Summary of Projected Water Demands

Projected water demands in five year increments for the proposed LLV, Southtown, and Rice McMurtry projects are combined in Table 15. In addition, existing baseline water demands for the City and other future anticipated demands from other cumulative developments in the City are included. Baseline City demand is based on 2003 monthly water production as reported by the City of Vacaville (production for the month of December 2003 was projected). Water demands for the year 2025 were based on the growth projected in the most recent land use database prepared by the City's Community Development Department and the land use plans provided for each developments' EIR. It was also assumed that all three developments would be built out by 2025. The five-year incremental demands were estimated using linear interpolation between 2003 and 2025.

As summarized in Table 15, total average annual demand for the three projects, the existing City, and other future developments will reach 31,331 ac-ft/yr in the Year 2025. This figure will be compared to available water supply in the subsequent report section.

TABLE 15
CITY OF VACAVILLE
SUMMARY OF NORMAL YEAR
ANNUAL WATER DEMAND (AC-FT/YR) IN FIVE YEAR INCREMENTS

Demand	2005	2010	2015	2020	2025
Existing City (2003)[a]	17,524	17,524	17,524	17,524	17,524
Lower Lagoon Valley	158	553	948	1,343	1,738[b]
Southtown	76	264	453	642	831[c]
Rice McMurtry	18	62	106	150	194[d]
Other Future Development in City	1,004	3,514	6,024	8,534	11,044
Total Demand	18,780	21,917	25,055	28,193	31,331

[a] Computed based on 2003 monthly water production (production for the month of December 2003 was projected) as reported by the City of Vacaville.
[b] See Table 12.
[c] See Table 13.
[d] See Table 14.

Summary of Demand Management Practices

Under drought conditions the City has an ability to reduce water demand. The primary mechanism for demand management is through public awareness and enforcement of water conservation ordinances. Specifically, the City's Urban Water Shortage Contingency Plan includes Ordinance No. 1431 *An Urgency Ordinance of the City of Vacaville Establishing Water Conservation Requirements and Water Rate Structures to Address Normal, Drought, and*

Emergency Conditions [10]. As drought or emergency conditions are declared by the City Council, additional rate tiers are added to the existing rate structure to promote conservation. A target water use amount is determined for all residential customers and based on past usage patterns for commercial, industrial, and landscape customers. Customers using water above their target amount pay increasingly higher rates for that water.

The City is also committed to implementing water conservation programs. To achieve short term and long term conservation the City has implemented, is planning to implement, or is studying the following Demand Management Measures (DMMs), as described in the *2000 Urban Water Management Plan Update* [6]:

DMM 1 - Water survey programs for single-family residential and multi-family residential customers
DMM 2 - Residential plumbing retrofit
DMM 3 - System water audits, leak detection and repair
DMM 4 - Metering with commodity rates for all new connections and retrofit of existing connections
DMM 5 - Large landscape conservation programs and incentives
DMM 6 - High-efficiency washing machine rebate programs
DMM 7 - Public information programs
DMM 8 - School education programs
DMM 9 - Conservation programs for commercial, industrial, and institutional accounts
DMM 10 - Wholesale agency assistance programs
DMM 11 - Conservation pricing
DMM 12 - Conservation coordinator
DMM 13 - Water waste prohibition
DMM 14 - Residential ultra low flow toilet (ULFT) replacement

In past drought years demand management practices have been effective in reducing water demand. As shown in Table 16, during the 1991 - 1993 drought the per capita demand was reduced from 181 gpd/person to 139 gpd/person or 23 percent. Based on historical experience, the City has the ability to reduce demand by 10 percent during a single dry year and by 20 percent during a multiple dry year. These demand reductions are reflected in Tables 17 and 18.

TABLE 16
CITY OF VACAVILLE
CHANGE IN WATER PRODUCTION (DEMAND) DURING DROUGHT YEARS (1990 - 1995)

Year	Population[a]	Water Production		Per Capita Demand	Demand
		ac-ft/yr	mgd	gpd/person	Change[b]
1990	71,476	14,511	13.0	181	0%
1991	75,103	11,672	10.4	139	-23%
1992	77,504	12,036	10.7	139	-23%
1993	79,956	12,764	11.4	142	-22%
1994	81,592	14,189	12.7	155	-14%
1995	83,040	14,695	13.1	158	-13%

[a] State of California, Department of Finance, Demographic Research Unit [11]
[b] Reduction in per capita demand as compared to 1990 demand.

TABLE 17
CITY OF VACAVILLE
SUMMARY OF SINGLE DRY YEAR[a]
ANNUAL WATER DEMAND (AC-FT/YR)
IN FIVE YEAR INCREMENTS

Demand	2005	2010	2015	2020	2025
Existing City (baseline)	15,772	15,772	15,772	15,772	15,772
Lower Lagoon Valley	142	498	853	1,209	1,564
Southtown	68	238	408	578	748
Rice McMurtry	16	56	95	135	175
Other Future Development in City	904	3,163	5,422	7,681	9,940
Total Demand	16,902	19,726	22,549	25,374	28,197

[a] Based on historical experience, the City has the ability to reduce demand by 10 percent during a single dry year.

TABLE 18
CITY OF VACAVILLE
SUMMARY OF MULTIPLE DRY YEAR[a]
ANNUAL WATER DEMAND (AC-FT/YR)
IN FIVE YEAR INCREMENTS

Demand	2005	2010	2015	2020	2025
Existing City (baseline)	14,019	14,019	14,019	14,019	14,019
Lower Lagoon Valley	126	442	758	1,074	1,390
Southtown	61	211	362	514	665
Rice McMurtry	14	50	85	120	155
Other Future Development in City	803	2,811	4,819	6,827	8,835
Total Demand	15,024	17,533	20,043	22,554	25,065

[a] Based on historical experience, the City has the ability to reduce demand by 20 percent during a multiple dry year.

ANALYSIS OF WATER SUPPLY RELIABILITY

In this section, the City's groundwater and surface water supplies previously identified are analyzed. The sources are identified for their availability during normal, single, and multiple dry years as determined by the Department of Water Resources' Sacramento Valley Water Hydrologic Classifications. The three separate hydrologic conditions considered are described as follows:

Normal year: This is a year when average rainfall has been received. During a normal year, the water availability from some sources may be less than the allocated amount.

Single dry year: This is a solitary dry or critical dry year and may be the first year of a multiple year drought.

Multiple dry years: This is a series of four consecutive dry and/or critical dry years. This is consistent with the *City of Vacaville 2000 Urban Water Management Plan Update.*

Groundwater

An analytical groundwater flow model was used to provide a preliminary assessment of water level impacts from future increases in groundwater pumpage by the City to meet future water demands. The modeling effort included simulations of eight future pumping scenarios in which pumpage would be increased and/or redistributed within the study area. The simulation results provided a basis for better defining the annual pumpage amount that could be used on average in conjunction with surface water. The recommended pumpage amounts are summarized in

Table 19. Details regarding the model simulations and suggested pumping practices are found in Appendix A.

TABLE 19
CITY OF VACAVILLE
PROJECTED GROUNDWATER PUMPING (AC-FT/YR)
DURING NORMAL, SINGLE DRY, AND MULTIPLE DRY YEARS [3]

Year	Normal Year	Single Dry Year	Multiple Dry Year
2005	7,000	8,400	7,700
2010	7,500	9,000	9,000
2015	7,500	9,000	9,000
2020	8,000	9,600	9,600
2025	8,000	9,600	9,600

Surface Water

The following contains a description of the availability of the City's surface water sources during normal, single and multiple dry years.

Solano Project (Vacaville Supply, SID Agreement)

The Solano Project has an annual water supply of 207,350 ac-ft/yr. As shown in Table 10, Vacaville is entitled to 15,800 ac-ft/yr of this annual yield. The Solano Project differs from other reservoir projects in California due to the reservoir storage size relative to the watershed yield. This means it may take a relatively long time to deplete the reservoir, but, in turn, it takes a relatively long time to fill the reservoir. Due to the size of the reservoir as a function of its yield, the long-term reliability for the Solano project is excellent.

