geophysical surveys in key new private wells and exploration borings as they are identified during the permitting process.

Several new monitoring wells are planned for the explicit purpose of salt impact monitoring (see Chapter 6, Salt Management Monitoring Plan). Besides providing additional water level, flow gradient and water quality data, they provide an opportunity to collect additional geological information such as: lithology, geologic heterogeneity, and aquifer thickness near the basin margins.

Lawrence Livermore National Laboratories (LLNL) has recently obtained a grant from the State Water Resources Agency to investigate the vulnerability of groundwater supplies throughout the state by age dating the water from several hundred production wells. Zone 7 and several other local groundwater producers may cooperate in this investigation. The results may be used to refine the current understanding of flow velocities and directions and aquifer mixing.

3.7 Groundwater Model

A groundwater model is a device that represents an approximation of a groundwater basin. Physical models such as laboratory sand tanks simulate groundwater flow directly. A mathematical groundwater model simulates groundwater flow indirectly by means of equations to represent the physical process that occur in the groundwater basin. A mathematical model can be solved analytically or numerically. Since analytical solutions are not suitable due to complexities in the groundwater flow modeling, numerical groundwater modeling is more often used for groundwater basin modeling.

Groundwater models are useful for predicting the consequences of a proposed groundwater basin management action. Groundwater models can also be used to learn about the controlling parameters in a site-specific setting such as establishing locations and characteristics of aquifer boundaries.

The original Main Basin groundwater model was developed by Zone 7 and the California Department of Water Resources (DWR) in the 1970's and is documented in DWR Bulletin 118-2. Davies (a Stanford graduate student) developed a groundwater model of the Amador Sub-basin in 1981. Danskin (another Stanford graduate student) extended this model into the Bernal Sub-basin in December 1985 and calibrated the model for average fluxes for the period 1977-1981. Although these models and the associated documentation provided some useful technical information, Zone 7 did not use them for basin management studies.

In 1996, Zone 7 staff retained consultant CH2M Hill to assist with the development of a groundwater flow and solute (salt) transport model for the main groundwater basin. The model was designed to be useable by Zone 7 staff for evaluating alternative Salt Management Plan (SMP) strategies (see Chapter X) and future Main Basin management options. The resultant model, as currently used by Zone 7 staff, includes the Visual MODFLOW for Windows version 2.61 by Waterloo Hydrologic, Inc. package. Visual MODFLOW uses the three-dimensional MODFLOW code to simulate groundwater flow and the three-dimensional MT3D code to simulate solute transport.

3.7.1 Model Grid and Properties

The model grid has four layers and a uniform 500 x 500 foot grid in X and Y directions covering the entire Livermore-Amador Valley Groundwater Basin. Figure 3.12 shows the modeled area. It is a three dimensional model and the thickness of the grid cells varies throughout the model area. The top three layers represent the upper unconfined aquifer, the deep confined aquifer and an intervening aquitard layer, respectively. Figures 3.13 and 3.14 present cross-sectional profiles in the North-South and East-West directions. These cross-sections illustrate typical layer geometry. The model layer elevations for the major portion of the model are based upon a number of geologic well logs.

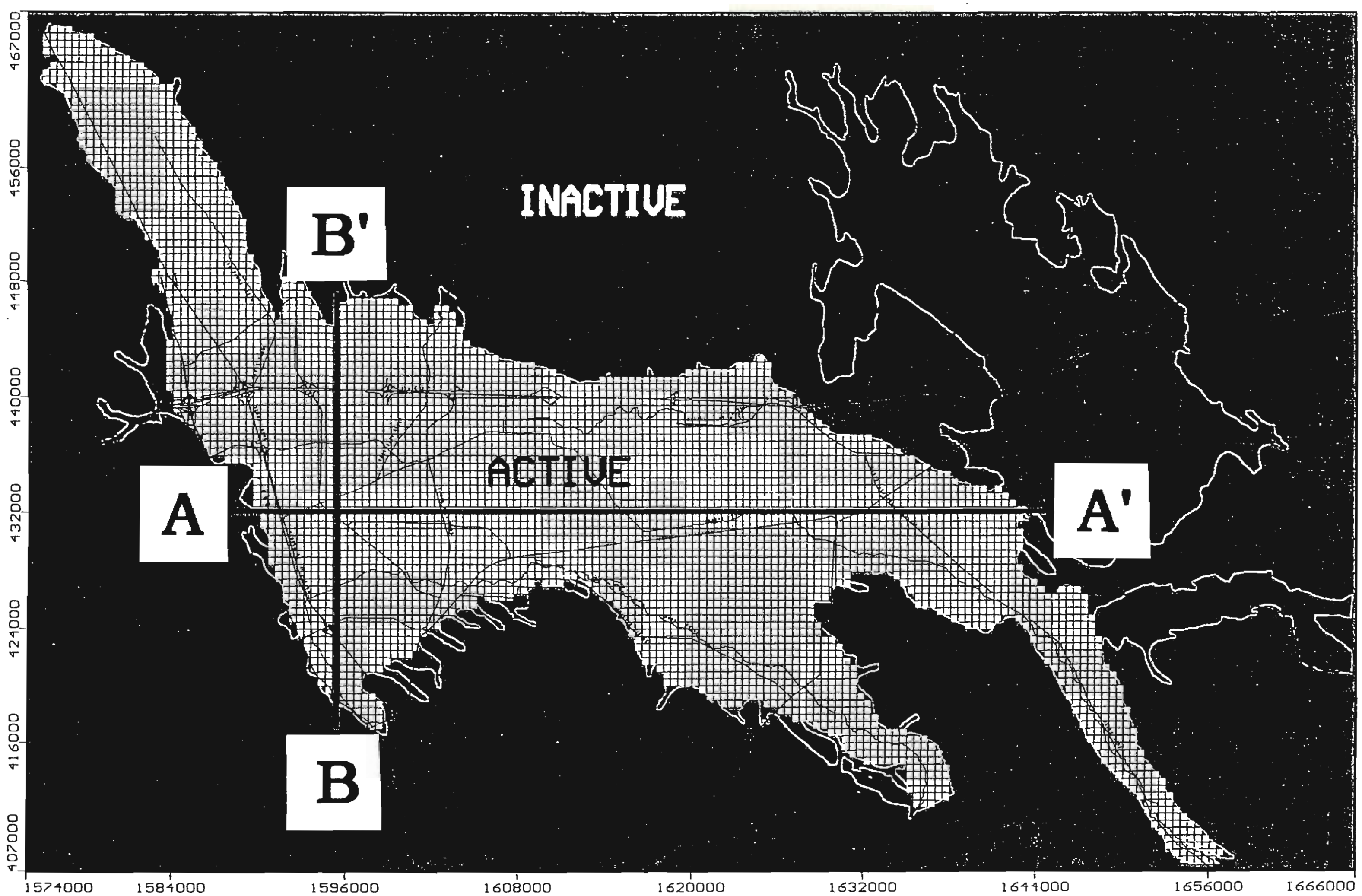
Most of the municipal wells are screened in the deep aquifer. The fourth layer of the model represents the Livermore and Tassajara formations. This layer at this time is inactive since the Livermore and Tassajara formations are low yielding it is believed that there is not any significant interaction with the deep aquifer. To further focus Zone 7 resources it was decided to activate only the Main Basin and some key fringe basins. The current active model area therefore covers the Main Basin (Amador, Bernal, Castle and Mocho II sub-basins) plus the Dublin, Camp, and Bishop fringe sub-basins. The active and inactive areas of the model are shown in Figure 3.12. The boundary between the active and inactive areas represents a no flow boundary.

Figures 3.15 through 3.17 show the hydraulic conductivity distribution for the three active model layers. The hydraulic conductivity ranges from 0.7 to 134 ft/day for model layer 1 (upper aquifer), 0.001 to 0.2 ft/day for model layer 2 (aquitard layer) and 1 to 350 ft/day for model layer 3 (deep aquifer). Figures 3.18 and 3.19 show the distribution of specific yield (Sy) in the model layer 1 and specific storage (Ss) in model layer 3.

The Livermore, Mocho, Parks and Pleasanton faults are represented in the model using the MODFLOW horizontal flow boundary package. Figure 3.20 shows the location of the faults in the deep aquifer. Groundwater monitoring data and earlier investigations indicate that these faults impede flow across them only in the deep aquifer.

