SACRAMENTO GROUNDWATER AUTHORITY

State of the Basin Report-2002

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ACRONYMS AND ABBREVIATIONS

AB 303	Assembly Bill 303
Aerojet	GenCorp Aerojet
AF	Acre Feet
AFB	Air Force Base
AFO	American River At Fair Oaks
afy	acre feet per year
BMO	Basin Management Objective
BPA	Baseline Pumping Allowance
CALFED	CALFED Bay Delta Program
CDEC	California Data Exchange Center
CAR	DMS symbol used for Carmichael Water District
CHG	Chicago
CHWD	DMS symbol used for Citrus Heights Water District
CIZ	DMS symbol used California-American Water Company
COC	Chain of Custody
CSUS	California State University Sacramento
CWD	Community Water District
CWS	Community Water System
CVP	Central Valley Project
DBP	Dibromopropane
DCA	Dichloroethane
DCE	Dichloroethene
DHS	California Department of Heath Services

DMS	Data Management System
DPM	DMS symbol used for Del Paso Manor Water District
DPR	California Department of Pesticide Regulations
DWR	California Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection
EIR	Environmental Impact Report
EPA	Environmental Protection Agency
EWA	Environmental Water Account
FAI	DMS symbol used for Fair Oaks Water District
ft	feet
FLD	American River at Folsom Dam
FPT	Sacramento River at Freeport
gpm	Gallons per minute
HAAs	Haloacetic Acids
IDSE	Initial Distribution System Evaluation
IGSM	Integrated Groundwater Surface Water Model
ISI	Integrated Storage Investigation
JPA	Joint Powers Authority
Mather	Former Mather Air Force Base
McClellan	Former McClellan Air Force Base
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg/l	Milligrams per liter
MMM	Multimedia Mitigation Program
msl	Mean Sea Level

MWH	Montgomery Watson Harza
NCMWC	Natomas Central Mutual Water Company
NGS	National Geodetic Survey
PCA	Potential contaminating activity
PCE	Perchloroethylene
pCi/L	pico-Curies per liter
PCWA	Placer County Water Agency
POU	Place of Use
QA/QC	Quality Assurance / Quality Control
RLE	DMS symbol used for Rio Linda/Elverta CWD
RLN	Rio Linda
RWA	Regional Water Authority
RWMP	Regional Water Master Plan
RWQCB	Regional Water Quality Control Board
SAC	DMS symbol used for City of Sacramento
SAFCA	Sacramento Area Flood Control Agency
SB 1938	Senate Bill 1938
SCWA	Sacramento County Water Agency
SCA	DMS symbol used for Southern California Water Company
SCO	DMS symbol used for Sacramento County Water Agency
SGA	Sacramento Groundwater Authority
SOCs	Synthetic Organic Compounds
SOP	Standard Operating Procedure
SOW	Scope of Work
SQL	Sequel Server Database

SSWD	Sacramento Suburban Water District
TAF	Thousand Acre Feet
TCE	Trichloroethylene
TCR	Total Coliform Rule
TDS	Total Dissolved Solids
TOC	Top of Casing
TM	Technical Memorandum
TS	Technical Summary
TTMH	total trihalomethanes
µg/L	microgram per liter
USACE	United State Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV	Ultraviolet
VOCs	Volatile Organic Compounds
WC	Water Company
WD	Water District
WSC	Water Service Company

1.0 INTRODUCTION

This document presents a summary of basin conditions, or "State of the Basin", in calendar year 2002 for the area located within the Sacramento Groundwater Authority's (SGA) jurisdiction. The Placer County line bounds this area on the north, the Sacramento River on the east, and the American River to the south and east (**Figure 1-1**).

1.1 SACRAMENTO GROUNDWATER AUTHORITY

The Sacramento Groundwater Authority (SGA) is a joint powers authority (JPA) created to manage the Sacramento region's North Area Groundwater Basin. The SGA's formation in 1998[1] resulted from a coordinated effort by the Sacramento Metropolitan Water Authority (SMWA) and the Sacramento Area Water Forum (Water Forum) to establish an appropriate management entity for the basin. The SGA is recognized as one of the essential tools to implement a comprehensive program to preserve the lower American River and ensure a reliable water supply through the year 2030.

The SGA draws its authority from a joint powers agreement signed by the cities of Citrus Heights, Folsom, and Sacramento and the County of Sacramento to exercise their common police powers to manage the underlying groundwater basin. In turn, these agencies chose to manage the basin in a cooperative fashion by allowing representatives of the 14 local water purveyors and a representative from each agricultural and self-supplied pumpers to serve as the Board of Directors of the SGA[2]. At the core of the SGA's management responsibility is a commitment to not exceed the average annual sustainable yield of the basin, which was estimated to be 131,000 acre-feet[3] in the Water Forum Agreement (WFA)[4].

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1 The SGA was originally formed in 1998 as the Sacramento North Area Groundwater Management Authority. In 2002, it was renamed the Sacramento Groundwater Authority.

2 SGA Board members include representatives of California-American Water Company, Carmichael Water District, Citrus Heights Water District, City of Folsom, City of Sacramento, County of Sacramento, Del Paso Manor Water District, Fair Oaks Water District, Natomas Central Mutual Water Company, Orange Vale Water Company, Rio Linda/Elverta Community Water District, Sacramento Suburban Water District, San Juan Water District, Southern California Water Company, and individual representatives from agriculture and self-supplied groundwater users (principally parks and recreation districts).

3 This value was estimated based on water use and facilities in the basin at the time of the WFA. This value was based on a number of assumptions, and was not intended to be a fixed value that could not be modified as conditions and assumptions changed in the basin. Examples of changed conditions include new or improved water conveyance, treatment, and storage facilities or changes in water supply contracts.

4 The WFA is available online at http://www.waterforum.org or contact the Water Forum office at (916) 264-1999.

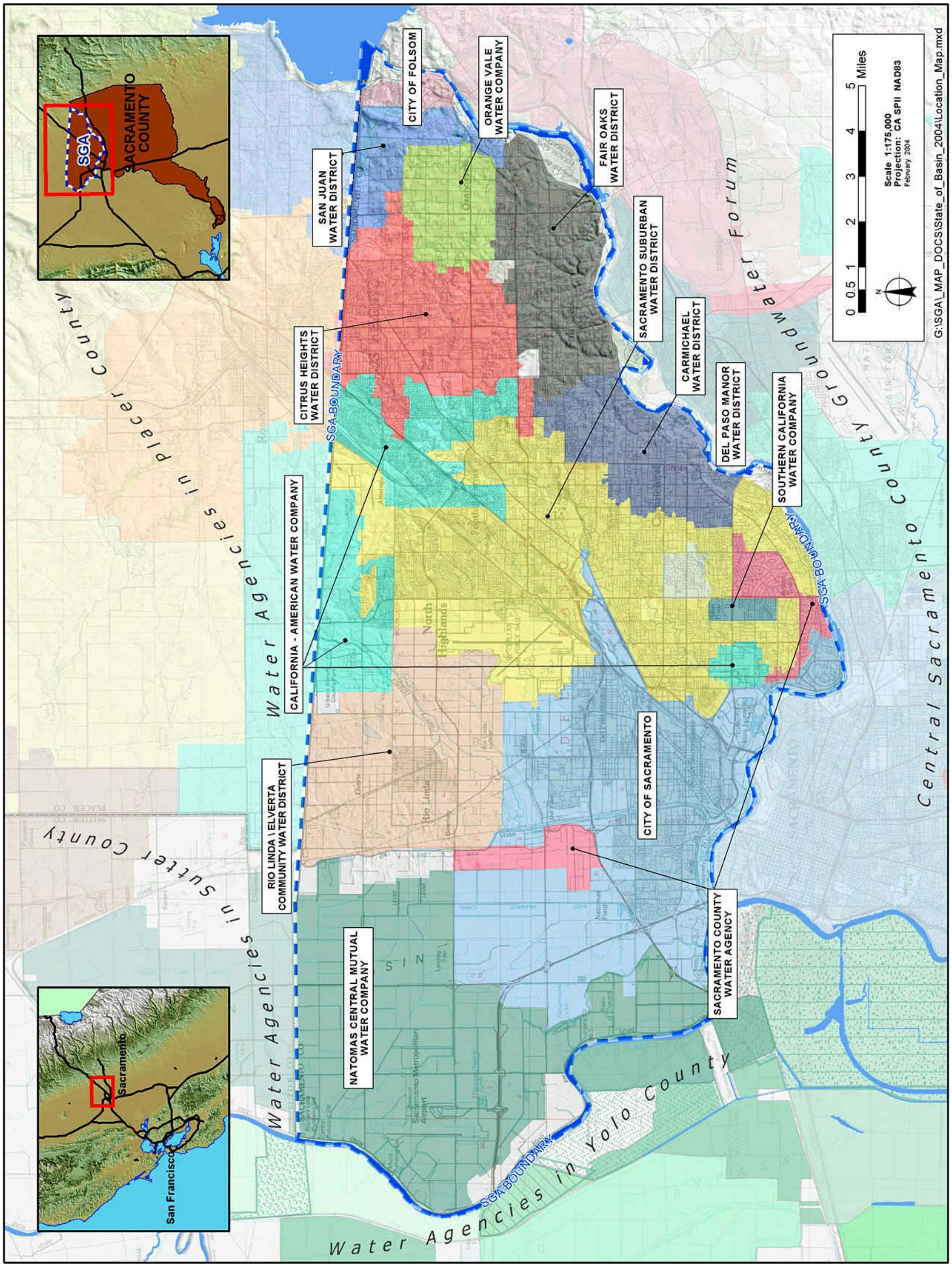


Figure 1-1 Location of Sacramento Groundwater Authority

1.2 DATA MANAGEMENT SYSTEM DEVELOPMENT

The SGA was formed by local municipal water purveyors and the Sacramento County Water Agency to address groundwater quantity and quality issues in the portion of Sacramento County north of the American River. To address these issues the SGA has developed a data storage and accounting tool, the Data Management System (DMS), to better manage the groundwater data and assess groundwater conditions. The tool was developed by MWH (formerly Montgomery Watson) under contract with the U.S. Army Corps of Engineers (USACE). Funding for the work was made possible through a Cost Sharing Agreement between the USACE and local sponsors. In this case, the local sponsors included the California Department of Water Resources (DWR) and the SGA.

The development of the DMS was completed in two phases. Phase I was completed in January 2003 and included construction of the user interface and population of the

DMS to "demonstration level". Through Phase II, the DMS has been fully populated, includes enhanced features, and is now being used as a management tool by the SGA. In addition to developing the DMS, many other activities were performed with these funds including:

- Acquisition of groundwater data from SGA member agencies.
- Assessment of impacts and growing threats to surface water quality and groundwater quality.
- Assessment of the quality of groundwater data provided by member agencies.
- Conduct member agency interviews to assess how groundwater data is collected and archived.
- Development of recommendations on automating the flow of data from point of collection into the DMS.
- Documentation protocols for collection of water level and water quality data.
- Development of user manuals, conducting training on the use of the DMS and providing DMS demonstrations to each of the member agencies.
- Documenting basin conditions.
- Assistance in the development of a groundwater management plan (GMP).

1.3 PURPOSE AND SCOPE OF REPORT

This document represents the culmination of the data collection effort, population of the DMS with groundwater data through calendar year 2002, and presentation of the groundwater basin conditions based on these data. Subsequent "State of the Basin" reports prepared by the SGA will continue to improve the understanding of basin conditions. This "State of the Basin" for calendar year 2002 serves as the accepted "point of comparison", allowing project stakeholders to quantify the impacts of current and future SGA projects on the groundwater system. This document meets the following objectives:

1. Report on the status of key management parameters (i.e. groundwater elevation, groundwater extraction, contaminant migration, and general water quality parameters).
2. Meet the SGA's principal reason for existence, (i.e., to ensure implementation of the groundwater elements of the Water Forum Agreement)
3. Assist the SGA Board in policy drafting and implementation, and report on and evaluate the impacts of these policies.

1.4 REPORT ORGANIZATION

This report is organized into the following sections:

Section 1: Introduction

Section 2: Basin Conditions in 2002

Section 3: Water Resources Development and Management Activities (2002/2003)

Section 4: Recommendations to Improve Understanding and Management of the Basin

Section 5: Bibliography

2.0 BASIN CONDITIONS IN 2002

This section provides a detailed description of SGA basin conditions including:

- Location.
- Surface water hydrology.
- Groundwater flow.
- Groundwater quality.
- Groundwater production.

Basin conditions described below are based on calendar year 2002 groundwater data obtained from the SGA DMS. Surface water data were obtained from supplemental sources referenced in this section.

2.1 BASIN DESCRIPTION

The SGA is located within the North American Subbasin as defined by the map showing the area of this subbasin, in DWR Bulletin 118 (2003). The SGA boundaries within this basin are presented in **Figure 2-1.**

The North American Subbasin is defined by DWR as the area bounded on the west by the Feather and Sacramento rivers, on the north by the Bear River, on the south by the American River, and on the east by the Sierra Nevada (DWR, 2003). DWR Bulletin 118 (2003) provides additional information about the North American Subbasin on the agency's Web site[5] including:

- Surface Area: 548 square miles.
- The eastern basin boundary is an approximate north-south line extending from the Bear River south to immediately west of Folsom Reservoir. This represents the approximate edge of the alluvial basin where subsurface groundwater flows into the groundwater basin from the Sierra Nevada come predominantly from fractured rock aquifers. Other eastern boundary conditions affecting the basin are the sources of surface water from local streams and major rivers.

[5] At: http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/5-21.64_North_ American.pdf.

- The western portion of the subbasin consists of nearly flat flood basin deposits from the Bear, Feather, Sacramento and American rivers, and several small tributaries

The SGA area is located in the southern portion of the North American Subbasin extending as far north as the Sacramento-Placer County line.

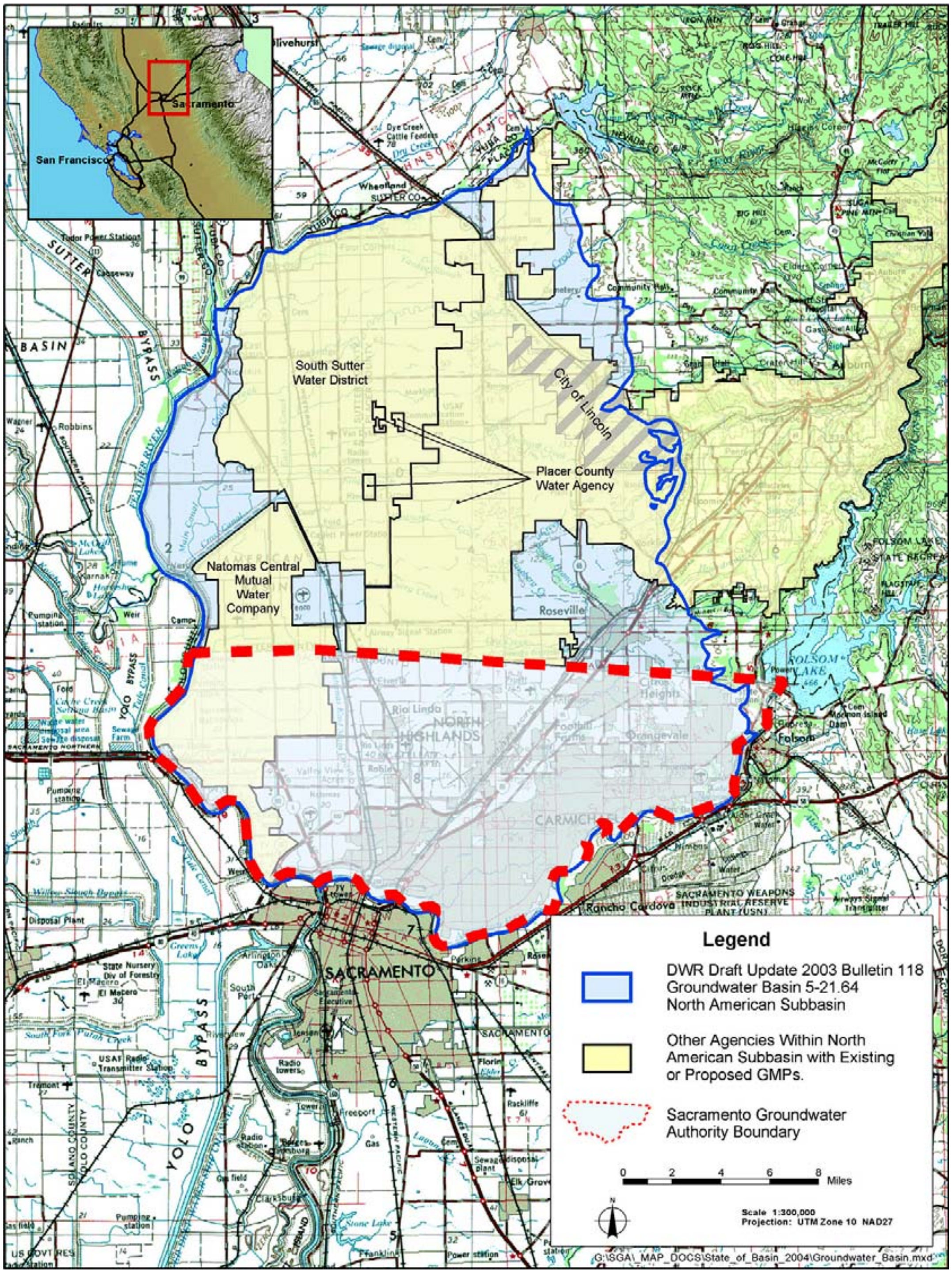


Figure 2-1
Location of SGA within the North American Groundwater Subbasin

2.2 BASIN SURFACE WATER HYDROLOGY (2002 CONDITIONS)

2.2.1. Water Forum Agreement Year Type

The annual unimpaired inflow of the American River into Folsom Lake was 2,025 TAF for Water Year 2002 (from October 1, 2001 through September 30, 2002). For most water purveyors, the annual unimpaired inflow to the Folsom Lake may not be as meaningful as March-through-November total unimpaired inflow due to the limitations for diverting from the American River stipulated in the Water Forum Agreement (WFA, 2003). **Table 2-1** shows the water year types defined by the WFA. The total unimpaired flow to Folsom Lake from March through November 2003 is about 1,405 TAF; that is, 2002 is considered an average year according to WFA year type classifications. **Figure 2-2** shows the statistics of historical (1901 through 2003) unimpaired inflow to Folsom Lake from March through November. As indicated in **Figure 2-2**, there are about 66.3 percent of the years that have more unimpaired flow amount during March through November than 2002, and 2002 is at the high end of the category.

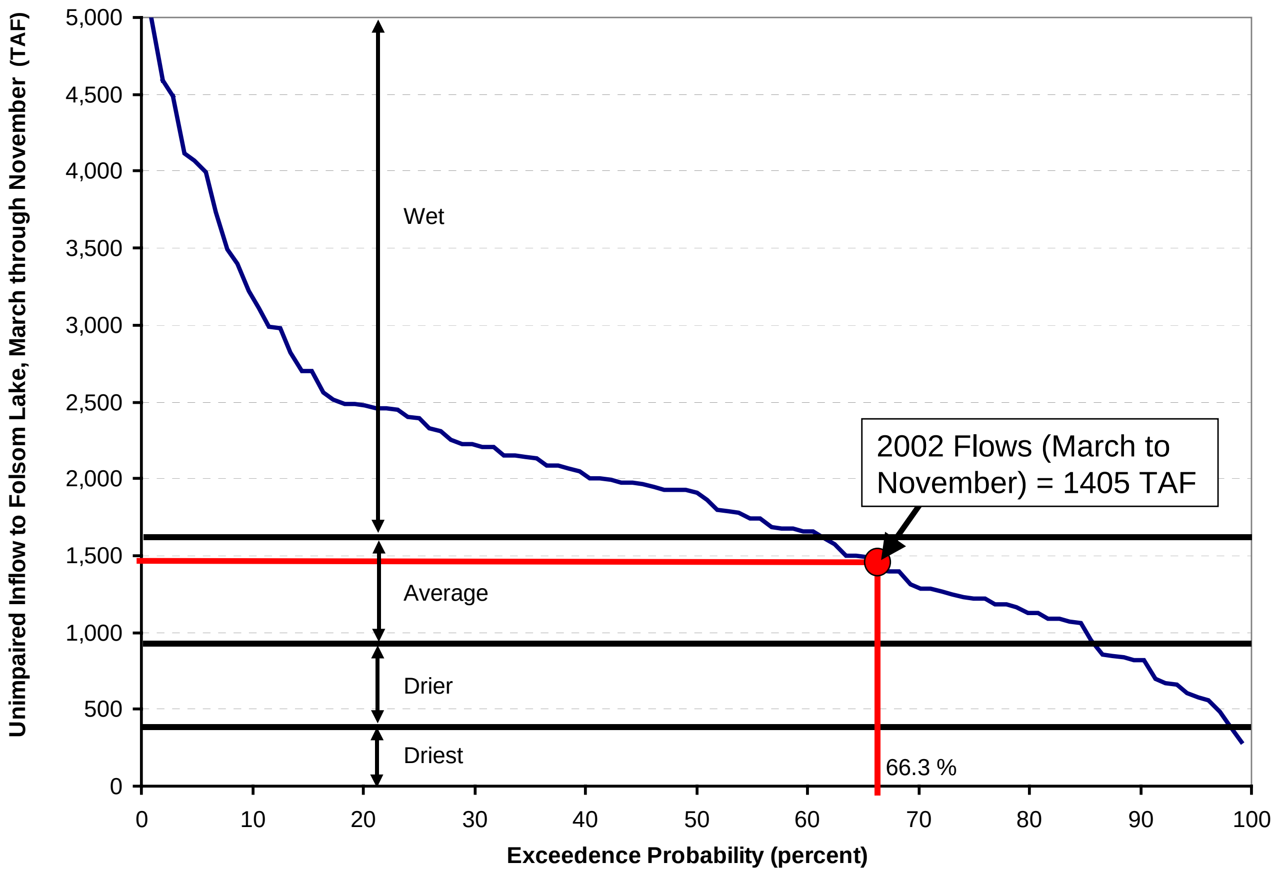


Figure 2-2
Percent Exceedence of Unimpaired Inflow into Folsom Lake (1901-2003)

Table 2-1
Water Forum Agreement Water Year Types

Year Type	Unimpaired Inflow to Folsom Lake, March through November (AF)	Occurrence Frequency, 1901 through 2003[a]
Wet	Greater than 1,600,000	64 out of 103 years (62%)
Average	Greater than 950,000 and less than 1,600,000	25 out of 103 years (24%)
Drier	Greater than 400,000 and less than 950,000	12 out of 103 years (12%)
Driest (i.e. conference years[c]	Less than 400,000	2[b] out of 103 years (2%)

[a] Data source: California Data Exchange Center (CDEC). [b] 1924 and 1977. [c] Conference years are years when signatory WFA meet and confer on how best to meet demands.

2.2.2. Precipitation Summary

Total rainfall distribution during 2002 within the SGA area ranges from a minimum of 9.69 inches at the Folsom Dam (FLD) rainfall station to a maximum of 16.96 inches at the Chicago (CHG) rainfall station **(see Figure 2-3 for rainfall station locations)**. Daily precipitation values were collected at the Rio Linda gauge between January and December 2002 **(Figure 2-4)**. Seasonal trends are observed with increased precipitation in the winter between November and April and decreased precipitation between May and October. Data plotted on **Figures 2-2** through **2-4** were obtained from the California Data Exchange Center (CDEC) at: http://cdec.water.ca.gov/.

2.2.3. Stream Flow Summary

Stream gauge data for 2002 were obtained from CDEC at: http://cdec.water.ca.gov/. Gauge locations are shown on **Figure 2-3**. Flows in the American River are largely controlled by releases from Folsom and Nimbus dams and were typically below 5,000 cfs in 2002 (**Figure 2-5)**. Total flows in the American River from October, 2001 through September, 2002 were 2,288 TAF. Between October 1996 and September 2001, average annual flows were 3,063 TAF indicating that 2002 was at 75 percent of the 5 year average. Flows in the Sacramento River were more variable than those in the American River and appeared to follow a more seasonal trend ranging from 10,000 to 65,000 cfs.