Because of the high degree of reliability and historical records, the City anticipates receiving 100 percent of the entitlement (and SID agreement water) during normal, single dry, and multiple dry years. Solano Project availability percentages for the City are derived using Sacramento Valley Water Year Hydrologic Classifications and historical records and are included in Appendix C, *Solano Project Water Supply Availability.*

State Water Project (North Bay Aqueduct)

Supply from the NBA originates from the State Water Project and has a similar level of priority as all the other 28 contractors to the project. As a result, this source is subject to significant cutbacks during dry years. Specifically, the City anticipates 64 percent availability during a single dry year and 47 percent availability during multiple dry years for this source. State Water Project availability percentages for the City are derived from CALSIM II Model Studies for State

Water Project Delivery Capability and are included in Appendix D, *State Water Project Water Supply Availability.*

Settlement Water (DWR Agreement)

In lieu of an Area of Origin Water Rights filing by the City, DWR and the City entered into a settlement agreement for water, with DWR. Appendix E is a copy of an analysis performed by CH2MHill which addresses the expected reliability of the water to be provided to the City in accordance with the settlement agreement. As a result, the City anticipates receiving 100 percent of the allocation during normal, single dry, and multiple dry years.

Recycled Water

Preliminary planning estimates indicate that recycled water will be available for delivery in 2015. Recycled water is a 100 percent reliable source of non-potable water and is completely independent of hydrologic conditions. Therefore, the City anticipates that this source will be 100 percent available during normal, single dry, and multiple dry years.

Summary of Water Supply Availability

This section contains a determination of the water supply availability. As previously described, the amount of water entitled to the City is increasing until the maximum entitlement is reached by year 2020. Furthermore, each source has a different availability under normal, single dry, and multiple dry years. Information on supply entitlement and availability is shown in Tables 20 through 24 for normal, single dry, and multiple dry years in five-year increments between 2005 and 2025. The water supply availability is summarized in Tables 25, 26, and 27.

TABLE 20
CITY OF VACAVILLE
WATER SUPPLY IN YEAR 2005

		Normal Year		Single Dry Year		Multiple Dry Year	
Sources of Supply	Entitlement	% Available	ac-ft/yr	% Available	ac-ft/yr	% Available	ac-ft/yr
Solano Project							
Vacaville Entitlement	5,750	100	5,750	100	5,750	100	5,750
SID Agreement	3,000	100	3,000	100	3,000	100	3,000
State Water Project							
Vacaville Table A	6,100	89	5,429	64	3,904	47	2,867
KCWA Agreement	2,878	89	2,561	64	1,842	47	1,353
Settlement Water	9,320	100	9,320	100	9,320	100	9,320
Groundwater[a]	7,000	100	7,000	120	8,400	110	7,700
Total	34,048		33,060		32,216		29,990

[a] Recommended groundwater pumping

TABLE 21
CITY OF VACAVILLE
WATER SUPPLY IN YEAR 2010

		Normal Year		Single Dry Year		Multiple Dry Year	
Sources of Supply	Entitlement	% Available	ac-ft/yr	% Available	ac-ft/yr	% Available	ac-ft/yr
Solano Project							
Vacaville Entitlement	5,750	100	5,750	100	5,750	100	5,750
SID Agreement	8,000	100	8,000	100	8,000	100	8,000
State Water Project							
Vacaville Table A	6,100	89	5,429	64	3,904	47	2,867
KCWA Agreement	2,878	89	2,561	64	1,842	47	1,353
Settlement Water	9,320	100	9,320	100	9,320	100	9,320
Groundwater[a]	7,500	100	7,500	120	9,000	120	9,000
Total	39,548		38,560		37,816		36,290

[a] Recommended groundwater pumping

TABLE 22
CITY OF VACAVILLE
WATER SUPPLY IN YEAR 2015

		Normal Year		Single Dry Year		Multiple Dry Year	
Sources of Supply	Entitlement	% Available	ac-ft/yr	% Available	ac-ft/yr	% Available	ac-ft/yr
Solano Project							
Vacaville Entitlement	5,750	100	5,750	100	5,750	100	5,750
SID Agreement	10,000	100	10,000	100	10,000	100	10,000
State Water Project							
Vacaville Table A	6,100	89	5,429	64	3,904	47	2,867
KCWA Agreement	2,878	89	2,561	64	1,842	47	1,353
Settlement Water	9,320	100	9,320	100	9,320	100	9,320
Groundwater[a]	7,500	100	7,500	120	9,000	120	9,000
Recycled Water	880	100	880	100	880	100	880
Total	42,428		41,440		40,696		39,170

[a] Recommended groundwater pumping

TABLE 23
CITY OF VACAVILLE
WATER SUPPLY IN YEAR 2020

		Normal Year		Single Dry Year		Multiple Dry Year	
Sources of Supply	Entitlement	% Available	ac-ft/yr	% Available	ac-ft/yr	% Available	ac-ft/yr
Solano Project							
Vacaville Entitlement	5,750	100	5,750	100	5,750	100	5,750
SID Agreement	10,050	100	10,050	100	10,050	100	10,050
State Water Project							
Vacaville Table A	6,100	89	5,429	64	3,904	47	2,867
KCWA Agreement	2,878	89	2,561	64	1,842	47	1,353
Settlement Water	9,320	100	9,320	100	9,320	100	9,320
Groundwater[a]	8,000	100	8,000	120	9,600	120	9,600
Recycled Water	880	100	880	100	880	100	880
Total	42,976		41,990		41,346		39,820

[a] Recommended groundwater pumping

TABLE 24
CITY OF VACAVILLE
WATER SUPPLY IN YEAR 2025

		Normal Year		Single Dry Year		Multiple Dry Year	
Sources of Supply	Entitlement	% Available	ac-ft/yr	% Available	ac-ft/yr	% Available	ac-ft/yr
Solano Project							
Vacaville Entitlement	5,750	100	5,750	100	5,750	100	5,750
SID Agreement	10,050	100	10,050	100	10,050	100	10,050
State Water Project							
Vacaville Table A	6,100	89	5,429	64	3,904	47	2,867
KCWA Agreement	2,878	89	2,561	64	1,842	47	1,353
Settlement Water	9,320	100	9,320	100	9,320	100	9,320
Groundwater[a]	8,000	100	8,000	120	9,600	120	9,600
Recycled Water	880	100	880	100	880	100	880
Total	42,978		41,990		41,346		39,820

[a] Recommended groundwater pumping

TABLE 25
CITY OF VACAVILLE
WATER SUPPLY DURING
NORMAL YEAR (AC-FT/YR)

	Year				
Sources of Supply	2005	2010	2015	2020	2025
Solano Project					
Vacaville Entitlement	5,750	5,750	5,750	5,750	5,750
SID Agreement	3,000	8,000	10,000	10,050	10,050
State Water Project					
Vacaville Table A	5,429	5,429	5,429	5,429	5,429
KCWA Agreement	2,561	2,561	2,561	2,561	2,561
Settlement Water	9,320	9,320	9,320	9,320	9,320
Groundwater	7,000	7,500	7,500	8,000	8,000
Recycled Water	--	--	880	880	880
Total	33,060	38,560	41,440	41,990	41,990

TABLE 26
CITY OF VACAVILLE
WATER SUPPLY DURING
SINGLE DRY YEAR (AC-FT/YR)

	Year				
Sources of Supply	2005	2010	2015	2020	2025
Solano Project					
Vacaville Entitlement	5,750	5,750	5,750	5,750	5,750
SID Agreement	3,000	8,000	10,000	10,050	10,050
State Water Project					
Vacaville Table A	3,904	3,904	3,904	3,904	3,904
KCWA Agreement	1,842	1,842	1,842	1,842	1,842
Settlement Water	9,320	9,320	9,320	9,320	9,320
Groundwater	8,400	9,000	9,000	9,600	9,600
Recycled Water	--	--	880	880	880
Total	32,216	37,816	40,696	41,346	41,346

TABLE 27
CITY OF VACAVILLE
WATER SUPPLY DURING
MULTIPLE DRY YEAR (AC-FT/YR)

	Year				
Sources of Supply	2005	2010	2015	2020	2025
Solano Project					
Vacaville Entitlement	5,750	5,750	5,750	5,750	5,750
SID Agreement	3,000	8,000	10,000	10,050	10,050
State Water Project					
Vacaville Table A	2,867	2,867	2,867	2,867	2,867
KCWA Agreement	1,353	1,353	1,353	1,353	1,353
Settlement Water	9,320	9,320	9,320	9,320	9,320
Groundwater	7,700	9,000	9,000	9,600	9,600
Recycled Water	--	--	880	880	880
Total	29,990	36,290	39,170	39,820	39,820

COMPARISON AND DETERMINATION OF SUFFICIENT SUPPLY

This section compares projected water demand to available water supply during normal, single, and multiple dry years. As shown in Table 28, Vacaville has sufficient water to meet its customers' needs through 2025, including the proposed development in LLV, Southtown, and Rice McMurtry. This is based on continued application of the water conservation ordinance and on-going conjunctive use of water supply sources.

