NEWMARK PROJECT FLOW MODEL
TECHNICAL MEMORANDUM

PART II

TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS (Cont'd.)

FIGURES

ATTACHMENTS

* plates are located at end of this appendix

2.1 INTRODUCTION

This memorandum is an addendum to the Newmark Preliminary Steady-State Model Technical Memorandum (October 1991), which has been renamed to Newmark Project Flow Model Technical Memorandum, Part I and is included in Appendix A. Newmark Project Flow Model Technical Memorandum, Part I described the initial calibration steps of the steady-state flow model for Newmark Wellfield. This memorandum (Newmark Project Flow Model Technical Memorandum, Part II) will continue the description of the steady-state model calibration and then describe the calibration of the transient-state model.

The following aspects of the project flow model were discussed in the Newmark Project Flow Model Technical Memorandum, Part I:

- Data collection
- Development of the conceptual model
- Preparation of the input data for the steady-state model
- Preliminary calibration of the steady-state model

In this memorandum, Section 2.1 discusses how this memorandum ties in with the Newmark Project Flow Model Technical Memorandum, Part I, describes the difference between steady-state and transient-state conditions, and describes the groundwater flow equation used in the project flow model. Section 2.2 will mention the particular steady-state calibration runs that were completed previously for the Newmark Project Flow Model Technical Memorandum, Part I and those that were completed for this memorandum. Section 2.3 will describe the modifications made to the steady-state model for Runs 8A1219 through 16B0309. The modifications made to steady-state Runs 1A0411 through 7D0628 were discussed in the Newmark Project Flow Model Technical Memorandum, Part I.

Section 2.4 will discuss the preparation of the input data for simulation of the transient-state model. This section will describe the changes made to the input data for the calibrated steady-state model which were then used as the input data for the transient-state model. Section 2.5 will briefly describe the set up of the transient-state model and will state how many calibration runs were made for the transient-state model. Section 2.6 will describe the modifications made to the transient-state model for Runs 17A0324 through 25B0511. Section 2.7 will briefly discuss the application of the calibrated transient-state model to assessing several extraction scenarios. These extraction scenarios will be used to determine an efficient and feasible remediation extraction system for the Newmark plume. Section 2.8 will focus on the calibration and results of the transient-state model, which will become the project flow model used in the determination of a remediation extraction system for the Newmark plume.

2.1.1 Groundwater Flow Equation

The partial differential equation used to describe the three-dimensional movement of groundwater of constant density through porous earth material in MODFLOW is given below:

$$\partial/\partial x \, (K_{xx} \, \partial h/\partial x) + \partial/\partial y \, (K_{yy} \, \partial h/\partial y) + \partial/\partial z \, (K_{zz} \, \partial h/\partial z) - W = S_s \, \partial h/\partial t \qquad (1)$$

where K_{xx}, K_{yy} and K_{zz} are values of hydraulic conductivity along the x,y and z coordinate axes, which are assumed to be parallel to the major axes of hydraulic conductivity (L/t); h is the potentiometric head (L); W is a volumetric flux per unit volume and represents sources and/or sinks of water (1/t); S_s is the specific storage of the porous material (1/L); and t is time (t).

In simple terms, equation (1) can be described by the continuity equation (Wang and Anderson, 1982) given below:

$$\text{Input - Output = Change in storage} \qquad (2).$$

Equation (2) describes transient-state groundwater flow conditions where water is released or stored in the aquifer at a particular rate. However, in steady-steady groundwater flow conditions, change in storage equals zero and, therefore, can be described as:

$$\text{Input} = \text{Output} \qquad (3).$$

2.1.2 Steady-state Vs. Transient-state Model

The project flow model has entailed two calibration periods. The first calibration period was the steady-state period that was from January 1982 through January 1986. This steady-state calibration period was used because the heads did not change significantly over this time period. The input data, boundary conditions and initial calibration of the steady-state model are described in the Newmark Project Flow Model Technical Memorandum, Part I. The final calibration of the steady-state model is discussed in Section 2.2 and the modifications made during the calibration of the steady-state model are described in Section 2.3.

The second calibration period (transient calibration period) was from January 1986 to December 1990. The calibrated input data and boundary conditions for the steady-state model were used as the input data and boundary conditions for the transient-state model. The water elevations that were simulated by the calibrated steady-state model for January 1986 were used as the initial water elevations for the transient-state model. Pumpage data for the water-supply wells for January 1986 through December 1990 were collected and prepared in input data format for the transient-state model. Preparation of the input data and boundary conditions for the transient-state model are described in Section 2.4. The calibration of the transient-state model is discussed in Section 2.5 and the modifications made during the calibration of the transient-state model are described in Section 2.6.

2.2 CALIBRATION OF STEADY-STATE MODEL

In Newmark Project Flow Model Technical Memorandum, Part I, calibration process of steady-state model was described for Runs 1A0411 through 7D0628, which consisted of a total of 29 runs. The last completed calibration Run 7D0628 consisted of the original input files with the following changes:

- Transmissivities and hydraulic conductivities were interpreted from this initial analysis of recent water supply tests and historical data were replaced with those used by Hardt and Hutchinson (1980).

- The STR input file was replaced with the RIV and GHB input files to provide greater flexibility. The lateral area of the stream alluvium was widened and all percolation basins were modified so that all incoming surface-water recharged the groundwater.

Calibration of the steady-state model resumed with Run 8A1219 and continued through Run 16B0309. Run 16A0309 became the final and calibrated steady-state simulation. Several modifications were made to the steady-state model during Runs 8A1219 through 16B0309. In the next section, these modifications are described.

The heads for January 1986 produced from the calibrated steady-state model reasonably matched the observed heads for January 1986, except in the area surrounding the Shandin Hills adjacent to the San Andreas fault (just northeast of Shandin Hills). This same problem area was present in the calibration of the transient-state model and will be discussed in Section 2.8.

More importantly, the flow directions simulated by the steady-state model match observed flow directions very well. More detail on matching of the simulated and observed water elevations will be given in Sections 2.5, 2.6 and 2.8, since water elevations and general flow directions did not change much between the calibrated steady-state and transient-state models.

2.3 MODIFICATIONS OF STEADY-STATE MODEL

In this section, modifications made to the steady-state model for Runs 8A1219 through 16B0309 will be described. Table 8 summarizes the modifications and results of these steady-state simulations. The major modifications made to the steady-state Runs 8A1219 through 16B0309 are described in more detail below:

- The constant-head conditions along the eastern and western boundaries were changed to general-head boundary conditions during Run 8A1219 to allow for better control of the flow entering the model area through these side boundaries.

- An evapotranspiration (EVT) input file was created and first used during Run 8A1219. A maximum evapotranspiration rate of 8.64 (10^{-3}) ft/day and a maximum extinction depth of 10 feet from the ground surface were used in the EVT input file.

- As described in Section 1.4.3 of Newmark Project Flow Model Technical Memorandum, Part I, the alluvium was divided within the model area into two aquifer systems which were separated by a zone consisting predominantly of discontinuous clay lenses. Through interpretation of the drillers' logs, the portion of the study area north of Shandin Hills probably contains few and scattered thin clay lenses; therefore, the aquifer in this area is considered to be an unconfined aquifer (or water-table aquifer). South of Shandin Hills the alluvium becomes interfingered with many clay lenses. In this area, the alluvium divides into two major aquifers. The upper aquifer remains an unconfined aquifer; but, the lower aquifer is confined by the overlying zone of interfingered clay lenses.

Appendix J

Table 8

SUMMARY OF ADDITIONAL CALIBRATION RUNS FOR STEADY-STATE MODEL

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
8A1219 8B0107 8C0108	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 7D0628 were initially used. 2) Evapotranspiration input file was created. 3) Corrected locations of percolation basins for East Twin Creeks in RIV package. 4) Used hydraulic conductivities and transmissivities from 3A0425. 5) Then adjusted hydraulic conductivities and transmissivities near Shandin Hills. 6) Increased conductance values for GHB file for eastern and western boundaries.	1) Simulation converged for 8A1219, but many cells went dry. 2) Simulation did not converge for 8B0107. 3) Simulation converged for 8C0108, but many cells went dry.
9A0124 9B0130 9C0130 9D0204 9E0206	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 8C0108 were initially used. 2) Changed aquifer conditions for layer 2 from confined to unconfined/confined. This instigated the changes listed below: 3) For region north of south edge of Shandin Hills, decreased layer 2 thickness to approximately 25 feet. 4) Changed transmissivity values to hydraulic conductivities for layer 2. 5) Adjusted top elevation array for layer 2. 6) Created new bottom elevation array for layer 2 (new bedrock elevations). Adjusted them specifically around Shandin Hills, Wiggins Hill and Badger Hill. 7) Changed vertical leakance for northern area, where clay does not exist, to 0.1 day^{-1}.	1) Simulations 9A0124 through 9D0204 did not converge. 2) For 9E0206, the acceleration parameter was changed so that it would converge slowly. Simulation 9E0206 went through 1000 iterations with a convergence closure of 0.5.

Appendix J

Table 8 (Cont'd.)

SUMMARY OF ADDITIONAL CALIBRATION RUNS FOR STEADY-STATE MODEL

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
10A0210 10B0213 10C0217 10D0218 10E0218	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 9E0206 were initially used. 2) Still adjusted bedrock elevations around bedrock hills to maximize saturated thickness. 3) Adjusted heads in RIV cells for upper area of Lytle Creek and percolation basins in northern area. 4) Increased heads for GHB input file for eastern boundary between San Bernardino Mountains and Perris Hill, but then were changed back to original heads.	1) Simulation for 10A0210 converged with -0.7% water balance discrepancy. Reduced the amount of dry cells produced in the previous simulation (9E0206) 2) Simulation for 10B0213 converged with only 10 dry cells near southeast corner of Shandin Hills. 3) Simulation for 10C0217 converged with only one dry cell at (23, 29, 2). 4) Simulations for 10D0218 and 10E0218 converged with only one dry cell at (23, 29, 2).
11A0219 11B0219 11C0219	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 10E0218 were initially used. 2) Adjusted heads and conductance values in RIV cells for upper area of Lytle Creek and percolation basins in northern area and added in RIV conditions for Cable Creek.	1) Simulations for 11A0219, 11B0219 and 11C0219 converged with -40.11%, -75.71% and -72.08% water balance discrepancy respectively. One dry cell was produced at (14, 23, 1).
12A0221 12B0224 12C0224 12D0225	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 11C0219 were initially used. 2) Adjusted heads and conductance values in RIV cells for Cable Creek.	1) Simulations for 12A0221, 12B0224, 12C0224 and 12D0225 converged with -58.42%, -58.61%, -58.11% and -58.60% water balance discrepancy respectively.
13A0227 13B0227 13C0302 13D0302 13E0302 13F0302	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 12D0225 were initially used. 2) Adjusted hydraulic conductivities for northern region of model area. 3) Started using Pre-conjugated Gradient (PCG) solver during Run 13C0302.	1) Simulations of 13A0227 and 13B0227 converged with -58.49% and -53.84% water balance discrepancy respectively. 2) For simulations 13C0302, 13D0302, 13E0302 and 13F0302, the PCG parameters were adjusted in order to solve for the heads most efficiently.
14A0302 14B0303 14C0304 14D0304	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 13F0302 were initially used. 2) Adjusted hydraulic conductivities for northern region of model area. 3) Adjusted heads in RIV cells for Cable Creek.	1) Simulations for 14A0302, 14B0303, 14C0304 and 14D0304 converged with 0%, 0.01%, 0% and 0% water balance discrepancy respectively.