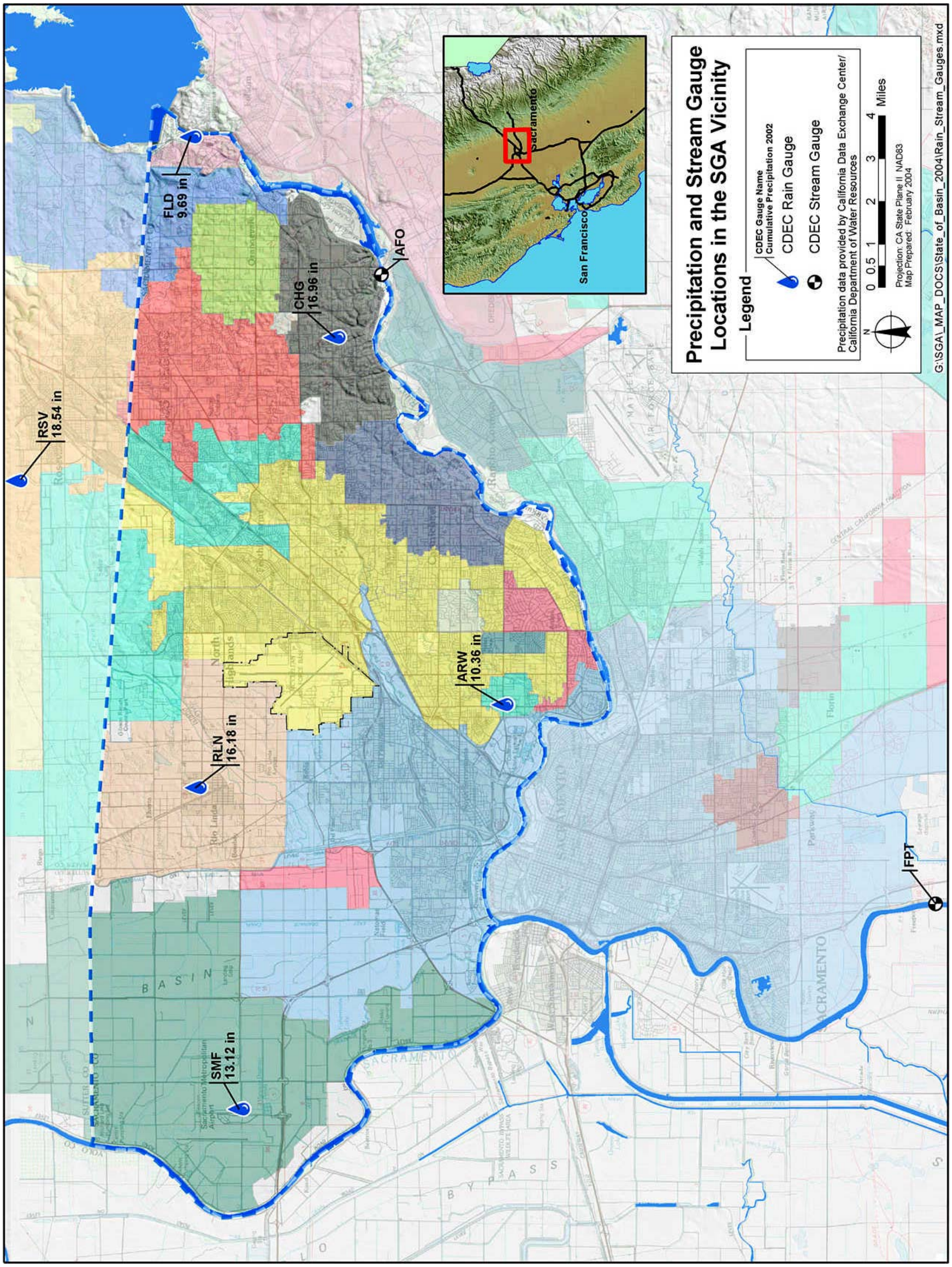


Figure 2-3
Precipitation Distribution in the SGA Vicinity

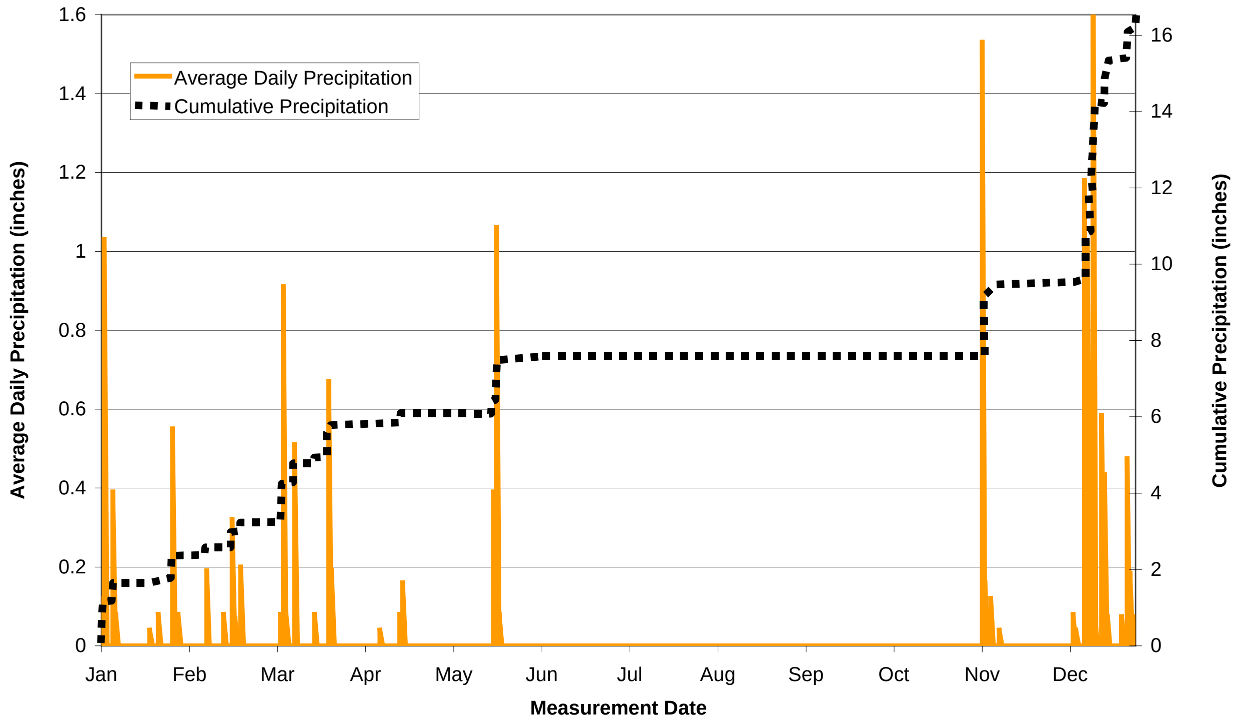


Figure 2-4
Daily Precipitation for 2002 at Rio Linda (RLN) Gauge

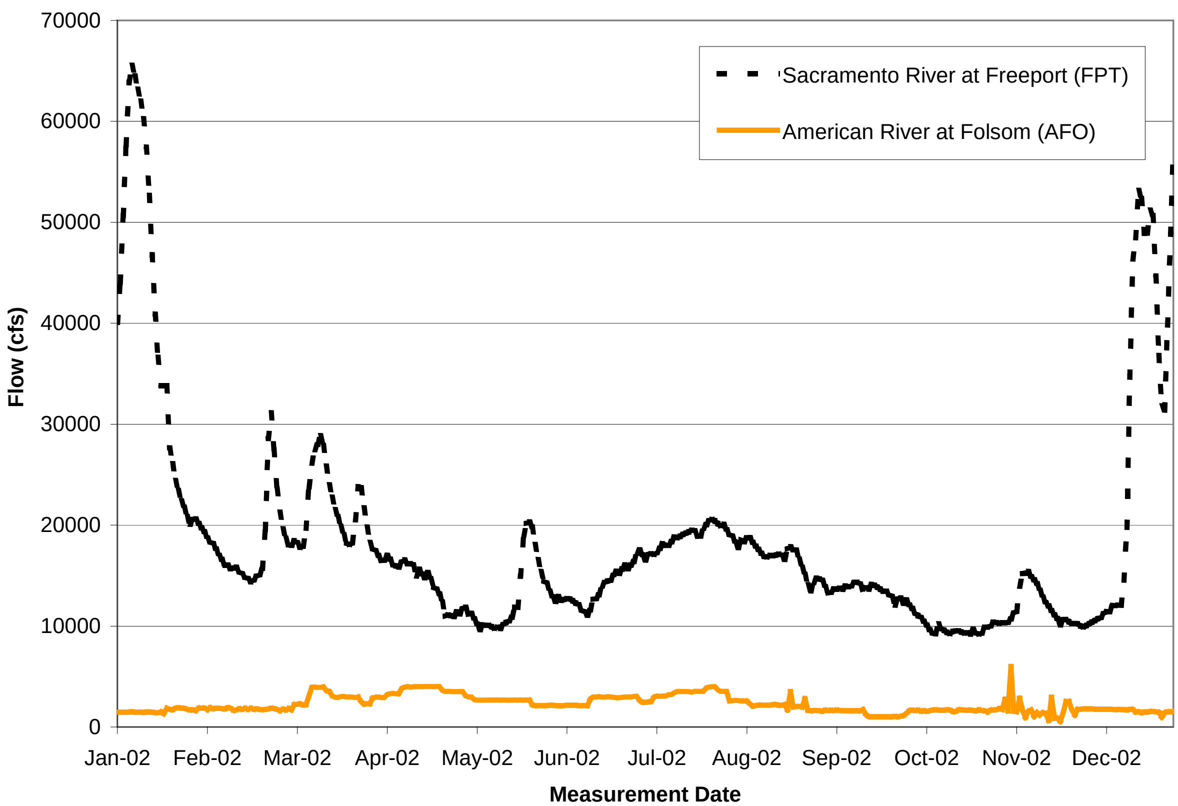


Figure 2- 5
2002 Daily Flows in the American and Sacramento Rivers

2.3 HYDROGEOLOGIC CONDITIONS

This section provides a comprehensive description of the groundwater conditions with in SGA in 2002 based on data analyzed from the DMS and other data sources as cited. Included in these descriptions are the following topics:

- Hydrostratigraphy within the SGA Area
- Groundwater levels
- Groundwater quality
- Groundwater production

Land subsidence is not addressed in this section because no additional information was obtained in 2002 to add to the description provided in the Summary of Basin Conditions Report (MWH, 2003). However, land subsidence will be monitored and reported on by SGA in the future as described in Section 4.

2.3.1. Hydrostratigraphy of SGA Area

DWR Bulletin 118-3 identifies and describes the various geologic formations that constitute the water-bearing deposits underlying Sacramento County. These formations include an upper, unconfined aquifer system consisting of the Riverbank (formerly known as Victor) and Turlock Lake/Laguna (formerly known as Fair Oaks-Laguna) Formations, and a lower, semi-confined aquifer system consisting primarily of the Mehrten Formation. These formations are shown on **Figure 2-6** and are typically composed of lenses of inter-bedded sand, silt, and clay, interlaced with coarse-grained stream channel deposits. **Figure 2-6** illustrates that these deposits form a wedge that generally thickens from east to west to a maximum thickness of about 2,000 feet (ft) under the Sacramento River.

Groundwater occurs in unconfined to semi-confined states throughout the North American Subbasin. Semi-confined conditions occur in localized areas; the degree of confinement typically increases with depth below the ground surface. Groundwater in the Victor, Fair Oaks, and Laguna Formations (upper aquifer) is typically unconfined. However, due to the heterogeneous nature of the alluvial depositional system, semi-confined conditions can be encountered at shallow depths in the aquifer. The deeper Mehrten Formation (lower aquifer) typically exhibits semi-confined conditions. There are no regionally-extensive fine grained layers in the subsurface to create a regionally confined aquifer such as is observed in the San Joaquin Valley from the Corcoran Clay layer.

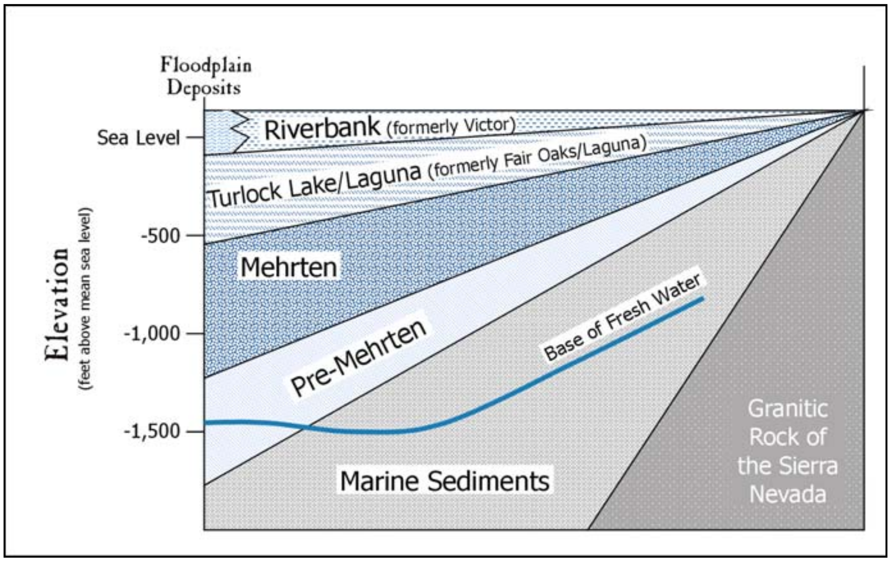


Figure 2- 6
Representative Stratigraphic Profile in the SGA Region

2.3.2. Regional and Local Groundwater Elevation in 2002

Figure 2-7 shows the interpreted groundwater elevation surface generated based on data collected by DWR and the SCWA in Spring of 2002. The map indicates that groundwater flows from a high of 120 ft above mean sea level (msl) in the east to 40 ft below msl in the central SGA area. The hydraulic gradient is steep and dips west in the eastern SGA area, but is relatively flat in the western area where it gently rises to 10 ft above msl.

The groundwater elevation surface was prepared using water elevation data from DWR's water data library available on-line at: http://wdl.water.ca.gov. The Inverse Distance to a Power gridding method was used to contour the water elevation data posted on **Figure 2-7**. This contouring method is a weighted average interpolator and is best used when there is a uniform distribution of data. With Inverse Distance to a Power, data are weighted during interpolation such that the influence of one point relative to another declines with distance from the grid node. Normally, Inverse Distance to a Power behaves as an exact interpolator. When calculating a grid node, the weights assigned to the data points are fractions, and the sum of all the weights are equal to 1.0. Following interpolation, a California Certified Hydrogeologist reviewed the interpolated surface and made adjustments to the location of contour lines as necessary to fit specific well data.

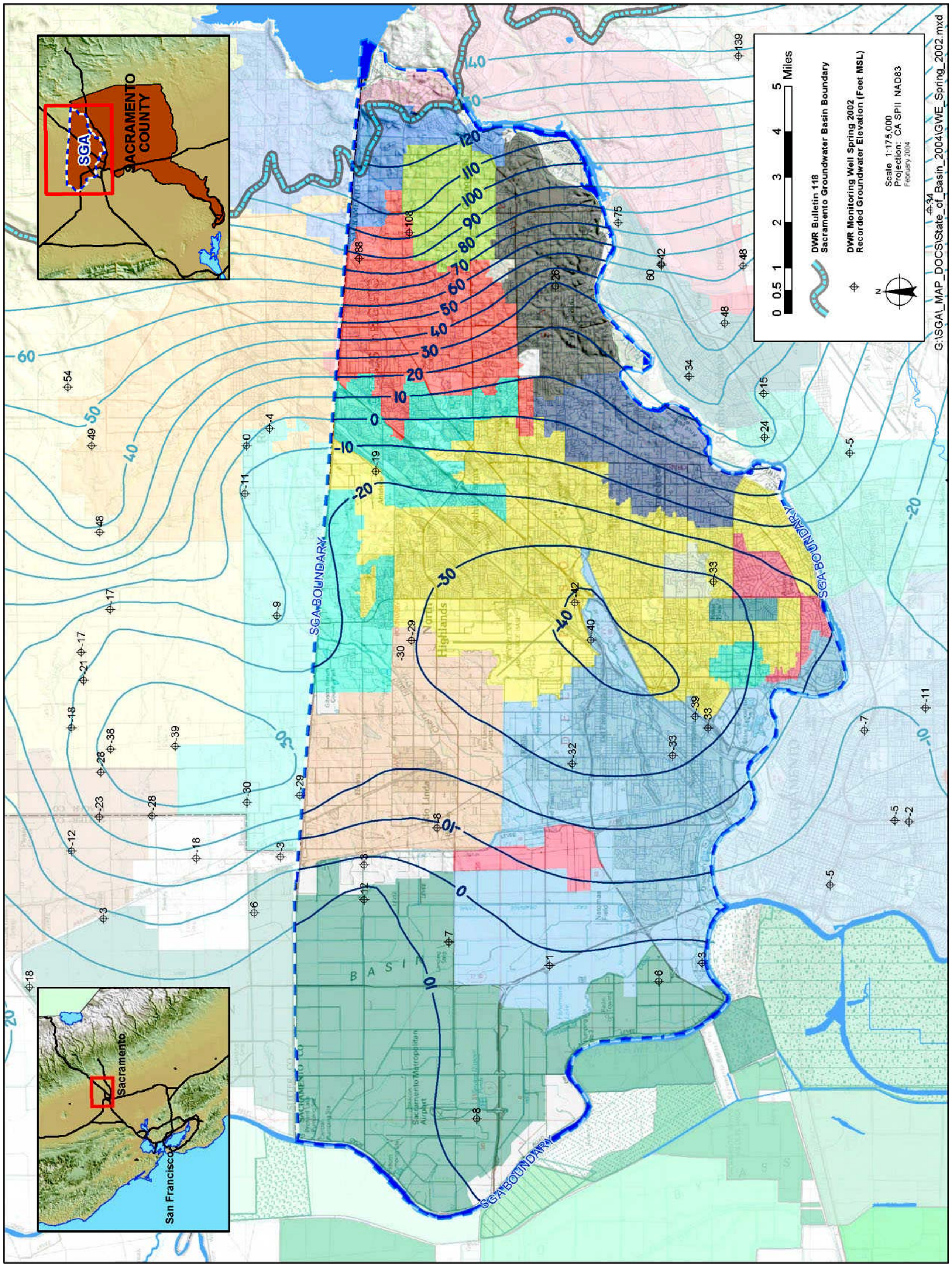


Figure 2-7 Spring 2002 Groundwater Surface Elevation in SGA Vicinity

2.3.2.1 Recharge

Groundwater in northern Sacramento County moves from sources of recharge to areas of discharge. Recharge to the local aquifer system occurs along active river and stream channels where extensive sand and gravel deposits exist, particularly in American River and Sacramento River channels. Prior to development of the area, additional recharge would have occurred along the eastern boundary of the SGA area at the transition point from consolidated rocks of the Sierra Nevada to the alluvial deposited basin sediments (**Figure 2-7**). Other sources of recharge within the area include inflow of groundwater generally from the northeast; subsurface recharge from fractured geologic formations to the east; and deep percolation from applied surface water, precipitation, and small streams. An example of recharge from deep percolation can be seen in the western SGA area where extensive agricultural operations in NCMWC have redistributed surface water from the Sacramento River over a much broader area. A portion of applied irrigation water in excess of crop demands becomes recharge water through deep percolation.

The rate of recharge from streams that are hydraulically disconnected from the groundwater surface is indifferent to changes in groundwater elevations or gradient. This is typically true with smaller streams where the groundwater surface is located far below the streambed. In such cases, surface water percolates through the unsaturated zone to the groundwater and is a function of the aquifer materials underlying the streambed and the water level in the surface stream. The rate of infiltration under these conditions is not controlled by the change in elevation of the underlying groundwater. There is also some evidence to suggest these conditions exist along the Sacramento River in northern Sacramento County.

2.3.2.2 Regional Impacts of Groundwater Extraction.

Large regional cones of depression can form in areas where multiple groundwater extraction wells are in operation. The location and shape of a regional cone of depression is influenced by the same factors as a single well. The regional cone of depression within the SGA area is shown on **Figure 2-7** . Fluctuations in regional cones of depression are measured over years and result from: (1) changes in recharge, and (2) changes in extractions from increasing and decreasing water demands. A sequence of successive dry years can decrease the amount of natural recharge to the aquifer and often a coinciding increase in groundwater extraction, creating an imbalance between natural recharge and extractions. Consequently, groundwater elevations decrease in response to this imbalance between recharge and extraction. Over time, the shape and location of the aquifer's regional cone of depression fluctuates.

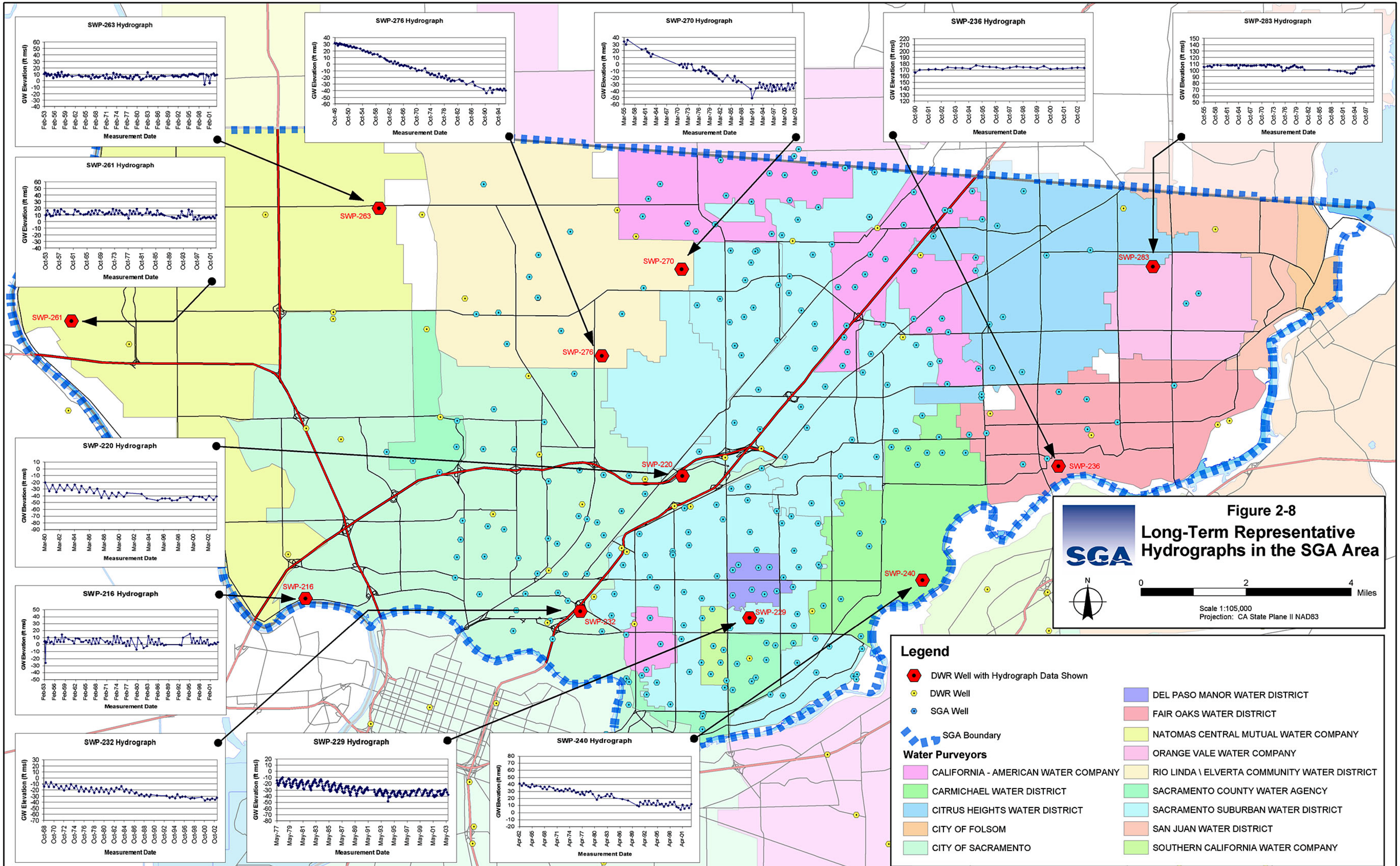
Intensive use of the groundwater basin has resulted in a general lowering of groundwater elevations near the center of the basin away from the sources of recharge. As early as 1968, pumping depressions were evident in northern Sacramento County. These depressions have grown and coalesced into a single cone of depression centered in the SGA area as shown in **Figure 2-7**.

2.3.2.3 Key Well Hydrographs

Groundwater Level Trends. To observe characteristic trends in groundwater elevation, selected well hydrographs have been prepared and are presented on **Figure 2-8.** For the purpose of this discussion, the SGA area has been divided into four sub-areas.

Western Area. The western portion of the SGA area is bounded by the Sacramento River and is relatively undeveloped compared to the rest of the SGA area. Groundwater level trends in this area can be seen in hydrographs from wells SWP-261 and SWP-216, located near the Sacramento River, and SWP-263, located near the northern SGA boundary. These locations are shown on **Figure 2-8**. Hydrographs for these wells show groundwater levels varying between -5 and 20 ft msl between wells. Long-term trends of increasing or decreasing groundwater levels are not evident in these wells, however, groundwater levels do fluctuate seasonally in each well.

North-Central Area. The north-central portion of the SGA area is bounded by the county line on the north. Water for municipal and agricultural demands in the north-central portion of the SGA area is supplied entirely by groundwater sources. Furthermore, pumping of groundwater occurs at treatment extraction wells being operated at the former McClellan Air Force Base (McClellan), which is located in the center of this region of the SGA area. The general trend in this area is steeply declining groundwater levels until the early 1990s and then stabilized levels resulting from a reduction in groundwater pumping and some use of surface water in-lieu of groundwater (beginning in 1997). For example, SWP-276 (**Figure 2-8**) shows a decline of about 17 ft per decade from 1950 to 1990 and then stabilization of groundwater elevation at approximately 40 ft below msl to the end of the record in 1996. Water level trends in SWP-270 show the same decline from 1955 to 1990 followed by stabilized levels (with seasonal fluctuation) at 40 feet below msl from 1990 to the present.