Groundwater and surface water supplies are projected to meet or exceed projected water demands even during extended drought conditions. This was demonstrated during a previous drought that lasted for seven years. In view of this demonstrated reliability of the City's conjunctive water supply strategy, future water supply will be adequate to offset future water demands during normal, single, and multiple dry years.

TABLE 28
CITY OF VACAVILLE
SUMMARY OF PROJECTED WATER DEMAND VERSUS AVAILABLE SUPPLY DURING NORMAL, SINGLE DRY, AND MULTIPLE DRY YEARS (AC-FT/YR)

	Normal Year		Single Dry Year		Multiple Dry Year	
Year	Projected Demand	Available Supply	Projected Demand	Available Supply	Projected Demand	Available Supply
2005	18,780	33,060	16,902	32,216	15,024	29,990
2010	21,917	38,560	19,726	37,816	17,533	36,290
2015	25,055	41,440	22,549	40,696	20,043	39,170
2020	28,193	41,990	25,374	41,346	22,554	39,820
2025	31,331	41,990	28,197	41,346	25,065	39,820

REFERENCES

[1] City of Vacaville, *2025 A Vision for Our Community: Community Profile and Trends Report*, May 2001.

[2] City of Vacaville, *Connection and Development Fees*, January 2003.

[3] Luhdorff and Scalmanini, Consulting Engineers, *SB 610 Water Supply Assessment Ground-Water Source Sufficiency, Administrative Draft 2,* July 2003.

[4] Luhdorff and Scalmanini, Consulting Engineers, *Conceptualization of the Aquifer System for the City of Vacaville*, March 2003.

[5] Solano County Water Agency, *SCWA Briefing Book*, January 2002.

[6] Nolte Associates, Inc., *2000 Urban Water Management Plan Update*, December 2001.

[7] State of California Department of Water Resources, *The State Water Project Delivery Reliability Report (Draft)*, August 2002.

[8] Carollo Engineers, *City of Vacaville Recycled Water Master Plan (Draft),* July 2003.

[9] West Yost & Associates, *Proposed Water Demand/Wastewater Generation Factors*, April 1994.

[10] City of Vacaville Ordinance 1431, *An Urgency Ordinance of the City of Vacaville Establishing Water Conservation Requirements and Water Rate Structures to Address Normal, Drought, and Emergency Conditions,* adopted March 12, 1991.

[11] Population data from State of California Department of Finance, Demographic Research Unit.

APPENDIX A

SB 610 WATER SUPPLY ASSESSMENT

GROUNDWATER SOURCE SUFFICIENCY

City of Vacaville

SB 610 Water Supply Assessment
Groundwater Source Sufficiency

Prepared for

City of Vacaville

Prepared by

Luhdorff and Scalmanini
Consulting Engineers

September 2003

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Executive Summary

This SB 610 Water Supply Assessment for Groundwater Source Sufficiency (Groundwater Summary Assessment) provides an overview of a comprehensive study being conducted on behalf of the City of Vacaville. The study ***"Evaluation of Hydrogeologic Conditions and Groundwater Supplies for SB 221/610 Requirements"*** (SB 221/610 Groundwater Report, LSCE 2003 in progress) responds to the requirements contained in Government Code Section 66473.7 and Water Code (WC) Sections 10631 and 10910 that relate to the determination of the sufficiency of groundwater as a source of supply. This Groundwater Summary Assessment summarizes the analyses conducted to address the SB 610 requirements related to groundwater for the three new development projects proposed within the City of Vacaville Urban Water Management planning area.

Conjunctive Water Use and Management

The City conjunctively manages its groundwater and surface-water resources to most effectively use those resources during different water year types. These water year types are referred to in the above codes as "normal, single-dry and multiple-dry" year periods. Continued use of conjunctive water management is expected to enable the City to meet its future water demands to a 20-year horizon and beyond in a manner that mitigates the impact of additional groundwater development and increased use of groundwater during dry periods. The City's conjunctive water management approach includes:

"Base Year" Conditions as a Conjunctive Management Tool: Historical groundwater levels for 1992-2003, that reflect the recovery of the aquifer system to the estimated annual sustainable pumpage, are being used as a conjunctive water management tool. These levels are referred to as "base year" groundwater levels. Additionally, spring groundwater levels in 2002-2003 were similar to the "base year", and summer levels measured in 2002 provide the best estimate of "historical low levels" during the last 20 years. The 1992-1993 and 2002-2003 groundwater levels and response of the aquifer system are implicitly linked to "normal" water year conditions, or a year during which a sustained pumpage amount (depending on the pumpage distribution) would result in comparable groundwater levels.

Conjunctive Use of Water Resources: During dry year periods, short-term pumpage by the City for a single year or a series of dry years, may be increased above "normal" year pumpage amounts or the amount of pumpage that is recommended on a sustained basis. Increased pumpage to meet dry year demands would be expected to cause temporary groundwater level declines. Following a dry year period and increased pumpage, the City's conjunctive water management approach will be employed to restore groundwater levels to base year conditions through a corresponding reduction in pumpage and increased utilization of surface-water supplies.

Groundwater Development: Additional groundwater will be developed to meet future water demands. This will require distribution of the increased pumpage away from the principal wellfield to prevent excessive water level drawdown and to ensure that persistent water level declines do not occur. As the City adds new wells northeast of the existing Elmira Road wellfield, pumpage distribution and an expanded monitoring program are major factors in refining the estimates of annually sustainable pumpage, and pumpage for single and multiple-dry year periods.

Study Results -- Groundwater Supplies to 2025

Based on the results of this study, the total "normal" water year sustained pumpage amount for the City is projected to be 7,000 acre-feet in 2005 and increase to 8,000 acre-feet by 2025. Single-dry year pumpage is projected to range from 8,400 acre-feet in 2005 to 9,600 acre-feet in 2025. Multiple-dry year pumpage levels are projected to range from 9,000 acre-feet in 2005 to 9,600 acre-feet in 2025.

Ongoing Monitoring

The long-term effectiveness of City pumpage redistribution to the northeast and capacity for replenishment to occur in the aquifer from which the majority of City pumpage occurs are not well understood, due in part to the limited available water level data outside of the City's present wellfield. Additional water level data and geologic characterization are needed to better understand recharge mechanisms in the northeastern area. A monitoring program is described in the SB 221/610 Groundwater Report that involves ongoing collection and evaluation of water level data in the study area. Continued groundwater level monitoring is important for ensuring that when pumpage is increased for multiple-dry year periods that groundwater levels, particularly in the City's present well field, do not drop below historical low levels during the summer. Similarly, continued monitoring will help to ensure that groundwater levels recover to spring base year levels after the dry period is over. The amount of pumpage considered to be sustainable may change in the future as a result of the ongoing evaluation of monitoring data, managed extraction from the basal zone, and continued application of conjunctive water management.

I. Introduction

This SB 610 Water Supply Assessment for Groundwater Source Sufficiency (Groundwater Summary Assessment) provides an overview of a study being conducted on behalf of the City of Vacaville. This study comprehensively evaluates subsurface hydrogeologic conditions and describes the City's approach to managing groundwater resources. The study describes present and planned utilization of groundwater resources for a 20-year planning horizon, including results of a groundwater flow model and an initial estimate of the sustainable pumpage for the principal aquifer in the study area. The results of the study, including recommendations for future monitoring and assessment of the aquifer system, are presented in the full report ***"Evaluation of Hydrogeologic Conditions and Groundwater Supplies for SB 221/610 Requirements"*** (SB 221/610 Groundwater Report; LSCE 2003 in progress) and are part of the City's compliance with the requirements of portions of Senate Bill (SB) 221 and SB 610, as enacted in 2001 and contained in Government Code Section 66473.7 and Water Code (WC) Sections 10631 and 10910, that relate to groundwater as a source of supply (DWR, 2002).

SB 610 Requirement to Determine Groundwater Supply Sufficiency

SB 610 (particularly WC Section 10910(f)(5)) requires the water supplier to make a determination "of the sufficiency of the groundwater from the basin or basins from which the proposed project will be supplied to meet the projected water demand associated with the proposed project." A "sufficient water supply" is defined in Government Code 66473.7 as "the total water supplies available during the normal, single-dry, and multiple-dry years within a 20-year projection that will meet the projected demand associated with the proposed subdivisions, in addition to existing and planned future uses, including, but not limited to, agricultural and industrial uses." SB 610 also requires updating of the Urban Water Management Plan if groundwater is part of the City's water supply.