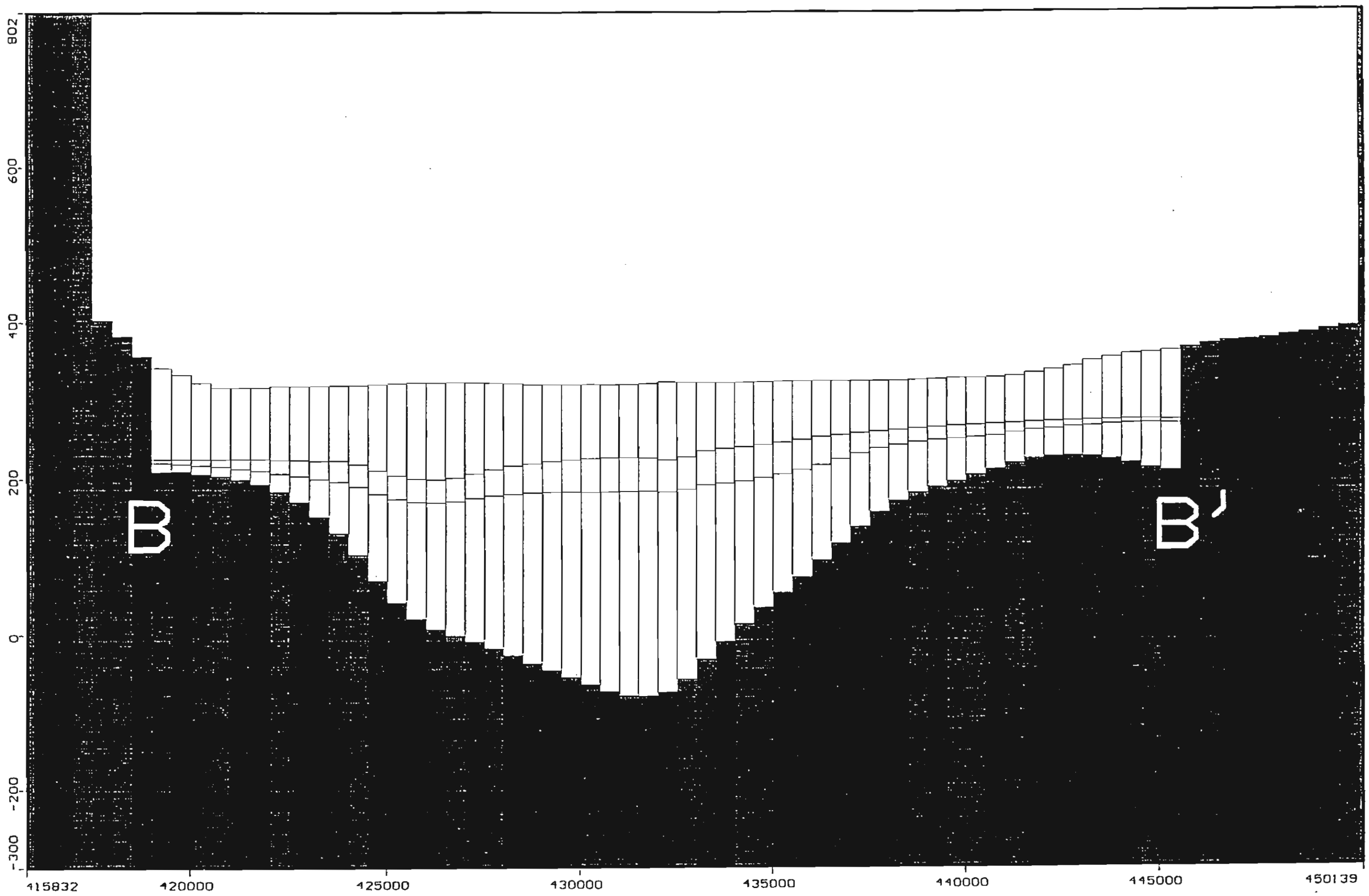
3.7.2 Model Fluxes

The model flux sources (i.e., inputs) include rainfall recharge, applied irrigation water recharge, stream recharge, and injection well recharge. Flux sinks (outputs)



CH2M Hill Inc – Oakland, CA Project: LVGWB Model v. 2.0.55 Description: Model Grid Modeller: CH2M Hill 9 Jan 98	Visual MODFLOW v.2.61, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 184 NR: 120 NL: 4 Current Layer: 1

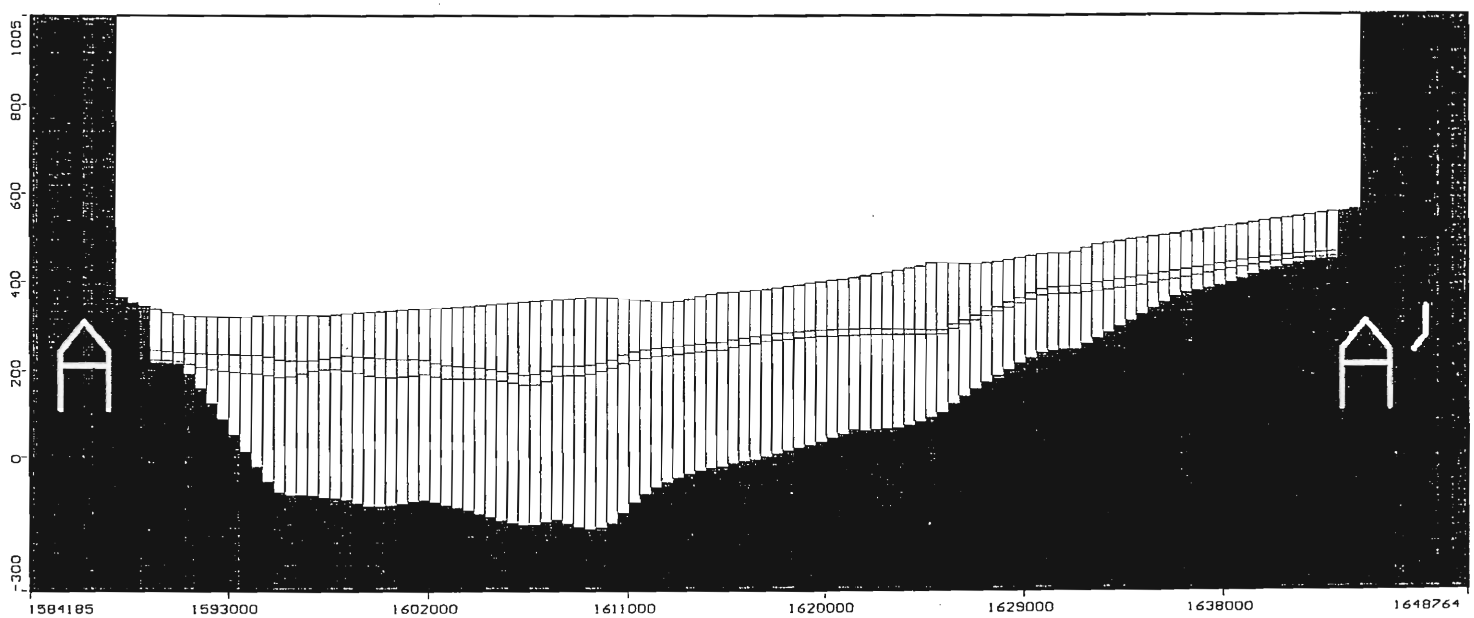
FIGURE 3.12



CH2M Hill Inc – Oakland, CA
Project: LVGWB Model v. 2.0.55
Description: Cross Section B–B' (C43)
Modeller: CH2M Hill
9 Jan 98

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Column: 43

FIGURE 3.13



CH2M Hill Inc – Oakland, CA Project: LVGWB Model v. 2.0.55 Description: Cross Section A–A' (R70) Modeller: CH2M Hill 9 Jan 98	Visual MODFLOW v.2.61, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 184 NR: 120 NL: 4 Current Row: 70 FIGURE 3.14

include groundwater well pumping, gravel mining pumping and groundwater outflow (gaining streams).

Each of these main flux components has sub-components. For example, stream recharge includes natural recharge, artificial recharge, and gravel mining recharge. Recharge on each stream is also divided into a number of reaches since recharge rates vary depending on stream location. Based upon monitoring program data, two databases were prepared that had monthly data for each component of recharge and pumpage for the period 1974-95. Tables 3.3, 3.4 and 3.5 list the components of recharge and pumpage. Each of the recharge components was also assigned a TDS value based upon the monitoring data. Table 3.6 lists the TDS in mg/L for each recharge component.

The rainfall recharge and applied water recharge in the model are combined as areal recharge. The areal recharge amounts and TDS vary with soil type and hydrologic conditions throughout the model area. To address this situation, the areal recharge was distributed using DWR model nodal zone designations. Fig 3.21 presents the node numbers and the average TDS of areal recharge for each node.

Natural stream recharge, artificial stream recharge and gravel mining stream recharge are modeled using the MODFLOW river package. The river package is used in the model in such a way that the recharging streams operate as specified flux boundaries. The gaining streams and mining gravel pits are modeled using the MODFLOW drain package. During the model application for salt management plan simulations, the mining ponds (Chain of Lakes) were modeled as evaporation boundaries with the west face (recharging face) of Lake I modeled as injection wells into the upper aquifer.

3.7.3 Initial Conditions

Initial conditions for the flow model were based upon Zone 7 fall 1975 groundwater level data for the upper and lower aquifers. The initial conditions for the aquitard were assumed to be the same as for the upper aquifer. The initial conditions for the solute transport model were also based upon actual Zone 7 data (generally 1990-1995 monitoring data) for the upper and lower aquifers. The aquitard TDS used was the average of upper and lower aquifer TDS.

3.7.4 Model Flow Calibration

Model calibration typically involves running the model, comparing the model output with the observed data, adjusting the model properties and/or model fluxes, and then redoing this repeatedly until there is a reasonable fit between the predicted and observed data. Comparisons between contour maps of measured and simulated heads provides a qualitative measure of the similarity between patterns, thereby giving an idea of the spatial distribution of error. Comparisons between

ZONE 7
WATER RESOURCES ENGINEERING

DESCRIPTION OF RECORDS IN "RECHRAGE.DBF" FILE

THE DBF FILE IS LOCATED AT E:\MODFLOW\CH2M\FLOWDATA\RECHARGE.DBF. THE FILE CONTAINS THE RECHARGE COMPONENTS FOR THE MAIN GW BASIN FOR 1974-95.