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South-Central Area. The south-central portion of the SGA area is bordered to the south by the American River and is supplied by approximately even proportions of surface water and groundwater. The general trend in this area is gently to moderately declining groundwater levels over time **(Figure 2-8)**. Water level trends in this area can be seen in hydrographs from wells SWP-232 and SWP-240 (located near the river), SWP-220 (located south of McClellan and away from the American River), and SWP-229 (located approximately 2 miles north of the American River). The hydrograph from well SWP-232 shows approximately 20 ft of groundwater elevation decrease over a 34-year period ending 2002.

Eastern Area. Foothills bound the eastern portion of the SGA area. The eastern portion of the SGA area has experienced rapid residential growth in recent years and extends into the Sierra Nevada foothills. The water supply in this area is approximately 80 percent from surface water sources and 20 percent from groundwater sources. The general trend in this area is stable groundwater elevations near the American River and generally higher groundwater elevations in the foothills. Groundwater levels typically decline away from the river and west of the foothills. Water level trends in this area can be seen in hydrographs from wells SWP-236 (located near the River), and SWP-283 (located high in the foothills). The hydrographs for these wells show stable groundwater levels near the river and in the foothills.

2.3.2.4 Analysis of Nested Well Data

Water level data from nested wells was compiled and analyzed to determine the vertical gradients at selected locations within the SGA. Vertical gradients provide an improved understanding of recharge and discharge areas and compartmentalization within the groundwater aquifer. Gradients are in important parameter in calculating the direction and rate of groundwater movement. Another governing parameter in the calculation is aquifer permeability. This section addresses gradients, but information on field measured aquifer permeability was not available from member agencies for entry into the DMS.

Figure 2-9 shows the locations of the six nested wells described below. These wells are discretely screened allowing for comparison of water levels from multiple depths within the aquifer.

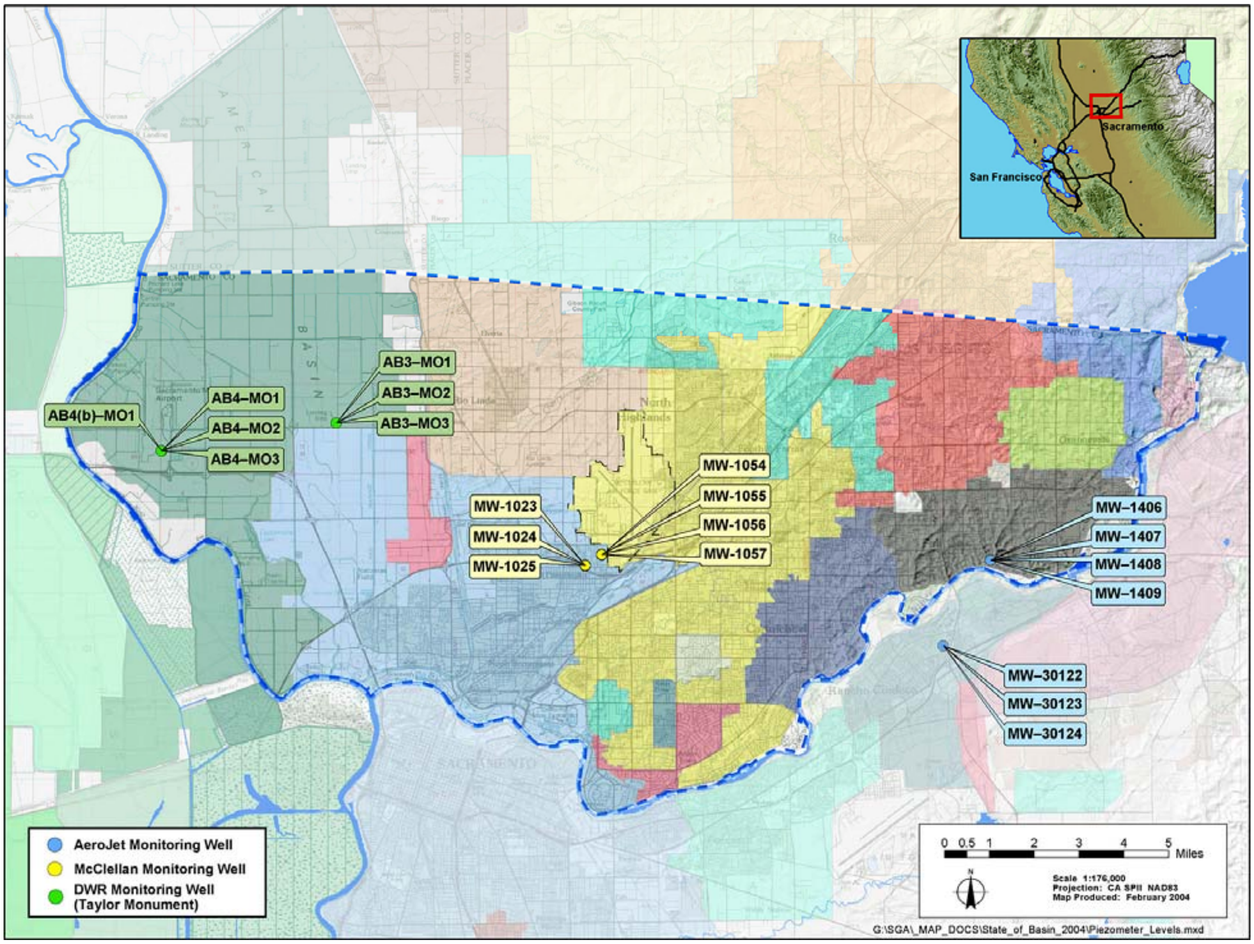

Figure 2-9
Locations of Selected Nested Wells in SGA Vicinity

Time series hydrographs of nested wells at three locations yield information regarding vertical gradients and seasonal fluctuations in water level elevation. On the eastern boundary of the SGA near the Aerojet facility and the American River, water levels have declined with time from 1985 through 2002 **(Figure 2-10)**. Water level elevations recorded in July and October of 2002 were especially low compared to previous trends but recovered by April of 2003. In wells 1406 through 1409, the deepest well has the lowest water level elevation (downward gradient) with water levels in the two shallow wells approximately 5 to 10 ft higher. Water levels for these Aerojet wells were obtained from the Regional Water Quality Control Board (RWQCB) (e-mail communication from Alex McDonald on 2/9/04).

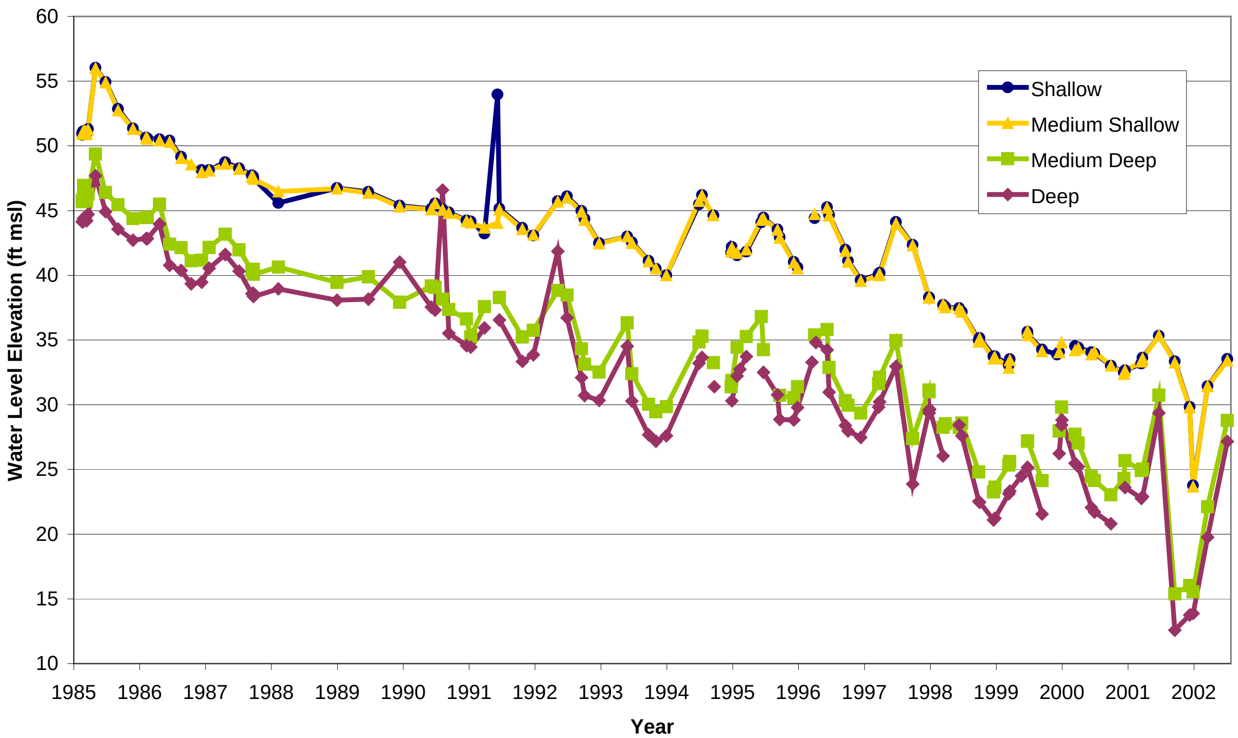

Figure 2-10
Water Level Elevations in Nested Aerojet Wells 1406 –1409

In the western part of the SGA area there are two nested wells installed and monitored by DWR, AB3 and AB4. Time series data from these wells show similar trends where water level elevation decreases with depth of well indicative of a downward gradient **(Figures 2-11 and 2-12)**. Seasonal fluctuations in water level elevation can also be observed in these wells with elevated levels in the winter months, peaking in March and April, compared to the summer months with lows in August and September.

Vertical gradients were calculated for the six sets of nested wells in the SGA vicinity. These results are tabulated in **Table 2-2**. Most other vertical gradients are downward, with a maximum of -0.0621 between AB3-MO1 and AB3-MO3 and a minimum of –0.0066 between MW-1023 and MW-1025. This downward trend is expected for semi-confined aquifer systems such as the SGA. These data indicate the potential for water to gradually flow downward in the aquifer system from shallow areas of recharge to deeper pumping zones. Downward gradients at the Aerojet wells support the understanding that surface water from the American River is likely recharging the aquifer in this area.

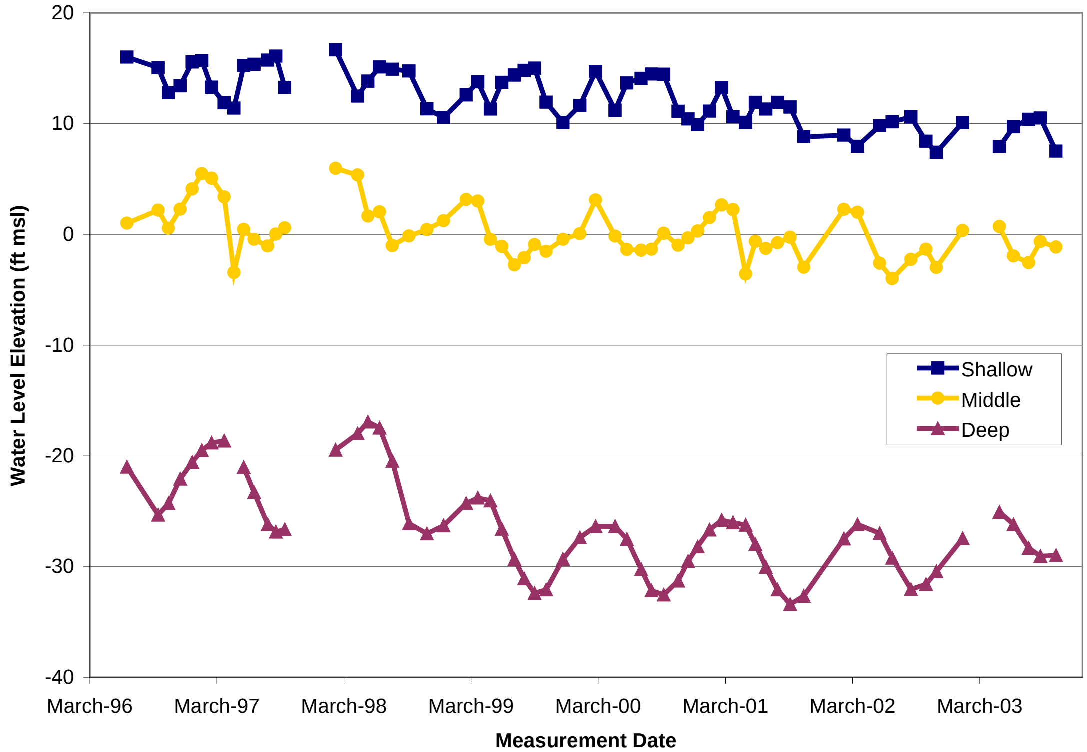

Figure 2-11
Water Level Elevations in Nested Well AB3

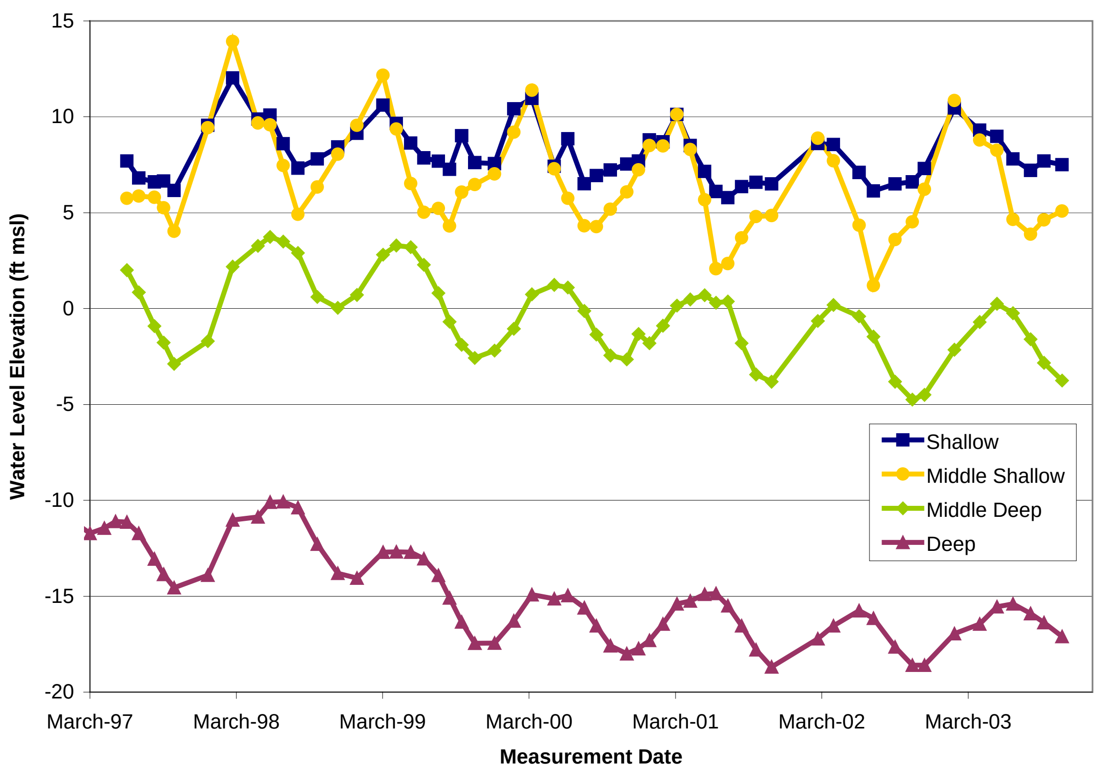

Figure 2-12
Water Level Elevations in Nested Well AB4

Monitoring wells MW-1054 through MW-1057 located on the former McClellan AFB have a gradient of 0.0183 upward from the deepest to most shallow well. This upward gradient implies that groundwater has the potential to rise from deeper zones to more shallow zones within the aquifer if the confining layers are penetrated with wells or soil borings. The actual upward movement of water may be very slow given the very low permeability of the silts and clays creating the confinement between these zones.

Table 2-2
Water Levels and Vertical Gradients in Nested Wells

Well ID	Measuring Point Elevation	Total Well Depth	Top of Screen Elevation	Bottom of Screen Elevation	April 2002 Water Level Elevation	Water Level Gradient	Gradient Flow Direction	Water Level Gradient	Gradient Flow Direction
	feet amsl	feet	feet amsl	feet amsl	feet amsl	-	-	-	-
1406	102.75	401	7.75	-2.25	33.97				
						0.0020	upward		
1407	102.75	401	-47.25	-57.25	34.08				
						-0.0733	downward	-0.0485	downward
1408	102.75	401	-177.25	-198.25	24.15				
						-0.0390	downward		
1409	102.75	401	-245.25	-255.25	21.71				
30122	108.02	400	-122.98	-134.98	25.66				
						-0.0037	downward		
30123	108.02	400	-184.98	-198.98	25.43			-0.0083	downward
						-0.0158	downward		
30124	108.02	400	-222.98	-240.98	24.8				
MW-1054	54.95	122.95	-58	-68	-46.37				
						0.0098	upward		
MW-1055	55.58	182.78	-117.2	-127.2	-45.79				
						0.0057	upward	0.0183	upward
MW-1056	55.3	268.5	-203.2	-213.2	-45.3				
						0.0474	upward		
MW-1057	55.22	322.62	-257.4	-267.4	-42.73				
MW-1023	51.81	115.35	-53.54	-63.54	-46.68				
						-0.0107	downward		
MW-1024	52.02	145.48	-83.46	-93.46	-47			-0.0066	downward
						-0.0040	downward		
MW-1025	52.91	195.76	-132.85	-142.85	-47.2				
AB3-MO1	27	210	190	210	7.95				
						-0.0213	downward		
AB3-MO2	27	490	470	490	2			-0.0621	downward
						-0.1044	downward		
AB3-MO3	27	985	745/975	755/985	-26.2				
AB4-MO1	17	190	170	190	8.55				
						-0.0040	downward		
AB4-MO2	17	400	380	400	7.7				
						-0.0183	downward	-0.0284	downward
AB4-MO3	17	805	795	805	0.18				
						-0.0631	downward		
AB4-MO4	17	1070	1060	1070	-16.55				

2.3.3. Groundwater Quality Summary

This description of background water quality is based on data used to populate the DMS. Available groundwater quality data from 262 wells between 1984 and 2002 were used to populate the DMS. All samples were collected in wells with total depths ranging from 180 to 645 feet bgs. The DMS was used to query data and develop statistics and graphics for the constituents included in this evaluation. Evaluations were performed for constituents of primary concern related to aesthetics, regulatory impacts, and contaminant plumes. **Table 2-3** summarizes the general water quality constituents described in detail below.

Table 2-3
Groundwater Quality Summary for Select Constituents

Constituent	Minimum Concentration[a]	Maximum Concentration	Maximum Contaminant Levels (MCL)
Total Dissolved Solids (TDS)	34 mg/L	657 mg/L	500 mg/L [b]
Iron	<10 µg/L	16,000 µg/L	300 µg/L
Manganese	<2 µg/L	1,700 µg/L	50 µg/L
Arsenic	<1 µg/L	22 µg/L	10 µg/L [c]
Total Chromium	<1 µg/L	52 µg/L	50 µg/L
Nitrate (as NO_3)	<15 mg/L	45 mg/L	45 mg/L

[a] Numbers displayed to the right of the "<" symbol are method reporting limits. Constituents may be present in water and even detected with the laboratory methods used, however concentrations below these values cannot be quantified.

[b] Recommended MCL for TDS is 500 mg/L, Upper end MCL for TDS is 1,000 mg/L, and Short Term MCL for TDS is 1,500 mg/L (Source: California Code of Regulations Title 22, Division 4 June 23, 1995).

[c] Currently the Primary federal MCL for Arsenic is 10 µg/L, however compliance is not yet required in California below 50 µg/L.

µg/L – micrograms per liter

mg/L – milligrams per liter

2.3.3.1 Total Dissolved Solids

Total dissolved solids (TDS) is the measurement of minerals in water and is derived from contact with rock and soil. This constituent is conservative (no loss of energy) over time for a given water source and can be found at varying levels in groundwater. Currently, there is a secondary maximum contaminant level (MCL) for TDS recommending levels below 500 milligrams per liter (mg/L).

TDS results from samples collected in most wells between 1984 and 2002 are within the secondary drinking water standard; therefore, TDS will not limit the potable use of groundwater by the overlying agencies. The TDS levels vary quite significantly throughout the GSA portion of the basin, ranging from 34 to 657 mg/L, although most wells have levels between 140 and 320 mg/L. There is an upper limit set at 1,000 mg/L and a short-term limit set at 1,500 mg/L.

Figure 2-13 shows TDS concentration trends (symbol color) with well depth (symbol size increases with depth) from samples collected after January 2000. The highest levels of TDS are observed in shallow to medium depth wells (approximately 0 to 400 feet below ground surface) in Citrus Heights, North Highlands, and East Natomas, and deeper wells (greater than 400 feet bgs) in the Arcade area near the American River.

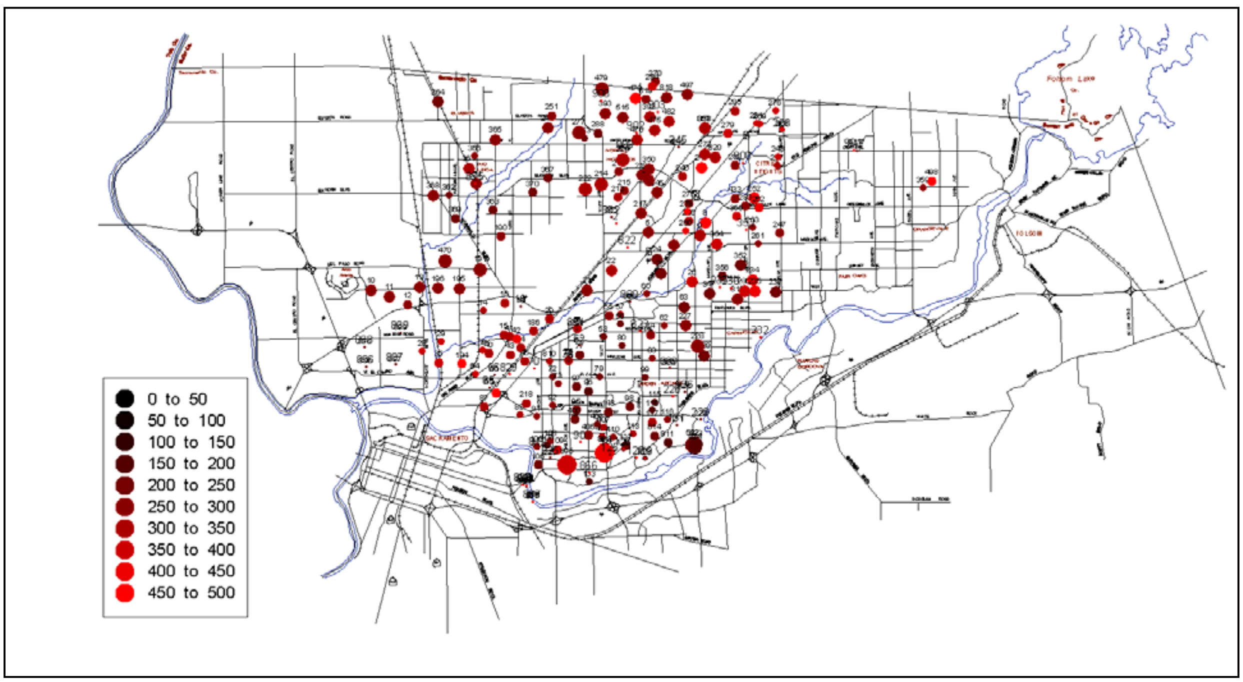

Figure 2-13
TDS Concentrations (mg/L) in SGA Area (2000-2002)

2.3.3.2 Iron

Iron is an element that occurs naturally in the earth's crust. It is found in groundwater as a metallic ion. It can be elevated in some wells and impart taste concerns. Iron is generally soluble in natural waters, but when oxidized can precipitate into a visible, red-brown solid particle.

Within the SGA region, 1984 through 2002 sample analysis results for iron can range from non-detect, less than 10 micrograms per liter (μg/L), to very high levels such as 16,000 μg/L. Most wells have average values less than 200 μg/L. Currently there is a secondary MCL for iron of 300 micrograms per liter (μg/L).

Figure 2-14 shows high iron concentrations at medium depth wells near the center of the SGA region. Samples included were collected between January 2000 and February 2003.