Although three water year terms (normal, single-dry and multiple-dry years) are identified in Government Code 66473.7, definitions for these water years are not included in the Code. The following definitions (Nolte and Associates, 2003) are used for purposes of this Groundwater Summary Assessment:

> ***Normal year***: This is a year when average rainfall has been received. During a normal year, the water availability from some sources (surface water) may be less than the entitlement amount.
>
> ***Single Dry Year***: This is a year when less than average rainfall has been received and may be the first year of a multiple year drought period.
>
> ***Multiple Dry Years***: This is a series of years when less than average rainfall has been received.

Scope of SB 221/610 Groundwater Study

The SB 221/610 Groundwater Report responds to the requirements contained in Government Code Section 66473.7 and Water Code (WC) Sections 10631 and 10910 that relate to the determination of the sufficiency of groundwater as a source of supply. One requirement (WC Section 10631) is that the groundwater management plan for the City be included in the Urban Water Management Plan. The City adopted an AB 3030 Plan in February 1995 (West Yost, 1995) and subsequently prepared plan updates (West Yost, 2001 and LSCE, 2003). The SB 221/610 Groundwater Report addresses other SB 610-related Code requirements through an in-depth evaluation of hydrogeologic conditions, including the description of the groundwater basins from which the City of Vacaville pumps groundwater and presentation of new information on the subsurface geology. This information includes analysis of the City's historical use of groundwater and the groundwater levels observed in response to City and other pumpage in the study area as the basis for addressing the SB 221/610 requirements. Most importantly, the SB 221/610 Groundwater Report provides the basis for estimating the potentially sustainable level of annual pumpage and also the reasonably foreseeable impacts of projected municipal demands on the availability of water for agricultural and industrial users within the City water service area that are not currently receiving water from the City but draw from the same aquifer.

An analytical groundwater model was developed to simulate the response of the principal aquifer used by the City for meeting municipal demands under various pumping scenarios through the year 2025. Key groundwater and pumpage data used for model development, calibration, and simulation included:

1. Groundwater level data for 2002-2003. These data provide the most complete groundwater level record for assessing the response to pumping of the principal study area aquifer by the City and others, particularly during summer months. These data were used for model calibration.

2. Projected municipal pumpage through the year 2025. Eight future pumping scenarios were developed that represent increasing levels of municipal pumpage through the year 2025. The projected pumpage is based on the estimated annual sustainable pumpage in the City's Elmira Road well field and also the expanded distribution of pumpage at other locations in the study area.

The SB 221/610 Groundwater Report also recommends expansion of the City's groundwater monitoring program. This program would collect data that would be used to evaluate future pumpage sustainability based on the criteria discussed below.

Conjunctive Water Use and Management

The City conjunctively manages its groundwater and surface-water resources to most effectively use those resources during different water year types. This has been previously demonstrated to be an effective and flexible management approach. Continued use of conjunctive water management is expected to enable the City to meet its future water demands to a 20-year horizon and beyond. Groundwater-related objectives of the conjunctive water management plan are to: 1) recognize and implement actions to prevent persistent water level declines, and 2) when water levels temporarily decline during dry years, water levels will still be maintained above historical low levels to minimize adverse consequences due to over pumping of the aquifer system.

Groundwater monitoring data collected by the City, particularly from the Elmira Road well field, indicate the response of the aquifer system to varied pumping operations during wet and dry periods. Spring groundwater levels measured during 1992-1993 were initially used to establish "base year" groundwater levels, or the levels to which the aquifer has recovered in response to an estimated sustainable level of pumpage from the Elmira Road well field. As discussed below, the 1992-1993 "base year" groundwater levels have been augmented with more complete data collected in 2002-2003, especially during the summer months. This "base year" groundwater level concept serves to guide conjunctive management of the City's water resources. Base year water levels are anticipated not to be exceeded during "normal" water years in response to the pumpage associated with those years. It is also recognized that during dry years, whether for a single dry year or a multiple-dry year period, water levels would temporarily decline to below base year levels in response to increased pumpage. Following a dry year condition and increased pumpage levels, the base year groundwater levels then provide a target to which to restore water levels.

In summary, the City's conjunctive water management approach is based on the following:

1. Spring 1992-1993 groundwater levels represent "base year" spring groundwater recovery levels.

2. The base year groundwater levels are based on a historical level of pumpage for the Elmira Road well field that appears to be sustainable.

3. During dry years with increased pumpage, groundwater levels may be lower than base year groundwater levels and the reverse would generally occur during periods of reduced pumpage. Following a dry year condition where increased pumpage has occurred, conjunctive water management will be used to restore groundwater levels to base year conditions.

4. The 1992-1993 base year groundwater levels, in conjunction with the 2002-2003 levels which include more complete data during peak extraction periods, provide an important means for measuring aquifer system response to future pumping that occurs as part of the City's conjunctive water management plan.

5. The distribution and management of pumpage in the study area is a major factor when considering future groundwater levels in relation to the 1992-1993 base year conditions. As the City's wellfield expands to the northern part of the study area, additional groundwater monitoring will be necessary to evaluate water level responses to the additional groundwater development and provide a better understanding of spring water groundwater level recovery and recharge mechanisms.

Groundwater Summary Assessment Outline

This Groundwater Summary Assessment complements the overall response to the SB 221/610 requirements (Nolte and Associates, 2003) and summarizes the analyses necessary to address the groundwater supply sufficiency portion of the SB 610 requirements for the three new development projects proposed within the Urban Water Management planning area. Specifically, this Groundwater Summary Assessment provides an overview of the following:

1. Groundwater conditions and source of municipal supplies.
2. Analysis of future pumping impacts.
3. Model results and groundwater supply sufficiency.
4. Summary.

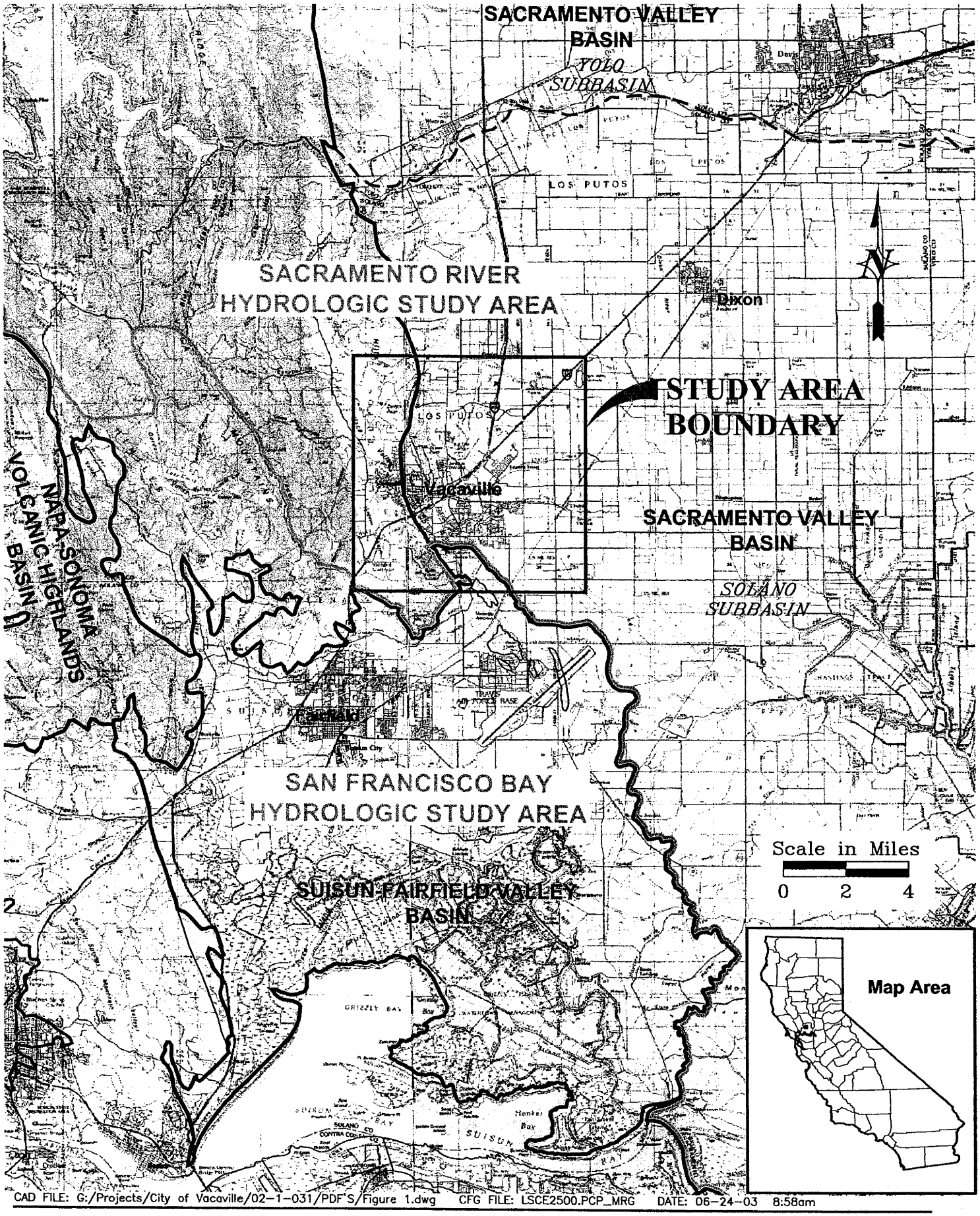
II. Groundwater Conditions and Source of Municipal Supplies