STATION	FIRST YEAR	Rech/Pump	Layer	Description
ADLL_OUT_M1	1974	Recharge	1	ADLLP outflow
ALP_RC_M1	1974	Recharge	1	ALP conservation rech. thru M1
ALP_RC_M2	1974	Recharge	1	ALP conservation rech. thru M2
ALP_RC_M3	1974	Recharge	1	ALP conservation rech. thru M3
ALP_RN_M1	1974	Recharge	1	ALP natural rech. thru M1
ALP_RN_M2	1974	Recharge	1	ALP natural rech. thru M2
ALP_RN_M3	1974	Recharge	1	ALP natural rech. thru M3
AM_RC_M1	1974	Recharge	1	AM conservation rech. thru M1
AM_RC_M2	1974	Recharge	1	AM conservation rech. thru M2
AM_RC_M3	1974	Recharge	1	AM conservation rech. thru M3
AM_RC_M4	1974	Recharge	1	AM conservation rech. thru M4
AM_RC_M5	1974	Recharge	1	AM conservation rech. thru M5
AM_RC_M6	1974	Recharge	1	AM conservation rech. thru M6
AM_RCM_M4	1974	Recharge	1	AM recharge from Calmat thru M4
AM_RKA_M5	1974	Recharge	1	AM recharge from Kaiser thru M5
AM_RN_M1	1974	Recharge	1	AM natural rech. thru M1
AM_RN_M2	1974	Recharge	1	AM natural rech. thru M2
AM_RN_M3	1974	Recharge	1	AM natural rech. thru M3
AM_RN_M4	1974	Recharge	1	AM natural rech. thru M4
AM_RN_M5	1974	Recharge	1	AM natural rech. thru M5
AM_RN_M6	1974	Recharge	1	AM natural rech. thru M6
AV_RC_M1	1974	Recharge	1	AV conservation rech. thru M1
AV_RC_M2	1974	Recharge	1	AV conservation rech. thru M2
AV_RC_M3	1974	Recharge	1	AV conservation rech. thru M3
AV_RC_M4	1974	Recharge	1	AV conservation rech. thru M4
AV_RC_M5	1974	Recharge	1	AV conservation rech. thru M5
AV_RKA_M4	1974	Recharge	1	AV recharge from Kaiser thru M4
AV_RLS_M4	1974	Recharge	1	AV recharge from Lonestar thru M4
AV_RN_M1	1974	Recharge	1	AV natural rech. thru M1
AV_RN_M2	1974	Recharge	1	AV natural rech. thru M2
AV_RN_M3	1974	Recharge	1	AV natural rech. thru M3
AV_RN_M4	1974	Recharge	1	AV natural rech. thru M4
AV_RN_M5	1974	Recharge	1	AV natural rech. thru M5
INFLOW_N15	1974	Recharge	1	Inflow into Node 15
INFLOW_N16	1974	Recharge	1	Inflow into Node 16
INFLOW_N23	1974	Recharge	1	Inflow into Node 23
RC_AW_U_N15	1974	Recharge	1	Urban Applied Water Recharge in Node 15
RC_AW_U_N16	1974	Recharge	1	Urban Applied Water Recharge in Node 16
RC_AW_U_N17	1974	Recharge	1	Urban Applied Water Recharge in Node 17
RC_AW_U_N18	1974	Recharge	1	Urban Applied Water Recharge in Node 18
RC_AW_U_N19	1974	Recharge	1	Urban Applied Water Recharge in Node 19
RC_AW_U_N20	1974	Recharge	1	Urban Applied Water Recharge in Node 20
RC_AW_U_N23	1974	Recharge	1	Urban Applied Water Recharge in Node 23
RC_AW_U_N24	1974	Recharge	1	Urban Applied Water Recharge in Node 24
RC_AW_U_N25	1974	Recharge	1	Urban Applied Water Recharge in Node 25
RC_AW_U_N26	1974	Recharge	1	Urban Applied Water Recharge in Node 26
RC_AW_U_N29	1974	Recharge	1	Urban Applied Water Recharge in Node 29
RC_AW_U_N30	1974	Recharge	1	Urban Applied Water Recharge in Node 30
RC_AW_U_N31	1974	Recharge	1	Urban Applied Water Recharge in Node 31
RC_AW_U_N33	1974	Recharge	1	Urban Applied Water Recharge in Node 33
RC_AW_U_N34	1974	Recharge	1	Urban Applied Water Recharge in Node 34
RC_AW_U_N35	1974	Recharge	1	Urban Applied Water Recharge in Node 35
RC_AW_U_N38	1974	Recharge	1	Urban Applied Water Recharge in Node 38
RC_AW_U_N39	1974	Recharge	1	Urban Applied Water Recharge in Node 39
RC_AW_U_N40	1974	Recharge	1	Urban Applied Water Recharge in Node 40
RC_AW_U_N41	1974	Recharge	1	Urban Applied Water Recharge in Node 41
RC_AW_U_N42	1974	Recharge	1	Urban Applied Water Recharge in Node 42
RC_LWRP_N29	1974	Recharge	1	LWRP Applied Water Recharge in Node 29
RC_LWRP_N30	1974	Recharge	1	LWRP Applied Water Recharge in Node 30
RC_LWRP_N33	1974	Recharge	1	LWRP Applied Water Recharge in Node 33

ZONE 7
WATER RESOURCES ENGINEERING

DESCRIPTION OF RECORDS IN "RECHRAGE.DBF" FILE

THE DBF FILE IS LOCATED AT E:\MODFLOW\CH2M\FLOWDATA\RECHARGE.DBF. THE FILE CONTAINS THE RECHARGE COMPONENTS FOR THE MAIN GW BASIN FOR 1974-95.

RC_RR_N15	1974	Recharge	1	Rainfall Recharge in Node 15
RC_RR_N16	1974	Recharge	1	Rainfall Recharge in Node 16
RC_RR_N17	1974	Recharge	1	Rainfall Recharge in Node 17
RC_RR_N18	1974	Recharge	1	Rainfall Recharge in Node 18
RC_RR_N19	1974	Recharge	1	Rainfall Recharge in Node 19
RC_RR_N20	1974	Recharge	1	Rainfall Recharge in Node 20
RC_RR_N23	1974	Recharge	1	Rainfall Recharge in Node 23
RC_RR_N24	1974	Recharge	1	Rainfall Recharge in Node 24
RC_RR_N25	1974	Recharge	1	Rainfall Recharge in Node 25
RC_RR_N26	1974	Recharge	1	Rainfall Recharge in Node 26
RC_RR_N29	1974	Recharge	1	Rainfall Recharge in Node 29
RC_RR_N30	1974	Recharge	1	Rainfall Recharge in Node 30
RC_RR_N31	1974	Recharge	1	Rainfall Recharge in Node 31
RC_RR_N33	1974	Recharge	1	Rainfall Recharge in Node 33
RC_RR_N34	1974	Recharge	1	Rainfall Recharge in Node 34
RC_RR_N35	1974	Recharge	1	Rainfall Recharge in Node 35
RC_RR_N38	1974	Recharge	1	Rainfall Recharge in Node 38
RC_RR_N39	1974	Recharge	1	Rainfall Recharge in Node 39
RC_RR_N40	1974	Recharge	1	Rainfall Recharge in Node 40
RC_RR_N41	1974	Recharge	1	Rainfall Recharge in Node 41
RC_RR_N42	1974	Recharge	1	Rainfall Recharge in Node 42
RC_SFWD_N19	1974	Recharge	1	SFWD Applied Water Recharge in Node 19
RC_SFWD_N20	1974	Recharge	1	SFWD Applied Water Recharge in Node 20
RC_UNAG_N15	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 15
RC_UNAG_N16	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 16
RC_UNAG_N17	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 17
RC_UNAG_N18	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 18
RC_UNAG_N19	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 19
RC_UNAG_N20	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 20
RC_UNAG_N23	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 23
RC_UNAG_N24	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 24
RC_UNAG_N25	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 25
RC_UNAG_N26	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 26
RC_UNAG_N29	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 29
RC_UNAG_N30	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 30
RC_UNAG_N31	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 31
RC_UNAG_N33	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 33
RC_UNAG_N34	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 34
RC_UNAG_N35	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 35
RC_UNAG_N38	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 38
RC_UNAG_N39	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 39
RC_UNAG_N40	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 40
RC_UNAG_N41	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 41
RC_UNAG_N42	1974	Recharge	1	Unmetered Ag.Water Recharge in Node 42

ZONE 7
WATER RESOURCES ENGINEERING

DESCRIPTION OF RECORDS IN "WELLPRO2.DBF" FILE

THE DBF FILE IS LOCATED AT E:\MODFLOW\CH2M\FLOWDATA\WELLPRO2 .DBF. THE FILE CONTAINS THE PRODUCTION COMPONENTS FOR THE MAIN GW BASIN FOR 1974-95.

STATION	YEAR	Rech/Pump	Layer	Description
CASTLEWOOD_G	1974	Pumpage	3	Pumpage from Well 3S/1E 19A 3
CWS#20 (18B)	1974	Pumpage	3	Pumpage from Well 3S/2E 18B 1
CWS#24 (7P3)	1974	Pumpage	3	Pumpage from Well 3S/2E 7P 3
GWP_3S1E1P3	1974	Pumpage	3	Pumpage from Well 3S/1E 1P 3
GWP_3S1E20B2	1974	Pumpage	3	Pumpage from Well 3S/1E 20B 2
GWP_3S1E20C3	1991	Pumpage	3	Pumpage from Well 3S/1E 20C 3
GWP_AG_SFWD	1974	Pumpage	3	Pumpage from Well 3S/1E 20E 1
GWP_CASTLE	1974	Pumpage	3	Pumpage from Well 3S/1E 29E 4
GWP_CM_R16	1984	Pumpage	1	Calmat Pumpage From R16
GWP_CM_R17	1983	Pumpage	1	Calmat Pumpage From R17
GWP_CM_R19	1987	Pumpage	1	Calmat Pumpage From R19
GWP_CM_R21	1994	Pumpage	1	Calmat Pumpage From R21
GWP_CM_R3	1974	Pumpage	1	Calmat Pumpage From R3
GWP_CM_R5	1976	Pumpage	1	Calmat Pumpage From R5
GWP_CM_R8	1980	Pumpage	1	Calmat Pumpage From R8
GWP_KA_K24	1980	Pumpage	1	Kaiser Pumpage From K24
GWP_KA_K28	1983	Pumpage	1	Kaiser Pumpage From K28
GWP_KA_K30	1974	Pumpage	1	Kaiser Pumpage From K30
GWP_KA_K34	1987	Pumpage	1	Kaiser Pumpage From K34
GWP_KA_K35	1990	Pumpage	1	Kaiser Pumpage From K35
GWP_KA_K36	1985	Pumpage	1	Kaiser Pumpage From K36
GWP_LS_P20	1985	Pumpage	1	Lonestar Pumpage From P20
GWP_LS_P21	1987	Pumpage	1	Lonestar Pumpage From P21
GWP_LS_P22	1974	Pumpage	1	Lonestar Pumpage From P22
GWP_LS_P23	1980	Pumpage	1	Lonestar Pumpage From P23
GWP_LS_P30	1990	Pumpage	1	Lonestar Pumpage From P30
GWP_LS_P31	1983	Pumpage	1	Lonestar Pumpage From P31
GWP_LS_P7	1979	Pumpage	1	Lonestar Pumpage From P7
GWP_TVGLF	1992	Pumpage	3	Pumpage from Well 3S/1E 2P 7
GWP_UAG_N15	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 15
GWP_UAG_N16	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 16
GWP_UAG_N17	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 17
GWP_UAG_N18	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 18
GWP_UAG_N19	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 19
GWP_UAG_N20	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 20
GWP_UAG_N23	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 23
GWP_UAG_N24	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 24
GWP_UAG_N25	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 25
GWP_UAG_N26	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 26
GWP_UAG_N29	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 29
GWP_UAG_N30	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 30
GWP_UAG_N31	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 31
GWP_UAG_N33	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 33
GWP_UAG_N34	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 34
GWP_UAG_N35	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 35
GWP_UAG_N38	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 38
GWP_UAG_N39	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 39
GWP_UAG_N40	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 40
GWP_UAG_N41	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 41
GWP_UAG_N42	1974	Pumpage	3	Unmetered Ag.Water Pumpage in Node 42
HOP 1	1974	Pumpage	3	Pumpage from Well 3S/1E 18A 1
HOP 4	1974	Pumpage	3	Pumpage from Well 3S/1E 17D 2
HOP 6	1974	Pumpage	3	Pumpage from Well 3S/1E 18A 6
MOCHO 1	1974	Pumpage	3	Pumpage from Well 3S/1E 9M 2
MOCHO 2	1974	Pumpage	3	Pumpage from Well 3S/1E 9M 3
PLEAS #5	1974	Pumpage	3	Pumpage from Well 3S/1E 16L 5
PLEAS #6	1974	Pumpage	3	Pumpage from Well 3S/1E 16L 7
PLEAS #7	1974	Pumpage	3	Pumpage from Well 3S/1E 18A 5
PLEAS #8	1993	Pumpage	3	Pumpage from Well 3S/1E 16A 2
STONERIDGE_1	1992	Pumpage	3	Pumpage from Well 3S/1E 9B 1

ZONE 7
WATER RESOURCES ENGINEERING

DESCRIPTION OF RECORDS IN " RECHG_E. DBF" FILE

THE DBF FILE IS LOCATED AT E:\MODFLOW\CH2M\FLOWDATA\RECHG_E.DBF. THIS FILE CONTAINS THE RECHARGE AND DISCHARGE COMPONENTS FOR DUBLIN, CAMP AND BISHOP SUBBASINS. IT ALSO CONTAINS THE ADDITIONAL AG APPLIED WATER RECHARGE IN NODE 40 OF MOCHO SUBBASIN DUE TO DELIVERIES FROM SBA REACH 4 OF SBA.. THIS DBF FILE FOR THE PERIOD 1974-1995.