Appendix J

Table 8 (Cont'd.)

SUMMARY OF ADDITIONAL CALIBRATION RUNS FOR STEADY-STATE MODEL

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
15A0304 15B0305 15C0305 15D0305 15E0305	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 14D0304 were initially used. 2) Adjusted heads in GHB cells for upper Lytle Creek area. 3) Adjusted heads in RIV cells for East Twin Creek and Waterman percolation basins. 4) Adjusted hydraulic conductivities for northern region of model area.	1) Simulations for 15A0304, 15B0305, 15C0305, 15D0305 and 15E0305 converged with 0.02%, 0.02%, 0%, 0% and 0.02% water balance discrepancy respectively.
16A0309 16B0309	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 15E0305 were initially used. 2) Adjusted hydraulic conductivities next to San Andreas fault.	1) Simulations for 16A0309 converged with a 0.03% water balance discrepancy. 2) Simulations 16A0309 and 16B0309 both ended with 5 dry cells next to San Andreas fault. 3) Best simulation for calibration of steady-state model was 16A0309.

Originally, the aquifer conditions for layer 2 (lower aquifer) of the entire model area was confined. The aquifer conditions for layer 2 were changed during grouped Runs 9A0124 through 9E0206 to unconfined/confined. Unconfined/confined aquifer conditions in MODFLOW allows for the aquifer to fluctuate between unconfined and confined conditions depending on the location of the head relative to the top elevation of the aquifer. This allowed for the lower aquifer in the northern region of the model area to simulate unconfined conditions and the lower aquifer in the southern region to simulate confined conditions.

- The aquifer system north of the southern edge of Shandin Hills is considered as one aquifer. In order to improve simulation of the single aquifer in the northern region, the thickness of layer 2 (lower aquifer) was decreased to approximately 25 feet, which in turn increased the thickness for layer 1 (upper aquifer).

  Also, the confining clay unit thickness in the northern region was reduced from 1 to 0 feet where the bottom elevations for layer 1 were the same as the top elevations for layer 2. The vertical leakance for the confining clay unit in the northern region was increased to 0.1 day^{-1}.

  The alluvium thickness was increased around the bedrock hills in the northern region in order to rewet some of the grid cells in these areas. Since the bedrock elevations around the bedrock hills were not confirmed by known data, the alluvium thickness was increased by lowering the bedrock elevations in these areas.

- Minor adjustments were made to the hydraulic conductivity values for the model area and the heads and conductance values for the RIV and GHB grid cells. The final calibrated values will be discussed further in Section 2.5.

2.4 PREPARATION OF TRANSIENT-STATE MODEL

This section discusses the preparation of the input data for simulation of the transient-state model. The transient-state model was simulated for the time period between January 1986 through December 1990. Before simulation and calibration of the transient-state model began, the conceptual model was developed, the input files for the steady-state model was calibrated, and a few of the transient-state input files were revised. Development of the conceptual model, preparation of the input files for the steady-state model and some of the calibration process for the steady-state model are discussed in the Newmark Project Flow Model Technical Memorandum, Part I. The final calibration of the steady-state model were discussed in Sections 2.2 and 2.3 of this memorandum. The following input data were prepared and calibrated for the steady-state model (Run 16A0309) and then were used as the initial input data for the transient-state model:

- Top and bottom elevations of the hydrogeologic layers
- Boundary conditions
- Stream recharge and percolation basins
- Hydraulic conductivity and/or transmissivity values
- Vertical leakance values for confining clay unit

These input data, calibrated for the steady-state model and then used as initial input data for the transient-state model, were discussed in Section 1.5 of the Newmark Project Flow Model Technical Memorandum, Part I and in Sections 2.2 and 2.3 of this memorandum. The input data for the hydrogeologic layers are displayed in Figure 15 (Revised Thickness of Alluvium), Figure 16 (Revised Bedrock Elevations), Figure 7 (Structure Map of Top Elevation for Confining Middle Clay Unit), and Figure 17 (Revised Structure Map for Base Elevation for Confining Middle Clay Unit). The boundary conditions are displayed in Figure 18. Locations of the percolation basins are shown in Figure 1. The input data for the streamflow values are listed in Table 9. The input data for the hydraulic conductivity values are shown in Figure 19.

Appendix J

Table 9

STREAMFLOW DATA FOR THE SAN BERNARDINO AREA (1986-1989)

Station Name	Station Number	Map No. on Figure 10	Streamflow (ft^3/day)			
			1986	1987	1988	1989
Santa Ana River near Mentone [a]	110510501	515	5,144,000	2,867,000	2,533,000	2,110,000
Mill Creek near Yucaipa [a]	11054001	540	2,608,000	1,344,000	1,158,000	924,000
Plunge Creek near East Highlands [a]	11055501	555	596,000	248,000	234,000	251,000
City Creek near Highland	11055800	558	658,000	288,000	288,000	241,000
San Timoteo Creek near Redlands	11058000	570	72,000	14,000	40,000	72,000
East Twin Creek near Arrowhead Springs	11057000	585	431,000	149,000	155,000	148,000
Waterman Canyon Creek near Arrowhead Springs	11058600	586	247,000	75,000	66,000	118,000
Lytle Creek near Fontana [a]	11062001	620	3,205,000	1,645,000	1,873,000	1,211,000
Lone Pine Creek near Keenbrook	11063651	635	865,000	539,000	562,000	339,000
Devil Canjon Creek near San Bernardino[a]	11063680	636.8	354,000	238,000	69,000	90,000
Santa Ana River at E Street	11059300	593	6,733,000	4,141,000	3,918,000	3,584,000
Lytle Creek at Colton	11065000	650	556,000	206,000	228,000	116,000

[a] Combined flow, includes diversions.

Some input data for the transient-state model have undergone revisions before beginning the calibration process:

- Initial head conditions
- Well pumpage
- Storage coefficient values

These input data will be described in the next sections.

2.4.1 Initial Head Conditions

The calibrated heads (January 1986) for the steady-state model were used as the initial heads for the transient-state model. These values were transferred from the calibrated steady-state output file (16A0309.OUT) to the BAS input file for the first simulation of the transient-state model. Figure 20 displays the January 1986 initial water elevations for the upper aquifer (layer 1). Figure 21 displays the January 1986 initial water elevations for the lower aquifer (layer 2).

2.4.2 Well Pumpage

Most of the discharge from the groundwater system in the model area is from water-supply wells. The well pumpage input data vary with time and, therefore, up-to-date values were obtained for the transient-state model. Well pumpage data for the time period from January 1986 through December 1990 were obtained from the following water agencies:

- City of San Bernardino Water Department
- City of Riverside Public Utilities Department
- West San Bernardino City Water District
- City of Colton Public Works Department
- Meeks & Daley Water Company (now Elsinore Valley Municipal Water Department)
- Riverside Highland Water Company
- East Valley Water District
- City of Rialto Water Division
- Muscoy Mutual Water Company No. 1

The well pumpage data were arranged in average quarterly values for each year:

- Quarter 1 well pumpage of each water-supply well was averaged from pumpage values for January through March;

- Quarter 2 well pumpage of each water-supply well was averaged from pumpage values for April through June;

- Quarter 3 well pumpage of each water-supply well was averaged from pumpage values for July through September; and

- Quarter 4 well pumpage of each water-supply well was averaged from pumpage values for October through December.

The quarterly well pumpage for each water-supply well from January 1986 through December 1990 was arranged with the appropriate model grid cell and placed in the well (WEL) input file for the transient-state model. The well pumpage for each water-supply well for Quarter 4 of 1990 is listed in Table 10. Table 10 also lists the model grid cell and map number on Figure 22 for each water-supply well. The locations of these wells are shown in Figure 22.

Appendix J

Table 10

WELL PUMPAGE FOR LAST QUARTER OF 1990
(October, November & December)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Grid Cell (x, y)	Pumpage (ft^3/day)
City of Riverside, Poole	1S4W01E01S	303601462	1	(42, 43)	0
East San Bernardino County Water District., #22	1S4W01E02S	303601668	2	(42, 43)	NI
City of San Bernardino, Newmark #4	1N4W16E	303602399	3	(23, 17)	305,197
Arrowhead Country Club #1	1N4W23E	303601810	4	(36, 24)	30,074
Del Rosa Mutual Water Co. Parkside #2	1N4W23E	303601925	5	(36, 24)	NI
E. San Bernardino County Water District, #24B (E. Valley Water District)	1N4W26A	303602337	6	(41, 29)	113,328
E. San Bernardino County Water District, #24A (E. Valley Water District)	1N4W26A02S	303601671	7	(41, 29)	392,231
City of San Bernardino, Lynwood	1N4W26G	303600727	8	(39, 30)	45,150
City of San Bernardino, Perris Hill #5	1N4W26P03S	303601115	9	(38, 33)	60,320
City of San Bernardino, Mt. View Cemetary #1	1N4W26	Unknown	10	(36, 31)	0
City of San Bernardino, Mt. View Cemetary #2	1N4W26	Unknown	11	(36, 31)	0
City of San Bernardino, Leroy	1N4W27A	303602401	12	(34, 29)	0
City of San Bernardino, Waterman Avenue	1N4W27A01S	303600728	13	(34, 29)	503,207
31st Street & Mt. View	1N4W27B	303602081	14	(32, 29)	172,762
City of San Bernardino, 30th Street & Mt. View (Marshall)	1N4W27G01S	303600719	15	(33, 30)	247,655
City of San Bernardino, North "E" Street	1N4W27M01S	303600727	16	(30, 32)	52,055
City of San Bernardino, 27th Street	1N4W27M02S	303601671	17	(29, 32)	1,130
City of San Bernardino, 23rd Street	1N4W27N01S	303602264	18	(29, 34)	0

Appendix J

Table 10 (Cont'd.)