Study Area

The study area includes the incorporated area of Vacaville and projected areas of future growth (Figures 1 and 2), and it overlies portions of two California Department of Water Resources (DWR)-designated groundwater basins (DWR, 2003). The study area primarily overlies the northwestern portion of the Solano Subbasin of the Sacramento Valley Basin. It also overlies a very small portion of the Suisun-Fairfield Valley Basin. The Solano Subbasin includes the southernmost portion of the Sacramento Valley Basin and extends into the northern portion of the Sacramento-San Joaquin Delta. The Solano Subbasin boundaries are defined by Putah Creek on the north, the Sacramento River on the East (from Sacramento to Walnut Grove), the North Mokelumne River on the southeast (from Walnut Grove to the San Joaquin River), and the San Joaquin River on the South (from the North Mokelumne River to the Sacramento River). The western portion of the study area is located roughly near the western boundary of the *Sacramento River and San Francisco Bay* Hydrologic Study Areas but does not overlie any area currently designated by DWR as a groundwater basin or subbasin.

Municipal water supplies for the City of Vacaville are located in the portion of the study area overlying the Solano Subbasin, with the exception of Well 1, which is located east of the surface exposure of the English Hills fault but is completed in geologic formations west of the fault. Based on an analysis of the regional and local geology and the hydrologic conditions, the Vacaville study area can be divided along the English Hills fault into western and eastern regions in regard to water supply development (Figure 3; see SB 221/610 Groundwater Report for in-depth geologic and hydrologic descriptions). The primary source for municipal water supply in the eastern portion of the Vacaville area is the basal zone of the Tehama Formation (Figure 4). Development of groundwater from this zone has been largely limited to the City of Vacaville, with little additional development by others in or immediately adjacent to the study area. As further discussed below, analyses in response to the SB 610 requirements include assessment of the potential impacts of projected pumpage on others that are reasonably anticipated to use the basal zone as a source of supply.

The alluvial deposits and the upper and middle zones of the Tehama Formation are not heavily developed in the Vacaville area and are used primarily for domestic and agricultural purposes in unincorporated portions of the study area. East of the Vacaville area, these aquifers are more heavily utilized by the Solano Irrigation District (SID) to supplement surface-water supplies and to assist in lowering high groundwater table conditions in the shallow aquifer. Water pumped for drainage purposes is also used to supplement the surface-water supplies. In the western portion of the Vacaville area west of the English Hills fault, there is little groundwater development due to the absence of the Tehama Formation and the presence of the pre-Tehama deposits. The pre-Tehama formations generally have poor quality water and low yields compared to the Tehama Formation.



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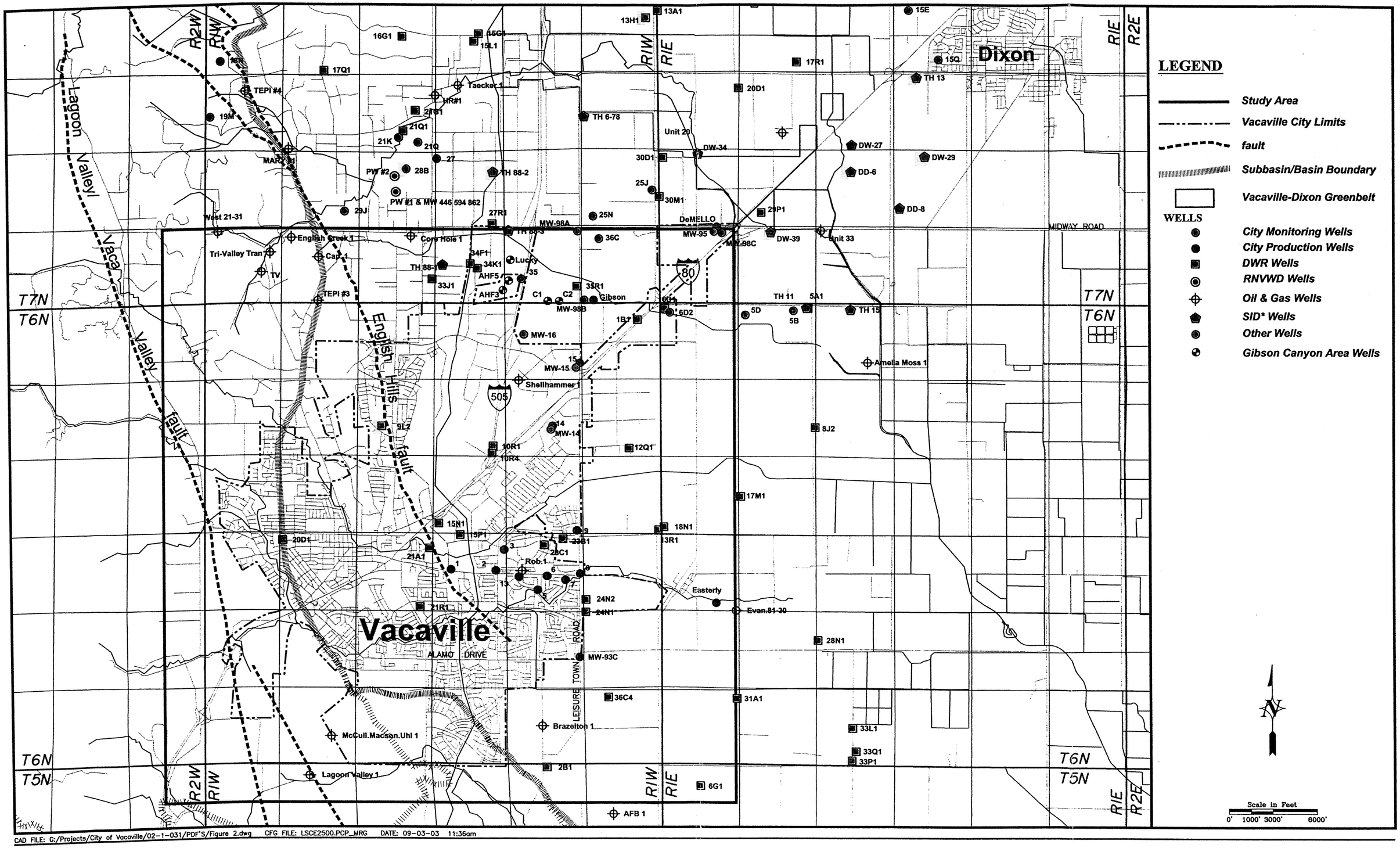
LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure 1
Regional Site Map
City of Vacaville