STATION	FIRST YEAR	RECHARGE/ DISCHARGE	LAYER	DESCRIPTION
ALMO_OUT_M1	1974	DISCHARGE	1	GW OUTFLOW INTO REACH M1 OF ALAMO CANAL
ALMO_OUT_M2	1974	DISCHARGE	1	GW OUTFLOW INTO REACH M2 OF ALAMO CANAL
DUB_OUT_M2	1974	DISCHARGE	1	GW OUTFLOW INTO REACH M2 OF DUBLIN CREEK
RC_AW_U_N1	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N10	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N11	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N12	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N13	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N14	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N2	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N21	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N22	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N27	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N28	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N3	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N32	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N37	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N4	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N5	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N6	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N7	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N8	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_AW_U_N9	1974	RECHARGE	1	URBAN APPLIED WATER RECHARGE IN NODE # ---
RC_RR_N1	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N10	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N11	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N12	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N13	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N14	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N2	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N21	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N22	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N27	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N28	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N3	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N32	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N37	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N4	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N5	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N6	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N7	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N8	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_RR_N9	1974	RECHARGE	1	RAINFALL RECHARGE IN NODE # ----
RC_SBA4_N40	1974	RECHARGE	1	AG APPLIED WATER RECHARGE IN NODE 40 FROM SBA DELIVERIES IN RECCH 4 OF SBA
SMON_OUT_M2	1974	DISCHARGE	1	GW OUTFLOW INTO REACH M2 OF SAN RAMON CREEK
TJ_RN_M2	1974	RECHARGE	1	NATURAL STREAM RECHARGE IN REACH 2 OF TASAJARA CRE
DSRSD#1	1974	GW PUMPAGE		GW PUMPAGE FROM LAYER #3 BY WELL # 3S/1W 1B 1 CCE=1588899.8, CCN=442474.5
DSRSD#2	1974	GW PUMPAGE		GW PUMPAGE FROM LAYER #3 BY WELL # 3S/1W 1G 2 CCE=1589903.5, CCN=442109.7
DSRSD#3	1974	GW PUMPAGE		GW PUMPAGE FROM LAYER #3 BY WELL # 3S/1W 1H 2 CCE=1590968.1, CCN=441785.4

MODFLOW\RECH_TDS.WK4

TABLE 3.6

RECHARGE WATER TDS IN mg/l

year	ARROYO VALLE					ARROYO MOCHO				ARROYO LAS POSITAS				TASAJARA CREEK	TDS OF BLENDED AREAL RECHARGE (INCLUDED AW_U, RR, AW_UNAG AND LWRP RECHARGE)					SUBSURFACE INFLOW	SUBSURFACE OUTFLOW	MINING COMPANY RECHARGES
	NATURAL		ARTIFICIAL	BLENDED TDS FOR		NATURAL	ARTIFICIAL	BLENDED TDS FOR		NATURAL	ARTIFICIAL	WASTEWATER	ALP BLENDED TDS	NATURAL RECHARGE TDS	ALL MAIN BASIN NODES EXCEPT NODES 29,30 & 33	NODES 29,30&33 (LWRP)	NODES 1 THROUGH 5	NODES 6 THROUGH 14	NODES 21,22,27 28, 32 & 37			
	upper reaches AV REACHES M1 TO M3	lower reaches AV REACHES M4 TO M5		REACHES M1 - M3	REACHES M4 - M5			REACHES M1 - M3	REACHES M4 - M6													
1974	597	233	150	**341**	**372**	400	150	**314**	**321**	700		650	**675**	**609**			**168**	**716**	**0**	**1,500**		450
1975	404	194	200	**268**	**280**	400	200	**335**	**355**	700		650	**670**	**609**			**171**	**659**	**0**	**1,500**		450
1976	800		200	**292**	**334**	400	200	**229**	**251**	700		650	**663**	**609**			**700**	**2384**	**0**	**1,500**		450
1977	800		500	**555**	**551**	400	500	**490**	**484**	700		650	**663**	**609**			**700**	**4807**	**0**	**1,500**		450
1978	478	209	350	**398**	**402**	400	350	**384**	**386**	700	350	650	**659**	**609**			**119**	**624**	**0**	**1,500**		450
1979	800	250	200	**295**	**295**	400	200	**234**	**265**	700		650	**670**	**609**	FOR ALL MAIN BASIN NODES, SEE TABLE 3.6A FOR AREAL RECHARGE TDS.		**370**	**1164**	**0**	**1,500**	**850**	450
1980	561	214	200	**282**	**282**	400	200	**264**	**302**	700	200	650	**590**	**609**			**125**	**332**	**0**	**1,500**	**850**	450
1981	800	250	200	**262**	**268**	400	200	**229**	**269**	700	200		**455**	**609**			**700**	**2111**	**0**	**1,500**	**850**	450
1982	441	209	200	**299**	**309**	400	200	**319**	**340**	1,000	200		**834**	**609**			**34**	**99**	**0**	**1,500**	**850**	460
1983	298	193	150	**257**	**283**	400	150	**376**	**394**	1,200			**1,200**	**609**			**25**	**58**	**0**	**1,500**	**850**	430
1984	739	247	150	**556**	**508**	400		**400**	**405**	1,200			**1,200**	**609**			**261**	**605**	**0**	**1,500**	**850**	420
1985	800	250	200	**430**	**425**	400		**400**	**404**	1,200			**1,200**	**609**			**700**	**2176**	**0**	**1,500**	**850**	420
1986	345	177	240	**320**	**394**	400		**400**	**402**	1,200			**1,200**	**609**			**69**	**257**	**0**	**1,500**	**850**	460
1987	800	250	240	**451**	**473**	400		**400**	**400**	1,200			**1,200**	**609**			**700**	**2424**	**0**	**1,500**	**850**	480
1988	800	250	330	**557**	**552**	400	330	**360**	**360**	1,200			**1,200**	**609**			**700**	**3492**	**0**	**1,500**	**850**	550
1989	800	250	270	**425**	**489**	400	270	**291**	**291**	1,200			**1,200**	**609**			**700**	**3128**	**0**	**1,500**	**900**	510
1990	850	250	320	**539**	**500**	400	295	**305**	**305**	1,070			**1,070**	**609**			**700**	**3280**	**0**	**1,500**	**920**	490
1991	535	203	320	**453**	**535**	400	360	**375**	**375**	980			**980**	**609**			**535**	**3044**	**0**	**1,500**	**900**	570
1992	710	250	330	**545**	**548**	350	330	**345**	**345**	1,180			**1,180**	**609**			**520**	**2772**	**0**	**1,500**		550
1993	377	247	240	**317**	**427**	410	260	**330**	**339**	1,150			**1,150**	**609**			**61**	**229**	**0**	**1,500**		550
1994	570	250	270	**362**	**482**	580	260	**308**	**323**	850			**850**	**609**			**700**	**2619**	**0**	**1,500**		540
1995	409	239	200	**341**	**435**	370	160	**246**	**314**	1,000			**1,000**	**609**			**47**	**146**	**0**	**1,500**	**830**	520

AREAL RECHARGE TDS FOR ALL MAIN BASIN NODES

Table 3.6A

	Model stress period in days		BLENDED TDS FOR EACH NODE(FOR APPLIED URBAN, APPLIED UNAG, RAIN , LWRP and AG applied water reharge) NODE NMBERS																				AVERAGE
YEAR			15	16	17	18	19	20	23	24	25	26	29	30	31	33	34	35	38	39	40	41	42	
1974			1420	295	565	432	1014	885	706	600	529	1774	2427	1873	253	1844	1476	301	710	491	620	515	512	916
1975			1319	261	519	332	303	300	627	342	504	1677	2626	1872	243	2072	1348	274	631	430	642	455	460	821
1976	0.0	365.0	4115	2384	3419	2563	2717	2545	3220	2603	3229	4331	5302	4781	4800	5046	4215	1201	2511	953	946	953	953	2990
1977	365.0	730.0	4802	4807	4804	4807	4804	4805	4805	4807	4804	4801	5393	4800	4800	5567	4802	1922	4807	1923	1923	1923	1923	4182
1978	730.0	1095.0	1068	307	481	427	619	574	548	392	520	1466	2550	1706	189	2369	1256	290	645	496	861	527	528	849
1979	1095.0	1460.0	1199	404	950	565	1140	977	650	515	881	2444	3379	2604	494	3046	2126	421	838	498	689	516	520	1184
1980	1460.0	1825.0	179	132	391	163	357	326	190	170	330	1428	2369	1445	172	2464	1130	183	368	230	471	244	247	618
1981	1825.0	2190.0	844	704	1432	924	1919	1837	889	864	714	2299	4086	2974	367	3747	1398	626	1458	629	788	641	644	1418
1982	2190.0	2555.0	58	47	128	63	120	126	61	63	43	315	803	300	14	667	289	54	189	92	279	100	101	186
1983	2555.0	2920.0	33	27	71	33	231	187	35	40	29	162	636	194	0	566	177	31	84	56	182	61	70	138
1984	2920.0	3285.0	274	228	650	256	398	441	287	271	327	1087	2497	1445	0	1959	803	183	440	304	483	318	359	619
1985	3285.0	3650.0	544	524	470	622	1688	1586	573	666	866	2049	3383	2471	499	2644	2984	376	960	558	686	575	574	1205
1986	3650.0	4015.0	125	91	92	116	547	412	132	147	166	407	1028	713	0	939	686	111	241	199	402	214	215	332
1987	4015.0	4380.0	1717	1526	2564	1662	3453	3069	1792	1678	1934	2508	4644	3840	0	3998	2254	742	2197	880	919	887	891	2055
1988	4380.0	4745.0	2235	1979	1996	2162	3310	3095	2235	2253	2641	3168	5017	3790	0	4610	2489	1194	2584	1234	1288	1247	1241	2370
1989	4745.0	5110.0	1912	1825	1760	1981	3087	2948	1912	2040	2522	2976	4801	3633	0	4546	1840	1119	2283	1116	1164	1123	1124	2177
1990	5110.0	5475.0	2577	2369	2460	2492	3574	3410	2577	2589	2829	3580	5068	4000	0	4650	3265	1347	2751	1233	1236	1239	1246	2595
1991	5475.0	5840.0	252	185	172	205	955	821	269	224	170	698	2396	1080	0	2353	570	145	348	329	944	353	361	611
1992	5840.0	6205.0	1028	834	731	951	916	958	1084	1057	821	1185	3051	1452	0	3024	1140	524	1296	918	1133	947	951	1143
1993	6205.0	6570.0	130	94	92	120	109	128	137	130	117	185	1020	238	0	933	109	73	198	197	388	212	214	230
1994	6570.0	6935.0	853	702	672	837	772	841	894	924	726	801	3226	1580	0	3091	757	476	1148	721	885	739	741	1018
1995	6935.0	7300.0	86	62	61	80	72	78	91	92	66	73	596	161	0	641	61	52	124	130	282	140	140	147
			1217	899	1113	991	1459	1380	1078	1021	1126	1792	3014	2134	538	2763	1599	529	1219	619	782	633	637	1264