WELL PUMPAGE FOR LAST QUARTER OF 1990
(October, November & December)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Grid Cell (x, y)	Pumpage (ft^3/day)
City of San Bernardino, Darby	1N4W29E01S	303601878	19	(17, 27)	0
City of San Bernardino, Colima	1N4W29F01S	303601880	20	(18, 30)	0
City of San Bernardino, Gardena	1N4W29	303601879	21	(17, 32)	0
Mt. Vernon Water Company, #1	1N4W31A01S	303600319	22	(14, 35)	13,974
Southern California Water Company, Berdoo #1	1N4W31H	303601588	23	(15, 36)	NI
City of San Bernardino, 19th Street #1	1N4W32D03S	303600717	24	(17, 35)	14,420
City of San Bernardino, 19th Street #2	1N4W32D04S	303600718	25	(17, 35)	15,432
City of San Bernardino, Baseline	1N4W32N	303602400	26	(16, 40)	0
City of San Bernardino, 17th Street	1N4W34G01S	303600725	27	(33, 37)	120,184
City of San Bernardino, 16th Street	1N4W34G03S	303600726	28	(32, 37)	73,597
City of San Bernardino, Perris Hill #2	1N4W35C01S	303601114	29	(37, 35)	0
City of San Bernardino, Perris Hill #3	1N4W35C02S	303601116	30	(37, 35)	0
City of San Bernardino, Perris Hill #4	1N4W35C03S	303601117	31	(37, 35)	15,295
Baseline Gardena Mutual Water Company, Pac & Barl	1N4W35J02S	303600457	32	(41, 38)	NI
Van Loon Mutual Water Company, W3-Gilbert	1N4W35K	303602067	33	(39, 38)	NI
City of San Bernardino, Gilbert Street	1N4W35M03S	303600729	34	(35, 38)	68,598
Baseline Gardens Mutual Water Company, PS & B2	1N4W36M01S	303600458	35	(42, 38)	NI
City of Riverside, Stiles	1S4W2A3	303601463	36	(41, 41)	125,143
Van Loon Mutual Water Company, #1	1S4W02B	303602066	37	(39, 41)	NI

Appendix J

Table 10 (Cont'd.)

WELL PUMPAGE FOR LAST QUARTER OF 1990
(October, November & December)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Grid Cell (x, y)	Pumpage (ft^3/day)
City of San Bernardino, Antil #5	1S4W02K02S	303600731	38	(40, 45)	346,232
City of San Bernardino, Antil #4	1S4W02K03S	303600734	39	(40, 45)	347,859
City of San Bernardino, Antil #6	1S4W02K08S	303602422	40	(40, 45)	158,021
City of Riverside, Scheuer	1S4W2L1	303601489	41	(38, 45)	2,334
City of Riverside, Garner #5	1S4W02P01S	303601468	42	(38, 47)	111,003
City of Riverside, Garner #1	1S4W02P06S	303601464	43	(38, 47)	309,102
City of Riverside, Garner #2	1S4W02Q03S	303601465	44	(40, 47)	56,325
City of Riverside, Garner #4	1S4W02Q06S	303601467	45	(40, 47)	65,896
City of San Bernardino, 7th Street	1S4W03J5	303602265	46	(34, 44)	612,424
West San Bernardino Water District, Plant #15	1S4W05E05S	303601848	47	(16, 43)	312,916
City of Colton, #8	1S4W08F	303601254	48	(18, 49)	65,767
City of Colton, #13	1S4W08F	303601257	49	(18, 49)	82,136
City of Colton, #19	1S4W08F	303602405	50	(18, 49)	34,943
Terrace Water Company, #3	1S4W08F	303601686	51	(18, 49)	97,765
City of Colton, #16	1S4W08F01S	303601260	52	(18, 49)	296,241
Terrace Water Company, Large #1	1S4W08F06S	303601684	53	(18, 49)	NI
City of Colton, #5	1S4W08R	303601251	54	(21, 52)	26,551
City of Colton, #7	1S4W08R	303601253	55	(21, 52)	143,588
City of Colton, #14	1S4W08R	303601258	56	(21, 52)	50,888
Ice Products, Inc., #2	1S4W09B03S	303600970	57	(27, 48)	NI
City of Riverside, Cooley H	1S4W11D02S	303601228	58	(36, 48)	116,703
City of Riverside, Cooley I	1S4W11D03S	303601229	59	(36, 48)	311,837
Cardiff Farms Mutual Water Company, #1	1S4W12D	303600973	60	(42, 48)	NI

Appendix J

Table 10 (Cont'd.)

WELL PUMPAGE FOR LAST QUARTER OF 1990
(October, November & December)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Grid Cell (x, y)	Pumpage (ft^3/day)
Cardiff Farms Mutual Water Company	1S4W12D	303601619	61	(42, 48)	NI
City of Riverside - Gage Canal, #29-2	1S4W13N01S	303600791	62	(42, 59)	533,241
City of Riverside - Gage Canal, #29-3	1S4W13N02S	303600792	63	(42, 59)	316,291
San Bernardino County Water District, Norman Rd.	1S4W14J	303602123	64	(41, 58)	NI
City of Riverside, Raub #3	1S4W14P06S	303601239	65	(38, 59)	18,527
National Orange Show	1S4W15D	303601924	66	(29, 54)	NI
Meeks & Daley Water Company, #59	1S4W15L03S	303601887	67	(31, 57)	0
Meeks & Daley Water Company, New "E" Street	1S4W15M10S	303602169	68	(29, 57)	0
Meeks & Daley Water Company, Coburn	1S4W16J09S	303601737	69	(28, 58)	36,173
City of Riverside, Thorn #10	1S4W22B03S	303601478	70	(33, 61)	7,786
City of Riverside, Thorn #3	1S4W22G14S	303601471	71	(33, 62)	0
City of Riverside, Thorn #2	1S4W22G15S	303601470	72	(33, 62)	0
City of Riverside, Thorn #5	1S4W22G16S	303601473	73	(33, 62)	0
City of Riverside, Thorn #7	1S4W22G17S	303601475	74	(33, 62)	0
City of Riverside, Thorn #6	1S4W22G18S	303601474	75	(33, 62)	0
City of Riverside, Warren #2	1S4W22H01S	303601231	76	(34, 62)	116,249
City of Riverside, Warren #4	1S4W22H02S	303601234	77	(34, 62)	106,019
City of Riverside, Warren #3	1S4W22H03S	303601230	78	(34, 62)	12,693
City of Riverside, Warren #1	1S4W22H04S	303601240	79	(34, 62)	295,416
Riverside Highland Water Company, #2 (FW #2)	1S4W22L00S	303601523	80	(31, 64)	5,549

Appendix J

Table 10 (Cont'd.)

WELL PUMPAGE FOR LAST QUARTER OF 1990
(October, November & December)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Grid Cell (x, y)	Pumpage (ft^3/day)
Riverside Highland Water Company, #18 (FW #18)	1S4W22L05S	303601533	81	(31, 64)	4,475
Riverside Highland Water Company #12	1S4W22L08S	303601530	82	(31, 64)	0
Riverside Highland Water Company, #24	1S4W22P05	303602254	83	(31, 65)	0
City of Riverside - Gage Canal #26-1	1S4W23A02S	303600787	84	(41, 61)	219,523
City of Riverside - Gage Canal #51-1	1S4W23A05S	303600796	85	(41, 61)	130,594
City of Riverside, Raub #2	1S4W23C02S	303601219	86	(38, 61)	0
City of Riverside, Raub #4	1S4W23C03S	303601238	87	(38, 61)	108,306
Meadowbrook Diary, Irrig #3	1S4W23D	303600030	88	(36, 61)	NI
City of Riverside - Gage Canal #66-1	1S4W23G	303602331	89	(39, 63)	244,089
City of Riverside - Gage Canal #27-1	1S4W23H01S	303600788	90	(41, 63)	267,957
City of Riverside - Gage Canal #27-2	1S4W23K01S	303600789	91	(39, 64)	264,277
City of Riverside - Gage Canal #29-1	1S4W23K02S	303600790	92	(39, 64)	272,311
Loma Linda University, #7	1S4W24N	30360213	93	(42, 66)	NI
Montecito Mutual Water Company, #1	1S4W26F01	303600119	94	(37, 69)	NI
City of San Bernardino, Devil Canyon #2	1N4W07F01S	313600711	98	(12, 11)	162,900
City of San Bernardino, Devil Canyon #1	1N4W08M01S	313600712	99	(16, 12)	169,916
City of San Bernardino, Newmark #2	1N4W16E	313600715	100	(23, 18)	67,066

Appendix J

Table 10 (Cont'd.)

WELL PUMPAGE FOR LAST QUARTER OF 1990
(October, November & December)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Grid Cell (x, y)	Pumpage (ft^3/day)
City of San Bernardino, Newmark #1	1N4W16E01S	313600714	101	(23, 18)	101,202
City of San Bernardino, Newmark #3	1N4W16E03S	313600716	102	(23, 18)	55,810
Baseline Gardens Mutual Water Company, #3	1N4W35R01S	303602528	103	(41, 40)	NI
City of Colton, #6B	1S4W08R07S	303602498	104A	(22, 53)	0
William E. Leornard, H. Payne	1S4W22A01S	303602499	104B	(34, 61)	NI
City of Riverside, Raub #5	1S4W14N09S	303602484	105	(36, 59)	229,061
Riverside Highland Water Company, Lytle Creek #1	1N4W31E01S	333601535	106	(10, 37)	162,007
City of San Bernardino, Mallory #3	1N4W30L	333601845	107A	(12, 32)	13,881
City of Colton, #21	1S4W08F15S	303602793	107B	(18, 49)	0
Loma Linda University, Anderson #1	1S4W25D07S	303602855	108	(42, 67)	NI
East Valley Water District, PL 11A	1S4W02Q10S	303602563	109	(40, 46)	173,080
San Bernardino Golf Club, Kline	1S4W22A01S	303602846	110	(34, 61)	NI
Loma Linda University, Anderson #2	1S4W25D06S	303602781	111	(42, 67)	NI
City of Riverside, Raub #6	1S4W14N10S	303602484	112	(36, 59)	406,227
City of Riverside, Hunt #11	1S4W22H01S	30602773	113	(34, 67)	NI
Meeks & Daley Water Company, Warren #4	1S4W22H01S	303602863	114 (Same as 77)	(34, 63)	0
Meeks & Daley Water Company, Raub #6	1S4W14N10S	303602864	115 (Same as 112)	(35, 59)	0
City of Riverside, Hunt #10	1S4W27A09S	303602772	116	(34, 67)	21,267
City of Riverside, Hunt #6	1S4W27A11S	303602771	117	(34, 67)	18,861

Appendix J

Table 10 (Cont'd.)