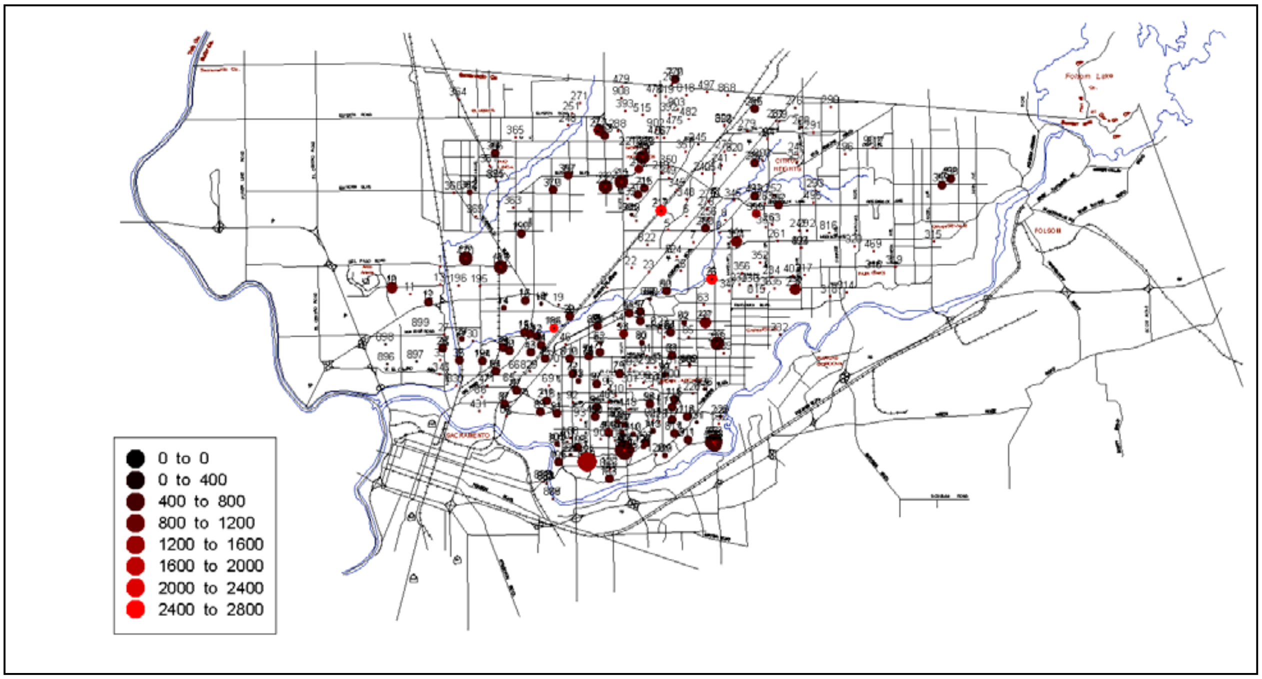

Figure 2-14
Iron Concentrations (μg/L) in SGA Area (2000-2002)

2.3.3.3 Manganese

Manganese is an element that occurs naturally in the earth's crust. Its is found in groundwater as a metallic ion. It can be in elevated levels in some wells and impart taste concerns. Manganese is generally soluble in natural waters, but when oxidized can precipitate into a visible, black solid particle.

Manganese concentrations measured from 1984 through 2002 range from non-detectable, less than 2 μg/L, to 1,700 μg/L, although most wells have average values less than 50 μg/L. Currently, there is a secondary MCL for manganese of 50 μg/L.

Elevated levels of Manganese are observed in shallow wells located throughout the region sampled after January of 2000 **(Figure 2-15)**. Moderate concentrations exist in medium depth wells near Carmichael.

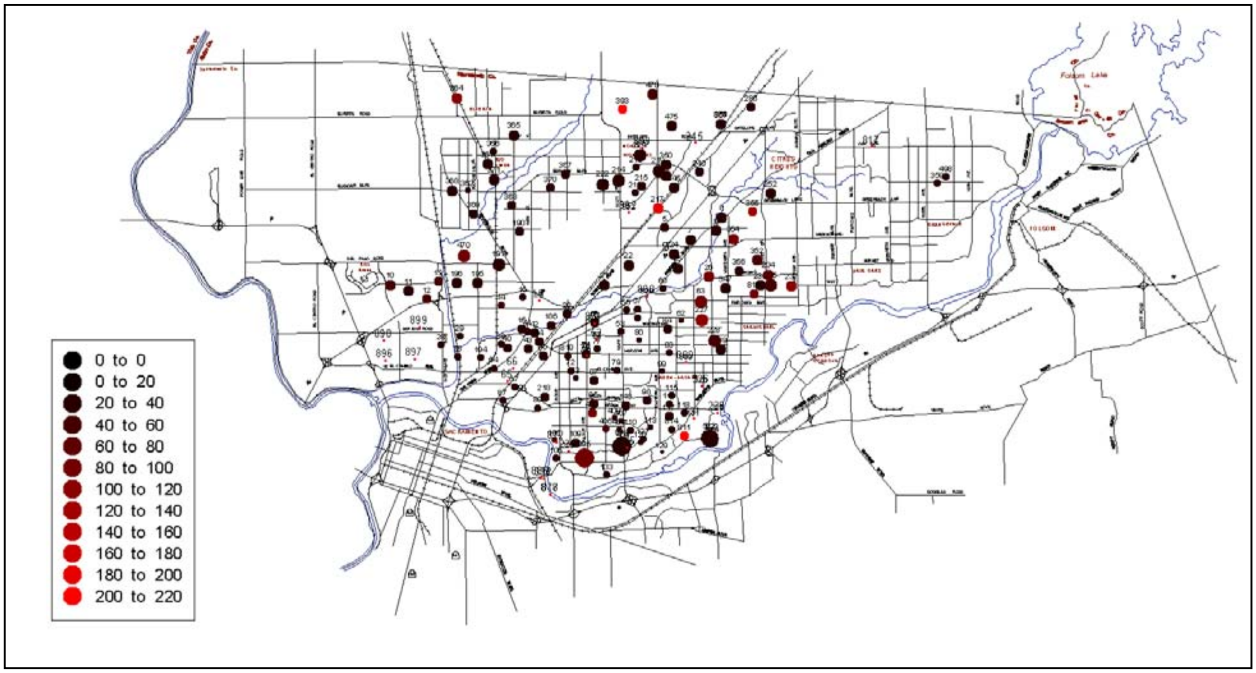

Figure 2-15
Manganese Concentrations (μg/L) in SGA Area (2000-2002)

2.3.3.4 Arsenic

Arsenic is an element that occurs naturally in the earth's crust. It occurs in groundwater as a result of contact with naturally occurring deposits. There are also industrial sources including semiconductor manufacturing, petroleum refining, wood preservatives, animal feed additives, and herbicides. Currently, there is a primary federal MCL for arsenic of 10 μg/L, however compliance is not yet required in California below 50 μg/L. This may be reduced by the California Department of Health Services (DHS) in 2004.

Between 1984 and 2000 only 37 SGA wells had historical arsenic concentrations greater than 3 μg/L, with 14 of these wells having concentrations greater than 5 μg/L and two of these wells having concentrations greater than 10 μg/L.

Elevated arsenic levels are present in wells sampled from 2000 through 2002 in Rio Linda **(Figure 2-16)**. Depths of these wells vary from shallow to deep.

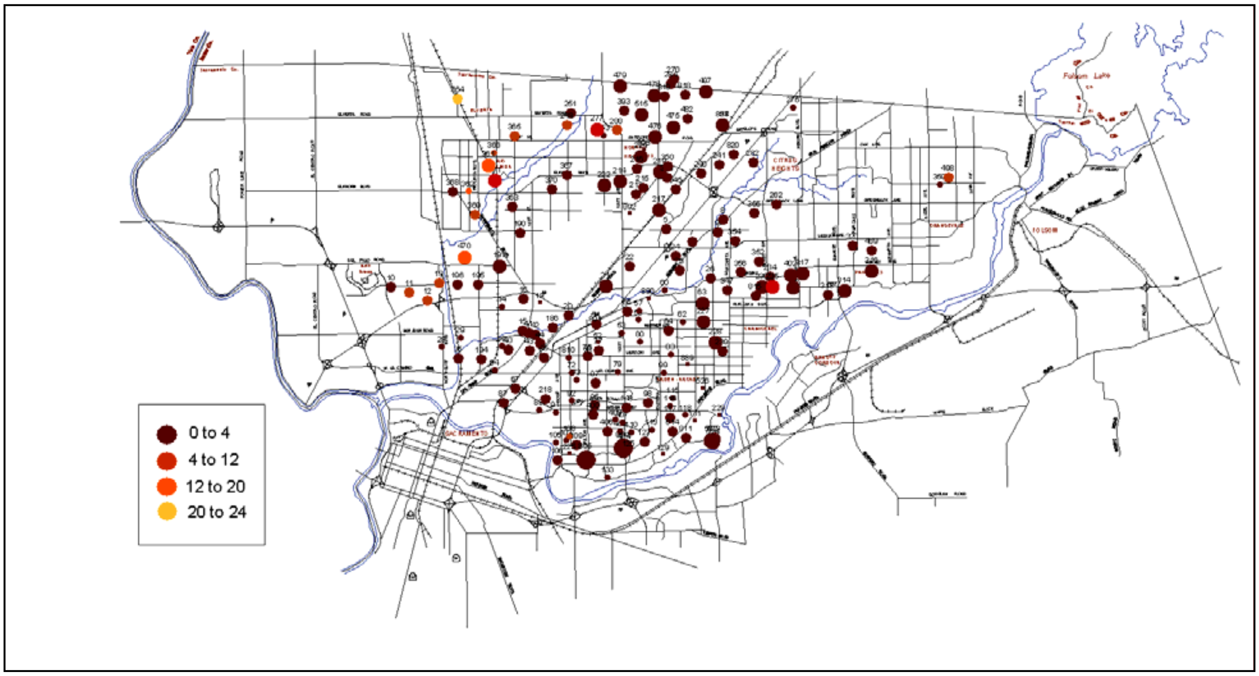

Figure 2-16
Arsenic Concentrations (μg/L) in SGA Area (2000-2002)

2.3.3.5 Total Chromium

Chromium is a naturally occurring element, the 11th most common in the earth's crust. It occurs in groundwater as a result of contact with naturally occurring deposits. Chromium is also an inorganic chemical that is used in many industrial processes including electroplating, wood treatment, pigments manufacture and cooling tower treatment for corrosion control. The two most common species of chromium are chromium III, an essential dietary nutrient, and hexavalent chromium (chromium VI), which can be toxic. The total chromium analysis detects the combined concentration of all chromium species (including chromium VI) present in the sample. Hexavalent chromium can constitute anywhere from 7% to 80% of the total chromium found in drinking water supplies.

Between the years 1984 and 2003, total chromium concentrations ranged from non-detectable, less than 1 μg/L, to 52 μg/L, although most wells ranged between 8 and 12 μg/L. Currently, total chromium has a primary MCL of 50 μg/L.

Elevated levels of chromium are observed in medium depth wells in Fair Oaks in samples collected between 2000 and 2003 **(Figure 2-17)**. Moderate concentrations of Chromium are observed in shallow wells throughout the SGA region.

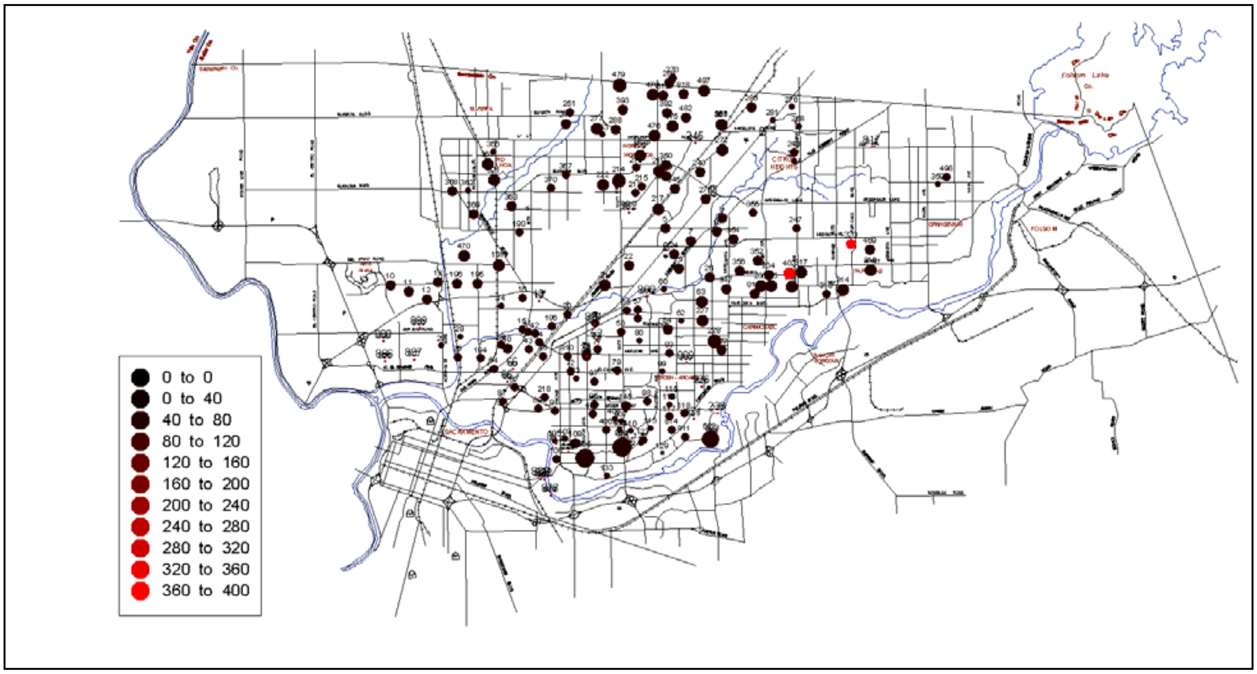

Figure 2-17
Chromium Concentrations (μg/L) in SGA Area (2000-2002)

2.3.3.6 Nitrate

Nitrate is one of the major ions in water. This nutrient is essential for plant growth. High levels of nitrate can cause adverse health effects such as methemoglobinemia and the formation of nitrosamines. This constituent can be high in groundwater supplies and sources of elevated nitrate concentrations include wastewater, urban runoff, and agricultural activities.

All wells measured between 1984 and March 2003 are within the current primary nitrate drinking water standard and nitrate will not limit the potable use of groundwater by the overlying agencies. Currently, nitrate has a primary MCL of 45 mg/L as nitrate.

Elevated nitrate concentrations (30 to 35 mg/L) are observed in samples collected between 2000 and 2002 in medium depth wells near Fair Oaks and Citrus Heights **(Figure 2-18)**. High concentrations are also detected in medium depth wells in the south-central area of the SGA region. Medium and deep wells near Rio Linda contain lower levels of nitrate than those previously mentioned.

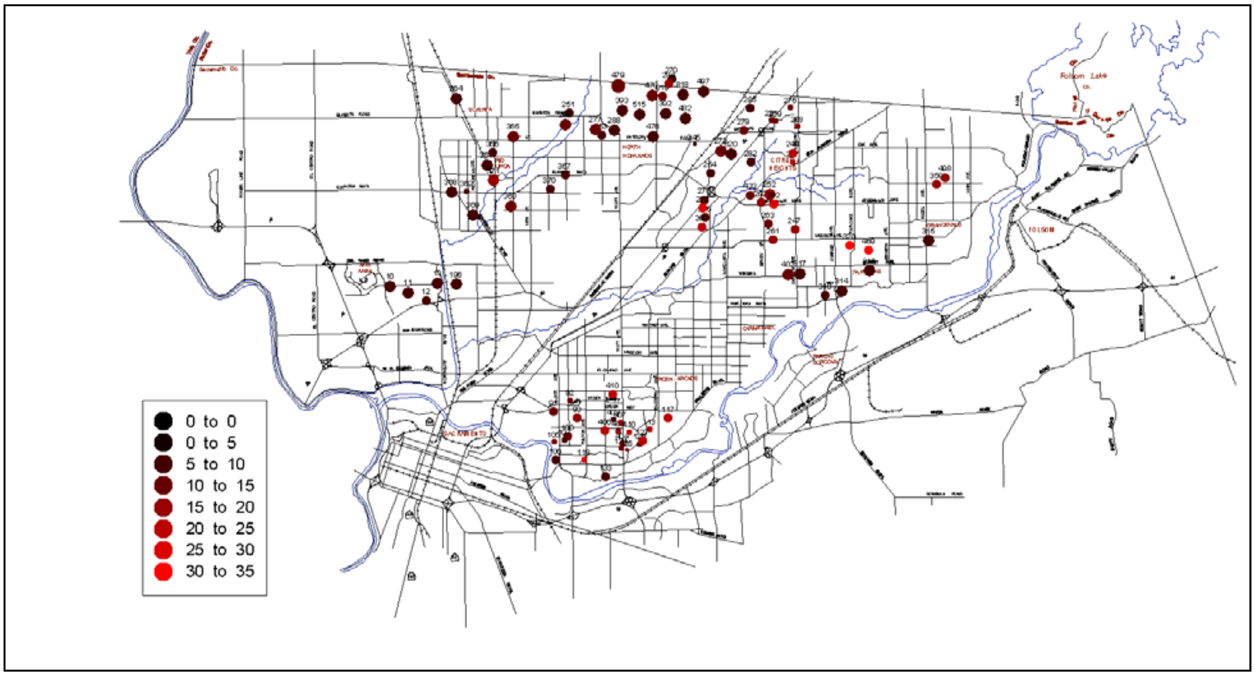

Figure 2-18
Nitrate Concentrations (mg/L) in SGA Area (2000-2002)

2.3.3.7 Spatial Geochemical Analysis

General chemistry trends of individual wells can be compared with each other by using stiff plots. Stiff plots are a graphical representation of four anions (chloride, bicarbonate, carbonate, and sulfate) and four cations (sodium, potassium, calcium, and magnesium) (see example stiff diagram in **Figure 2-19)**. Units are typically displayed in meq/L. Shape and size of each plot help characterize the water sample from that well.

Several stiff diagrams were produced in an attempt to show vertical and horizontal trends in water quality throughout the SGA region. Vertical trends are shown near the American River in samples collected from three different screen intervals: 126 to 163 feet below ground surface (bgs), 230 to 630 feet bgs, and 320 to 875 feet bgs. A stiff plot representing American River water was collected at Fair Oaks. In **Figure 2-19**, it is observed that concentrations become greater for each constituent as depth increases. The general shape of each stiff plot remains consistent.

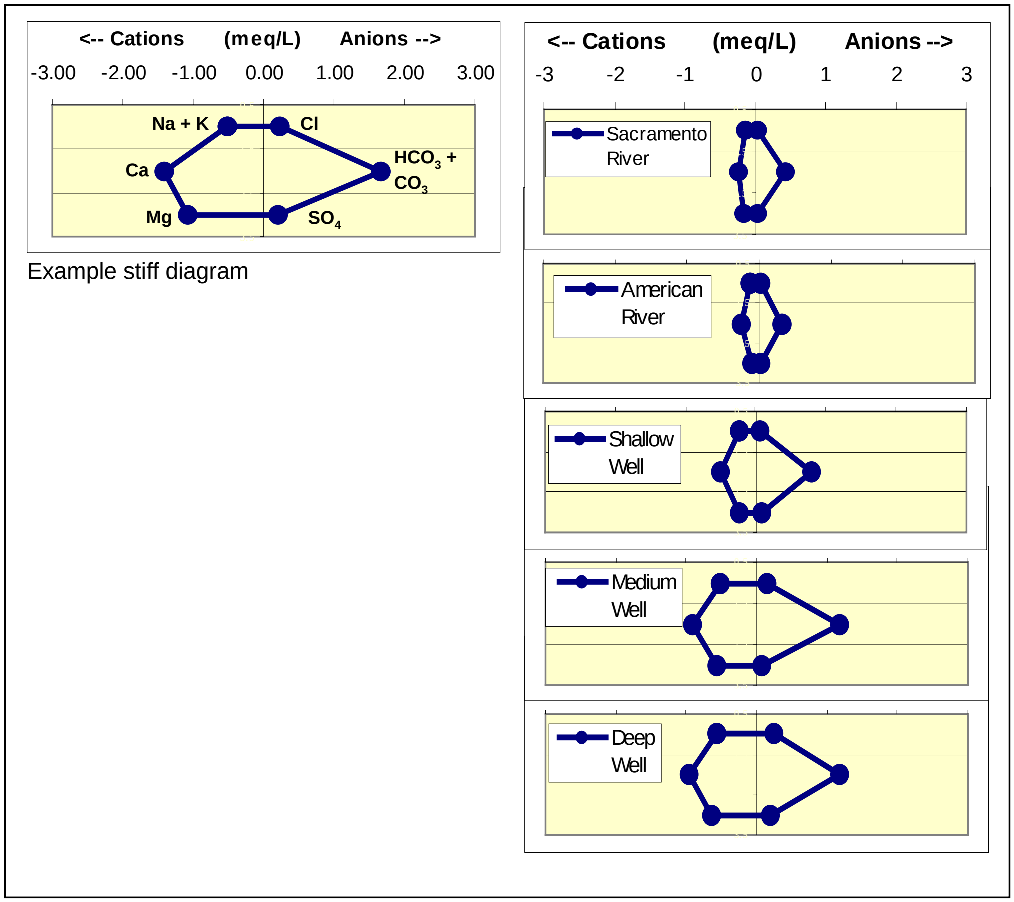

Figure 2-19
Vertical Chemical Profiling Near the American River at Fair Oaks

In **Figure 2-20,** similar stiff plot shapes are observed in three separate regions of the SGA. To the east are samples elevated in magnesium, calcium, and bicarbonate. In the central region of the SGA, samples display less variation in concentration between constituents. To the west, samples show elevated levels of sodium and potassium. All samples show elevated levels of bicarbonate relative to the other constituents. All samples displayed in **Figure 2-20** were taken from wells screened greater than 128 feet bgs and less than 493 feet bgs.

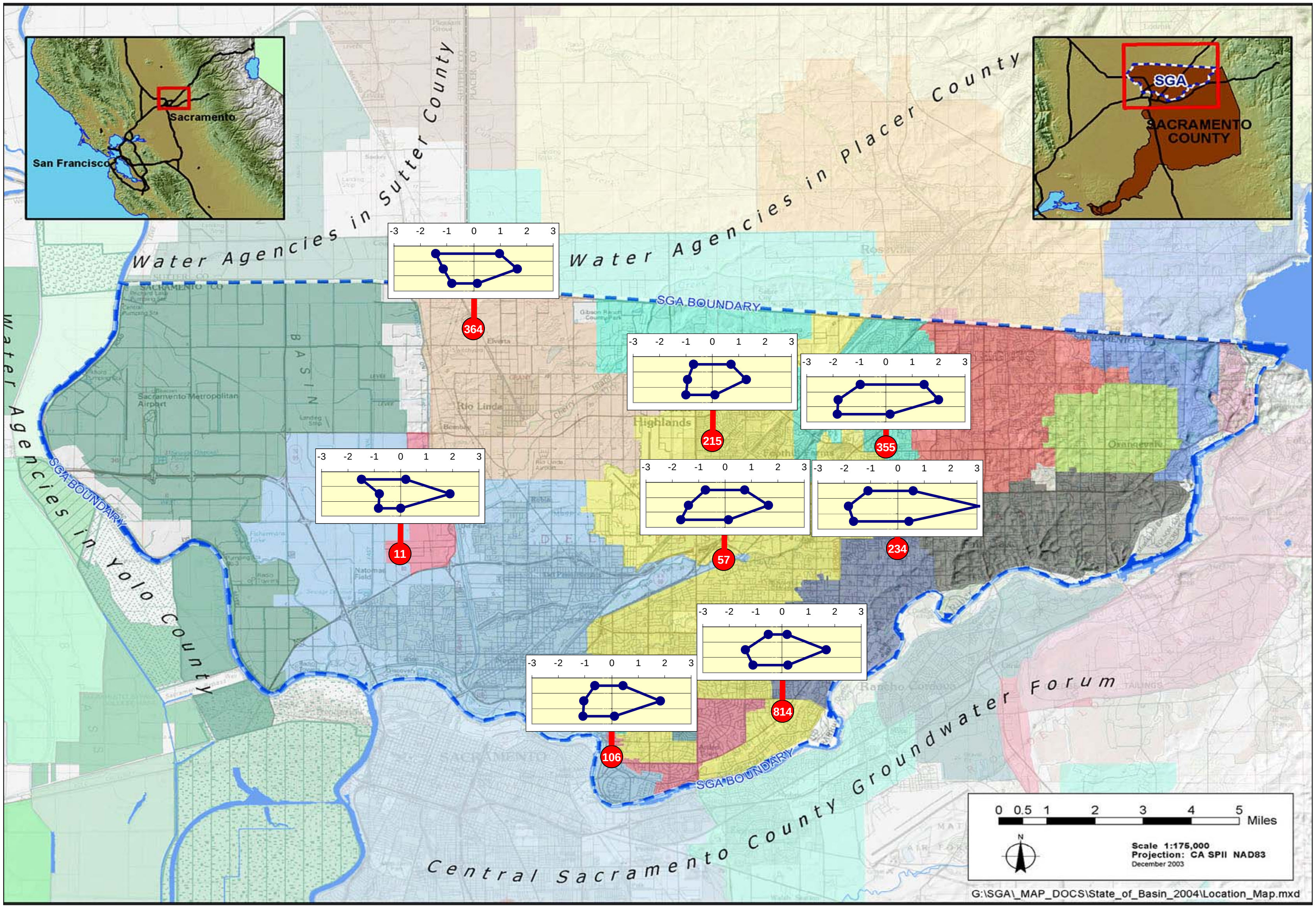

Figure 2-20 Stiff Plot Graphs of Wells Within the SGA Area

2.3.3.8 Volatile Organic Compounds

Trichloroethylene (TCE) is used as a solvent, metal degreaser, dry-cleaning agent, and in refrigerants and fumigants. Generally, Volatile Organic Compounds (VOCs), such as TCE, are not water soluble and are only present in wells associated with a groundwater contamination activity. Currently, there is a primary MCL for TCE of 5 μg/L. There are no detectable levels of TCE populated in the DMS at this time.