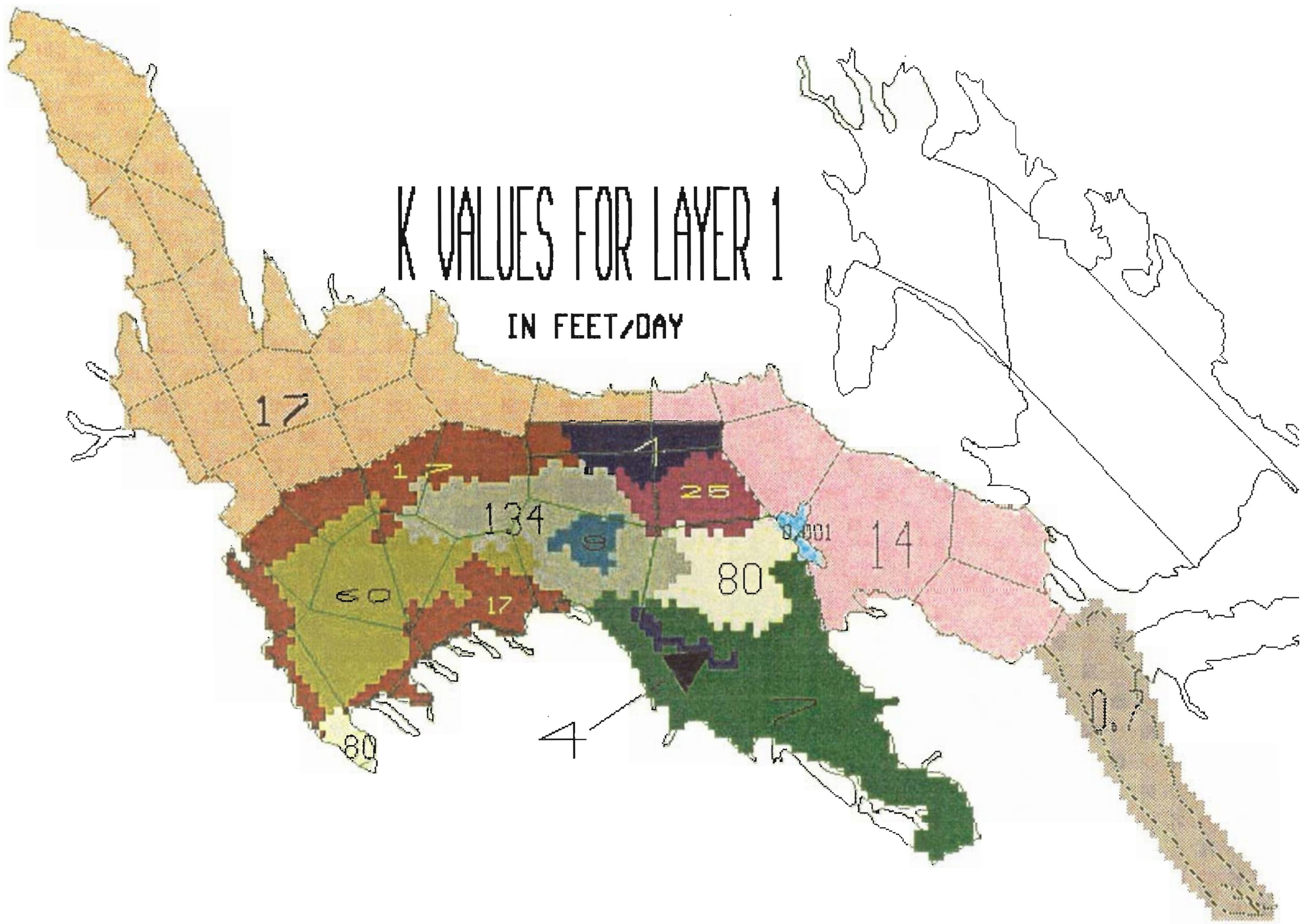

K VALUES FOR LAYER 1
IN FEET/DAY
17
17
1
25
134
8
0.001
14
80
60
17
80
4
7
0.7

FIGURE 3.15

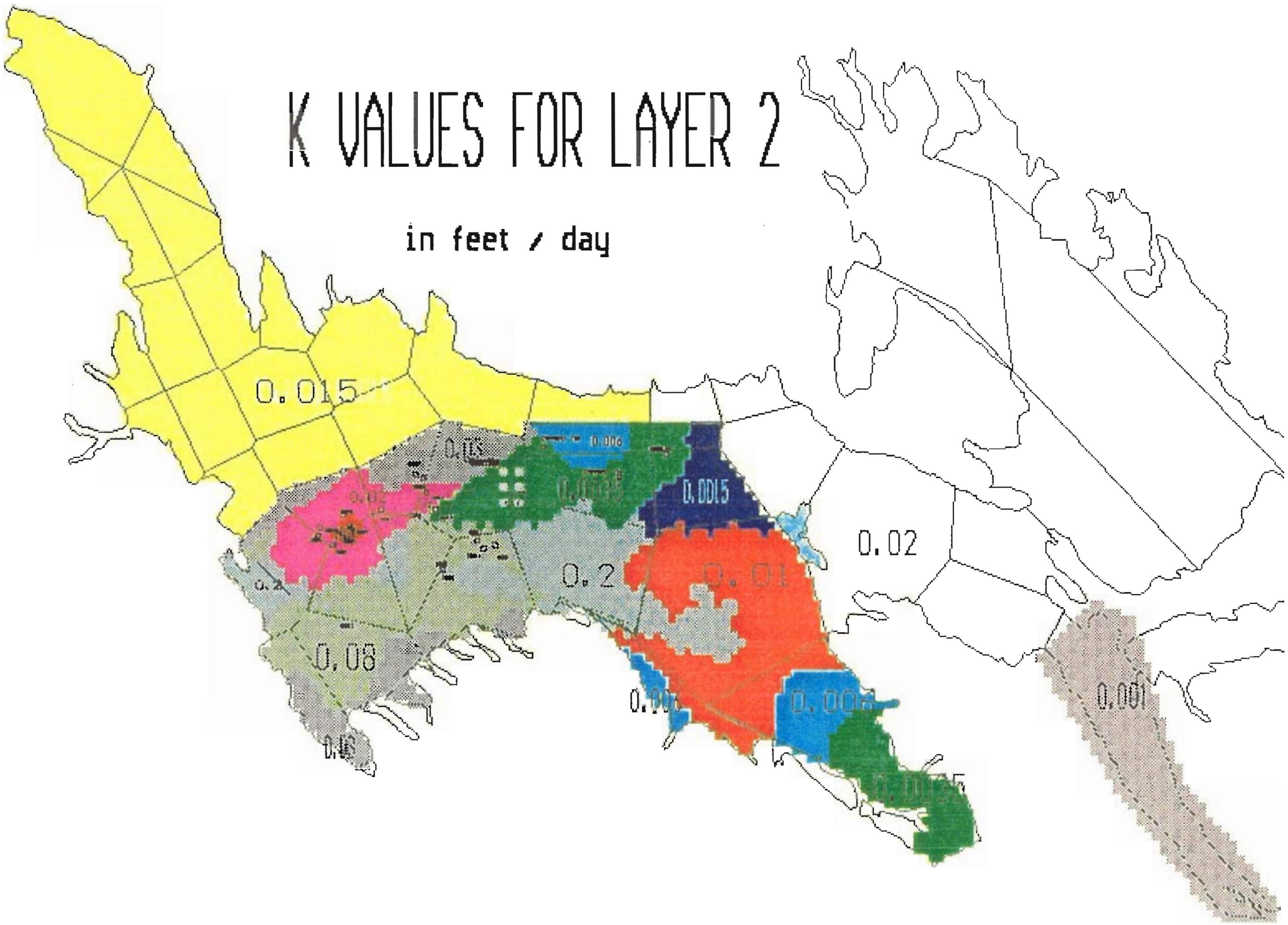

K VALUES FOR LAYER 2
in feet / day
0.015
0.02
0.2
0.01
0.08
0.0015
0.006
0.001

FIGURE 3.16

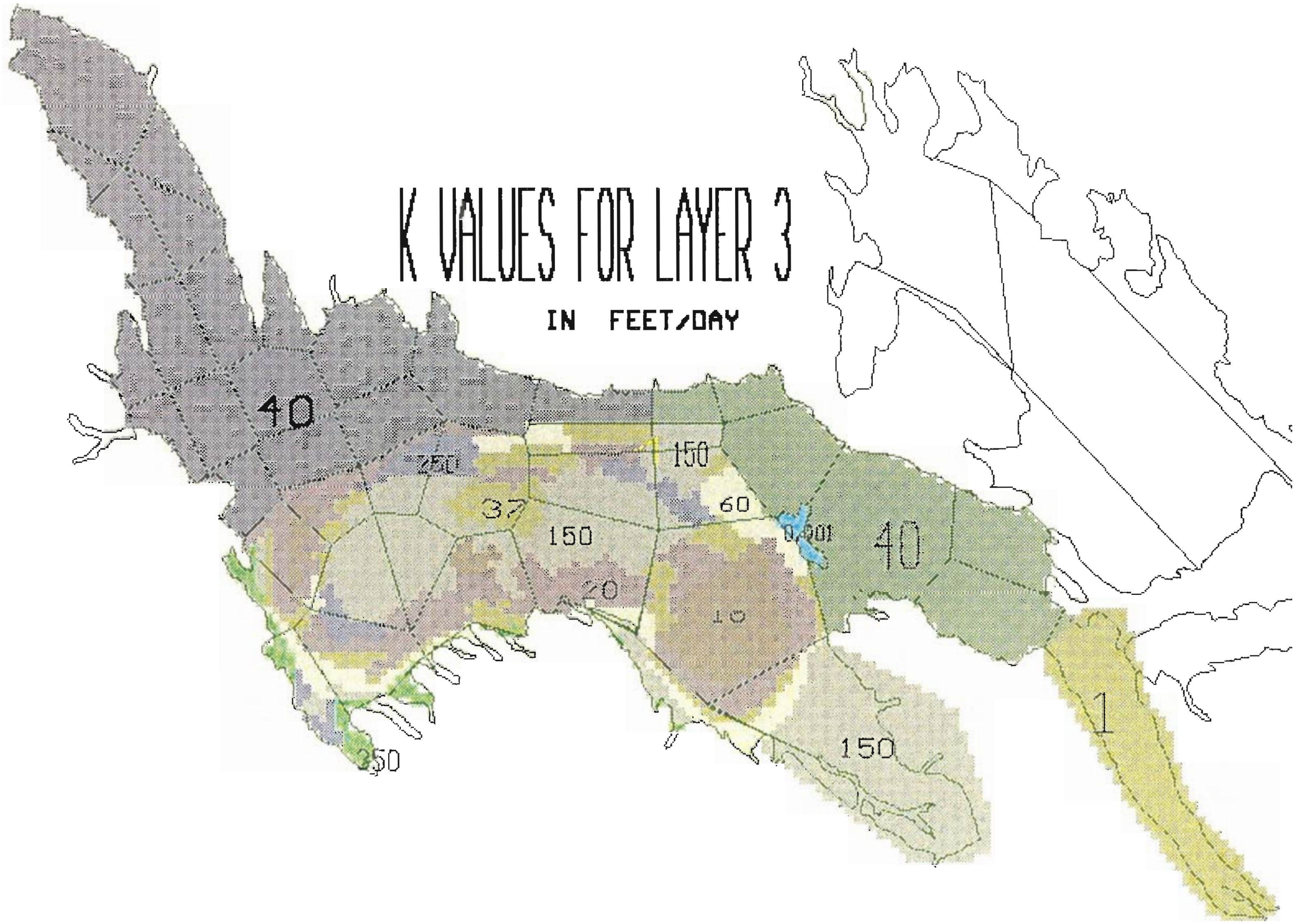

K VALUES FOR LAYER 3
IN FEET/DAY
40
250
37
150
20
150
60
0.001
40
1
150
350

FIGURE 3.17

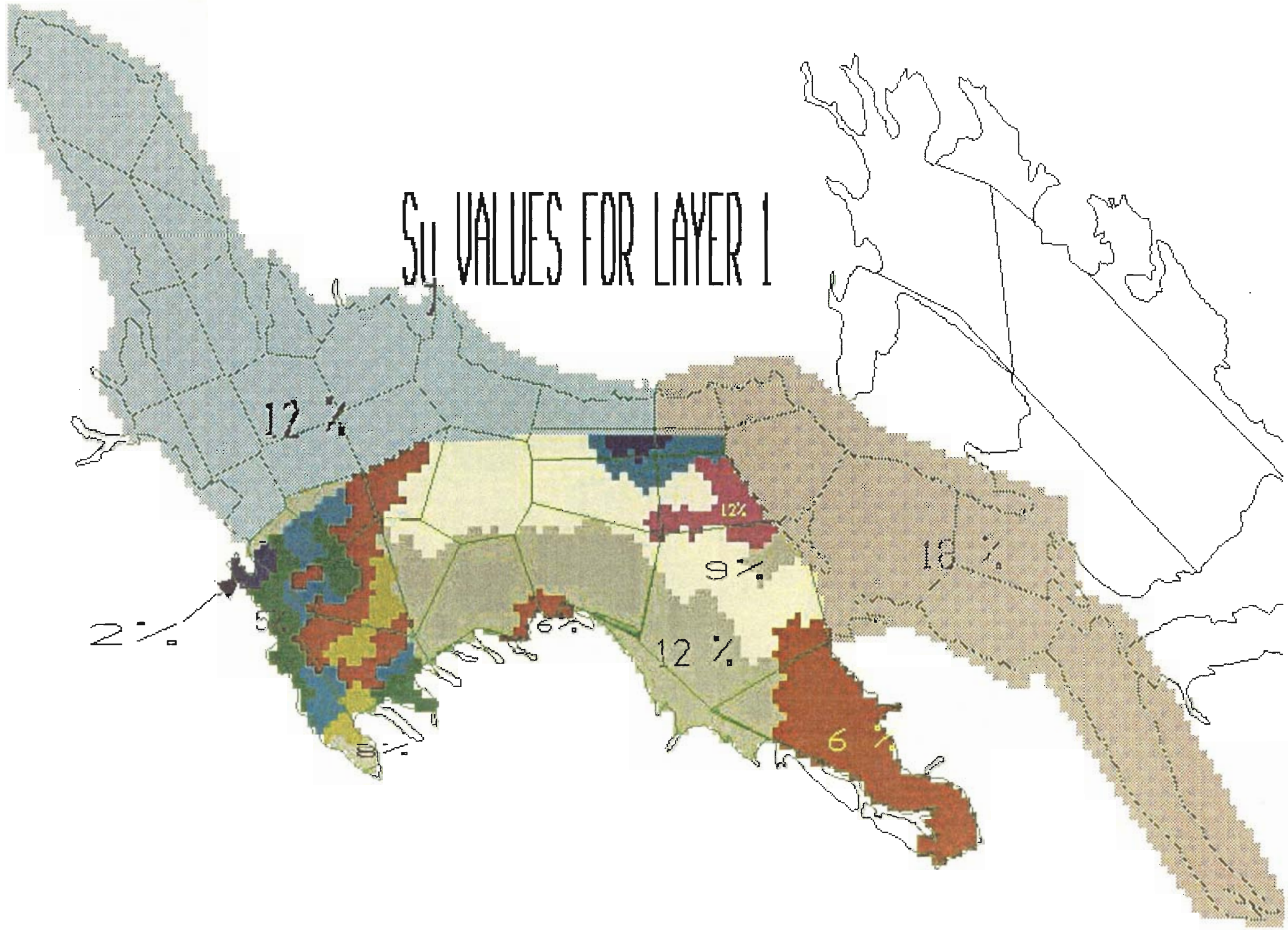


FIGURE 3.18

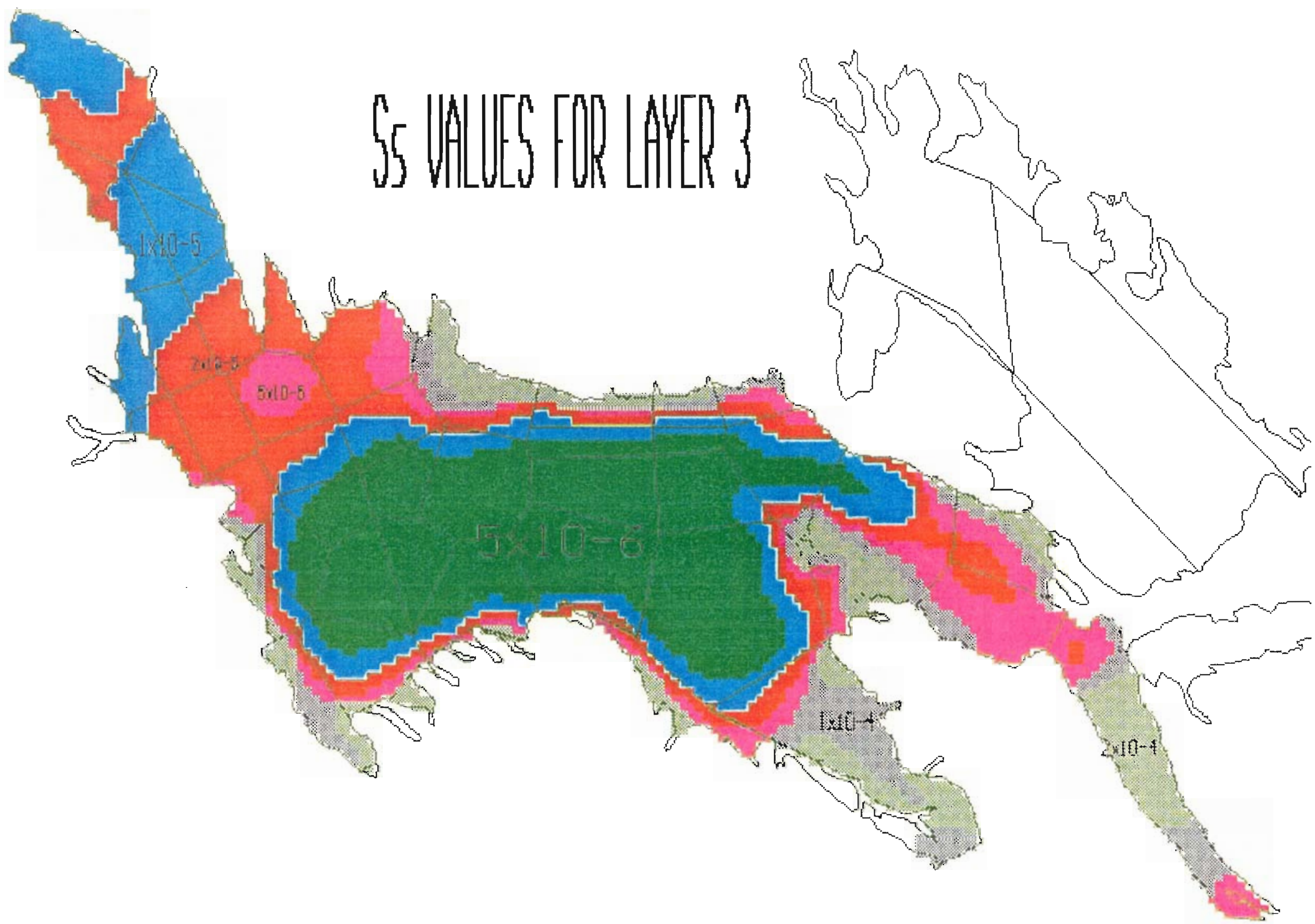
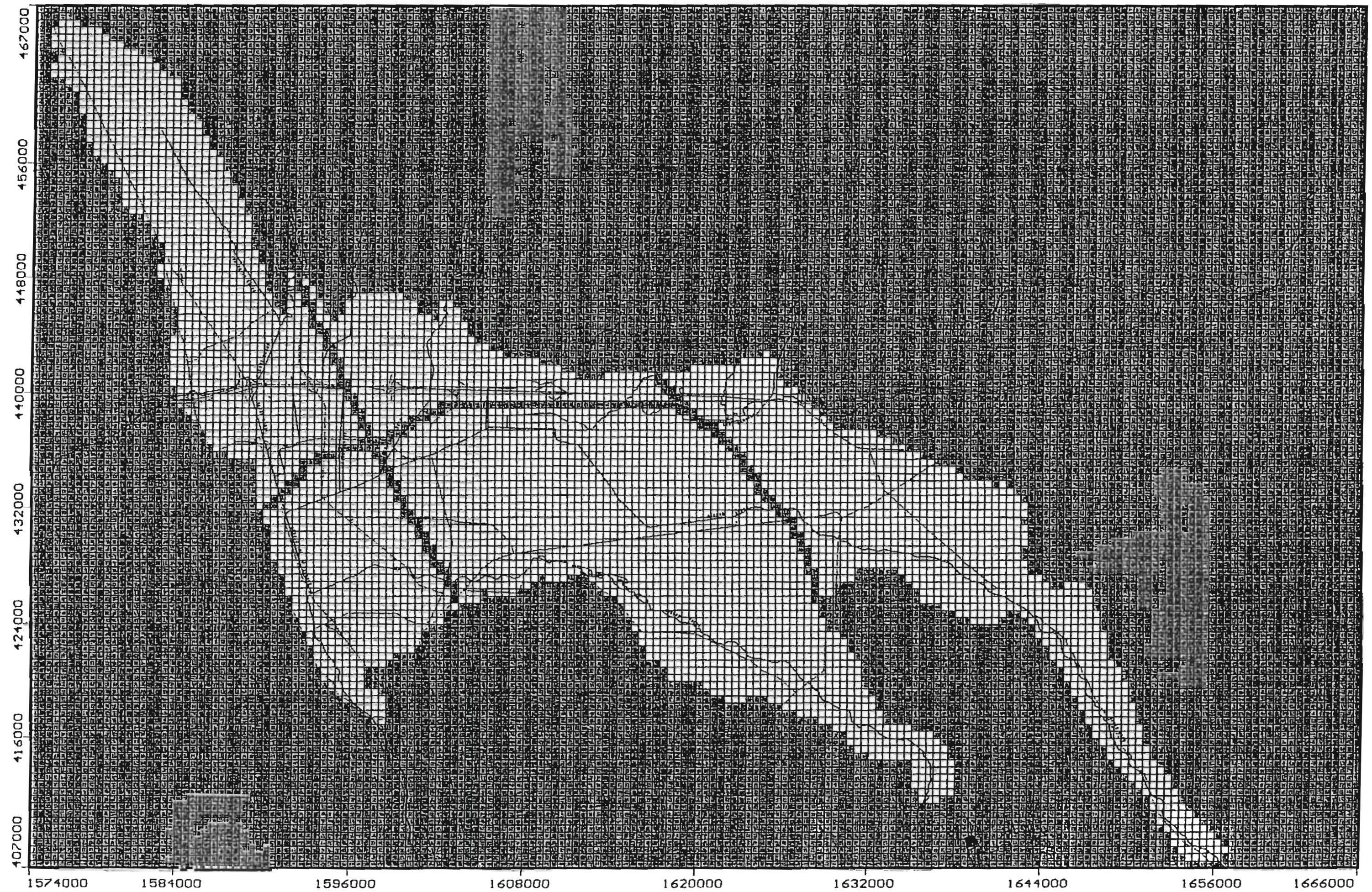


FIGURE 3.19

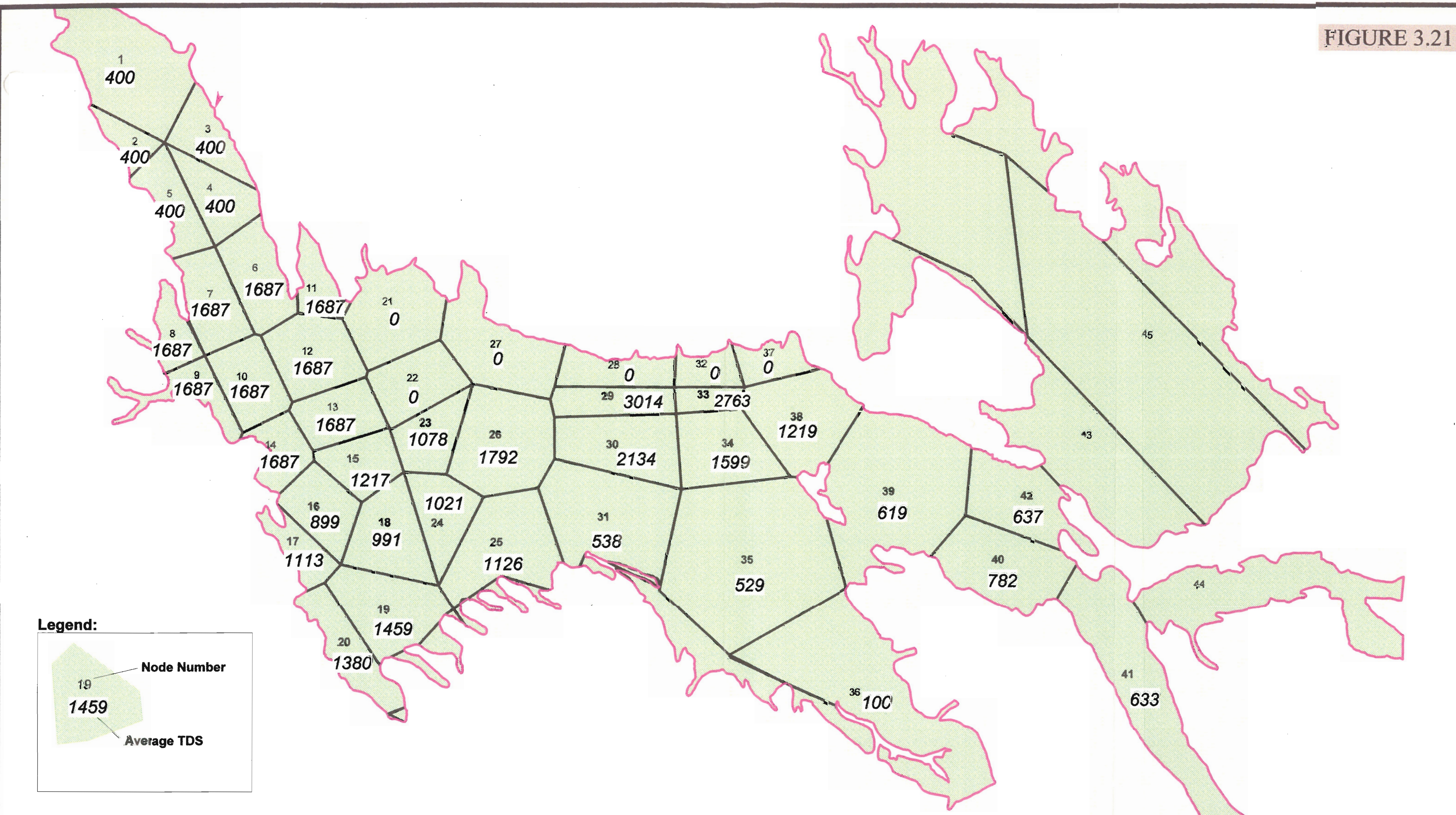