WELL PUMPAGE FOR LAST QUARTER OF 1990
(October, November & December)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Grid Cell (x, y)	Pumpage (ft^3/day)
West San Bernardino Water District., #30	1S4W06H02S	303602766	118	(15, 43)	NI
City of San Bernardino, Ice Deliver #1	1S4W09B01S	303600645	119	(27, 48)	0
City of San Bernardino, Antil #2	1S4W02K05	303600732	120	(40, 44)	0
City of San Bernardino, Antil #3	1S4W02K01	303600730	121	(39, 45)	0
City of San Bernardino, Hanford #2	1S4W10F05	303600724	122	(31, 50)	0
City of San Bernardino, A. Ree	1S4W11K01	---	123	(40, 51)	0
City of San Bernardino, Mill & "D" Street	1S4W10N06	303600737	124	(30, 53)	100,067
City of San Bernardino, South "G" Street	1S4W09J01S	303600736	125	(28, 51)	0
City of San Bernardino, Perris Hill #5	1N4W26P03	303601115	126	(37, 34)	0
Nevada California Power Company, #2	1S4W21Q3	—	127	(27, 66)	0
Riverside Water Company, Vaughn #1	1S4W21Q3	---	128	(27, 66)	0
City of San Bernardino, 9th & Perris	1S4W04G	—	129	(26, 42)	New
San Bernardino Valley Municipal Water District, 9th & Garner	1S4W04F	—	130	(24, 42)	New
City of San Bernardino, 10th & J	1S4W04B04	---	131	(27, 41)	New
City of San Bernardino, Olive & Garner	1S4W04C	—	132	(24, 41)	New
City of San Bernardino, Elena Brothers' #2			133	(18, 14)	11,109
City of San Bernardino, Lytle Creek #2	1N5W36J04		134	(11, 38)	327,977

Appendix J

Table 10 (Cont'd.)

WELL PUMPAGE FOR LAST QUARTER OF 1990
(October, November & December)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Grid Cell (x, y)	Pumpage (ft^3/day)
City of Riverside, Gage Canal #30-1	1S4W13M02	303600793	135	(42, 57)	281,768
City of Riverside, Stewart #20			136	(34, 69)	62
City of Riverside, Thorne #8	--	--	137	(32, 62)	0
City of Riverside, Thorne #12	--	--	138	(33, 61)	19,548
Riverside Highland, Lytle Creek #8	--	--	139	(11, 38)	19,405
Riverside Highland, FW #5	1S4W22L	--	140	(31, 65)	366,441
East Valley Water District, Well #12A	1S4W02Q	--	141	(40, 46)	148,429
Meeks & Daley Water Co., Station 66 Flow	1S4W153	3602329	142	(30, 56)	NI
City of Colton, #6	1S4W08G	--	143	(20, 49)	18,679
City of Rialto, City #3	1N5W36A01S	362848	144	(9, 35)	429,156
City of Rialto, City #4	1N4W31N02S	361085	145	(11, 39)	295,015
City of Rialto, City #5	1S4W06B01S	363030	146	(13, 41)	390,011
City of Rialto, City #6	1S4W06C04S	361929	147	(12, 41)	298,356
Muscoy Mutual Water Co. #1	1N5W23H01S	--	148	(2, 24)	22,544
Muscoy Mutual Water Co. #2	1N5W23A01S	--	149	(2, 22)	35,527
Muscoy Mutual Water Co. #3	1N5W23A02S	--	150	(2, 22)	179,346
Muscoy Mutual Water Co. #4	1N5W24D01S	--	151	(4, 23)	19,141
Muscoy Mutual Water Co. #5	1N5W24D	--	152	(4, 23)	708

New = Wells did not exist before 1986.
Source = Western Watermaster
NI = No information
Note: Wells with map numbers 95 through 97 do not exist.

Since the model area is represented by two layers, pumpage for each layer was estimated by well depth, location, and length of perforations. Pumpage was assigned to the upper model layer for wells perforated only in the upper aquifer. Pumpage for wells perforated only in the lower aquifer was assigned to the lower model layer. Pumpage from wells perforated in both aquifers was prorated, depending on the length of perforations in each aquifer system. The prorated discharge from each of these wells was allocated to the nearest nodes.

2.4.3 Storage Coefficient Values

In Section 2.1, the difference between steady-state and transient-state condition was described. It was explained that in transient-state groundwater flow conditions water is released from or stored in the aquifer material. This activity is characterized by dimensionless storage coefficient values. In the transient-state model, storage coefficient values are defined for both layers 1 and 2. For the confined layers (southern area of layer 2), these storage coefficient values are given by the specific storage of the grid cell material multiplied by layer thickness in the grid cell. For unconfined areas of layer 1, the storage coefficient values are equal to the specific yield of the material in the grid cell (McDonald and Harbaugh, 1988). Storage coefficient values of 0.15 and 0.001 were used for unconfined and confined aquifer conditions respectively.

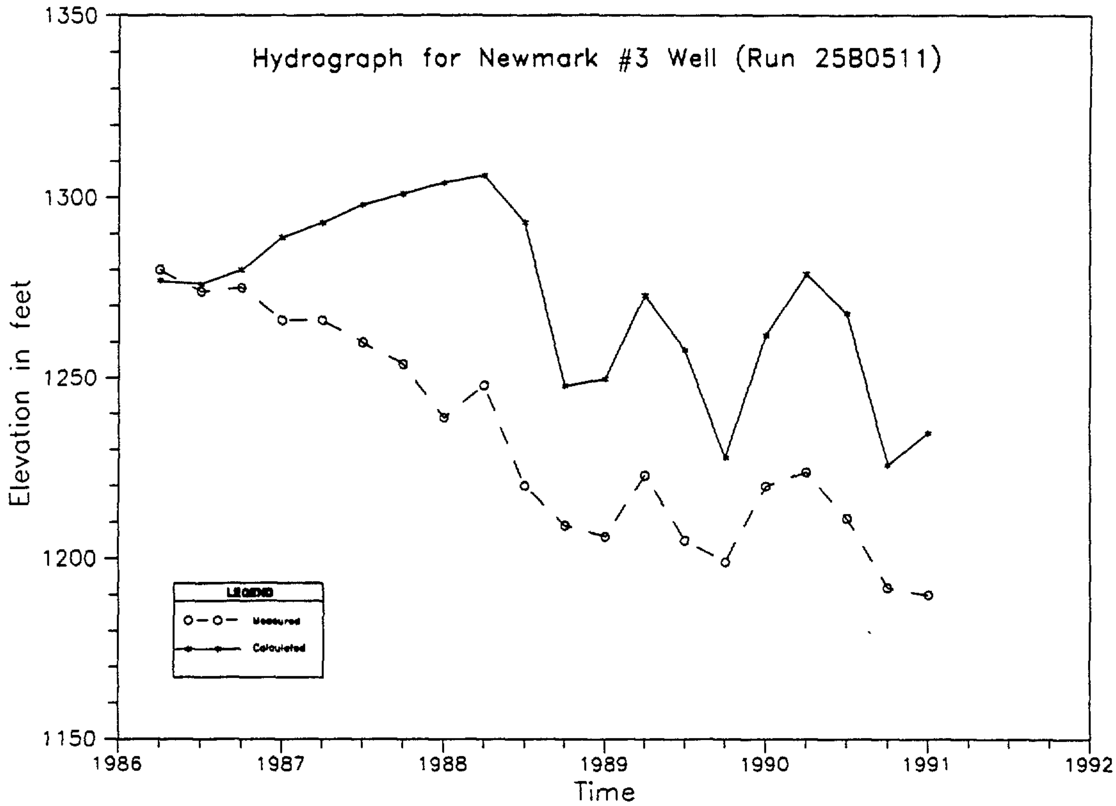
2.5 CALIBRATION OF TRANSIENT-STATE MODEL

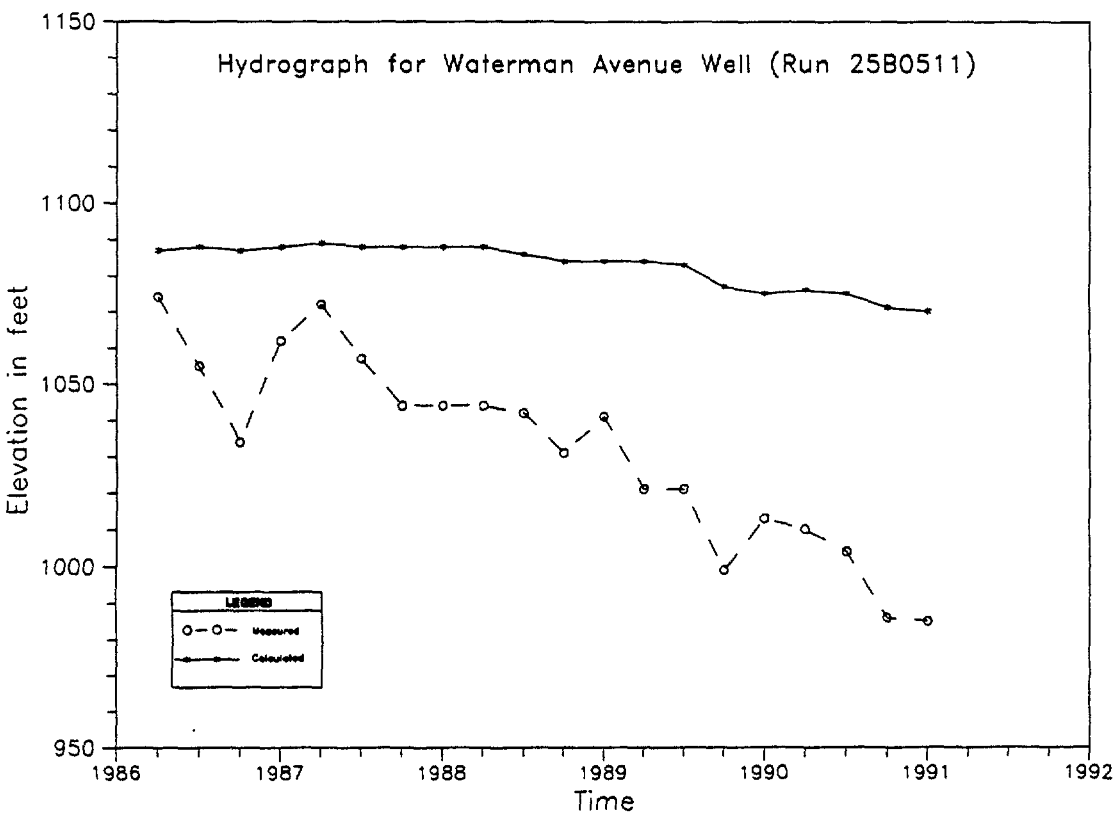
The transient-state model was simulated for the time period between January 1986 through December 1990. Four stress periods per year were used, for a total of 20 stress periods for an entire simulation. The input data for the transient-state model were modified during the calibration process. A total of 38 computer runs were made during the calibration process. The transient-state simulations started with Run 17A0324 and ended with Run 25D0513. Run 25B0511 became the final calibrated transient-state simulation, resulting in what is now known as the project flow model.

