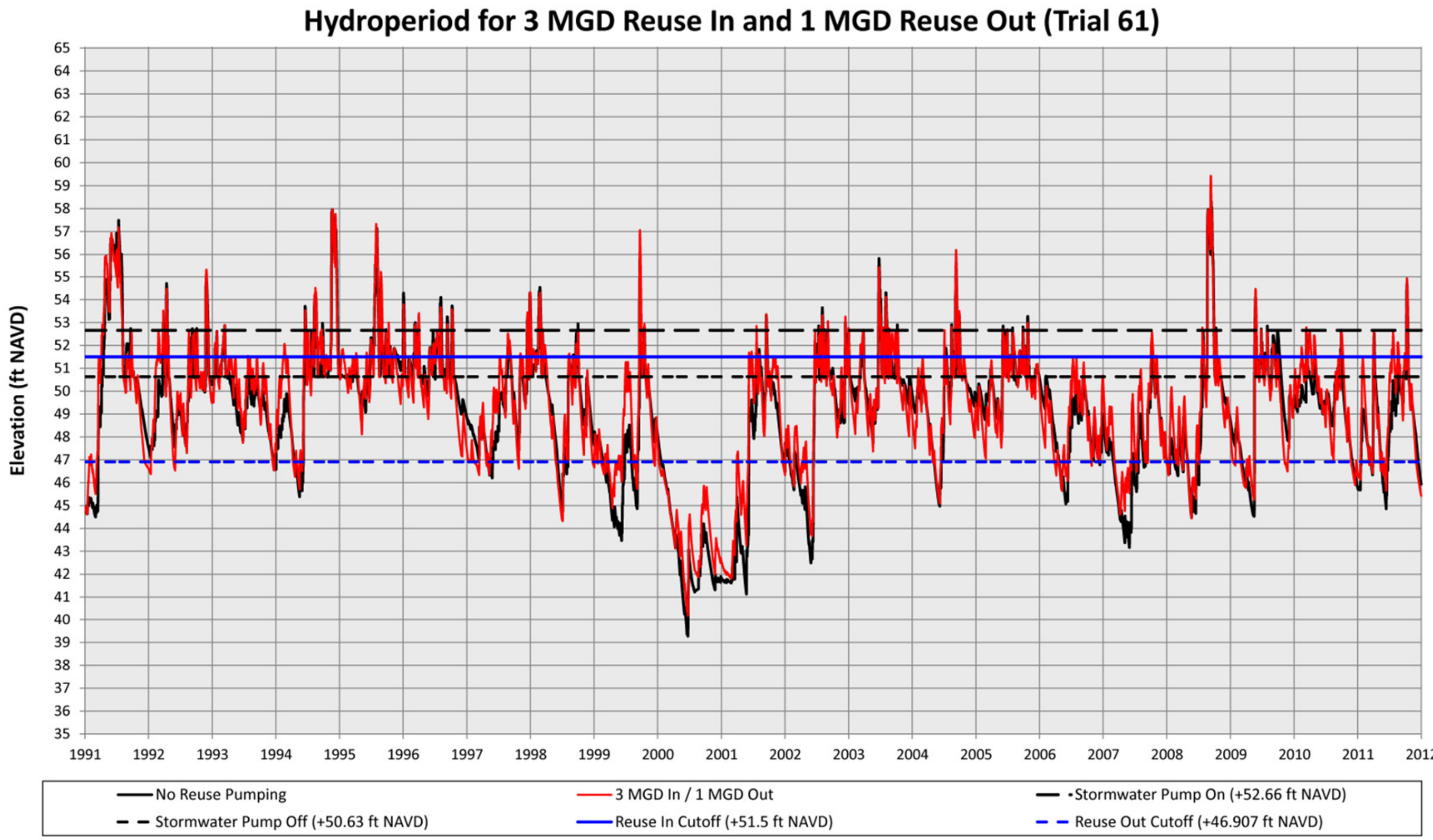

Figure B-17

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PRE VS. POST HYDROPERIOD FOR TRIAL 62