Zone 7 Water Agency – Pleasanton, CA
Project: LVGWB Model V 2.0.55
Description: Model Grid
Modeller: CH2M hILL & Zone 7
9 Jun 00

Visual MODFLOW v.2.61, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 184 NR: 120 NL: 4
Current Layer: 3

FIGURE 3.20

FIGURE 3.21



ZONE 7 WATER AGENCY **5997 Parkside Dr, Pleasanton, Ca.**	**Drawn By:** Todd Wendler **Designed By:** **Checked By:** **Approved by:**	WATER RESOURCES ENGINEERING **1974 - 95 AREAL RECHARGE (Rainfall and Applied Water) AVERAGE TDS**	**Scale:** 1"=6,000' **Date:** June 12, 2000 **File #:** H:\Geodata\avgtds2.wor

measured and simulated hydrographs at a given location help to evaluate the calibration in individual areas around the basin. Since most of the fluxes for the model were actual monitoring data, only model properties needed to be adjusted.

CH2M Hill performed 55 iterations by adjusting various model properties to calibrate the flow model. The availability of over 20 years of reliable hydrologic inventory and groundwater level data allowed for fairly precise calibration. The model properties were adjusted to match contour maps of measured and simulated heads, plus hydrographs of measured and simulated heads for nine selected wells.