Attachment B contains a list of all the input and output files associated with the 38 transient-state simulations. Several modifications were made to the transient-state model during Runs 17A0324 through 25B0511. These modifications are described in Section 2.6.

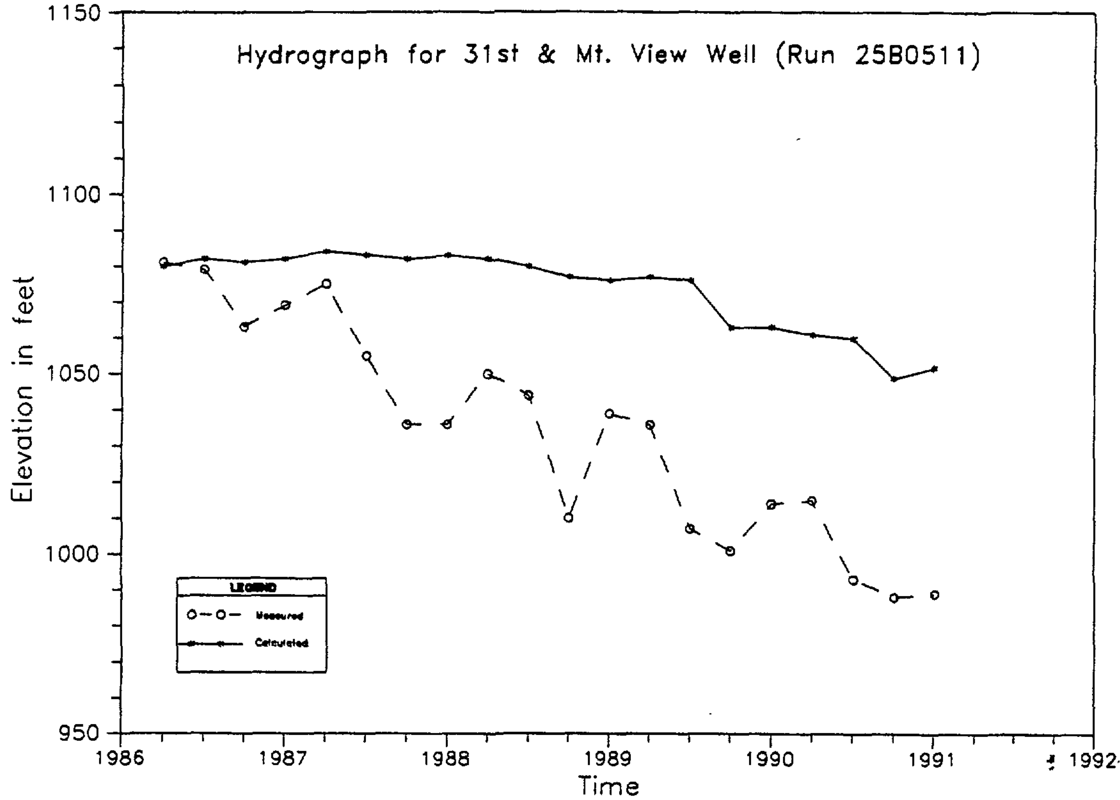
Figure 23 displays the December 1990 water elevations for the upper aquifer, which were estimated by the calibrated transient-state model. Figure 24 displays the December 1990 water elevations for the lower aquifer, which were estimated by the calibrated transient-state model.

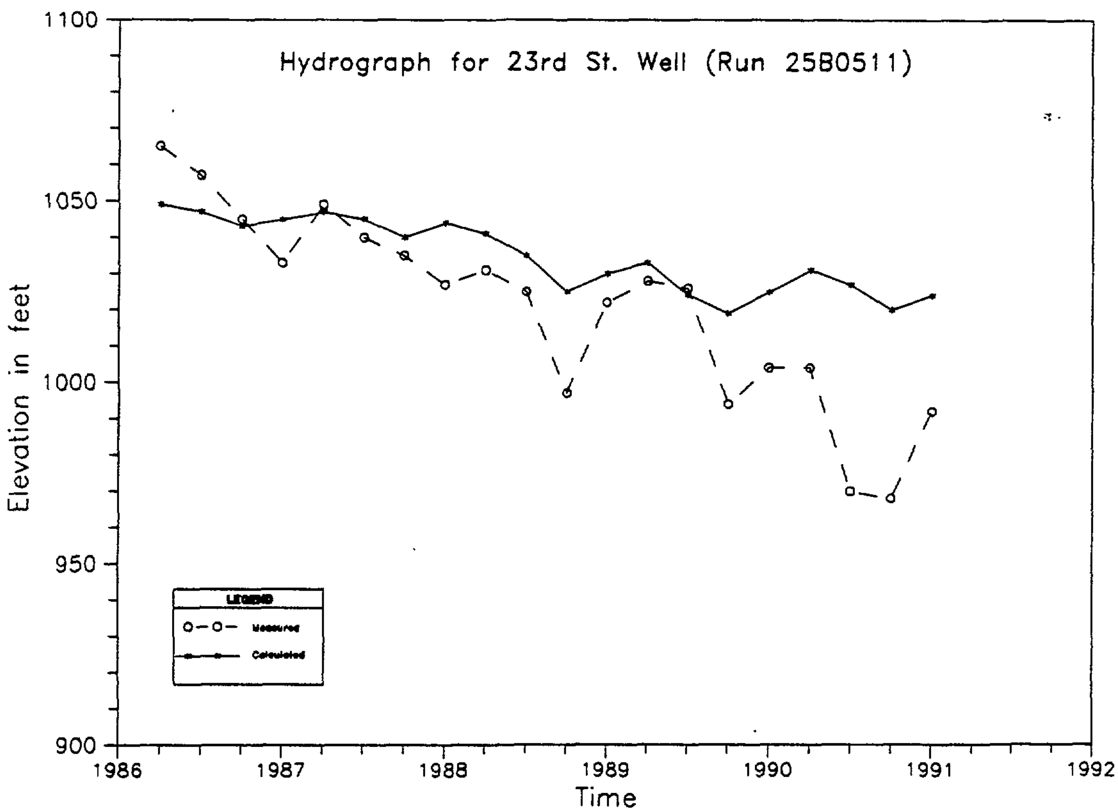
Hydrographs were constructed for the calculated and observed water elevations of several water supply wells in the Newmark plume area to aid in the calibration of the transient-state model. Figures 25 through 28 display hydrographs for the calibrated transient-state model (Run 25B0511). Figure 25 displays the hydrographs for the Newmark #3 Well and the Waterman Avenue Well. Figure 26 displays the hydrographs for the 31st Street and Mountain View Well and the 23rd Street Well. Figure 27 displays the hydrographs for the Perris Hill #2 Well and the 17th Street Well. Figure 28 displays the hydrographs for the Gilbert Street Well and the 7th Street Well. The results of the calibrated transient-state model will be discussed through interpretation of the water elevation maps (Figures 23 and 24) and the hydrographs (Figures 25 through 28) in Section 2.8.





URS CONSULTANTS 2710 GATEWAY OAKS DR. SUITE 250 NORTH SACRAMENTO, CA 95834 (916) 929-2346	NEWMARK GROUNDWATER SUPERFUND SITE NEWMARK OPERABLE UNIT, RI/FS REPORT ARCS, EPA REGIONS IX & X WA NO 34-10-9L28	**FIGURE 25** Hydrographs for Newmark #3 and Waterman Avenue Wells





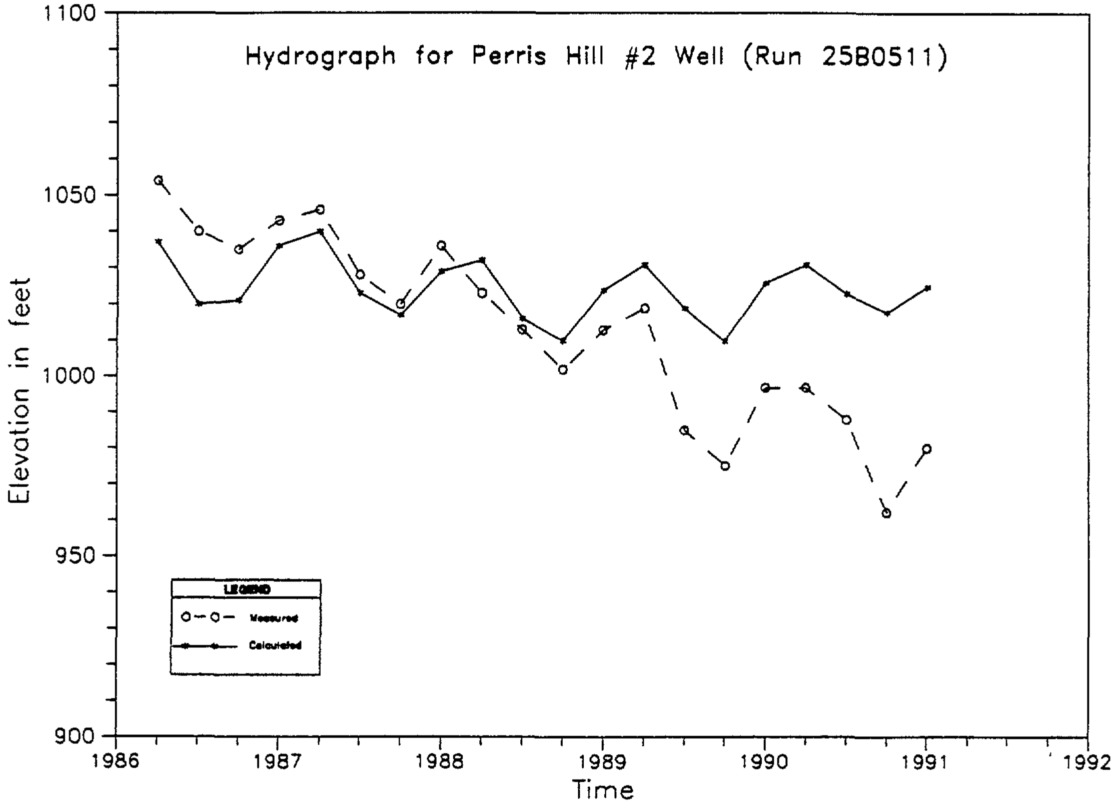
URS CONSULTANTS
2710 GATEWAY OAKS DR.
SUITE 250 NORTH
SACRAMENTO, CA 95834
(916) 929-2346