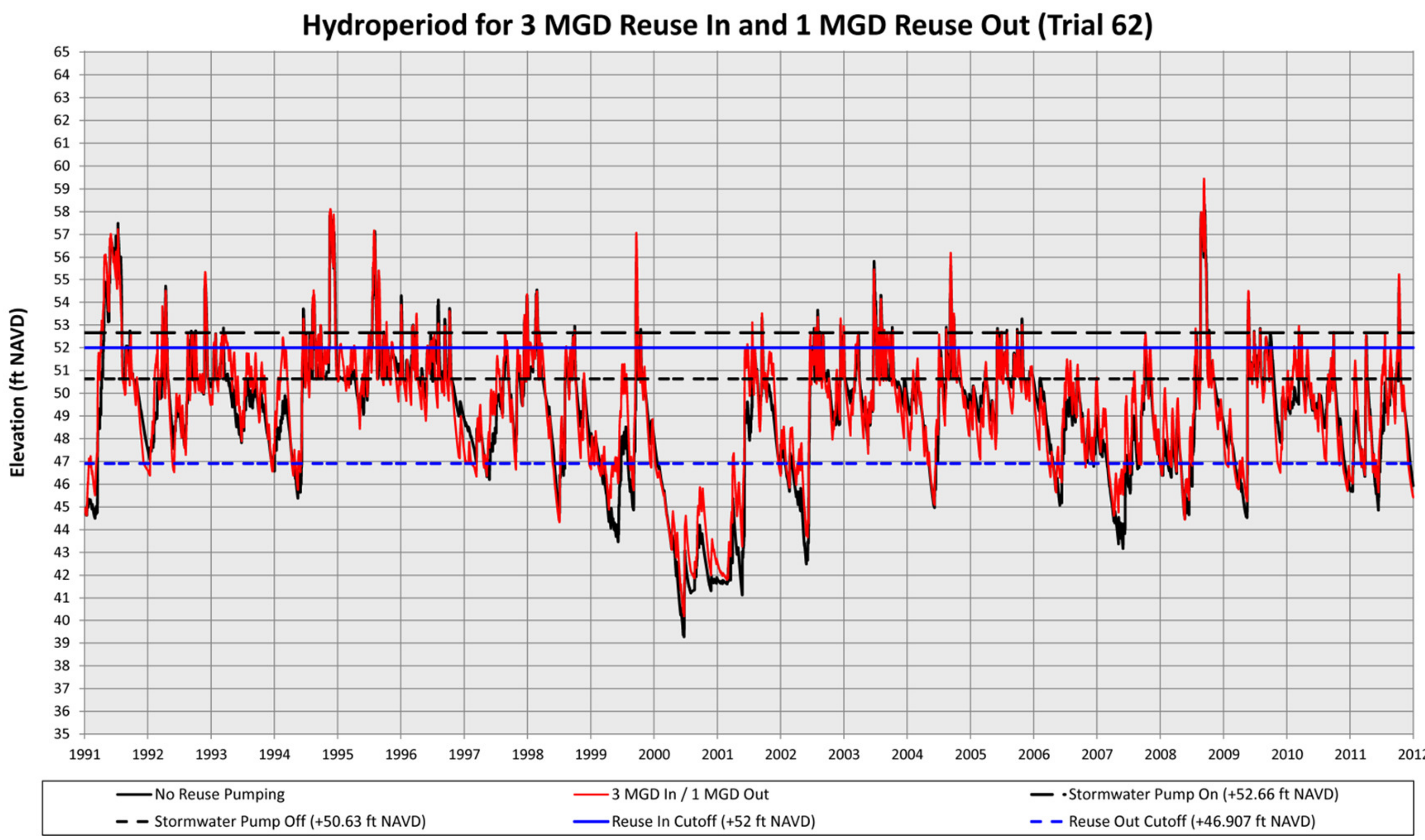

Figure B-18