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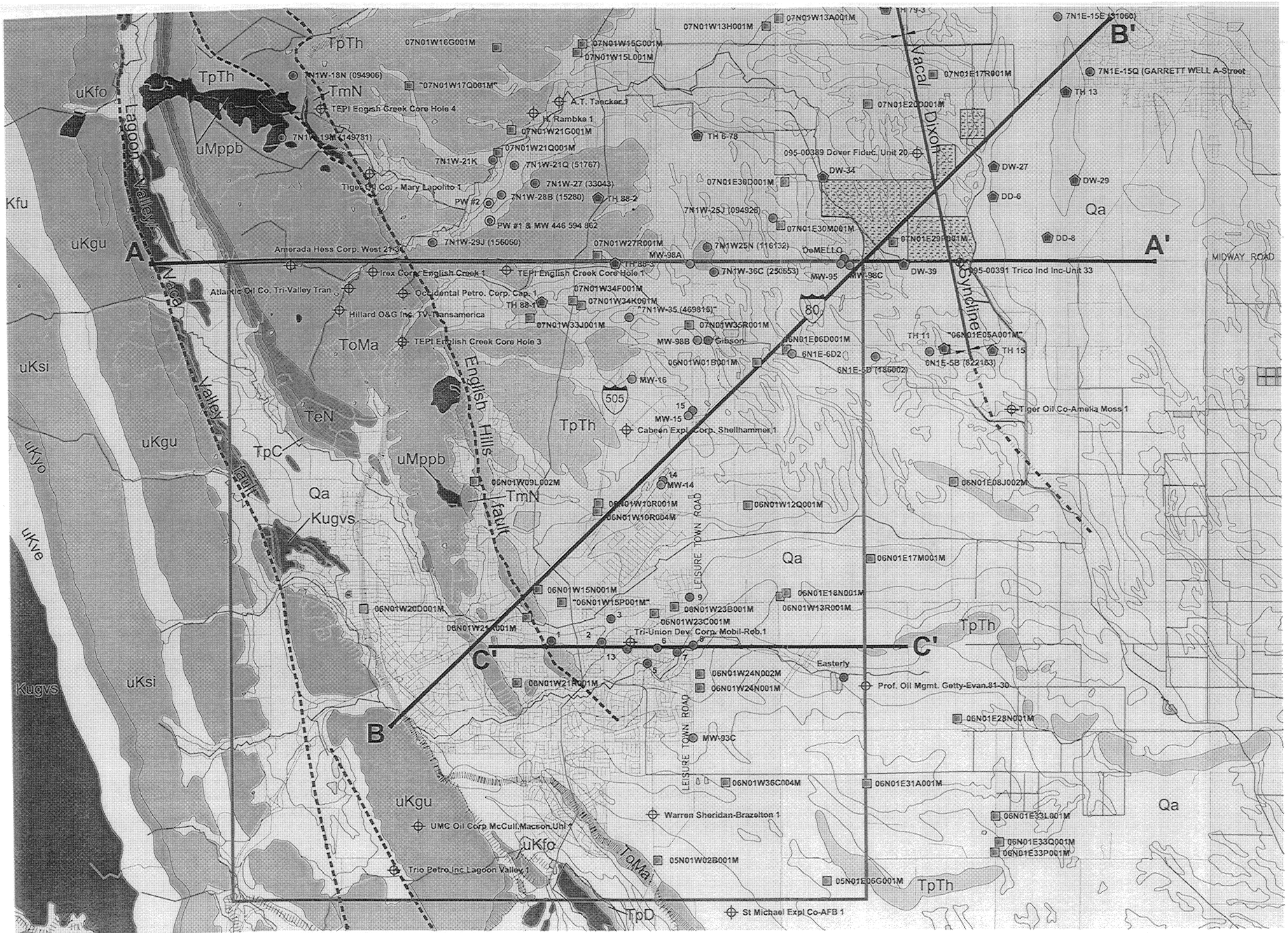
LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure 2
Study Area and Well Location Map
City of Vacaville



LEGEND

STRUCTURAL FEATURES

- *Syncline*
- *Projected Syncline*
- *Faults*
- *Cross-Section*
- *Study Area*
- *Vacaville-Dixon Greenbelt*

WELLS

- *City Monitoring Wells*
- *City Production Wells*
- *DWR Wells*
- *RNVWD Wells*
- *Oil & Gas Wells*
- *SID* Wells*
- *Other Wells*

* Indicates Wells with Locations only Known To Within 1/4 Mile

GEOLOGY

- *Open Water*
- *Landslide Deposits*
- Qa — *Quaternary alluvium*
- TpTh — *Tehama Formation*
- *Putnam Peak Basalt*
- TmN — *Neroly Sandstone*
- ToMa — *Markley Formation*
- TeN — *Nortonville Formation*
- TpD — *Domegine Formation*
- TpC — *Capay Formation*

Great Valley Sequence

- Kugvs — *Undifferentiated Great Valley Sequence*
- uKfo — *Forbes Formation*
- uKgu — *Guinda Formation*
- uKfu — *Funks Formation*
- uKsi — *Sites Formation*
- uKyo — *Yolo Formation*
- ukVe — *Venado Formation*

Scale in Feet
0' 1000' 3000' 6000'

CAD FILE: G:/Projects/City of Vacaville/02-1-031/PDF'S/Figure 3.dwg CFG FILE: LSCE2500.PCP_MRG DATE: 09-03-03 11:39am

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Figure 3
Area Geology and Well Location Map
City of Vacaville

STUDY AREA

ENGLISH HILLS fault

WELL NO.1

MW-93C

WELL NO.3

MOBIL-ROBBINS #1 (095-20039)

WELL NO.13

WELL NO.5

WELL NO.6

WELL NO.7

6N/1W-24N (51625)

WELL NO.8

6N/1E-31L (086633)

WELL NO.9

6N/1E-32 (208428)

6N/1E-30L (086610)

6N/1E-32 (208429)

6N/1E-30 (69884)

6N/1E-32 (208436)

EASTERLY (181390)

PROF. OIL MGMT. GETTY-EVANIKOFF 81-30 (095-20113)

C

C'

ELEVATION

400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
-1800
-2000
-2200
-2400

TmN

Qa

ToMa

TeN

TpD

Kugvs

uKfo

uKgu

Tupt

TpTh

Upper

Middle

Basal

LEGEND

MARINE DEPOSITS / ALLUVIAL DEPOSITS

- Qa — Quaternary alluvium
- TpTh — Tehama Formation
- TmN — Neroly Sandstone
- Undifferentiated Pre-Tehama: Tupt
- TeMa — Markley Formation
- TeN — Nortonville Formation
- TpD — Domegine Formation
- Great Valley Sequence: Kugvs — Undifferentiated Great Valley Sequence
- uKfo — Forbes Formation
- uKgu — Guinda Formation

Indicates Fault

Blue Clay Layer

Continuous Clay Layer

Cross Section Direction

West ⟶ East

Scale in Feet

0' 500' 1000' 2000'

Vertical Exag. 5X

CAD FILE: G:/Projects/City of Vacaville/02-1-031/Cross Section C-C(5X).dwg CFG FILE: LSCE2500.PCP_MRG DATE: 09-02-03 11:54am

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Figure 4
Geologic Cross Section C-C'
City of Vacaville

Aquifer System Response to Pumping

Aquifers overlying the basal zone (the Quaternary Alluvium and upper and middle zones of the Tehama Formation) are affected by year-to-year changes in precipitation and have also shown significant water level trends in response to changed sources of supply, i.e., water levels increased dramatically beginning in the 1960s in response to the delivery of surface water from the Solano Water Project and the corresponding reduction in groundwater pumpage. Water levels in the basal zone, on the other hand, do not appear similarly affected by year-to-year changes in precipitation or climatic conditions (droughts and wet periods).