Perchloroethylene (PCE) is used as a solvent, a heat transfer agent, and in the manufacture of fluorocarbons. Generally, VOCs, such as PCE, are not water-soluble and are only present in wells associated with a groundwater contamination activity.

PCE is absent from most wells within the SGA. Only four of the populated SGA wells had detectable levels of PCE. The wells with elevated detectable levels of PCE ranged from 0.5 to 3.2 μg/L. These wells are located in the south-central and eastern portions of SGA and are screened in the lower aquifer or across both aquifers. These detectable levels are not associated with the major contaminant plumes. It is likely that contamination is coming from a local activity, such as a leaking tank, pipeline or other illegal discharges.

Using data that is available in the DMS, it appears that most SGA wells are within the current primary drinking water standard and PCE will not be a limiting factor across the basin. It would be prudent to continue to monitor the detected wells to track movement or migration of the local contaminant plumes.

2.3.3.9 Distribution of Known Contaminant Plumes in Vicinity of SGA

Principal groundwater contaminant plumes within or near the SGA area are known to exist from source areas at the former McClellan Air Force Base, the former Mather AFB (Mather), and Aerojet and are shown on **Figure 2-21**. During Phase II development of the DMS, contaminant plume data were collected by SGA from the following documents:

- URS. Former McClellan AFB, Installation Restoration Program, Groundwater Monitoring Program: Quarterly Report, Third Quarter 2002. January 2003.
- MWH Harza (MWH). Mather AFB Annual and Fourth Quarter 2002 Sitewide Groundwater Monitoring Report. March 2003.

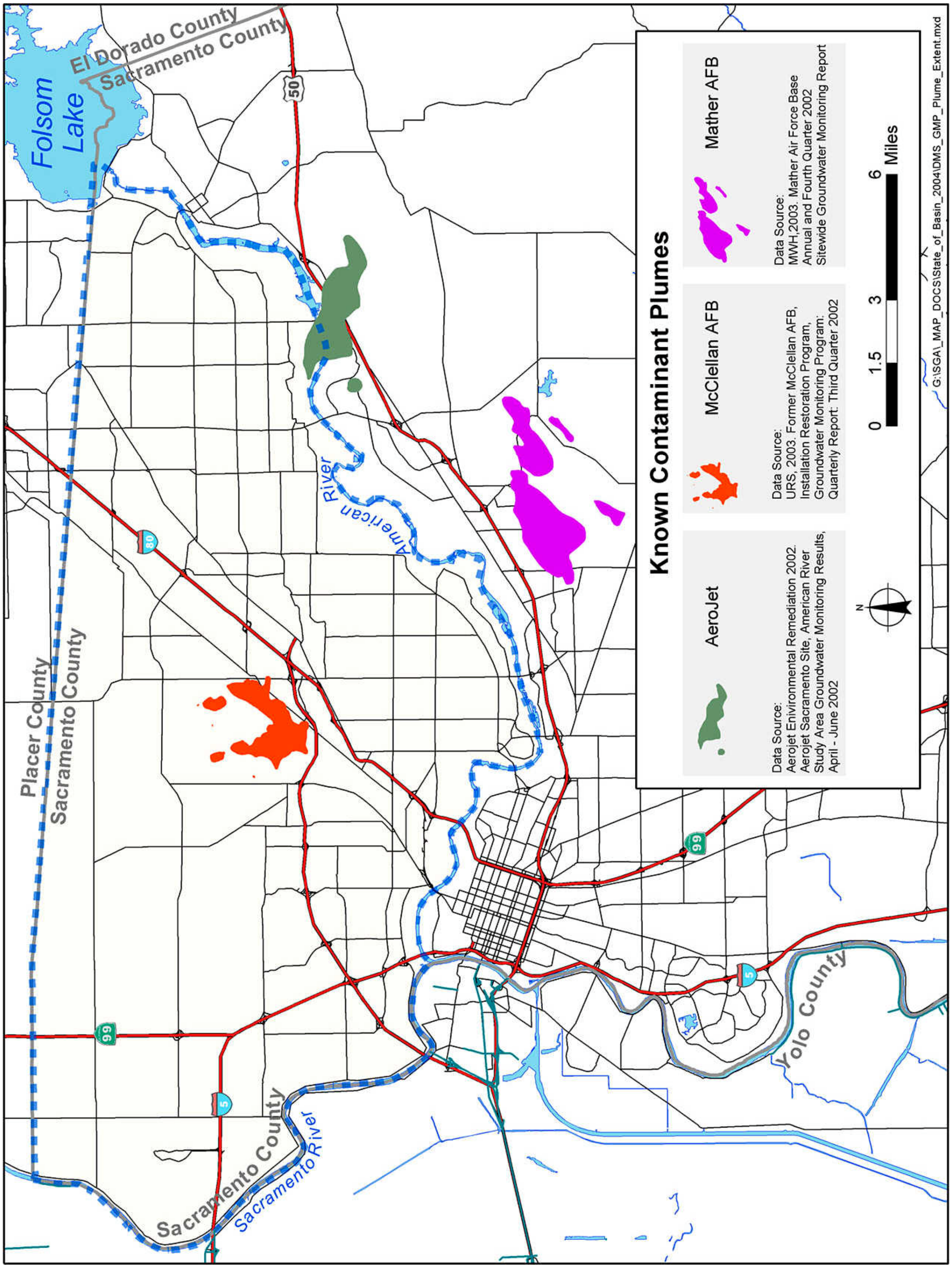

Figure 2-21 Principal Contaminant Plumes

- Aerojet Environmental Remediation. Aerojet Sacramento Site, American River Study Area Groundwater Monitoring Results, April – June 2002. August 2002.

Although other localized plumes exist within the SGA area, the principal plumes shown in **Figure 2-21** are the largest and have the greatest current impact on existing groundwater use. For the McClellan plumes, the primary contaminants of concern (COC) are trichloroethene (TCE), tetrachloroethene (PCE), cis-1,2-dichloroethene (DCE), and 1,2-dichloroethane (DCA). A brief explanation of each of the plumes shown on **Figure 2-21** follows:

- The McClellan plume boundary represents the California drinking water MCL of 5 μg/L TCE, the most extensive contaminant.
- The primary COCs in the Mather plume are TCE, PCE, and carbon tetrachloride. The Mather plume boundary represents a composite COC concentration of 0.5 μg/L, which is one-tenth of the MCL for these constituents.
- The primary COCs within the Aerojet plume are TCE and perchlorate. The Aerojet plume boundary represents a concentration of 5 μg/L TCE, the most extensive contaminant.

The plume boundaries have been digitized and entered into the DMS.

2.3.3.10 Leaking Underground Storage Tank Sites in Vicinity of SGA

Figure 2-22 shows the locations of active leaky underground storage tank (LUST) sites in vicinity of the SGA in 2002. The locations of these sites were obtained from the State Water Resources Control Board (source: http://geotracker.swrcb.ca.gov). There are currently about 190 active LUST sites within the SGA area. While many sites can be fully remediated, the aggregate impact from undetected contamination on groundwater quality in the basin cannot be determined at this time and may ultimately be considerable.

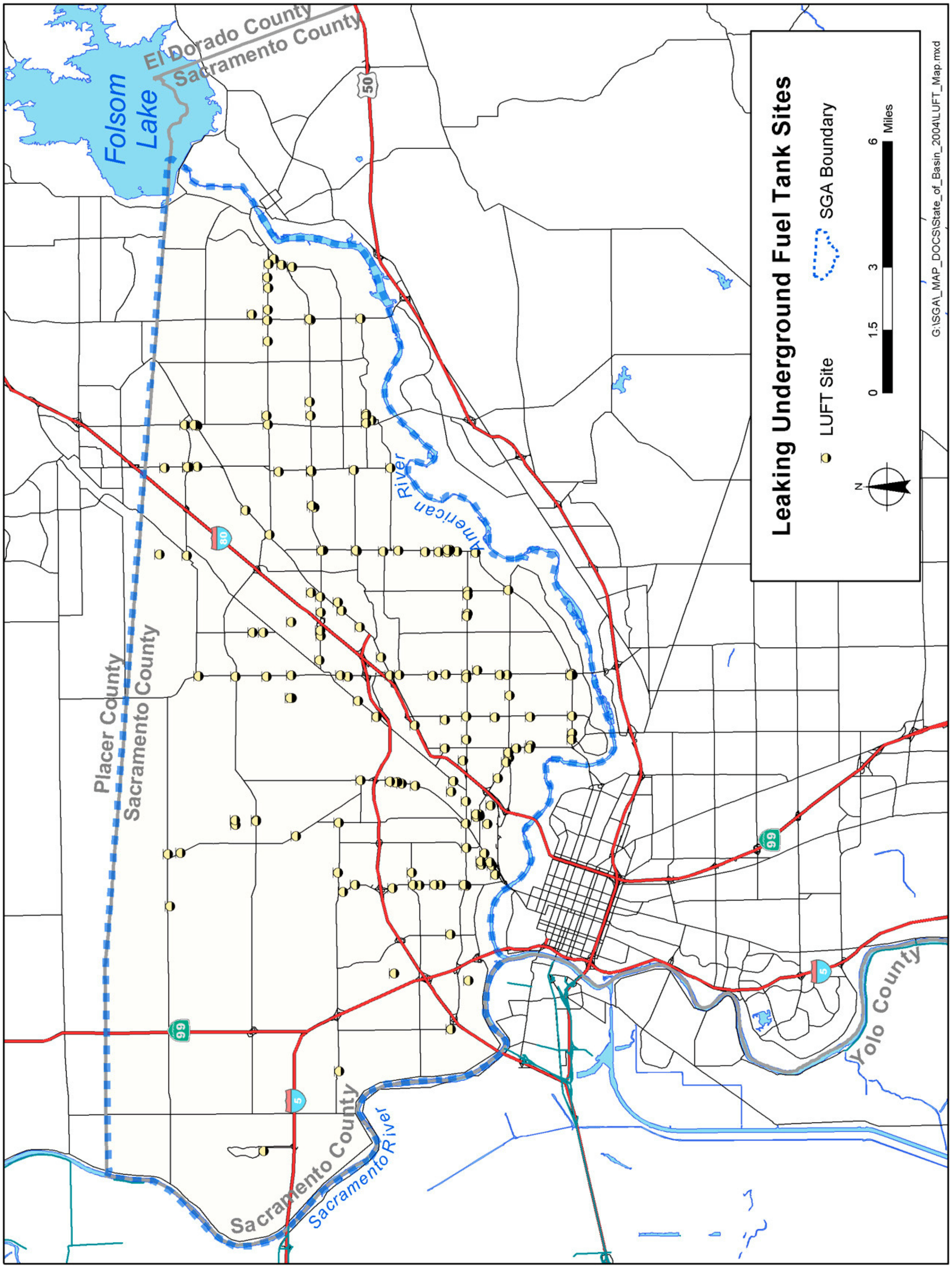

Figure 2-22 Locations of Leaking Underground Storage Tanks in the SGA Area

2.3.4. Water Production in 2002

Recent (year 2002) surface water and groundwater use by the member agencies within the SGA boundaries are shown in **Table 2-4** and on **Figure 2-23**.

Table 2-4
Year 2002 and Projected 2030 Water Supply Scenarios for Member Agencies within SGA Boundaries

Water Purveyor	2002 Water Supply Scenario: Annual Demands [1] (AF/year)	2002 Water Supply Scenario: Water Supply Mix, Surface Water/Supplemental Supply[1], [2] (AF/year)
Area "D" Agencies (within Sacramento's POU, north of American River) [3]:		
Cal-Am – Arden Service Area	-- [4]	-- [4]
Southern California Water Company – Arden Park Vista Service Area	-- [4]	-- [4]
Del Paso Manor Water District	1,692	0 / 1,692
Sac Suburban – Arcade Service Area (Town & Country Sub-area)	-- [4]	-- [4]
Southern California Water Company – Arden Town Service Area	1,317	0 / 1,317
Carmichael Water District	13,280	9,507 / 3,773
Folsom – north of American River only	1,149	1,149 / 0
Sacramento – north of American River only	51,732	26,734 / 24,998 [5]
Natomas Central Mutual Water Company	88,028 [6]	88,028 / 0 [6]
Sac Suburban and others within PCWA transfer water supply POU in Sacramento County:		
Cal-Am – Royal Oaks/Lincoln Oaks Service Areas	19,867 [4]	0 / 19,867 [4]
Rio Linda/Elverta Community Water District	3,367	0 / 3,367
Sac Suburban:		
Arcade Service Area, North Highlands Sub-area	22,711 [4]	0 / 22,711 [4]
Northridge Service Area	18,640	16,938 / 1,702 [5]
McClellan	-- [7]	-- [7]
Sacramento International Airport	-- [8]	-- [8]
Sacramento County Water Agency – Northgate Service Area	5,279 [4]	0 / 5,279 [4]
San Juan Water District and consortium in Sacramento County		
Citrus Heights Water District	19,913	17,617 / 2,296 [5]
Fair Oaks Water District	14,067	11,456 / 2,611 [5]
Orange Vale Water Company	4,377	4,377 / 0
San Juan Water District	4,661	4,661 / 0
Individual representatives from agriculture and self-supplied groundwater users	-- [8]	-- [8]

NOTES:
[1] Surface water/supplemental water supply mixes from SGA DMS – year 2002 values as reported by individual member agencies. Year 2002 water demands based on surface water/supplemental water supply mixes (assumes no shortages).
[2] Supplemental supplies may include groundwater extraction, demand management, and/or recycled water.
[3] Does not include portions of CWD and Sac Suburban (Northridge Service Area) also located within the Area "D" boundaries.
[4] SGA DMS reports data by water purveyor but not by service area.
[5] Data reflects participation in 2002 EWA Pilot Study.
[6] SGA DMS includes surface water diversions from both Sacramento and Sutter counties.
[7] McClellan included in Sac Suburban (Northridge) data.
[8] Currently not tracked in the SGA DMS.

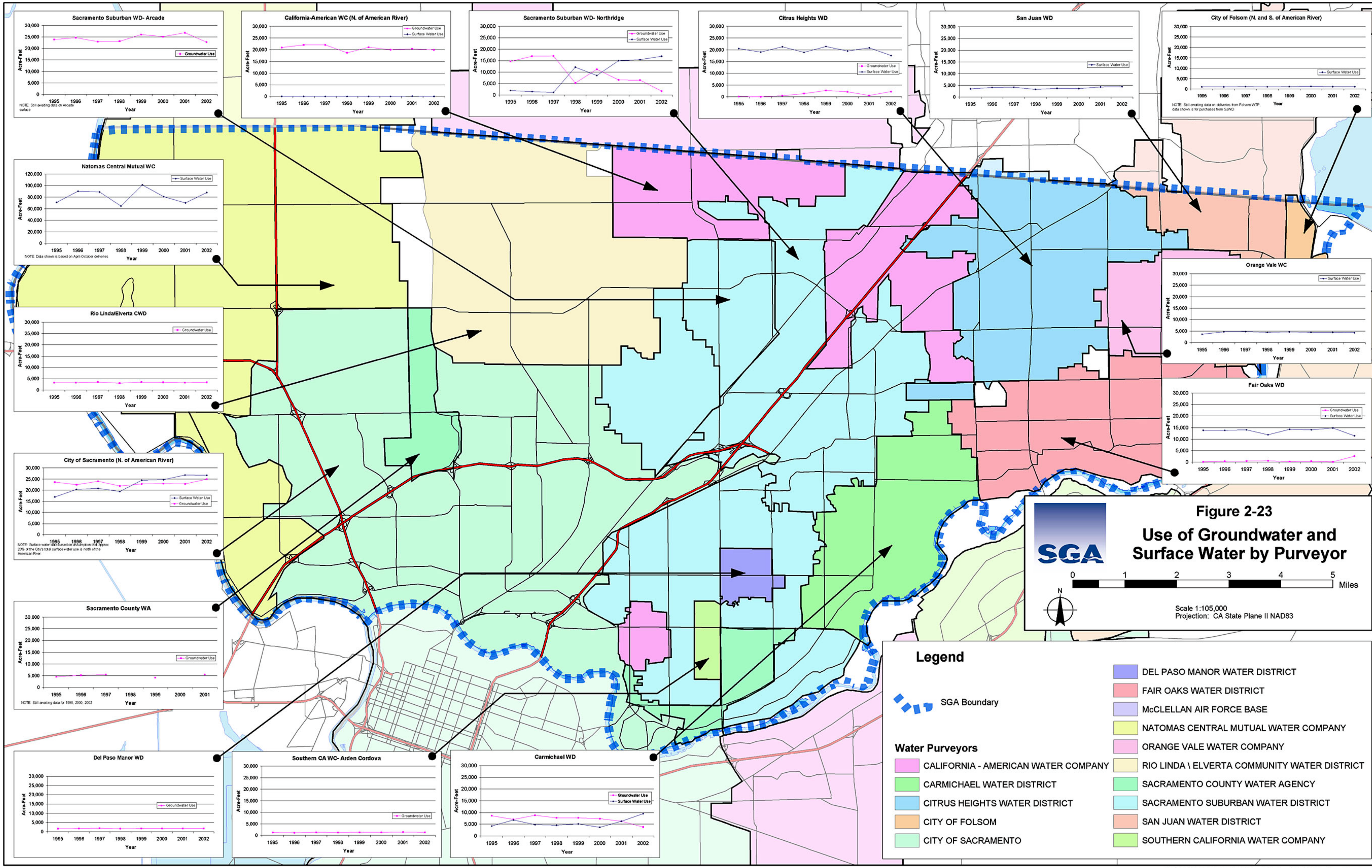

Figure 2-23

Use of Groundwater and Surface Water by Purveyor

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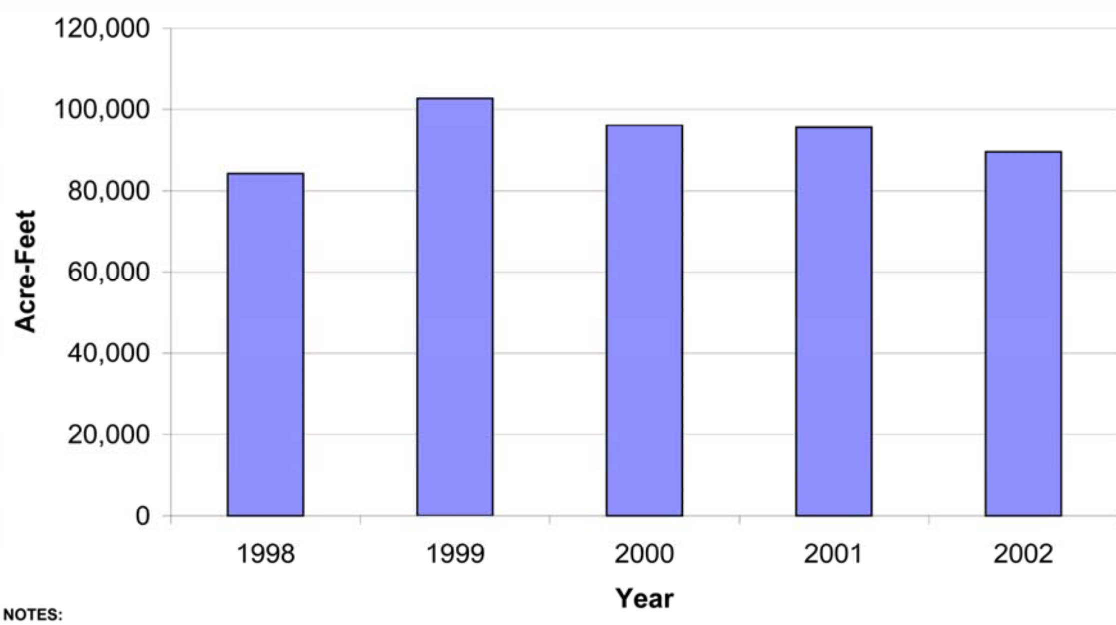
2.3.4.1 Surface Water Production Summary for 2002

Table 2-4 shows that use of surface water in 2002 ranged from a high of 88,028 Acre feet (AF) by NCMWC located in the western SGA area. To meet demand, NCMWC rely's entirely on surface water diversions from the Sacramento River in both Sacramento and Sutter counties. Member agencies located in the eastern SGA area, also rely almost completely on surface water to meet demand. **Figure 2-23** shows that Citrus Heights WD and Fair Oaks WD use groundwater in relatively low proportion to surface water.

2.3.4.2 Groundwater Production Summary for 2002

Table 2-4 shows that Sacramento, Sac Suburban, and Cal-Am extracted the largest volumes of groundwater. Annual use among these agencies varied between 24,998 and 19,867 AF in 2002. These districts serve the largest, and some of the most densely populated regions within the SGA boundaries. NCMWC, OVWC, Folsom, and SJWD extracted the least amount of groundwater. These agencies get the vast majority of their water from surface water sources, as shown in **Figure 2-23**. Total groundwater extraction by SGA member agencies during the last five years (1998 – 2002) is shown in **Figure 2-24**.



NOTES:
Does not include groundwater extraction by agriculture, self-supplied users, and private landowners.
1998 groundwater extraction does not include Sacramento County (still awaiting data).
1999 groundwater extraction includes participation in the SGA-Sacramento Area Flood Control Agency Pilot Study.
2000 through 2002 groundwater extraction reflects surface water deliveries to SSWD through its water sale agreement with PCWA.
2002 groundwater extraction also reflects participation in the CALFED Bay-Delta Program Environmental Water Account Pilot Study.

Figure 2-24
Total Annual Groundwater Extraction by SGA Member Agencies

3.0 WATER RESOURCES DEVELOPMENT AND MANAGEMENT ACTIVITIES (2002/2003)

Water resources development and management activities in the region, including SGA specific activities, are described in this section. These activities have an effect on groundwater levels within the basin and will continue to do so. These effects will continue to be addressed in future updates to the State of the Basin report.

The nexus of current levels of groundwater development, substantial surface water rights and contract entitlements, and the potential for integrated operation of Folsom Lake with the local groundwater basin present opportunities for conjunctive use in northern Sacramento County and southern Placer County. Over the last ten years, a progression of regional planning efforts has resulted in the development of a regional conjunctive use program. These regional planning efforts include the Water Forum, the Cooperating Agencies, the Regional Water Authority (RWA), and the Sacramento Groundwater Authority (SGA).

Although the Water Forum Agreement is based on projected year 2030 water demands, the opportunity exists to exercise the surface water forbearance pattern identified in the agreement immediately. Such an operation is referred to in the Regional Water Master Plan (RWMP) as Early Implementation. Many of the regional projects/programs are based on this operation.

This section provides a brief description of the status of regional projects/programs during this 2002/2003 reporting period. Included within these descriptions are specific groundwater management activities conducted by the SGA.

3.1 WATER FORUM ACTIVITIES

Begun in 1993, the Water Forum is a group comprised of business and agricultural leaders, citizens groups, environmentalists, water managers, and local governments in the Sacramento Region that joined together to fulfill two co-equal objectives:

- To provide a reliable and safe water supply for the region’s economic health and planned development through the year 2030.
- To preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River.

In 2000, Water Forum members approved the WFA, which consists of seven integrated actions necessary to accomplish these objectives. The WFA prescribes a local conjunctive use program for Folsom Reservoir, the lower American River, and the adjacent groundwater basin. One of the seven elements is groundwater management. This element divides Sacramento County groundwater basins into three subunits, the North, Central, and South areas, and recommends that the SGA (then known as the Sacramento North Area Groundwater Management Authority) serve as the governing body for the North Area Groundwater Basin. The groundwater element also estimated and recommended an average annual sustainable groundwater yield for the SGA area of 131,000 afy (roughly equivalent to the 1990 groundwater pumping rate within the North Area Groundwater Basin). The Water Forum continues to function with a dedicated staff in the Water Forum Successor Effort program to coordinate with other agencies and groups, such as the SGA, to ensure that the elements of the WFA are carried out.

3.2 AMERICAN RIVER BASIN COOPERATING AGENCIES

The Cooperating Agencies are an ad-hoc group of local water purveyors in northern Sacramento County and southern Placer County[6]. Each of the Cooperating Agencies is a signatory of the WFA. The Cooperating Agencies were formed to complete a RWMP, the objective of which is to identify the facilities and operational agreements necessary to implement the WFA for the northern Sacramento/Placer area. This plan will result in identifying opportunities to improve the availability of water supplies through additional conjunctive use of surface water and groundwater in the region. These expanded conjunctive use opportunities are a key component to assuring a sustainable groundwater resource within the SGA’s area. Upon completion of the RWMP in fall 2003, the Cooperating Agencies have sunset as an organization with much of their function assumed by the RWA.