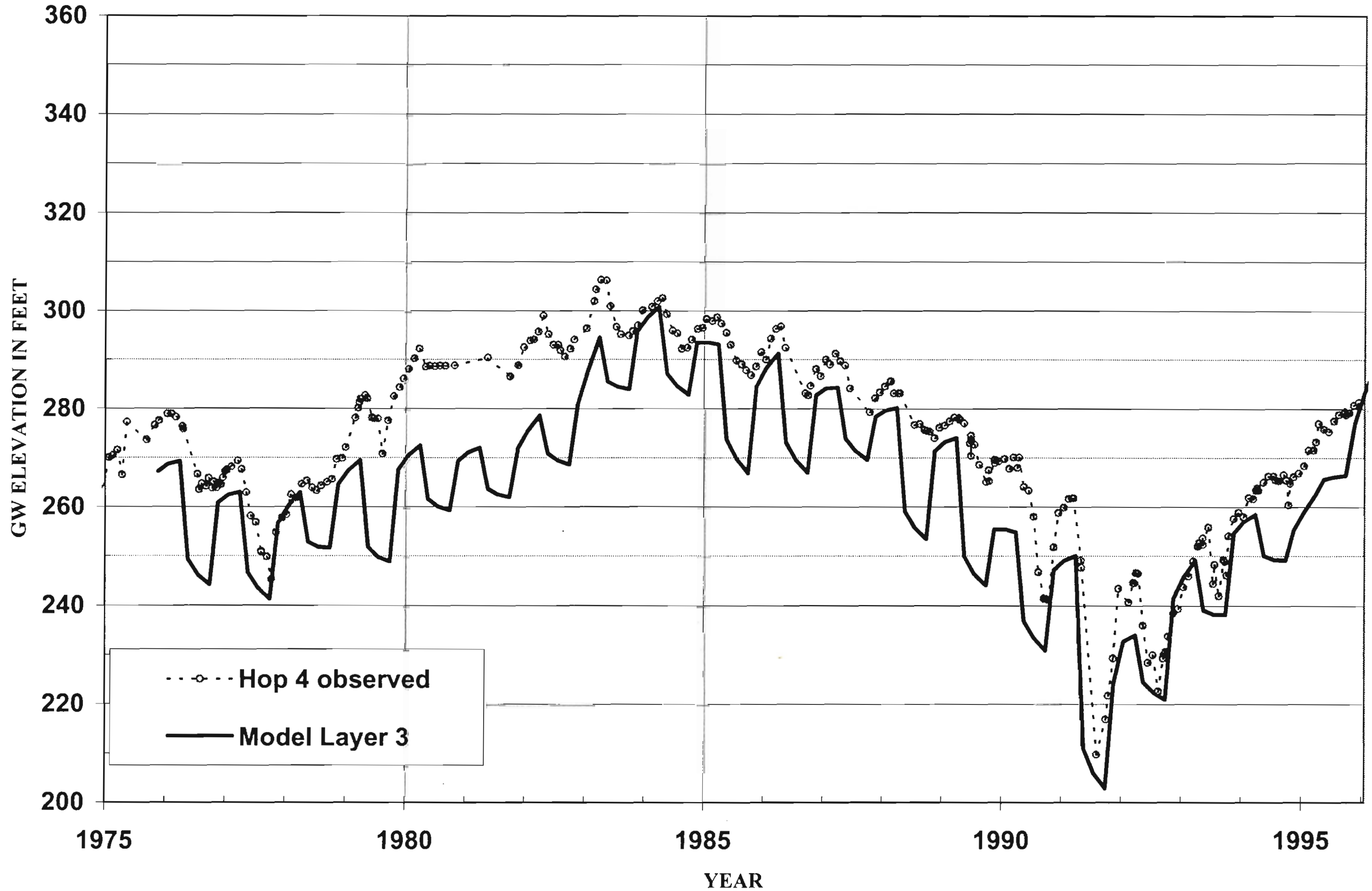
Calibration Hydrographs - As part of the calibrations, two wells from each sub-basin were selected for comparing observed and simulated outputs. Figure 3.22 presents the observed and simulated groundwater levels at the Hopyard well #4 in the Bernal sub-basin. The match between the observed and simulated groundwater levels was very good through most periods. The simulated and observed groundwater levels match very well from 1975 through 1979. During the 1980-83 period the simulated levels were about 20 feet lower than the observed groundwater levels. During 1984 the model groundwater levels recovered and by the end of 1984 and through the rest of the simulation period (1984-95) the simulated and observed groundwater levels matched well. Overall, the model acceptably matched both the long-term trends and semi-annual trends in observed groundwater levels.

Figure 3.23 presents the observed and simulated groundwater levels at the Mohr Avenue well (3s/1e 9p5) in the West Amador Sub-basin in model layer 1 (upper aquifer). The match between the observed and simulated groundwater levels is generally good. The simulated and observed groundwater levels match very well in 1978 (beginning of the observed data), show a similar trend between 1978-1995 and almost exactly match near the end of the simulation period in 1995. Overall, the model acceptably matched the long-term trend and end-of-period trend in observed groundwater levels.

Figure 3.24 presents the observed and simulated groundwater levels at the Mocho #2 well in the West Amador Sub-basin in model layer 3 (lower aquifer). The results at this location are very similar to the calibration simulation (above) for the Hop 4 location. The simulated and observed groundwater levels match very well from 1975 through the middle of 1980, while during the 1981-83 period the simulated levels were about 15 feet lower than the observed groundwater levels. During 1984 the model groundwater levels recovered and by the end of 1984 and through the rest of the simulation period (1984-95) the simulated and observed groundwater levels matched well. Overall, the model acceptably matched both the long-term trends and semi-annual trends in observed groundwater levels. The simulated groundwater levels almost exactly matched the observed levels near the end of the period.

Figure 3.25 presents the observed and simulated groundwater levels at the Hagemann key well in the East Amador Sub-basin in model layer 3 (lower

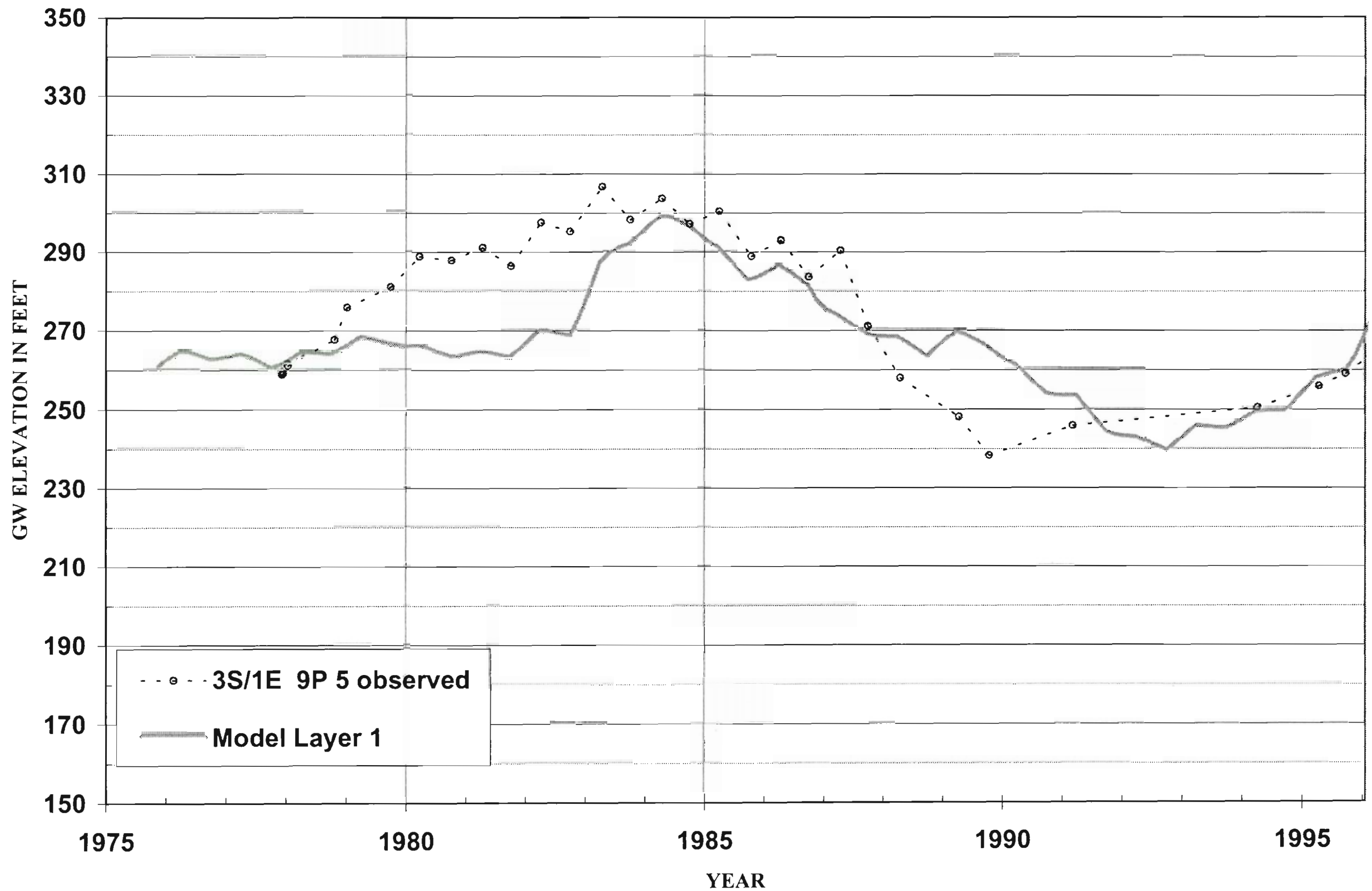
Hopyard-4 Well Hydrograph: Layer 3



6/16/00

FIGURE - 3.22

Well 3S/1E 9P 5 Hydrograph: Layer 1



6/16/00

FIGURE - 3.23

aquifer). The simulated and observed groundwater levels match very well from 1975 through the middle of 1987. During the 1987-90 and 1992-93 periods the simulated levels were about 30 feet higher than the observed groundwater levels, although at the end of 1991, the match is again very good. From the end of 1993 to the end of the simulation period the match remains very good. Although there are about six years out of 20 when the match is weaker than at the other wells shown, the overall calibration at this location appears acceptable.

These hydrographs indicate generally good agreement between simulated and observed groundwater levels. The hydrographs presented represent the Main Basin area of the model. For calibrations in the fringe basin area, see the CH2M Hill June 1998 technical memorandum that presents the complete calibration results (Reference A).

Groundwater Level Maps - Simulated groundwater level maps also show good agreement with observed groundwater level maps. Figure 3.26 is the groundwater level map prepared from the Zone 7 spring 1994 measured groundwater levels. The solid line contours represent groundwater levels in the upper aquifer and the dashed line contours (drawn only in applicable portions of the basin) represent the deep aquifer. Deep aquifer groundwater level data is limited to parts of the Main Basin.

Figure 3.27 presents the model simulated groundwater levels in the upper aquifer for spring 1994. The simulated and observed contour elevations and contour shapes match well. The elevation difference in the key high yielding basin areas is about +/- 20 feet and the contour pattern is very similar. Figure 3.28 presents the model simulated groundwater levels in the deep aquifer for spring 1994. Although there are only a few deep aquifer observed groundwater level contours drawn on Figure 3.26, the pattern and the elevations match very well with the simulated contours.

3.7.5 Solute Transport Calibration (Non-Reactive)

Solute transport calibration involves adjusting the solute transport model parameters and the recharge concentrations. Since most of the assigned recharge concentrations for the model were determined from actual monitored data, only model parameters were adjusted during calibration. In non-reactive (TDS) solute transport, advection is the primary mechanism responsible for TDS migration in aquifers. Advection involves transport by bulk movement where it is assumed that the dissolved solute travels in the same direction and with the same velocity as the groundwater itself. Since the model was already calibrated for flow, an acceptable level of non-reactive transport calibration was readily achievable. The calibration was checked by comparing the simulated and observed groundwater TDS hydrochemographs and groundwater TDS maps. Figures 3.29 through 3.32