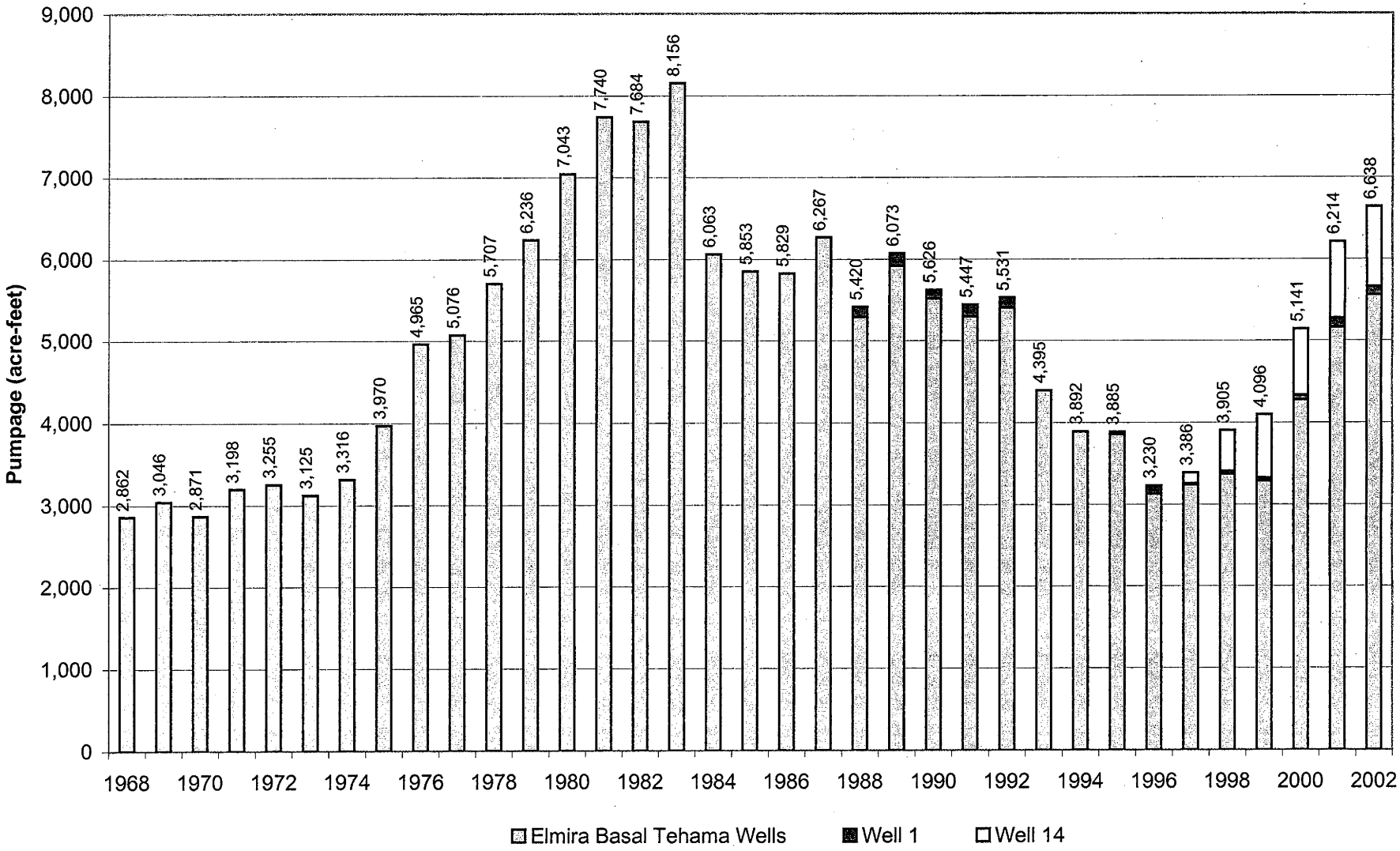
Groundwater pumpage from the highly confined basal zone of the Tehama Formation does not appear to directly affect water levels in the upper and middle zones of the Tehama Formation in most of the eastern portion of the Vacaville area where the Formation is present. However, where the Tehama Formation abuts the English Hills fault and outcrops to the north, the confining layers thin and contain more coarse-grained materials. This increases the potential for pumping stress to propagate from the basal zone into the upper and middle zones. Most of the recharge to the basal zone of the Tehama Formation is expected to occur east of the English Hills fault and to the north where the Formation outcrops. A significant portion of this recharge is the result of leakage from the overlying Quaternary alluvium and upper zone of the Tehama Formation and the Formation outcrops.

Groundwater level monitoring data for the basal zone of the Tehama Formation are limited to the Elmira Road well field, the Orange Drive area (Well 14), and the northern portion of the Vacaville area toward the Rural North Vacaville Water District (RNVWD) production wells. Eight of the ten City of Vacaville wells are located in the Elmira Road area. A localized groundwater depression exists in the vicinity of Elmira Road as a result of the concentrated pumpage in this area. The pumping depression is not evident to the west at Well 1, which is completed primarily in the Markley Formation west of the English Hills fault. Groundwater elevations in Well 1 have been above mean sea level (msl) since 1993 (ranging up to 32 feet msl), while water levels in the other Vacaville wells along Elmira Road have consistently been below sea level. The English Hills fault appears to act as at least a partial barrier to groundwater flow. Well 14, constructed in 1997, is located approximately two miles north of the Elmira Road well field. This well was (and future water supply wells will be) sited in consideration of the recommendations of the City's AB 3030 Groundwater Management Plan. Those recommendations include a wider distribution of future municipal pumpage throughout the area in order to reduce the extent and magnitude of the localized pumping depression in the Elmira Road area in the future.

City of Vacaville Historical Pumpage

Total pumpage for the City from 1968 through 2002 is shown on Figure 5. This figure shows the annual amount of groundwater produced by City wells completed in the basal zone of the Tehama Formation, including wells located in the Elmira Road well field and City Well 14, which is located approximately two miles north of the Elmira Road well field, and a small

Figure 5
Historical Pumpage - City of Vacaville



amount of pumpage, about 100 acre-feet per year of pumpage from non-basal formations, from Well 1. As shown on Figure 5, total City pumpage for the period from 1984 through 1992 ranged from 5,420 to 6,267 acre-feet per year, with an average of 5,790 acre-feet per year. During this period, the highest level of pumpage (6,267 acre-feet) occurred in 1987. From 1993 through 1999, the total pumpage was significantly less than during the 1984 to 1992 period. From 2000 to 2002 the total pumpage steadily increased. The total pumpage in 2002 was 6,638 acre-feet with 5,665 acre-feet from the Elmira well field and 973 acre-feet from City Well 14. Importantly, with regard to further discussion below concerning water levels, pumpage in the Elmira Road area during 1990 to 1992 ranged from 5,298 to 5,520 acre-feet, which is comparable to the 2002 pumpage for this area.

Historical Groundwater Levels

Groundwater elevations in the basal zone have shown considerable variation over time in direct response to changes in the amount of groundwater used as a source of supply by the City of Vacaville. An example of this is provided on Figure 6, which shows the trend in groundwater elevations in Well 7 (constructed in the basal zone of the Tehama Formation), total pumpage for the Elmira Road well field, and also the additional pumpage from Well 14 since 1997. Figure 7 shows the same hydrograph converted to depth to water. Notably, spring water levels shown on these hydrographs were similar in 1992-1993 and 2002-2003 (groundwater elevations of about –65 to –70 feet msl and depths to water of about 165 to 170 feet). This trend illustrates the close correlation of water level responses to pumpage. Pumpage from the basal zone in the Elmira Road well field (i.e., not including Well 1 or 14) during 1990, 1991, 1992, and 2002 was similar at 5,520; 5,298; 5,405; and 5,563 acre-feet, respectively.

Following three successive years of comparable pumping stress on the basal Tehama Formation from 1990 to 1992, the data indicate complete water level recovery between the spring 1992 and spring 1993 periods (in the range of –65 to –70 feet msl). Following a comparable level of pumpage in 2002 at the Elmira Road well field, but with added pumpage from the basal zone at City Well 14, the spring water levels recovered to an elevation of about –67 feet msl. Water levels measured in spring 2002 and spring 2003 shows a slight residual drawdown (about three feet). However, during the spring of 2003, the water level recovery was similar to the range of groundwater elevations observed in 1992-1993. The well field operating schedule may be the cause of the slight residual drawdown observed in spring 2003.

Beginning in spring 1992, the City implemented a program to obtain water level measurements from its production wells that best represent static conditions. Spring and fall static water levels are measured manually as part of this program. This monitoring program includes simultaneously shutting down wells for three days to ensure consistent (essentially static) monitoring conditions. However, these measurements do not reflect the lowest static groundwater levels, which typically occur during the summer. To overcome this limitation, selected transducer measurements from the City's SCADA system were used to represent the lower "static" summer levels. The 2002 to 2003 levels shown on Figures 6 and 7 represent transducer levels recorded when Well 7 (and other wells in the vicinity of Well 7) was not

Figure 6
City of Vacaville
Groundwater Elevation (Well 7) and Annual City Pumpage from Basal Tehama