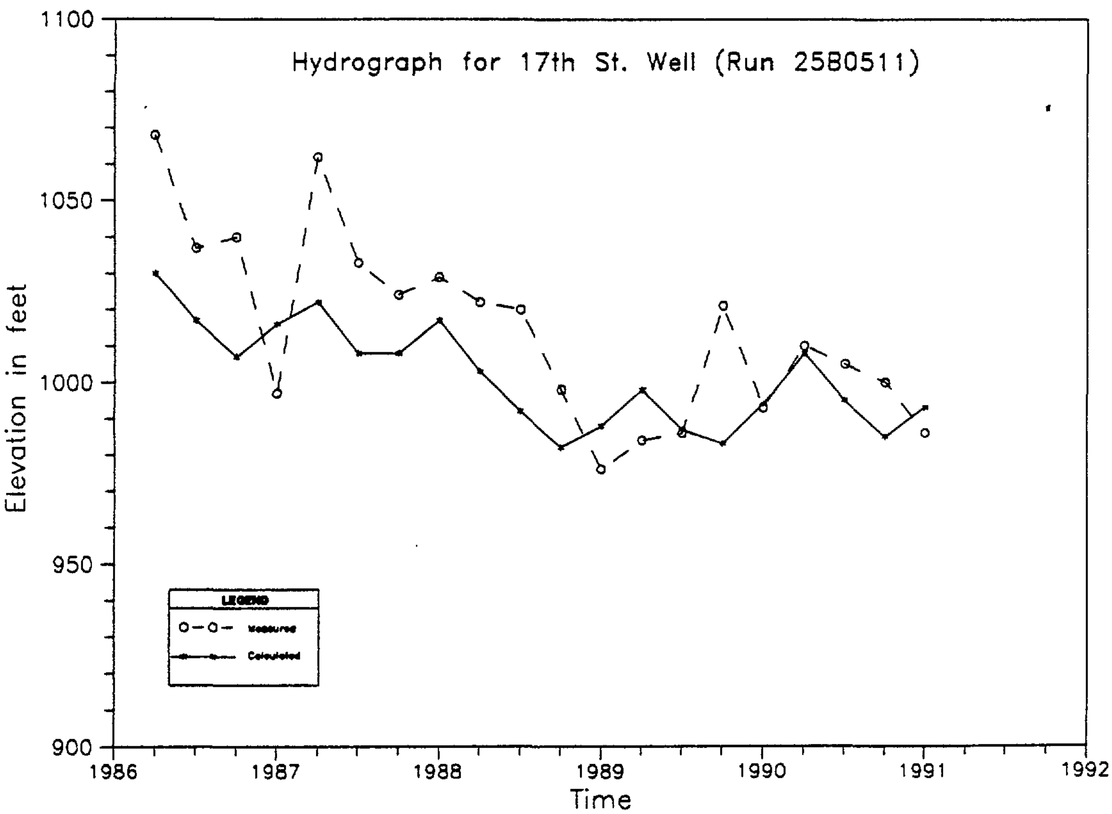
NEWMARK GROUNDWATER SUPERFUND SITE
NEWMARK OPERABLE UNIT, RI/FS REPORT

ARCS, EPA REGIONS IX & X | WA NO. 54-10-9LJ5

FIGURE 26

Hydrographs for 31st & Mt. View and 23rd St. Wells

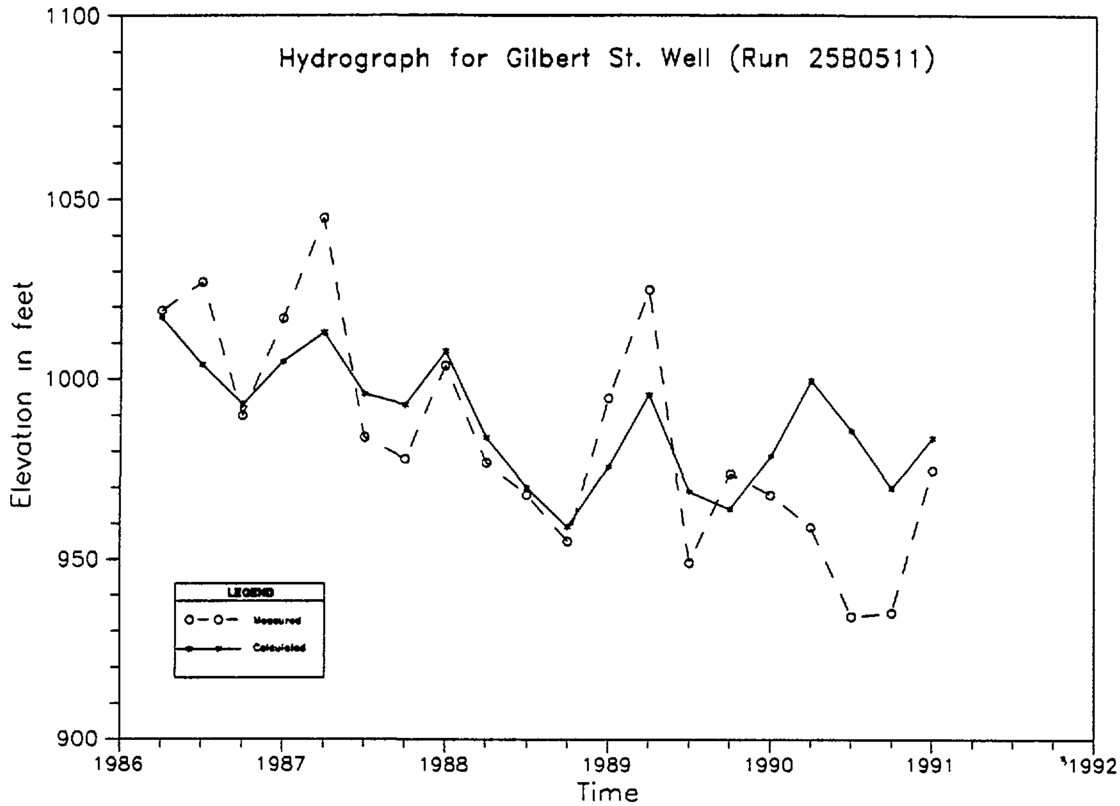


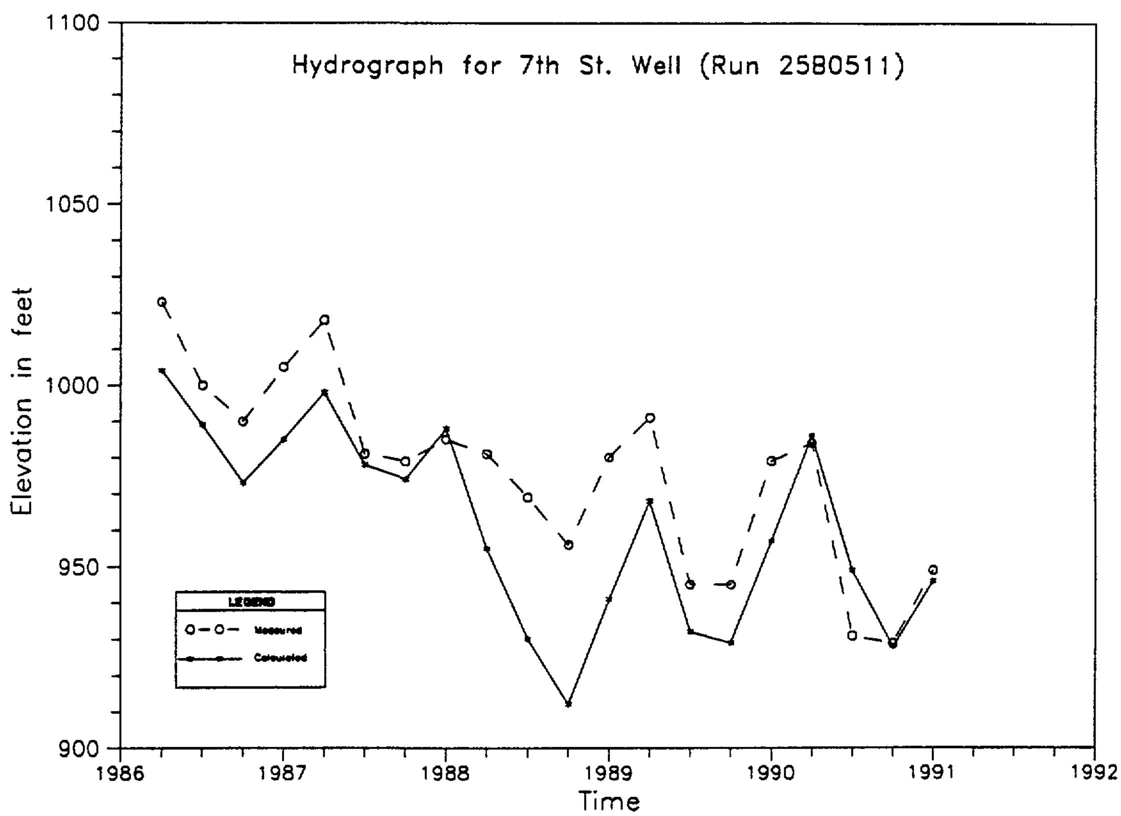


URS CONSULTANTS
2710 GATEWAY OAKS DR.
SUITE 250 NORTH
SACRAMENTO, CA 95834
(916) 929-2346

NEWMARK GROUNDWATER SUPERFUND SITE
NEWMARK OPERABLE UNIT, RI/FS REPORT
ARCS, EPA REGIONS IX & X — WA NO. 54-10-9LJ5

FIGURE 27
Hydrographs for Perris Hill #2 and 17th St. Wells





URS CONSULTANTS
2710 GATEWAY OAKS DR.
SUITE 250 NORTH
SACRAMENTO, CA 95834
(916) 929-2346

NEWMARK GROUNDWATER SUPERFUND SITE
NEWMARK OPERABLE UNIT, RI/FS REPORT

ARCS, EPA REGIONS IX & X WA NO 54-10-9LJ8

FIGURE 28

Hydrographs for Gilbert St. and 7th St. Wells

2.6 MODIFICATIONS OF TRANSIENT-STATE MODEL

This section details modifications made to the transient-state model for Runs 17A0324 through 25B0511. Table 11 summarizes the modifications and results of these transient-state simulations. No major modifications were made to the transient-state simulations. Minor modifications that were made to the transient-state Runs 17A0324 through 25B0511 are described in more detail below:

- Minor adjustments were made to the hydraulic conductivity values for the model area. Figure 19 displays the calibrated hydraulic conductivity values for the transient-state model. Table 12 lists the hydraulic conductivity values used for selected water-supply well areas.

- Minor adjustments were made to the heads and conductivity values for the RIV cells. Originally, the heads for the RIV cells were made 5 feet above the heads in the aquifer for the upstream sections of Lytle Creek Wash and Santa Ana River and for the entire stretches of the East Twin Creek and Cable Creek. However, in the final runs of the project flow model (Runs of 24A0427 through 24D0508), the heads in the RIV cells for the lower area of East Twin Creek (south of Perris Hill) were changed to 5 feet below the heads in the aquifer. The other RIV cells remained at 5 feet above the heads in the aquifer. The conductivity values for the RIV cells were reduced to values that match the revised hydraulic conductivity values identified for the aquifer.