3.3 REGIONAL WATER AUTHORITY

The RWA superceded the SMWA in 2001 through a JPA to serve and represent the regional water supply interests, and assist members in protecting and enhancing the reliability,

[6] The “Cooperating Agencies” include water purveyors in both Sacramento County and Placer County: California-American Water Company, Carmichael Water District, Citrus Heights Water District, City of Folsom, City of Roseville, City of Sacramento, Del Paso Manor Water District, Fair Oaks Water District, Placer County Water Agency, Rio Linda/Elverta Community Water District, Sacramento County Water Agency, Sacramento Suburban Water District, and San Juan Water District.

availability, affordability, and quality of water resources. One of the principal missions of the RWA is facilitating implementation of the conjunctive use program prescribed by the WFA and the RWMP. The RWA currently has eighteen members and three associate members[7] including each of the Cooperating Agencies except the SCWA. Nearly all members are signatory to the WFA.

3.3.1 Proposition 13 Groundwater Storage Program Construction Grant

In July 2002, the RWA received a commitment letter from DWR for a $21.7 million Groundwater Storage Program Construction Grant for the RWA American River Basin Regional Conjunctive Use Program (RWA Program). Participating RWA agencies include Citrus Heights WD, City of Roseville, City of Sacramento, Fair Oaks Water District, San Juan Water District, Sacramento Suburban Water District, and Placer County Water Agency. A schematic of the RWA Program is presented in **Figure 3-1.**

RWA Program facilities include an expansion of surface water treatment plant capacity, water transmission system improvements (including pipelines, a pump station, and an aboveground water storage tank for flow equalization), groundwater extraction wells, and meter replacements. This infrastructure will facilitate a groundwater banking and surface water exchange program integrating operation of Folsom Reservoir and the groundwater basin underlying the RWA's boundaries.

In "wet years", portions of the proposed facilities will be used to deliver treated surface water to areas that have historically utilized groundwater, resulting in the in-lieu banking of up to 40,200 afy of groundwater within the basin. In "dry-years", portions of the proposed facilities will be used to recover that banked water through groundwater extraction in areas that have historically used surface water, making possible the forbearance of up to 26,600 afyof surface water diversions. The average annual yield of the program is estimated at 21,400 afy.

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[7] The membership of the RWA encompasses water users in both Sacramento County and Placer County including: California-American Water Company, Carmichael Water District, Citrus Heights Water District, City of Folsom, City of Lincoln, City of Roseville, City of Sacramento, Del Paso Manor Water District, El Dorado Irrigation District, Fair Oaks Water District, Fruitridge Vista Water Company, Orange Vale Water Company, Placer County Water Agency, Rancho Murieta Community Services District, Rio Linda/Elverta Community Water District, Sacramento Suburban Water District, San Juan Water District, and the Southern California Water Company. Associate members do not directly retail drinking water and do not vote in RWA matters. Associate members include: El Dorado County Water Agency, Sacramento Municipal Utility District, and Sacramento Regional County Sanitation District.

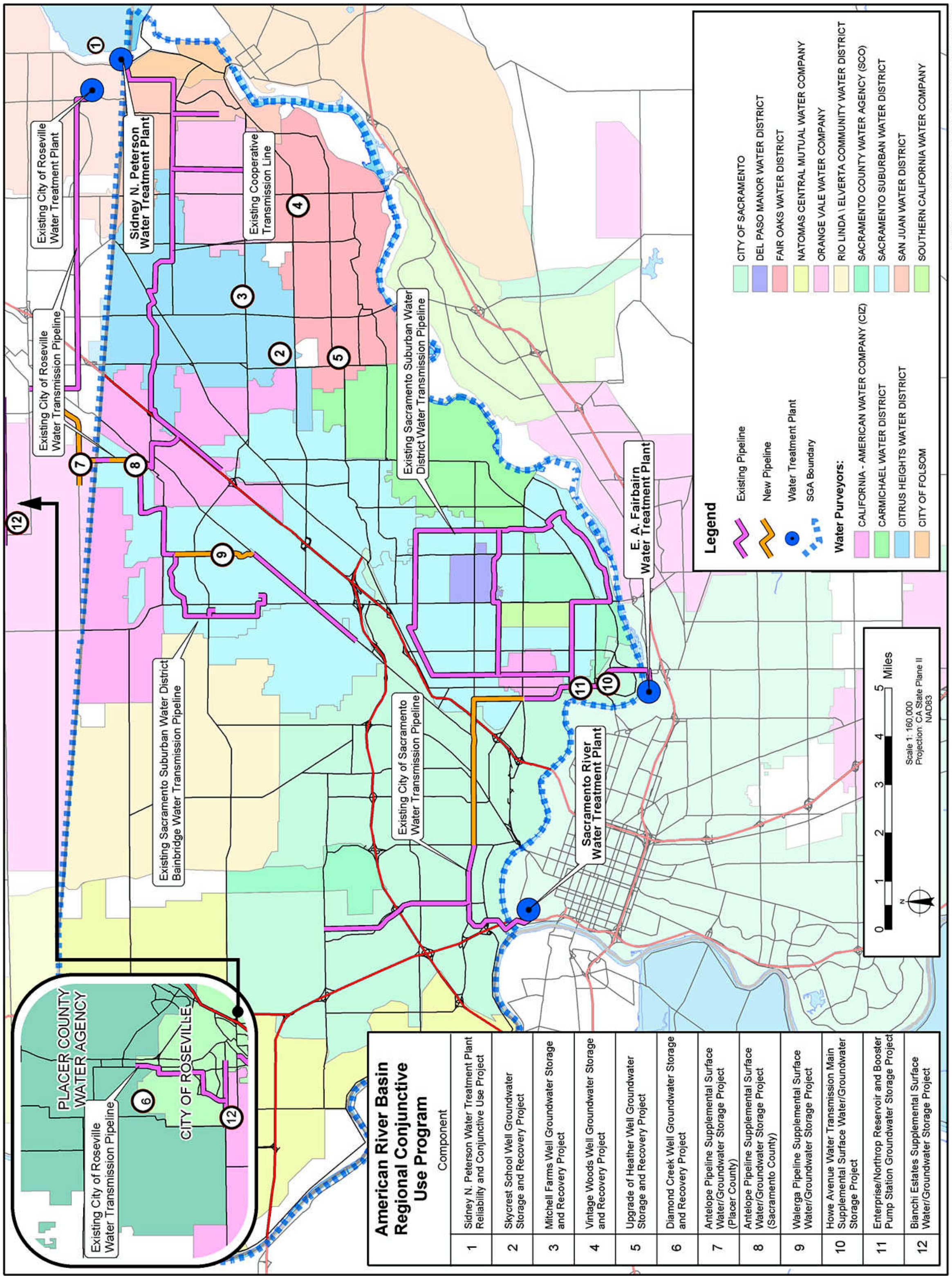

Figure 3-1 Existing Principal Infrastructure and Additional Infrastructure Resulting from American River Basin Regional Conjunctive Use Program

3.4 SGA-SPECIFIC ACTIVITIES

The Sacramento Groundwater Authority (SGA) performed the following activities in 2003.

3.4.1 Groundwater Management Plan

3.4.1.1 Background

The SGA formally adopted a GMP on December 11, 2003. The authority for SGA to prepare a GMP is provided through a Joint Exercise of Powers Agreement (pursuant to Chapter 5 of Division 7 of Title 1 of the California Government Code) by and among the cities of Folsom, Citrus Heights and Sacramento and Sacramento County.

3.4.1.2 Compliance of SGA GMP with Existing Statutes

The intent of SGA was to comprehensively address all statutory requirements in existence at the time of the writing of the GMP. The SGA GMP is in compliance with Water Code Section 10753.7 (as amended on January 1, 2003). In addition, the GMP was prepared consistent with the other provisions of Water Code Section 10753. This includes consideration of the optional plan components listed in Water Code Section 10753.8 (as amended on January 1, 2003). Finally, the plan incorporates the recommended components included in DWR's 2003 update to Bulletin 118.

3.4.1.3 Purpose of GMP

The purpose of the GMP is "to serve as the initial framework for coordinating the many independent management activities into a cohesive set of management objectives and related actions necessary to meet those objectives."

3.4.1.4 Goal of GMP

The goal of the plan is "to ensure a viable groundwater resource for the beneficial uses including agricultural, industrial, and municipal supplies that support the WFA's [Water Forum Agreement's] co-equal objectives of providing a reliable and safe water supply and preserving the fishery, wildlife, recreational, and aesthetic values of the lower American River."

3.4.1.5 Objectives of GMP

Five management objectives were adopted for the basin in the GMP. The objectives are:

- Maintain or improve groundwater quality in the SGA area for the benefit of basin groundwater users.
- Maintain groundwater elevations that result in a net benefit to basin groundwater users.
- Protect against any potential inelastic land surface subsidence.
- Protect against adverse impacts to surface water flows in the American River and Sacramento River.
- Protect against adverse impacts to water quality resulting from interaction between groundwater in the basin and surface water flows in the American River and Sacramento River.

3.4.1.6 Implementation Schedule

Plan implementation includes an annual report, future GMP review, financing, and a time schedule for plan actions. Implementation includes the following:

- GMP implementation progress will be documented in an annual "State of the Basin" report. A report will be prepared by April 1 of each year documenting conditions and activities through December 31 of the prior year.
- The GMP is intended to be a living document with changes that will be noted on an annual basis. It is important to all of the actions and objectives over time to determine how well they are meeting the overall goal of the plan. SGA intends to evaluate the entire plan within five years of adoption.
- SGA will develop a financing plan for the actions identified in the GMP within one year of adoption of the plan. At its November 13, 2003 Board of Directors meeting, SGA appointed a multi-year budget committee. The committee was specifically directed to consider costs of the "actions pursuant to the Groundwater Management Plan." The committee was given until March 2004 to prepare and review a draft multi-year SGA budget plan.
- The GMP identifies 63 actions that SGA will undertake during plan implementation. Each of these actions is identified as either on-going or to begin within 3, 6 or 12 months of plan adoption. The table is included in **Appendix A – GMP Implementation Schedule**.

3.4.2 Data Management System

The SGA completed population of the DMS in 2003 with data provided by member agencies through 2002. Historically, the member agencies have maintained a varying range of groundwater-related data in a wide variety of formats. In order for the SGA to achieve its primary objective of sustaining the groundwater resource of the North Area Groundwater Basin, it was essential to develop a data storage and analysis tool, the DMS. As described in Section 1, the DMS was developed by MWH under contract with the USACE. The local sponsors included DWR and the SGA.

The DMS is a public domain application developed in a Microsoft Visual Basic environment and is linked to an SQL database of the SGA purveyor data. The DMS provides the end-user with ready access to both enter and retrieve data in either tabular or graphical formats. Security features in the DMS allow for access restrictions based on a variety of user permission levels.

Data consist of two major groups including stationary and time dependent data. Stationary data consist of data having a fixed number of records in the DMS corresponding to the following categories:

- Well Information.
- Well Location.
- Well Construction.
- Pump/Motor Information.
- Geology/Aquifer Information.
- Wellhead Protection.
- Currently known locations of groundwater contamination and potentially contaminating activities.

Time dependent data do not have fixed number of records in the DMS because the volume of data is dependent on such factors as the age of the well, sampling and measurement frequency, etc. The DMS includes data categories for the following types of time-dependent data:

- Groundwater Levels.
- Groundwater Extraction.
- Surface Water Diversion for Water Supply.

- Well Injection.
- Water Quality.

A more comprehensive listing of data categories and fields related to the previous main data categories archived in the DMS is provided in **Appendix B**.

The DMS allows for the viewing of regional trends in water level and water quality not previously available to the SGA. The DMS has the capability of quickly generating well hydrographs and groundwater elevation contour maps using historic groundwater level data. The DMS also has the ability to view water quality data for Title 22 required constituents as a temporal concentration graph at a single well or any constituent can be plotted with respect to concentration throughout the SGA area. Presentation of groundwater elevation data and groundwater quality data in these ways will be useful for making groundwater basin management decisions.

The SGA is currently in the process of establishing data transfer protocols so that groundwater data within the SGA area (by member agencies, DWR, AFRPA, USGS, etc…) can be readily appended to the database and analyzed through the DMS. This document was prepared using the analysis tools in the DMS. The DMS will continue to be used to present groundwater basin data in future updates to the "State of the Basin" report.

3.4.2.1 Data Entry Methodology

In Phase II of the SGA DMS, the database was "fully populated" with available data supplied by member agencies. **Table 3-1** summarizes some of the major data categories populated and general data information from the "fully populated" DMS database.

Data from member agencies were received by MWH in two formats, electronic and hard copy. Over half of the data received from member agencies were in hard copy format. As previously discussed, data consist of two major groups including stationary and time-dependent data.

The majority of the hard copy member agency provided data were time-dependent data consisting of water quality, groundwater levels, and groundwater extraction records. All hard copy data were manually entered into the DMS database.

Table 3-1
Summary of Major Data Categories and Relevant Data Information of a "Fully Populated" DMS Database (February 2004)

Data Category	Dates	Total Number of Records	Number of Wells with Records
Purveyor Information[1]	NA	36	NA
Well Information	NA	919	919
Well Location	NA	919	916
Well Construction	1939-2002	370	368
Geology/Aquifer Info	NA	300	74
Groundwater Levels	1929-2003	51,674	747
Groundwater Extraction	1964-2002	11,063	493
Water Quality	1984-2002	130,220	262

NA – Not Applicable

[1]Includes information such as purveyor address, telephone number, contact person, population served, number of connections, etc.

Over 251,600 records were entered into the DMS database. Over half of those records were manually keypunched from hard copy data. MWH conducted quality assurance/quality control (QA/QC) checks to verify that member agency provided data were entered into the database without errors. MWH entered data as they were received from each member agency, providing no speculation or interpretation of data accuracy. However, the QA/QC process did allow MWH to improve the consistency between electronic and hard copy data. Please see **Appendix C** for a complete description of the QA/QC process.

3.4.3 Expanded Banking and Exchange Pilot Study.

In 2002, the SGA conducted an expanded pilot study. It entered into an agreement with Reclamation (on behalf of the Environmental Water Account) for the one-year sale of up to 10,000 AF of surface water. In 2002, 7,143 AF of water were delivered. A portion of this surface water (up to 5,000 AF) was made available in Folsom Reservoir through a transfer of a portion of SJWD's CVP contract entitlement. The other 5,000 AF was made available by Sacramento through forbearance of a surface water diversion right on the lower American River. In both cases, local demand was met by recovery of previously banked groundwater.

4.0 SUMMARY OF GROUNDWATER MANAGEMENT IMPROVEMENTS RESULTING FROM PHASE II DMS AGREEMENT

The findings and conclusions of the Phase II DMS contract culminated in assisting the SGA with development of the Groundwater Management Plan adopted by SGA in December 2003. The GMP identifies 63 actions that SGA will undertake during plan implementation. Each of these actions is identified as either on-going or to begin within 3, 6 or 12 months of plan adoption. The table is included in **Appendix A – GMP Implementation Schedule**.

This section summarizes the plan components that lead to an improved understanding of hydrogeologic conditions within the SGA area of the North American Groundwater Subbasin. Described below are the actions, and supporting rationale for actions, pertaining to groundwater level monitoring, groundwater quality monitoring, land surface subsidence monitoring, protocols for the collection of groundwater data, and maintenance of the DMS. Implementation of these actions and the improved understanding of basin condition that result will be the subject of future updates to the State of the Basin Report.

The DMS was especially useful in assessing the adequacy of the monitoring network. Queries were run to better understand the construction details and history of data collected at specific member agency wells. This understanding was helpful in selecting wells for the water level monitoring network described below.

4.1 GROUNDWATER ELEVATION MONITORING

The SGA has compiled historic water level data measurements extending from prior to 1950 through 2002. Sources of historic water level data for the SGA area include:

- DWR/SCWA
- SGA Member Agencies
- USGS
- CSUS

DWR and SCWA have maintained a program of measuring more than 30 wells in the basin, from which SCWA routinely generates annual contour maps for the county. However, the wells monitored have been added to and dropped off of the network over time, so it is difficult to compare a historic contour plot to a recent one. For this reason, the SGA is establishing a standardized network of wells that combines those monitored by DWR and SCWA with wells from member water purveyors and other sources. It is the SGA's intent that these wells be maintained as a consistent long-term network that represents overall groundwater elevation conditions in the basin. **Figure 4-1** shows the wells currently proposed for this network.

The wells were selected to provide uniform geographic coverage throughout the 195 square mile SGA area, and in an area around the northern, western, and southern perimeter of the SGA[8]. The well network was developed by first establishing a network of sampling grids using the following method:

- Overlay a matrix of evenly spaced points over the SGA area.
- Surround matrix of points with polygons.
- Conform boundaries of polygons to the SGA boundaries and regenerate area grids.

The resulting grid, shown on **Figure 4-1,** includes 44 polygons of roughly equal area of about five square miles each. The proposed set of member agency monitoring wells were selected from the DMS to represent water levels for as many polygons as possible. Individual wells were selected by:

- Giving preference to wells currently in DWR's and SCWA's monitoring program. These wells were selected because (a) they have long records of historic water level data and are useful in assessing trends within the groundwater basins, (b) uniform protocols were used in measuring and recording the water level data, and (c) these are non-producing wells, so water level readings represent relatively static levels.
- Identifying member agency wells with well construction information, long records of water level data and giving preference to those wells with the lowest recent extraction volumes.

[8] No wells were selected east of the boundary because it is in consolidated rock outside of the groundwater basin.

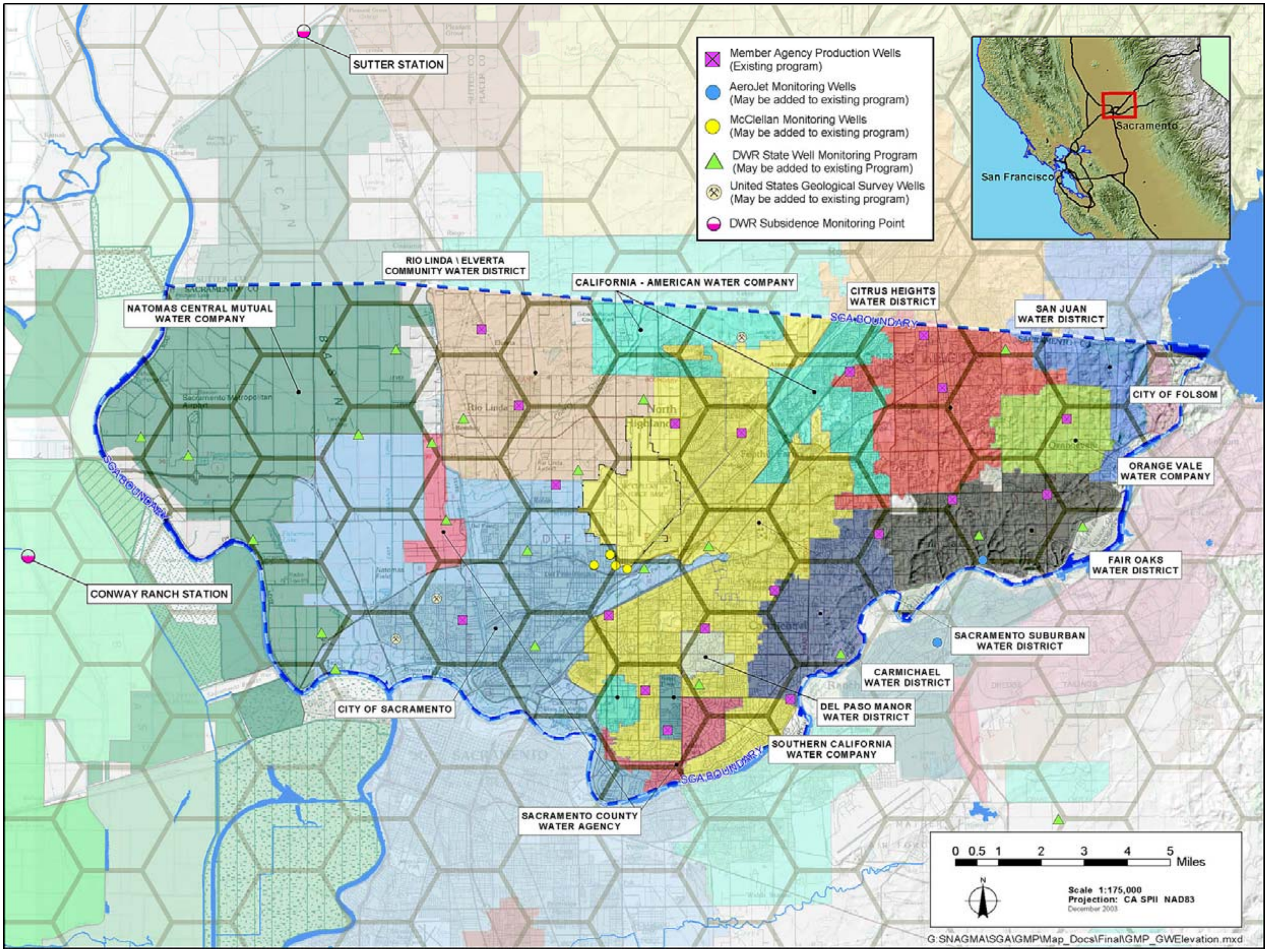

Figure 4-1 Initial Proposed Wells for Consideration in SGA Groundwater Elevation Monitoring Network

- Plotting the location of USGS wells within the SGA area and choosing wells in those areas void of DWR or member agency wells.

Actions. Additional actions by the SGA will include:

1. Coordinate with member agencies and DWR to identify an appropriate group of wells for monitoring for a spring 2004 set of groundwater elevation measurements.
2. Coordinate with DWR and SCWA to ensure that the selected wells are maintained as part of a long-term monitoring network.
3. Coordinate with DWR and SCWA to ensure that the timing of water level data collection by member agencies coincides within one month of DWR and SCWA data collection. Currently DWR and SCWA collect water level data in the spring and fall.
4. Coordinate with member agencies to ensure that needed water level elevations are collected and verify that uniform data collection protocols are used among the agencies.
5. Coordinate with the USGS to determine the potential for integrating USGS monitoring wells constructed for the NAWQA Program into the SGA monitoring network.
6. Consider ways to fill gaps in the monitoring well network by identifying additional suitable existing wells or identifying opportunities for constructing new monitoring wells.
7. Assess groundwater elevation trends and conditions based on the network annually.
8. Assess the adequacy of the groundwater elevation monitoring well network annually.
9. Identify a subset of monitoring wells that will be monitored more frequently than twice annually to improve the SGA's understanding of aquifer responses to pumping throughout the year.

4.2 GROUNDWATER QUALITY MONITORING

Because most of the wells in the basin are used for public water supply, an extensive record of water quality data is available for most wells dating from about 1985 to present. The SGA has compiled available historic water quality data for constituents monitored as required by DHS under Title 22. Sources of water quality data include:

- DWR
- SGA Member Agencies

- USGS
- CSUS

This level of monitoring is sufficient under existing regulatory guidelines to ensure that the public is provided with a safe, reliable drinking water supply. It would ultimately be important to have in place a network of shallow (less than 200 feet deep), dedicated monitoring wells to serve as an early warning system for contaminants that could make their way to the greater depths in the basin where SGA members primarily extract groundwater. The SGA has identified the locations of several wells associated with the USGS NAWQA program and is working with AFRPA to identify a subset of the approximately 400 monitoring wells located in and around the former McClellan AFB for integration into the SGA monitoring effort. The SGA will also coordinate with the CVRWQCB, which oversees the remediation of LUSTs, to identify existing dedicated monitoring wells in the basin.

Figure 4-2 shows the existing SGA member agency production wells. Title 22 water quality reporting is required by DHS for each of these public drinking water supplies. The SGA's water quality monitoring network includes these wells. The water quality monitoring well network may be expanded to include additional DWR, USGS, McClellan AFB, Aerojet, CVRWQCB, and privately owned wells, based on the outcome of coordination meetings with these agencies.

Actions. The following actions will be taken by the SGA to monitor and manage groundwater quality:

1. Coordinate with member agencies to verify that uniform protocols are used when collecting water quality data.
2. Coordinate with the USGS to obtain historic water quality data for NAWQA wells, determine timing and frequency of monitoring under USGS program, and to discuss the potential for integrating USGS monitoring resources with the SGA network.
3. Coordinate with member agencies and other local, state, and federal agencies to identify where wells may exist in areas with sparse groundwater quality data. Identify opportunities for collecting and analyzing water quality samples from those wells.
4. Assess the adequacy of the groundwater quality monitoring well network annually.