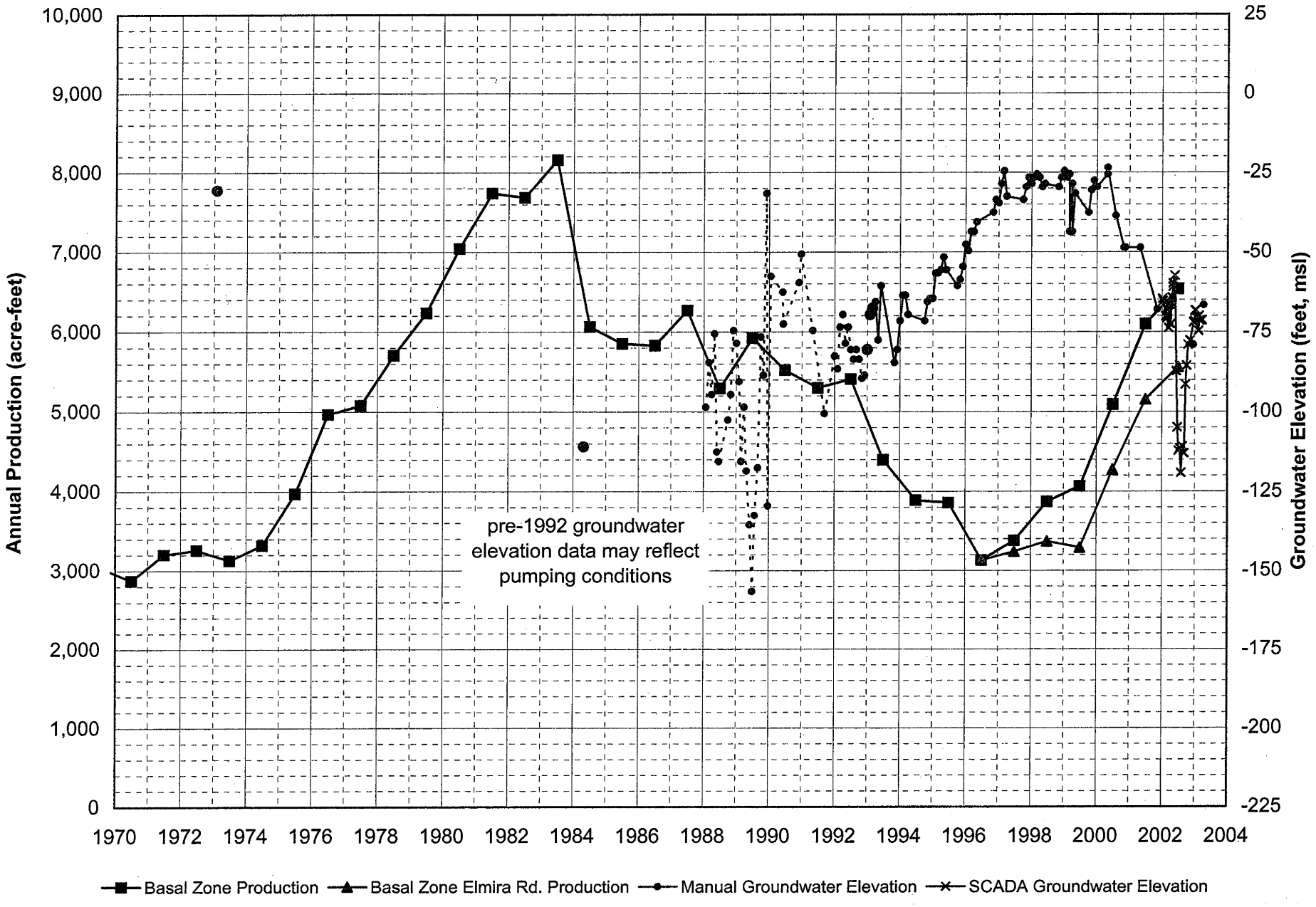
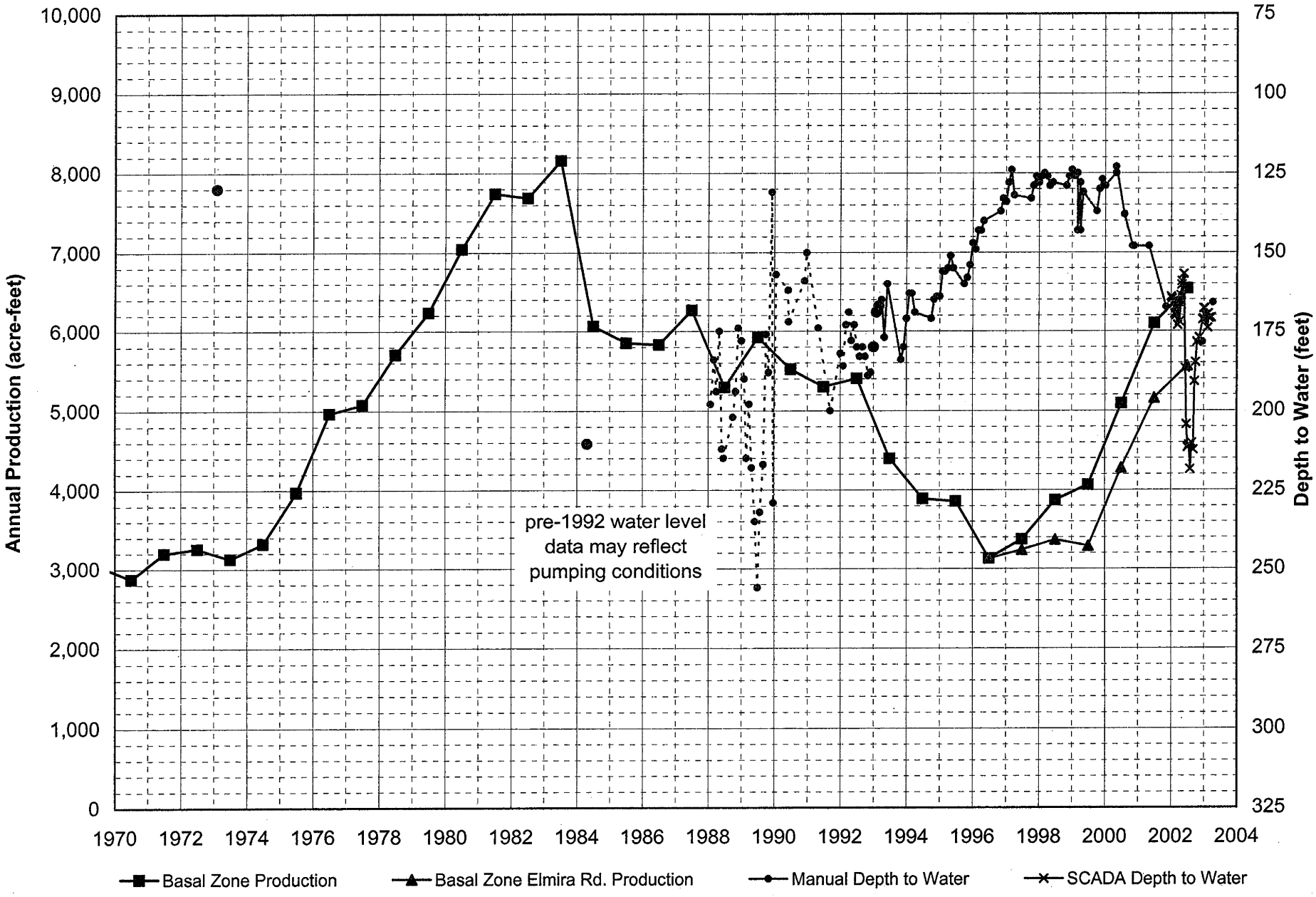


Figure 7
City of Vacaville
Depth to Water (Well 7) and Annual City Pumpage from Basal Tehama



operating. Pumpage during 1980 to 1983 was greater than in 2002, but the maximum drawdown measured in 2002 provides an indicator of historical low levels that have occurred since 1984.

Base Year and 2002-2003 Groundwater Levels

Groundwater monitoring data collected during 1992-1993 have previously been referred to by the City as representing the "base year" groundwater level condition. Pumpage and spring groundwater levels were similar in 1992-1993 and 2002-2003. However, there is a much greater availability of water level data representing approximately static conditions, including data collected during the summer months, for the 2002-2003 period. The maximum (spring) and minimum (summer) water levels in 2002-2003 are highlighted on Figure 8. In the analysis presented below, the 2002-2003 groundwater levels are used for purposes of evaluating the results and potential impacts of future pumping scenarios on groundwater levels.

The close correlation between water levels and pumpage also provides evidence that the aquifer system is responsive to conjunctive water management. During wet periods when more surface water is available to meet water demands and groundwater pumpage is accordingly decreased, water levels recover. Similarly, during dry periods when surface-water allocations are reduced and groundwater pumpage is increased to meet demands, water levels decrease.

Because existing water level data for the basal zone are largely limited to the Elmira Road well field, base year groundwater level conditions have only been established for this area. For purposes of this study, and based on current understanding of the local hydrogeology, the modeling analysis described below is based on the assumption that areas north of the Elmira Road well field would respond similarly to pumping. The data from the Elmira Road well field are used to establish the drawdown occurring in response to normal water year pumpage for that area. However, the drawdown occurring at this location would not be applicable to areas outside the Elmira Road well field.

Estimated Sustainable Pumpage for Elmira Road Well Field

Historical water level data provide two key indicators to assess the potential impacts of projected pumpage to the year 2025. One indicator concerns water level response/recovery trends. The recovery observed at Well 7 following the 1992 and 2002 groundwater extraction periods can be used as an indicator of a potentially sustainable level of pumpage from the Elmira Road well field. The water level recovery occurring in the spring of 1993 and spring of 2003 suggests that full recovery to previously observed spring levels can occur when pumpage from the Elmira Road well field does not exceed 1992/2002 volumes. A groundwater elevation of about –65 to –70 feet msl reflects the level to which water levels are expected to recover in response to pumpage at 1992/2002 levels from the basal Tehama Formation within the Elmira Road well field.

The second indicator for the assessment of potential impacts of projected future pumpage concerns the maximum drawdown observed during the summer months. The upper and middle