Appendix J

Table 11

SUMMARY OF TRANSIENT-STATE CALIBRATION RUNS

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
17A0324 17B0326 17C0327 17D0327 17E0330	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Used input files and calculated heads for calibrated steady-state model (Run 16A0309). 2) Used storage coefficient values of 0.15 and 0.001 for layers 1 and 2 respectively. 3) Adjusted storage coefficient values. 4) Adjusted hydraulic conductivities for area west of Shandin Hills and next to San Andreas fault and San Jacinto fault.	1) Simulation for 17A0324 converged with -0.04% water balance discrepancy. Produced high water elevations in area west of Shandin Hills. 2) Simulations for 17B0326 and 17C0327 converged with -0.04% and -0.03% water balance discrepancy. Produced 5 dry cells next to San Andreas fault. 3) Simulations for 17D0327 and 17E0330 converged with -0.05% water balance discrepancy each. Same dry cells were produced as in the previous simulations.
18A0331 18B0331 18C0401 18D0401 18E0403	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 17E0330 were initially used. 2) Adjusted hydraulic conductivities for area around Shandin Hills and in middle region of model area.	1) Simulations for 18A0331, 18B0331, 18C0401, 18D0401 and 18E0403 converged with -0.05% water balance discrepancy each. Same 5 dry cells were produced as in previous simulations. 2) Improved heads around east/west/north edges of Shandin Hills.
19A0407 19B0408 19C0408	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 18E0403 were initially used. 2) Decreased leakance values in confined area (southern region of model area). 3) Adjusted hydraulic conductivities for area west and southeast of Shandin Hills and next to San Andreas fault.	1) Simulations for 19A0407, 19B0408 and 19C0408 converged with -0.05% water balance discrepancy each. Same 5 dry cells were produced as in previous simulations.
20A0409 20B0410 20C0413 20D0413 20E0413	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 19C0408 were initially used. 2) Adjusted hydraulic conductivities for area north of Shandin Hills and next to San Andreas fault.	1) Simulations for 20A0409, 20B0410, 20C0413, 20D0413 and 20E0413 converged with -0.05% water balance discrepancy each. Same 5 dry cells were produced as in previous simulations.
21A0414 21B0414 21C0414	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 20E0413 were initially used. 2) Adjusted hydraulic conductivities for area between Wiggins and Badger Hills and in area of Newmark wells. 3) Adjusted leakance values north of Lytle Creek Wash area and just south of Shandin Hills.	1) Simulations for 21A0414, 21B0414 and 21C0414 converged with -0.05% water balance discrepancy each. Same 5 dry cells were produced as in previous simulations. 2) Improved heads in areas west and east of Shandin Hills. 3) Problems with heads still existed for area north of Shandin Hills and in Newmark well area.

Appendix J

Table 11 (Cont'd.)

SUMMARY OF TRANSIENT-STATE CALIBRATION RUNS

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
22A0415 22B0415 22C0420	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 21C0414 were initially used. 2) Adjusted hydraulic conductivities for area around Newmark wells and east of Shandin Hills. 3) Adjusted conductivity values for GHB cells for canyons entering model area. 4) Adjusted leakance values for southern region of model area.	1) Simulations for 22A0415, 22B0415 and 22C0420 converged with -0.05% water balance discrepancy each. Same 5 dry cells were produced as in previous simulations. 2) Improved heads slightly for layer 2 in southern region of model area.
23A0421 23B0423 23C0424 23D0426 23E0427 23F0427	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 22C0420 were initially used. 2) Adjusted conductivity values for GHB cells for Waterman and Devil's Canyons and eastern boundary between San Andreas fault and Perris Hill. 3) Adjusted conductivity values for RIV cells for upper Waterman and East Twin Creek area.	1) Simulations for 23A0421, 23B0423, 23C0424, 23D0426, 23E0427 and 23F0427 converged with -0.05%, -0.05%, -0.07%, -0.07%, -0.07% and 0% water balance discrepancy respectively. Same 5 dry cells were produced as in previous simulations. 2) Heads in plume area were lowered by 11 to 60 feet.
24A0427 24B0506 24C0507 24D0508	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 23F0427 were initially used. 2) Adjusted conductivity values and heads for RIV cells for upper East Twin Creek area. 3) Adjusted conductivity values for GHB cells for Santa Ana area. 4) Adjusted hydraulic conductivities for area around Newmark wells.	1) Simulations for 24A0427, 24B0506, 24C0507 and 24D0508 converged with 0%, 0%, 0% and -0.01% water balance discrepancy respectively. Same 5 dry cells were produced as in previous simulations. 2) Heads decreased in area east of Shandin Hills.
25A0511 25B0511 25C0512 25D0513	1) To match the computed heads with observed heads. 2) To eliminate dry cells.	1) Input files of 24D0508 were initially used. 2) Adjusted conductivity values for RIV cells for East Twin Creek percolation basins. 3) Adjusted storage coefficients for both layers. However, storage coefficients were changed back to original values (0.15 for layer 1 and 0.001 for layer 2).	1) Simulations for 25A0511, 25B0511, 25C0512 and 25D0513 converged with -0.01% water balance discrepancy each. Same 5 dry cells were produced as in previous simulations.

Appendix J

Table 12

HYDRAULIC CONDUCTIVITIES USED IN TRANSIENT-STATE FLOW MODEL

Well Name/Description	State Well Location	Map No. on Figure 14	Grid Cell (x, y)	Hyd. Cond. (ft/day)
City of San Bernardino, Newmark #1	1N4W16E01S	101	(23, 18)	20.0
City of San Bernardino, Newmark #2	1N4W16E	100	(23, 18)	20.0
City of San Bernardino, Newmark #3	1N4W16E03S	102	(23, 18)	20.0
City of San Bernardino, Newmark #4	1N4W16E	3	(23, 17)	20.0
City of San Bernardino, 16th Street	1N4W34G03S	28	(32, 37)	40.0
City of San Bernardino, Leroy	1N4W27A	12	(35, 29)	40.0
City of San Bernardino, 30th Street & Mt. View (Marshall)	1N4W27G01S	15	(33, 30)	40.0
City of San Bernardino, 31st Street & Mt. View	1N4W27B	14	(32, 29)	40.0
City of San Bernardino, 27th Street	1N4W27M02S	17	(29, 32)	40.0
City of San Bernardino, 23rd Street	1N4W27N01S	18	(29, 34)	40.0
City of San Bernardino, North "E" Street	1N4W27M01S	16	(30, 32)	40.0
City of San Bernardino, 19th Street #1	1N4W42D03S	24	(17, 35)	20.0
City of San Bernardino, 19th Street #2	1N4W32D04S	25	(17, 35)	20.0
City of San Bernardino, Waterman Avenue	1N4W27A01S	13	(34, 29)	40.0
City of San Bernardino, Gilbert Street	1N4W35M03S	34	(35, 38)	40.0
City of San Bernardino, 7th Street	1S4W03J	46	(34, 44)	50.0
City of San Bernardino, Perris Hill #4	1N4W35C03S	31	(37, 34)	30.0
City of San Bernardino, Perris Hill #5	1N4W26P03	126	(37, 34)	30.0
City of San Bernardino, Lynwood	1N4W26G	8	(39, 30)	40.0
City of San Bernardino, 9th & Perris	1S4W04G	129	(26, 42)	50.0
San Bernardino Valley Municipal Water Dist., 9th & Garner	1S4W04F	130	(24, 42)	50.0
City of San Bernardino, 10th & J	1S4W04B04	131	(27, 41)	50.0
City of San Bernardino, Olive & Garner	1S4W04C	132	(24, 41)	50.0

Appendix J

Table 13

CALIBRATED LEAKANCE
VALUES FOR MIDDLE
CONFINING CLAY UNIT USED IN THE
TRANSIENT-STATE FLOW MODEL

Well Name/Description	State Well Locations	Map No. on Figure 22	Grid Cell (x, y)	Leakance (ft/day)/ft
San Bernardino Ice Delivery #2	1S4W09B03	119	(27, 48)	1.18 (10^{-4})
Mt. Vernon Water Company	1N4W31A01S	22	(14, 35)	3.54 (10^{-2})
City of San Bernardino, Antil #2	1S4W02K01	120	(40, 44)	2.02 (10^{-5})
City of San Bernardino, Antil #3	1S4W02K01	121	(39, 45)	1.57 (10^{-5})
City of San Bernardino, Antil #4	1S4W02K03S	39	(40, 45)	2.57 (10^{-5})
City of San Bernardino, Antil #5	1S4W02K02S	38	(40, 45)	2.57 (10^{-5})
City of San Bernardino, Antil #6	1S4W02K08S	40	(40, 45)	2.57 (10^{-5})
City of San Bernardino, Hanford #2	1S4W10F05	122	(31, 50)	2.36 (10^{-5})
City of San Bernardino, A. Ree	1S4W11K01	123	(40, 51)	2.83 (10^{-4})
City of San Bernardino, Mill & "D" Street	1S4W10N06	124	(30, 53)	5.66 (10^{-5})
City of San Bernardino, South "G" Street	1S4W09J01S	125	(28, 51)	4.04 (10^{-5})
City of San Bernardino, 16th Street	1N4W34G03S	28	(32, 37)	1.23 (10^{-2})
City of San Bernardino, 17th Street	1N4W34G01S	27	(33, 37)	1.49 (10^{-2})
City of San Bernardino, 19th Street #1	1N4W43D03S	24	(17, 35)	2.57 (10^{-2})
City of San Bernardino, 19th Street #2	1N4W32D04S	25	(17, 35)	2.57 (10^{-2})
City of San Bernardino, 23rd Street	1N4W27N01S	18	(29, 34)	1.13 (10^{-2})
City of San Bernardino, North "E" Street	1N4W27M01S	16	(30, 32)	1.57 (10^{-2})
City of San Bernardino, 27th Street	1N4W27M02S	17	(29, 32)	1.57 (10^{-2})
City of San Bernardino, 30th Street & Mt. View (Marshall)	1N4W27G01S	15	(33, 30)	0.1[a]
City of San Bernardino, 31st Street & Mt. View	1N4W27B	14	(32, 29)	0.1[a]
City of San Bernardino, 7th Street	1S4W03J	46	(34, 44)	1.01 (10^{-4})
City of San Bernardino, Gilbert Street	1N4W35M03S	34	(35, 38)	2.02 (10^{-2})
City of San Bernardino, Lynwood	1N4W26G	8	(39, 30)	0.1[a]
City of San Bernardino, Newmark #1	1N4W16E01S	101	(23, 18)	0.1[a]
City of San Bernardino, Newmark #2	1N4W16E	100	(23, 18)	0.1[a]
City of San Bernardino, Newmark #3	1N4W16E03S	102	(23, 18)	0.1[a]
City of San Bernardino, Newmark #4	1N4W16E	3	(23, 17)	0.1[a]
City of San Bernardino, Perris Hill #5	1N4W26P03	126	(37, 34)	5.66 (10^{-2})
City of San Bernardino, Waterman Avenue	1N4W27A01S	13	(34, 29)	0.1 (NC)

Table 13 (Cont'd.)