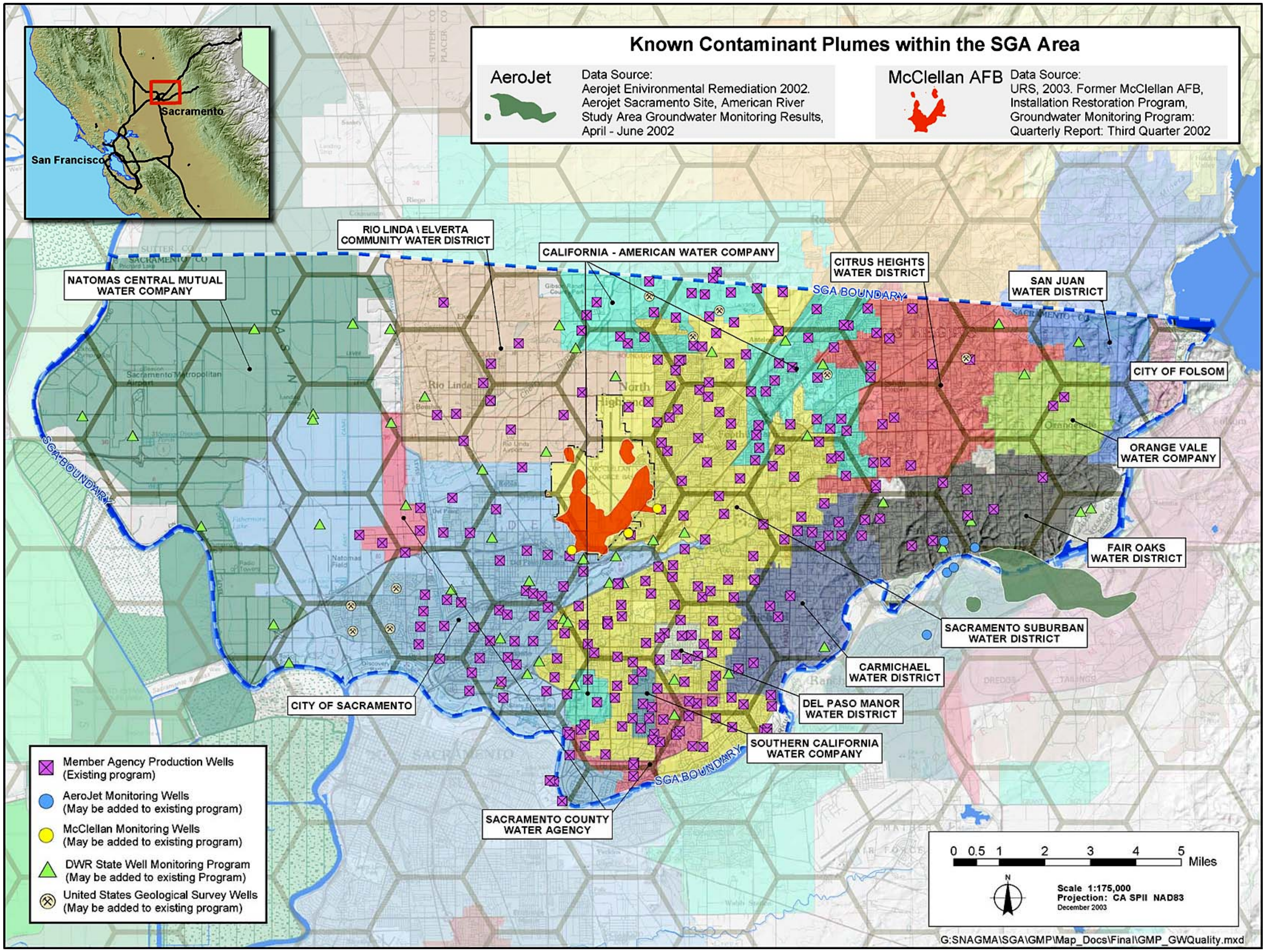

Figure 4-2 Existing and Proposed Wells in SGA Groundwater Quality Monitoring Network

4.3 LAND SURFACE ELEVATION MONITORING

Subsidence of the land surface resulting from compaction of underlying formations affected by head (water level) decline is a well-documented concern throughout much of the Central Valley. During a typical pumping season, changes in land surface elevation can be observed as a result of both elastic and inelastic subsidence in the underlying basin. Elastic subsidence results from the reduction of pore fluid pressures in the aquifer and typically rebounds when pumping ceases or when groundwater is otherwise recharged resulting in increased pore fluid pressure. Inelastic subsidence occurs when pore fluid pressures decline to the point that aquitard (a clay bed of an aquifer system) sediments collapse resulting in permanent compaction and reduced ability to store water in that portion of the aquifer.

While some land surface subsidence from compaction of water-bearing deposits caused by the removal of groundwater is known to have occurred west of the Sacramento River[9], the extent of subsidence east of the Sacramento River has been minimal. DWR maintains three subsidence monitoring stations in Sacramento Valley. The Sutter Station is located just north of the SGA area, where State Highway 99 crosses the Natomas Cross-Canal **(Figure 4-1)**. Total subsidence at the Sutter Station from spring 1995 to spring 2003 has been 0.026 feet (0.312 inch)[10]. Total subsidence at the Conaway Ranch Station, located west of the SGA area (**Figure 4-1**), from spring 1992 to spring 2003 has been 0.044 feet (0.526 inch)[11].

Historical benchmark elevation data for the period from 1912 through the late 1960s obtained from the National Geodetic Survey (NGS) were used to evaluate land subsidence in north Sacramento County. From 1947 to 1969 the magnitude of land subsidence measured at benchmarks north of the American River in Sacramento County ranged from 0.13 feet to 0.32 feet, with a general decrease in subsidence in a northeastward direction. This decrease is consistent with the geology of the area: formations along the eastern side of the Sacramento Valley are older than those on the western side and are subject to a greater degree of pre-

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9 From 1988-1992 cumulative net sediment compaction of 0.78 feet was measured at the extensometer in Yolo County between June 15, 1988 and October 1, 1992 (USGS data from the Woodland land subsidence monitoring station, Yolo County, California, water years 1988-1992, USGS Open File Report 94-494)

10 Based on information provided by Central District of DWR to MWH on 12/11/03.

11 Based on information provided by Central District of DWR to MWH on 12/17/03.

consolidation making them less susceptible to subsidence. The maximum documented land subsidence of 0.32 feet was measured at both benchmark L846, located approximately two miles northeast of the former McClellan AFB, and benchmark G846, located approximately one mile northeast of the intersection of Greenback Lane and Elkhorn Boulevard.

Another land subsidence evaluation was performed in the Arden-Arcade area[12] of Sacramento County from 1981 to 1991. Elevations of nine wells in the Arden-Arcade area were surveyed in 1981, 1986, and 1991. The 1986 results were consistently higher than the 1981 results; this was attributed to extremely high rainfall totals in early 1986 that recharged the aquifer and caused a rise in actual land surface elevations. The 1991 results were consistently lower than the 1986 results; this was attributed to five years of drought immediately preceding the 1991 measurements, which caused depletion of the aquifer and resulting land surface subsidence. Comparison of eight[13] of the locations indicates that seven benchmarks have lower elevations in 1991 than in 1981 and one benchmark has a higher elevation in 1991. Of the seven benchmarks with lower elevations in 1991, the maximum difference is 0.073 feet (less than one inch). Whether this is inelastic subsidence is indeterminate from the data, but it is clear that the magnitude of the potential subsidence in the benchmarks during that period is negligible.

Actions. While available data and reports indicate that land surface subsidence is not a problem in the SGA area, the SGA is interested in pursuing additional possible actions to continue to monitor for potential land surface subsidence. These may include:

1. Investigate the feasibility and costs of re-surveying the wells in the Arden-Arcade area that were last measured in 1991.

2. Coordinate with the USGS to ascertain the suitability of the use of Interferometric Synthetic Aperture Radar (IfSAR) images of the SGA and surrounding area. If the technology appears suitable, identify the costs of determining ground surface elevations and identify potential cost-sharing partners.

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[12] The boundaries of the Arden-Arcade area are (1) Sacramento's city limits on the west, (2) Sacramento's city limits and the American River on the south, (3) CWD on the east, and (4) Sacramento's city limits and Sac Suburban (Northridge Service Area) on the north.

[13] One of the nine wells could not be compared between 1981 and 1991 because the benchmark was destroyed and replaced between 1981 and 1986.

3. Coordinate with other agencies, particularly the City and County of Sacramento and the NGS to determine if there are other suitable benchmark locations in the SGA area to aid in the analysis of potential land surface subsidence.
4. Educate SGA member agencies of the potential for land surface subsidence and signs that could be indicators of subsidence.

4.4 SURFACE WATER GROUNDWATER INTERACTION MONITORING

The interaction between groundwater and surface water has not been extensively evaluated within the SGA area. The SGA is currently aware of the following:

- A recent draft decision by the State Water Resources Control Board (SWRCB, 2003) regarding the American River, the SWRCB concluded that from Nimbus Dam to about 6,000 feet below the dam, groundwater elevations and surface water elevations were similar enough to each other that groundwater could be tributary to the American River. Beyond 6,000 feet down reach from Nimbus Dam, groundwater elevations are sufficiently lower than the river channel to conclude that the American River is a losing reach down to the confluence with the Sacramento River.
- Groundwater modeling has been used to estimate flow volumes between surface water and groundwater for various hydrologic conditions.
- CSUS in cooperation with DWR has recently installed several monitoring wells in and adjacent to the American River to investigate groundwater interaction with the American River and how recent USACE levee reinforcement projects might have changed the surface water-groundwater flow relationships.
- In 1991, Sacramento Regional County Sanitation District (SRCSD), Sacramento County, and the City of Sacramento established the Sacramento Coordinated Water Quality Monitoring Program (CMP). Since that time, the CMP has monitored surface water quality for a variety of constituents including trace elements at several locations on the American River and Sacramento River. Within the SGA area, the CMP monitors the Sacramento River at the Interstate 5 Veteran Memorial Bridge, and the American River at Nimbus Dam and at Discovery Park.

Actions. The SGA will pursue actions to better understand the relationship between surface and groundwater in the SGA area, including:

1. Compile available stream gage data and information on tributary inflows and diversions from the American and Sacramento rivers to quantify net groundwater recharge or discharge between gages in the SGA area.
2. Coordinate with local, state, and federal agencies to identify available surface water quality data from the American and Sacramento rivers adjacent to the SGA area.
3. Correlate groundwater level data from wells in the vicinity of river stage data to further establish whether the river and water table are in direct hydraulic connection, and if the surface water is gaining or losing at those points.
4. Continue to coordinate with local, state, and federal agencies and develop partnerships to investigate cost-effective methods that could be applied to better understand surface water-groundwater interaction along the Sacramento and American rivers.
5. Coordinate with CSUS to analyze data obtained from recently constructed monitoring wells on the CSUS campus to better understand the relationship between the groundwater basin and surface water flows at that location.

4.5 PROTOCOLS FOR THE COLLECTION OF GROUNDWATER DATA

The SGA has evaluated the accuracy and reliability of groundwater data collected by member agencies (MWH, 2002). The evaluation indicated a significant range of techniques, frequencies and documentation methods, for the collection of groundwater level and groundwater quality data. Although the groundwater data collection protocol may be adequate to meet the needs of the individual water districts, the lack of consistency between districts in the past yields an incomplete picture of basin-wide groundwater conditions.

Actions. To improve the comparability, reliability and accuracy of groundwater data, the SGA will take the following actions:

1. Use a Standard Operating Procedure (SOP) for collection of water level data by each of the member agencies. An SOP was developed under Task 4 of Phase I DMS development. This SOP was prepared using guidance documents available through

USEPA and was included in the SGA technical memorandum summarizing the accuracy and reliability of groundwater data (MWH, 2002).

2. Provide member agencies with guidelines on the collection of water quality data developed by DHS for the collection, pretreatment, storage, and transportation of water samples (DHS, 1995).
3. Provide training on the implementation of these SOPs to member agencies, if requested.

4.6 DATA MANAGEMENT SYSTEM

The SGA is currently in the process of establishing data transfer protocols so that groundwater data within the SGA area (by member agencies, DWR, AFRPA, USGS, etc…) can be readily appended to the database and analyzed through the DMS. These protocols are summarized below:

- Water level measurements will be forwarded to SGA (preferably in spreadsheet format) from member agencies in Spring and Fall of each year for entry into DMS.
- Groundwater production data will be forwarded (preferably in spreadsheet format) to SGA in Spring and Fall of each year for entry into DMS.
- SGA to explore possibility of web based applications hosted on SGA's server to receive large data files from member agencies.
- SGA to develop standardized forms for data entry within the DMS. This will facilitate cutting and pasting data from spreadsheets into the DMS.
- SGA to coordinate with member agencies and their labs to either be copied directly from lab on electronic data deliverables of water quality analysis or sent electronic copies after member agencies have performed internal QA/QC checks on data results.
- SGA to pilot test use of PDAs for use in logging field observations and transferring data to SGA.
- SGA should ask member agencies to notify them when new wells are installed so that SGA is copied on drillers logs, lithologic logs and geophysical logs on all test borings.

<u>Actions.</u> To maintain and improve the usability of the DMS, the SGA will take the following actions:

1. Continue to update the DMS with current water purveyor data.
2. Make recommendations to the DMS developer on utilities to add to the DMS to increase its functionality.

4.7 PROPOSED GROUNDWATER INVESTIGATIONS

On January 28, 2004, the SGA and Sacramento Suburban Water District each submitted applications to DWR funding of groundwater investigation within the SGA area under the Local Groundwater Assistance Program (AB303). These applications to DWR will fill data gaps and complete many of the actions described in Sections 4.1.1 to 4.1.4. Each of these projects are briefly described below:

4.7.1 Sacramento Groundwater Authority Regional Monitoring Well Program

The SGA Program will consist of the construction and long-term monitoring of eleven wells, shown on **Figure 4-3**, to supplement the existing well network where critical data gaps were identified during development of the SGA groundwater management plan.

Data from these wells are important to managing the basin, which on average supplies about half of the public supply to more than 500,000 consumers in northern Sacramento County. The Program will assist groundwater management in a few ways. First, the Program will help establish the relationship between surface water and groundwater to ensure that area rivers are not threatened by increased groundwater extraction. Second, the Program wells will be constructed in the shallower portions of the aquifer to help serve as an early warning system of possible contaminants that could impact public water supplies. Finally, the wells will provide data on the basin's response to increased cycles of recharge and extraction, which will help SGA manage the basin by assessing and adapting to changing conditions in this important regional groundwater basin.

Figure 4-3
Proposed SGA Monitoring Well Locations for 2004 AB303 Grant

4.7.2 Sacramento Suburban Water District Groundwater Monitoring and Subsidence Survey

The proposed project includes the construction of three multi-level monitoring wells, shown on **Figure 4-4** (SSWDMW-1, SSWDMW-2, and SSWDMW-3) and equipping them with pressure transducers to collect water level and temperature data. The first two proposed multi-level monitoring wells, SSWDMW-1 and SSWDMW-2, will be located in the northern region of the District. These locations were chosen because they:

- Are near the northern SGA boundary and would help fill data gaps in the proposed GMP
- Will provide early detection of contamination to the public drinking water supply
- Will facilitate monitoring the groundwater depression in this region for changes in groundwater elevation, vertical and horizontal gradients needed to make informed basin management decisions

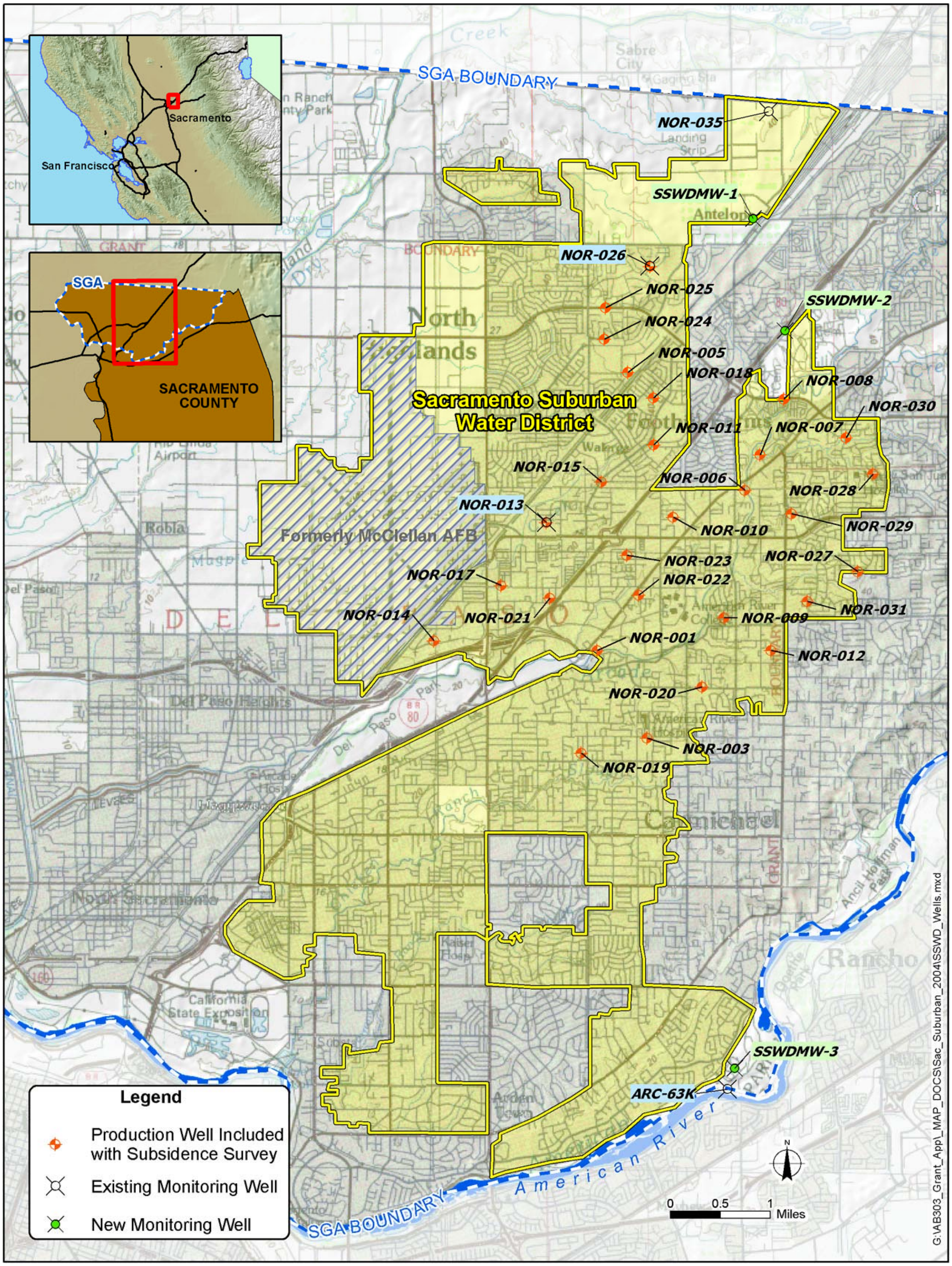

Figure 4-4
SSWD Monitoring Well Location Map for 2004 AB303 Grant

- May be used for future water production.

The third well, SSWDMW-3, is located near the American River at 1000 River Walk Way. This well will be used to better understand the river level impact on surface water and groundwater interactions and to conduct vertical gradient profiling. Upon completion, each of the nine nested piezometers will be equipped with a pressure transducer and data logger that will record water level data automatically. Groundwater samples will be collected and analyzed for EPA Title 22 constituents, MTBE, pesticides, and volatile organic chemicals.

The project also includes the installation of pressure transducers in four existing nested piezometers located in North Highlands and near the American River. The four locations include the Antelope North Well (NOR-035), Monument Well (NOR-026), Madison Well (NOR-013), and one of the American River Infiltration Wells (ARC-63K). Wells NOR-035, NOR-026, and NOR-013 are desirable locations to gather high frequency water level information because they are located nearby the local groundwater depression. Well ARC-63K is located near the American River and can help determine vertical gradients and surface water and groundwater interactions. The purpose of the pressure transducers in these three wells is to:

- Monitor magnitude and extent of the groundwater depression.
- Monitor fluctuations in water levels and temperature, and
- Monitor interactions between groundwater and surface water
- Collect data to improve the knowledge of the basin and aid in future decisions related to groundwater management and conjunctive use.

A subsidence survey of 29 monuments will build on earlier surveys performed in 1981 and 1992 by returning to the same survey locations for a third time to further demonstrate that land subsidence has not significantly occurred over the regional groundwater depression in the SGA area. Continued monitoring for subsidence at these identified survey locations is important given the plan to include the groundwater basin in a regional conjunctive use program.

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Appendix A
GMP Implementation Schedule

Table 6. Summary of GMP Actions

Description of Action	Implementation Schedule (approximate time for commencing activity following adoption of GMP)
I. COMPONENT CATEGORY 1: STAKEHOLDER INVOLVEMENT	
Involving the Public	
1 Continue efforts to encourage public participation as opportunities arise.	on-going
2 Review and take actions from the public outreach plan as necessary during implementation of various aspects of the GMP.	on-going
3 Provide briefings to the Water Forum Successor Effort on GMP implementation progress.	on-going
4 Work with members to maximize outreach on GMP activities including the use of the SGA Web site, member Web sites, or bill inserts.	12 months
Involving Other Agencies Within and Adjacent to the SGA Area	
1 Continue high level of involvement demonstrated through the SGA GMP development into implementation of the plan by continued participation on committees described above.	on-going
2 Provide copies of the adopted GMP and subsequent annual reports to representatives from Placer, Sutter, and Yolo counties, and the Groundwater Forum.	3 months
3 Meet with representatives from Placer, Sutter, and Yolo counties, and the Groundwater Forum as needed.	6 months
4 Coordinate a meeting with the agricultural groundwater pumpers in the SGA area to inform them of SGA's management responsibilities and activities, and develop and develop a list of agricultural groundwater pumpers concerns and needs relative to SGA's management of the area.	6 months
5 Coordinate a meeting with other self-supplied pumpers in the SGA area to inform them of SGA's management responsibilities and activities, and develop a list of self-supplied groundwater pumpers concerns and needs relative to SGA's management of the area.	6 months
Utilizing Advisory Committees	
1 Upon adoption of the GMP, the Policy Committee will meet to discuss the continuation and composition of committees to guide implementation of the plan.	3 months
Developing Relationships with State and Federal Agencies	
1 Continue to develop working relationships with local, state, and federal regulatory agencies.	on-going
Pursuing Partnership Opportunities	
1 Continue to promote partnerships that achieve both local supply reliability and achieve broader regional and statewide benefits.	on-going
2 Continue to track grant opportunities to fund groundwater management activities and local water infrastructure projects.	on-going
II. COMPONENT CATEGORY 2: MONITORING PROGRAM	
Groundwater Elevation Monitoring	
1 Coordinate with member agencies and DWR to identify an appropriate group of wells for monitoring for a spring 2004 set of groundwater elevation measurements.	3 months
2 Coordinate with DWR and SCWA to ensure that the selected wells are maintained as part of a long-term monitoring network.	3 months
3 Coordinate with DWR and SCWA to ensure that the timing of water level data collection by member agencies coincides within one month of DWR and SCWA data collection.	3 months
4 Coordinate with member agencies to ensure that needed water level elevations are collected and verify that uniform data collection protocols are used among the agencies.	3 months
5 Coordinate with the USGS to determine the potential for integrating USGS monitoring wells constructed for the National Water Quality Assessment (NAWQA) Program into the SGA monitoring network.	3 months
6 Consider ways to fill gaps in the monitoring well network by identifying additional suitable existing wells or identifying opportunities for constructing new monitoring wells.	3 months
7 Assess groundwater elevation trends and conditions based on the network annually.	Results and recommendations included in State of Basin report published in April of each year
8 Assess the adequacy of the groundwater elevation monitoring well network annually.	Results and recommendations included in State of Basin report published in April of each year
9 Identify a subset of monitoring wells that will be monitored more frequently than twice annually to improve the SGA's understanding of aquifer responses to pumping throughout the year.	12 months

Table 6. Summary of GMP Actions (continued)

	Description of Action	Implementation Schedule (approximate time for commencing activity following adoption of GMP)
	Groundwater Quality Monitoring	
1	Coordinate with member agencies to verify that uniform protocols are used when collecting water quality data.	6 months
2	Coordinate with the USGS to obtain historic water quality data for NAWQA wells, determine timing and frequency of monitoring under USGS program, and to discuss the potential for integrating USGS monitoring resources with the SGA network.	6 months
3	Coordinate with member agencies and other local, state, and federal agencies to identify where wells may exist in areas with sparse groundwater quality data.	6 months
4	Assess the adequacy of the groundwater quality monitoring well network annually.	Results and recommendations included in State of Basin report published in April of each year
	Land Surface Elevation Monitoring	
1	Investigate the feasibility and costs of re-surveying the wells in the Arden-Arcade area that were last measured in 1991.	12 months
2	Coordinate with the USGS to ascertain the suitability of the use of Interferometric Synthetic Aperture Radar (InSAR) images of the SGA and surrounding area. If the technology appears suitable, identify the costs of determining ground surface elevations and identify potential cost-sharing partners.	12 months
3	Coordinate with other agencies, particularly the City and County of Sacramento and the National Geodetic Survey to determine if there are other suitable benchmark locations in the SGA area to aid in the analysis of potential land surface subsidence.	12 months
4	Educate SGA member agencies of the potential for land surface subsidence and signs that could be indicators of subsidence.	12 months
	Surface Water Groundwater Interaction Monitoring	
1	Compile available stream gage data and information on tributary inflows and diversions from the American and Sacramento rivers to quantify net groundwater recharge or discharge between gages in the SGA area.	12 months
2	Coordinate with local, state, and federal agencies to identify available surface water quality data from the American and Sacramento Rivers adjacent to the SGA area.	12 months
3	Correlate groundwater level data from wells in the vicinity of river stage data to further establish whether the river and water table are in direct hydraulic connection, and if the surface water is gaining or losing at those points.	12 months
4	Continue to coordinate with local, state, and federal agencies and develop partnerships to investigate cost-effective methods that could be applied to better understand surface water-groundwater interaction along the Sacramento River and American River.	12 months
5	Coordinate with CSUS to analyze data obtained from recently constructed monitoring wells on the CSUS campus to better understand the relationship between the groundwater basin and surface water flows at that location.	6 months
	Protocols for the Collection of Groundwater Data	
1	Use a Standard Operating Procedure (SOP) for collection of water level data by each of the member agencies.	3 months
2	Provide member agencies with guidelines on the collection of water quality data developed by DHS for the collection, pretreatment, storage, and transportation of water samples (DHS, 1995).	3 months
3	3. Provide training on the implementation of these SOPs to member agencies, if requested.	3 months
	Data Management System	
	No Action Required	
III.	**COMPONENT CATEGORY 3: GROUNDWATER RESOURCE PROTECTION**	
	Well Construction Policies	
1	Ensure that all member agencies are provided a copy of the county well ordinance and understand the proper well construction procedures	3 months
2	Inform member agencies of Sacramento County's Consultation Zone and provide a copy of the boundary of the former McClellan AFB prohibition zone to appropriate member agencies.	6 months
3	Provide a copy of the most recently delineated plume extents at the former McClellan AFB, the former Mather AFB, and Aerojet to the EMD and SGA members for their review and possible use.	3 months
4	Coordinate with member agencies to provide guidance as appropriate on well construction. Where feasible and appropriate, this could include the use of subsurface geophysical tools prior to construction of the well to assist in well design.	3 months