CALIBRATED LEAKANCE VALUES FOR MIDDLE CONFINING CLAY UNIT USED IN TRANSIENT-STATE FLOW MODEL

Well Name/Description	State Well Locations	Map No. on Figure 22	Grid Cell (x, y)	Leakance (ft/day)/ft
City of San Bernardino, Baseline	1N4W32N	26	(16, 40)	2.18 (10^{-2})
City of San Bernardino, Darby	1N4W29E01S	19	(17, 27)	0.1[a]
City of San Bernardino, Colima	1N4W29F01S	20	(18, 30)	2.83 (10^{-5})
Nevada California Power Company #2	1S4W21Q3	127	(27, 66)	IN
Riverside Water Company., Vaugh #1	1S4W21Q3	128	(27, 66)	IN

[a] No confining clay was identified for this area so a minimal leakance value of 0.1 was used.
IN = Inactive area.

- The conductivity values for the GHB grid cells (for canyon areas entering the model area) were slightly modified during Runs 22A0415 through 24D0508. The conductivity values were reduced in order to produce flow into the model area that match the corresponding streamflow measurements listed in Table 9.

- The leakance values for the northern edge of the confining clay unit was increased to allow for more groundwater to be passed by layers 1 and 2. The leakance values for the middle area of the confining clay unit next to the San Jacinto fault were reduced so as to restrict the flow of groundwater between layers 1 and 2. Table 13 gives the representative leakance values for selective water-supply well areas that were used in the transient-state model. Table 13 also shows the leakance value of 0.1 day^{-1} that was used for the northern region of the model area where no substantial confining clay unit exists. This is shown for areas around the Newmark Wellfield Wells, the Waterman Avenue Well, the 30th and Mountain View Well, the 31st and Mountain View Well, and the Lynwood Well.

2.7 APPLICATION OF TRANSIENT-STATE MODEL

The calibrated transient-state model (Run 25B0511) has become the project flow model. The project flow model will be used to assess several extraction scenarios. The extraction scenarios will be simulated for the purpose of evaluating feasible remediation extraction systems for the Newmark plume.

For these extraction scenarios, several extraction areas will be placed at four regions of the Newmark Wellfield plume and pumped for 20 to 40 years into the future. Besides evaluating feasible remediation extraction systems, simulation of the extraction scenarios will also be used to:

- Estimate the position of the Newmark plume 35 years from January 1986;

- Determine if any existing water-supply wells within the Newmark plume have an influence can be utilized as possible extraction wells for the Newmark plume; and

- Calculate groundwater velocities for three areas of the Newmark plume.

The following extraction regions have been targeted:

- Downgradient edge of the Newmark Wellfield plume
- Middle of the Newmark Wellfield plume (adjacent to the eastern edge of Shandin Hills)
- Newmark Wellfield
- Centerline of the southern half of the Newmark Wellfield plume

2.8 SUMMARY

The summary of this memorandum will focus on the calibration and results of the transient-state model since the final calibrated transient-state model becomes the project flow model. The project flow model will be used in the determination of a remediation extraction system for the Newmark plume.

This memorandum (Newmark Project Flow Model Technical Memorandum, Part II) has discussed the following aspects of the project flow model:

- Final calibration of the steady-state model
- Preparation of the calibrated input data from the steady-state model for the transient-state model
- Calibration of the transient-state model
- Application of the calibrated transient-state model for designing a remediation extraction system for the Newmark Wellfield plume

Run 25B0511 became the final calibrated transient-state model, becoming the project flow model. Several tools aided in the calibration of the transient-state model:

- Water elevation maps for layers 1 and 2 generated from the output file of the transient-state simulations
- Hydrographs of the simulated and observed water elevations for several water-supply wells in the Newmark plume area
- Cell-by-cell flow files generated during each transient-state simulation

- Water budget summaries generated during each transient-state simulation and located in the output file

Some modifications were made to the transient-state model during the calibration process. Modifications were made to the:

- Hydraulic conductivity values
- Heads and conductivity values for the RIV grid cells
- Conductivity values for the GHB grid cells
- Leakance values for the confining clay unit

These modifications were made primarily to address the problem areas described in the next few paragraphs. The problem areas and limitations that persisted during the calibration of the transient-state model are described below:

- Several dry cells persisted throughout the calibration process. Dry cells (30,15,1), (30,16,1), (31,16,1), (32,16,1), (33,17,1), (34,17,1), (31,16,2) and (32,16,2) were located adjacent to the San Andreas fault, just north of the northeastern edge of Shandin Hills. These dry cells remained dry throughout the calibration of the transient-state model and simulations of the extraction scenarios. These dry cells were difficult to remedy due to the combination of boundary effects between the San Andreas fault and northeastern edge of Shandin Hills, and the groundwater gradient and flow direction in this same area.

- The water elevations simulated for the area surrounding Shandin Hills were not very accurate due to the boundary effects of Shandin Hills as no-flow area. Shandin Hills tended to prohibit the flow of groundwater around the east side of Shandin Hills in conjunction with the San Andreas Fault (which is also identified as a no-flow area to groundwater flow). The back-up of groundwater north of Shandin Hills is evident in the hydrographs for the Newmark #3

Well. The simulated water elevations for the Newmark #3 Well mimicked the actual trend of the observed water elevations, but still remained an average of 40 feet above the observed water elevations.

- The water elevations simulated for the middle area of the Newmark plume between East Twin Creek and Shandin Hills followed the same trend as the observed water elevations in this area. However, the simulated water elevations tended to be higher than the observed water elevations in this area.

This is evident in the hydrographs for the Waterman Avenue Well (Figure 25) and the 31st Street and Mountain View Well. For both of these hydrographs, the simulated water elevations followed the trend of the observed water elevations, but with not as much rise and fall. The simulated water elevations ranged from 20 to 80 feet above the observed water elevations. This seemed to be due to two model limitations: the model lacking capability of simulating the fluctuating recharge/discharge conditions of East Twin Creek on a very short-term basis and the boundary effects of the east side of Shandin Hills. It appears that the groundwater was not conveyed downgradient fast enough because it was held between East Twin Creek and Shandin Hills.

- A limitation of the water-supply well data possibly existed. The observed water elevations and the pumping rates for the water-supply wells were not all measured on the same days of the month. This could have caused some of the minor discrepancies between the simulated and observed water elevations evident in the hydrographs.

- As mentioned above, it was difficult to simulate the water elevations in the northern area (north and east of Shandin Hills). This problem was due to thinner alluvium in this area, particularly around Shandin Hills and next to the San Andreas fault. When the alluvium in one area is relatively thin compared to other areas of the same model layer, the model is sensitive to the solution of the water elevations in the area(s) of the thin alluvium.

Second, this problem could be due to the lack of knowledge on bedrock elevations in this area. Since the alluvium is thin in this area and the aquifer is unconfined, the water elevations, to some degree, probably follow the slope of the bedrock. However, very few data points of bedrock elevations were known throughout the entire model area and, therefore, this could have caused mismatches between simulated and observed water elevations in the area north and east of Shandin Hills.

The simulated water elevations for the lower one-third area of the Newmark plume matched the observed water elevations fairly well. This area was probably easier to simulate because it was downgradient of the boundary effects of Shandin Hills and the alluvium is thicker in this area. This correlation between simulated and observed water elevations is evident in the hydrographs for the 23rd Street Well, the Perris Hill #2 Well, the 17th Street Well, the Gilbert Street Well, and the 7th Street Well.

2.9 REFERENCES

City of Colton Public Works Department, Water Division. June 10, 1991. Water-supply well pumpage data for January 1986 through December 1990. Correspondence from Rex Meyers (City of Colton) to Natalyn Ala (URS Consultants).

City of Rialto Water Division. May 20, 1991 and December 23, 1991. Water-supply well pumpage data for January 1986 through December 1990. Correspondence from Bill Freels (City of Rialto) to Natalyn Ala (URS Consultants).

City of Riverside Public Utilities Department. June 3, 1991. Water-supply well pumpage data for January 1986 through December 1990. Correspondence from David V. Garcia, Water Engineering Mgr. (City of Riverside) to Natalyn Ala (URS Consultants).

City of San Bernardino Water Department. June 4, 1991. Water-supply well pumpage data for January 1986 through December 1990. Correspondence from Shirley Cismowski (City of San Bernardino) to Natalyn Ala (URS Consultants).

East Valley Water District. May 31, 1991. Water-supply well pumpage data for January 1986 through December 1990. Correspondence from Duncan Parkes (East Valley Water District) to Natalyn Ala (URS Consultants).

Hardt, W.F. and C.B. Hutchinson. September 1980. Development and Use of a Mathematical Model of the San Bernardino Valley Ground-Water Basin, California. USGS Open-File Report 80-576, 80 p.

McDonald, M.K. and A.W. Harbaugh. 1988. A Modular Three-Dimensional Finite Difference Groundwater Flow Model. USGS Techniques of Water-Resources Investigation. Book 6, Chapter A-1.

Meeks & Daley Water Company/Elsinore Valley Municipal Water Department. February 2, 1992. Water-supply well pumpage data for January 1986 through December 1990. Correspondence from Charles E. Smith, General Mgr. (Meeks & Daley Water Co.) to Natalyn Ala (URS Consultants).

Muscoy Mutual Water Company No. 1. May 31, 1991. Water-supply well pumpage data for January 1986 through December 1990. Correspondence from Maxine Malone (East Valley Water District) to Natalyn Ala (URS Consultants).

Riverside Highland Water Company. May 29, 1991. Water-supply well pumpage data for January 1986 through December 1990. Correspondence from Eugene McMeans, General Mgr. (Riverside Highland Water Company) to Natalyn Ala (URS Consultants).

URS Consultants, Inc. October 1991. Newmark Preliminary Steady-State Model Technical Memorandum. Vol. I-IV.

Wang, H.F. and M.P. Anderson. 1982 Introduction to Groundwater Modeling Finite Difference and Finite Element Methods. W.H. Freeman and Company. New York, NY. 237 p.

West San Bernardino City Water District. December 19, 1991. Water-supply well pumpage data for January 1986 through December 1990. Correspondence from Eugene Anthony Anaiza (West San Bernardino City Water District) to Natalyn Ala (URS Consultants).

PARTIALLY SCANNED OVERSIZE ITEM (S)

See Document # 2025205
for partially scanned image(s).

For complete version of oversize document(s), see paper copy.

OVD parent