Table 6. Summary of GMP Actions (continued)

Description of Action	Implementation Schedule (approximate time for commencing activity following adoption of GMP)
Well Abandonment and Well Destruction Policies	
1 Ensure that all member agencies are provided a copy of the code and understand the proper destruction procedures and support implementation of these procedures	3 months
2 Follow up with member agencies on the reported abandoned and destroyed wells to confirm the information collected from DWR	6 months
3 Provide a copy of the information on abandoned and destroyed wells in northern Sacramento County to fill any gaps in their records	12 months
4 Meet with the EMD to discuss ways to ensure that wells in the SGA area are properly abandoned or destroyed	6 months
5 Obtain "wildcat map from California Division of Oil and Gas to ascertain the extent of historic gas well drilling operations in the area as these wells could function as conduits of contamination if not properly destroyed.	12 months
Wellhead Protection Measures	
1 Request that member agencies provide vulnerability summaries from the DWSAP to the SGA to be used for guiding management decisions in the basin.	6 months
2 Contact groundwater basin managers in other areas of the state for technical advice, effective management practices, and "lessons learned," regarding establishing wellhead protection areas	12 months
Protection of Recharge Areas	
1 When CAS results are available, meet with the SWRCB to discuss those results and consider follow-on actions	6 months
Control of the Migration and Remediation of Contaminated Groundwater	
1 Coordinate with known responsible parties to develop a network of monitoring wells to act as an early warning system for public supply wells.	6 months
2 If detections occur in these monitoring wells, work with the responsible parties and the potentially impacted member agency to develop strategies to minimize the further spread of contaminants.	on-going
3 Provide SGA members with all information on mapped contaminant plumes and LUST sites for their information in developing groundwater extraction patterns and in the siting of future production or monitoring wells	6 months
4 Meet with representatives of the RWQCB to establish a mutual understanding about SGA's groundwater management responsibilities	6 months
Control of Saline Water Intrusion	
1 Track the progression, if any, of saline water bodies moving toward the east from the Delta.	on-going
2 Observe TDS concentrations in public supply wells of North Area Groundwater Basin water suppliers that are routinely sampled under the DHS Title 22 Program. These data will be readily available in the SGA's DMS and are already an on-going task for the annual review of basin conditions.	on-going
3 Inform all member water purveyor managers of the presence of the interface and the approximate depth of the interface below their service area for their reference when siting potential wells.	on-going
VI. COMPONENT CATEGORY 4: GROUNDWATER SUSTAINABILITY	
Conjunctive Management Activities	
1 Continue to investigate conjunctive use opportunities within the SGA area	on-going
2 Continue to investigate opportunities for the development of direct recharge facilities in addition to in-lieu recharge (e.g. injection wells or surface spreading facilities, through constructed recharge basins or in river or stream beds).	on-going
Demand Reduction	
1 Coordinate with the RWA and its members that have signed specific agreements to the WFA to ensure that those conservation efforts are on track. For members that are not signatory, the SGA will ensure that they are informed of the benefits and regional importance of RWA's WEP.	on-going
2 Coordinate with SRCSD through the RWA to investigate opportunities for expanded use of recycled water throughout the county.	on-going
V. COMPONENT CATEGORY 5: PLANNING INTEGRATION	
Existing Integrated Planning Efforts	
1 Prepare and adopt a formal integrated water management plan in accordance with CWC Section 10540 et seq. The SGA will form an ad hoc committee with the RWA to determine which agency would be most appropriate to prepare that plan.	12 months
2 Review the Water Forum Land Use procedures and make recommendations on what additional role, if any, SGA should take with respect to land use decisions within the SGA area	6 months

Appendix B

Data Management System Field Architecture

DATA MANAGEMENT SYSTEM

Field Architecture

Well Information

- Well ID
- Well Name
- Agency System ID
- Region ID
- State Well ID
- Primary Station Code (DHS ID)
- Well Group ID
- Purveyor Well Identifier
- Well Use
- Well Status
- X Coordinate (ft)
- Y Coordinate (ft)

Coordinate Data Source

- Well Accessibility
- Water Level Access
- Comment
- Drillers Report
- Geo Physical Log
- Screened Aquifer Zone

Well Location

- Alternate Name
- Street Address
- Nearest Cross Street
- Community Area Served
- Reference Point
- Reference Point Location
- Reference Point Source
- Reference Point Datum
- Reference Point Elevation
- Ground Surface Elevation

Well Construction

- Installation Date
- Well Depth
- Boring Depth
- Drilling Method
- Well Diameter
- Bore Hole Diameter
- Casing Diameter
- Bore Casing Bottom Depth
- Casing Material
- Type of Well
- Data Source
- Well Age
- Well Integrity
- Conductor Used
- Conductor Removed
- Depth to Top of Screen
- Length of Screen
- Screen Material
- Screen Slot Size
- Screen Diameter

Pump/Motor Info

- Pump Model
- Pump Type
- Pump Size
- Pump Capacity
- Depth to Intake
- Lubrication Type
- Power Type
- Maximum Pump Yield
- Well Metered
- Pumping Duration
- Operation Control
- Discharge Location
- Pump to Waste Capabilities
- Auxiliary Power Availability

Geology/Aquifer Info

- Geologist
- Boring Log
- Well Construction Diagram
- Date Last Redeveloped
- Transmissivity
- Hydraulic Conductivity
- Storativity
- Porosity
- Aquifer Data Source
- Type of Pump Test
- Geophysical Log
- Well Development Log
- Thickness of Confining Layer
- Begin Lithologic Zone
- End Lithologic Zone
- Lithologic Code
- Begin Geologic Stratum
- End Geologic Stratum
- Geologic Stratum
- Begin Aquifer Zone
- End Aquifer Zone
- Aquifer Zone

Well head Protection

- Annular or Sanitary Seal
- Depth of Annular Seal
- Annular Seal Material
- Dimensions of Annular Seal
- Length of Gravel Pack
- Depth of Gravel Pack
- Distance to Sewer
- Distance to Active Well
- Distance to Abandoned Well
- Distance to Surface Water
- 100 year flood plain
- Enclosure type
- Floor Material
- Pit
- Pit Depth
- Drainage Away From Well

Groundwater Levels

- Measurement Date
- Time of Measurement
- Depth to Water
- Standing Water Elevation
- Measurement Device
- Standard Measurement Codes
- Comments on No Measurement
- Questionable Measurement Codes
- Comments on Measurement
- Measuring Agency
- Measuring Person

Groundwater Extraction

- Type of Measurement
- Monthly/Annual Record type
- Annual Groundwater Production
- Year
- Jan
- Feb
- Mar
- Apr
- May
- June
- July
- Aug
- Sept
- Oct
- Nov
- Dec

Surface Water (by Purveyor)

- Monthly/Annual record Type
- Annual Surface Water Delivery
- Year
- Jan
- Feb
- Mar
- Apr
- May
- June
- July
- Aug
- Sept
- Oct
- Nov
- Dec
- Source ID

Well Injection

- Monthly/Annual record Type
- Annual Surface Water Recharged
- Year
- Jan
- Feb
- Mar
- Apr
- May
- June
- July
- Aug
- Sept
- Oct
- Nov
- Dec

- Source ID

Water Quality

- Sample Collection Date
- Sample Analysis Date
- Sample Location
- Sample ID
- Constituent Reported
- Less or Greater Than
- Analytical Results
- Unit of Measurement
- Detection Limit for Reporting
- Maximum Contaminant Level
- Reporting Lab
- Sample ID- Lab
- Lab QC Acceptable
- Comment on Acceptability

Appendix C
Phase II DMS QA/QC Process

MEMORANDUM

MWH

To:	Rob Swartz, Sacramento Groundwater Authority	**Date:**	December 5, 2003
From:	Ryan Murdock, MWH Trevor Joseph, MWH Brianne Foster, MWH		
Subject:	DMS Phase II QA/QC Process		

PURPOSE

The purposes of this memorandum are: 1) to provide documentation of the quality assurance/quality control (QA/QC) process that was performed by MWH on the purveyor-provided data contained in the DMS database, 2) to provide some comments on data entry and missing data, and 3) to list the improvements that have been made to the DMS program in this phase of work.

QA/QC

DATA TYPES

This section of the memorandum is organized by the various data types that exist in the DMS database, namely: Lithology, Well Construction, Water Levels, Groundwater Production, Surface Water Deliveries, and Water Quality.

GENERAL

MWH staff familiar with the program reviewed general functions of the SGA DMS. In doing so, specific changes were discussed, and made where appropriate. Some general changes that were made include the alteration of database fields where needed. Several fields were moved, renamed, or deleted from the database. The following is a list of fields that were added to the DMS after the data entry process was completed. Data is available for these fields, but has not been entered.

DMS Table	Field
Well Information	Well Owner
Well Information	Well Completion Report Number
Well Location	Ground Surface Elevation Source
Screen Specification	Screen Type
Pump/Motor Information	Pump Test Made

WELL CONSTRUCTION

The well construction detail reports for all SGA and DWR wells were printed out, reviewed, and changes were made where appropriate. The detail reports include various information for an individual well, such as well depth, well diameter, screen location, drilling method, and borehole diameter, and if any data was missing or looked inconsistent, the well completion reports were pulled from the hard-copy storage and cross-examined with the detail report.

LITHOLOGY

For purposes of lithologic QA/QC, sixteen cross-sections in parallel direction of the surface topography showing lithologic units were created. All of the driller's logs in the DMS from each purveyor were checked against these cross-sections. The cross-sections were analyzed for discontinuity, as well as for missing data among wells located within the same region. Further quality assurance was provided for screen interval irregularities, and the total depth of the well versus lithologic depths was analyzed. In many instances discontinuities could not be rectified due to either lack of available data or other limitations.

GROUNDWATER PRODUCTION

5.1 SOURCES OF DATA

- Pre-1990 groundwater production data in DMS comes from Sac County IGSM model; no QA/QC performed
- 1990-1997 data mostly provided from Sac County (some from Purveyors)
- 1998-2002 data mostly provided from purveyors (some from Sac County)

5.2 QA/QC STEPS

- Produced Well Pumping Summary Report for each purveyor showing monthly and annual well production volumes for all historical data in DMS
- Examined reports for years/months with data that doesn't follow generally observed trends, checked against original data
- Identified missing data

<u>Comments on Pumping Data</u>:

Sac Suburban Arcade- Missing December 2002 pumping data, 2002 pumping values are smaller than historically, likely due to increased surface water use (purchased from City of Sacramento).

Sac Suburban- Northridge patterns/volumes 98-2002 are not as consistent as 1990-1997. Volume for 2002 looks especially small. Data entered was provided by purveyor.

Southern California WC Arden System- 1990 production looks too high, Never received 1990 data from purveyor (data in DMS is assumed to be from IGSM).

California-American WC (Citizens) – Never received 1990-1995 production data from purveyor.

Citrus Heights- all data provided by purveyor, but patterns are not consistent (they use mostly surface water).

City of Sacramento- Feb 1995 looks abnormally high (wells 153 and 158), data is as provided by purveyor.

Orange Vale WC- No production data provided by purveyor for 1990-1995 and 2002, assumed to be zero.

Fair Oaks- All data provided by purveyor, inconsistent patterns and volumes (they use mostly surface water).

Sacramento County Water Agency- Missing monthly data by well from 1998, 2000, 2002.

SURFACE WATER DELIVERIES

5.3 COMMENTS ON PURVEYOR SURFACE WATER USE

According to information provided by the purveyors in Phase I, the following purveyors **do not use surface water**:

- Del Paso Manor Water District
- Rio Linda/Elverta Community Water District
- Sacramento County Water Agency- Arden Park Vista and Northgate 880 service areas
- Southern California Water Company- Arden System

The following purveyors do use surface water:

Carmichael Water District- 3 Ranney collectors on the American River, import water (emergency basis) from FOWD, CHWD.

City of Folsom- Uses all surface water, from American River at Folsom Dam, approximately 16,000 ac-ft per year. The only data in the DMS for City of Folsom is the surface water Folsom purchased from San Juan Water District, which averaged about 1,200 ac-ft per year from 1990-2002. Except for 1995-1997, Data was not provided from the City of Folsom Water Treatment Plant for the rest of their surface water supply to reach their estimated use of 16,000 af per yr. Only a small portion of the city of Folsom's service area is within SGA's boundary (north of the American River), and the numbers in the DMS (water purchased from SJWD) do not reflect an estimate of how much surface water is used in the area north of the American River. No such estimates were provided by Folsom.

Natomas Central Mutual Water Co- Uses approximately 120,200 ac-ft per year surface water from Sacramento River for agricultural use. The data from the DMS applies only to the irrigation season (April-Oct), when the US Bureau of Reclamation installs meters to measure the diversions. Natomas CMWC also has a winter water permit which allows them to divert up to 10,000 ac-ft of water during October- March.

San Juan Water District- 120 mgd plant for wholesale and retail. Detailed data provided and entered into DMS.

Citrus Heights Water District purchases treated surface water from San Juan Water District.

Fair Oaks Water District purchases treated surface water from San Juan Water District.

Orange Vale Water Company purchases treated surface water from San Juan Water District.

California-American Water Company (formerly Citizens Water Resources)- The only surface water supply for Cal-Am comes from the Sandalwood Intertie in the Lincoln Oaks System (according to the Phase I questionnaire). Cal-Am uses very little surface water. The only surface water data provided by Cal-Am was for 1997-2002, when they purchased a small amount from Citrus Heights Water District. All other surface water use data in the DMS from 1991-1996 is assumed to be zero.

City of Sacramento- The volumes in the DMS represent the total amount of surface water used by the City of Sacramento, both north and south of the American River. An estimated 20% of the city's surface water is used north of the American River.

Sacramento Suburban Water District- Northridge Service Area- Surface water use began in the Northridge area in December 1991. All surface water use data in the DMS was provided by the purveyor. Northridge gets a large portion of their surface water from San Juan Water District.

Sacramento Suburban Water District- Arcade Service Area- Arcade water district did not use surface water historically. Presently the Arcade Service area of Sacramento Suburban Water District purchases surface water from the City of Sacramento. This surface water data was not provided and is not included in the DMS.

GROUNDWATER LEVELS

- Water levels were updated for all of the State Water Project (SWP) wells monitored by DWR by importing recent data from the DWR website (EXTERRA).

- MWH did not QA/QC wells from exterra database since data was transferred electronically (no entry errors)
- The accuracy of the groundwater elevations also depends upon the ground surface elevation, since the DMS calculates the groundwater elevations as the ground surface elevation minus the depth to groundwater. The ground surface elevations were reviewed to assure continuity with relative topographical surroundings. Some ground elevation discrepancies were identified and corrected.

WATER QUALITY

Water quality data makes up the largest portion of data in the DMS database. The water quality table contains over 120,000 records. Water quality data was provided in various formats by the purveyors and labs. Challenges with the data included inconsistent constituent spelling and punctuation, alternative constituent names, inconsistent units between different data sources, and electronic data with no DLR (and in some cases no units) given.

Analysis was performed on the water quality data to:

- Ensure constituent name consistency
- Ensure unit consistency with each constituent
- Identify statistical “outliers” and correct the values where warranted

5.4 RESULTS

- The constituent spelling and naming is now consistent in the DMS for easier query capabilities.
- Based on constituent units reported on the DHS website, a consistent unit was assigned for each individual constituent. This assures that there will not be any misinterpretation when reviewing the data.
- The water quality data was analyzed for statistical outliers, which were checked against the original data, and fixed when values had been entered incorrectly.

The statistical analysis of water quality results provided an opportunity to query the database and evaluate consistency within the database as it may impact data evaluation. The statistical review identified water quality results that were much different than other values in the data set. Such results are referred to as an "outlier." The test for an outlier determines whether there is statistical evidence that a result that appears extreme does not fit the distribution of the rest of the data. The USEPA recommended that the statistical outlier test (Statistical Analysis Statistical of Ground-Water Monitoring Data at RCRA Facilities, Publication PB89 – 151047, April 1989) be used. When a result was identified as an outlier, additional focused QA/QC review was conducted to ensure that the result identified was not extreme due to an error in transcription of data. The statistical EPA guidance (1989) identified outlier data points where evidence was available which documents an error will be corrected and data points where evidence was not available which documents an error in the data point will be left unchanged in the database.

5.5 DETECTION LIMIT TABLE

The detection limit table is essentially the master list of all of the water quality constituents that could be entered into the DMS database, and also includes current DLRs, MCLs, and DHS storet #s for each constituent where applicable. Also in the detection limits table, each of the DMS water quality constituents were assigned to a chemical group: general chemistry, metals, radioactivity, microbial, volatile organic, semivolatile organic, or synthetic organic.

5.6 OTHER WATER QUALITY NOTES

California-American WC Water Quality Data- Values that were reported as zero in the electronic water quality data were not entered into the DMS database (although zero values may have represented non-detects) because units and DLRs were not provided with the data.

NonDetect field in water quality table- A new field was added to the water quality table called "NonDetect." This field is populated with "ND" when the analytical result was reported as ND, but no detection limit was given. These "NonDetect" records either have a null or zero value in the analytical result field.

DMS PROTOCOLS

5.7 WELL OWNERSHIP CHANGES

It is not uncommon for wells to change ownership between adjacent purveyors. When a well changed ownership, the well construction data stays with the well under the "old" owner, and the time variant data (WQ, WLs, production) is tracked under the new purveyor owner after the date of ownwership change. So there will be 2 wells in the DMS for wells that have changed ownership.

5.8 WELL ABANDONMENT DATES

When only year of well abandonment was known, date was entered as 1/1/yyyy (DMS needs m/d/y format).

5.9 WELL STATUS FIELD IN WELL INFORMATION TABLE

Well Status (choices are Active/Inactive/Standby/Pump Pulled/Abandoned/Destroyed/Test Hole Only) was not entered for wells where the purveyor did not provide such information. No assumptions were made on whether a well was active, inactive, etc if the data was not provided. The data was provided and entered for more than half of the purveyors, but the larger purveyors tended not to provide this data.

5.10 WELL USE FIELD IN WELL INFORMATION TABLE

All SGA purveyor wells are assumed to be municipal production wells.

DWR DATA SUMMARY

MWH received Drillers Reports/Well Completion Reports and other data for 44 wells from DWR. These wells are located in the western portion of the SGA boundary, where fewer purveyor wells exist. Most of these wells represent private wells. However, 7 of these wells were purveyor wells that were already in the DMS, and 11 of these wells were part of the state well program (wells monitored for water levels by various agencies; data is reported to DWR). State Well Program (SWP) wells had also already been entered into the DMS.

Data (including lithology and well construction) was entered for all of the 44 wells from the Drillers Reports. Water level data was received for 11 wells (the SWP wells) and entered into the DMS. Recent water quality data was received for only 2 wells (SAC-133 and RLE-09) and was entered into the DMS. The following table summarizes data regarding data received from DWR for the 44 wells, and how these wells were incorporated into the DMS.

State Well ID	Driller's Report #	DMS Well ID	DMS Well Name	Comments
09N/03E-02A	9462	831	DWR-01	
09N/04E-04	726506	832	DWR-02	
09N/04E-04	726507	833	DWR-03	
09N/04E-06D1	46832	834	DWR-04	
09N/04E-10K1		836	DWR-05	
09N/04E-13F01	9483	837	DWR-06	
09N/04E-13M	435838	838	DWR-07	
09N/04E-15B	94456	839	DWR-08	
09N/04E-15H	9460	840	DWR-09	
09N/04E-17J2	111583	841	DWR-10	
09N/04E-20A01	123114	842	DWR-11	
09N/04E-26F	181781	843	DWR-12	
09N/04E-27D01	97960	844	DWR-13	
09N/04E-27F03	61671	845	DWR-14	
09N/04E-27F05	61670	846	DWR-15	
10N/03E-23H01	110963	847	DWR-16	
10N/03E-26E01	84449	848	DWR-17	
10N/03E-27J01	60561	849	DWR-18	
10N/03E-36N01	46827	850	DWR-19	
10N/04E-22G1	111539	851	DWR-20	
10N/04E-33	234700	856	DWR-21	
10N/05E-30N02	37311	857	DWR-22	
09N/04E-26J08	43366	862	DWR-23	
09N/04E-28D07	97959	863	DWR-24	
10N/03E-35P01	72139	864	DWR-25	
10N/05E-19C01	81342	865	DWR-26	
10N/04E-30A01	45211	861	SIA-04	
10N/04E-30L01	77967	859	SIA-02	
10N/04E-30M01	77968/225514	858	SIA-01	
09N/05E-07C01	3612	1	SCO-16	
10N/04E-31C02	77970	860	SIA-03	
10N/05E-31A1	62170	368	RLE-09	water quality data

09N/05E-07J	77963	196	SAC-133	water quality data
09N/04E-10C01	52262	739	SWP-213	water level data (EXTERRA)
09N/04E-27F01		742	SWP-216	water level data (EXTERRA)
10N/03E-35A01		787	SWP-261	water level data (EXTERRA)
10N/04E-23A01	n/a	789	SWP-263	water level data (EXTERRA)
10N/04E-36B01		795	SWP-269	water level data (EXTERRA)
10N/05E-30L01		800	SWP-274	water level data (EXTERRA)
09N/04E-08L01		835	SWP-212	water level data (EXTERRA)
10N/04E-31M01		852	SWP-257	water level data (EXTERRA)
10N/04E-31M02		853	SWP-258	water level data (EXTERRA)
10N/04E-31M03		854	SWP-259	water level data (EXTERRA)
10N/04E-31M04		855	SWP-260	water level data (EXTERRA)

5.11 MISSING DATA

The following two tables identify the data that is missing from the DMS database. This data was not provided by the purveyors, although it was requested. Efforts in the future should focus on obtaining this data to complete the population of the DMS database.

4.7.3 SGA DMS PHASE II- MISSING DATA

Purveyor	Groundwater Production	Water Quality	Water Levels	Surface Water
California-American Water Company (formerly Citizens)	Monthly data by well for 1990-1995, 1998	Need to re-request electronic data from 1993-2002 with units and DLRs given	All wells 1949-present	monthly data 1991-2002
Citrus Heights Water District	OK	All wells 1999- present	All wells 1999-present	OK
City of Sacramento	OK	All wells- 2002	all wells pre-2001	OK
Del Paso Manor Water District	OK	All wells 1999- present	All wells 1949-present	N/A
Orange Vale Water Company	OK	OK	All wells 1949-present	Monthly data 1991-1994
Sacramento County Water Agency	Monthly data by well for 1998, 2000-2002	OK	Arden Park Vista service area: 1949-2002	N/A
Sacramento Suburban Water District	Arcade wells: Dec 2002	OK	Arcade wells: 1995- present	Northridge service area: monthly data 1991, Arcade Service Area: surface water purchased from City of Sacramento
Southern California Water Company	Monthly data by well for 1990	OK	OK	Arden System monthly data 1991-2002

City of Folsom	N/A	N/A	N/A	Monthly data 1991- present from City's treatment plant

4.7.3.1 MISSING WELL COMPLETION REPORTS / DRILLERS REPORTS

Purveyor	DMS Well ID	DMS Well Name	State Well ID	MWH Comments	Comments by Purveyors
Sac Suburban WD (Arcade)	52	ARC-007	09N/05E-23A01		
Sac Suburban WD (Arcade)	813	ARC-008			
Sac Suburban WD (Arcade)	889	ARC-032A		different from well Arcade well #32	
Sac Suburban WD (Arcade)	890	ARC-033A		different from well Arcade well #33	
Sac Suburban WD (Arcade)	891	ARC-040A		different from well Arcade well #40	
Sac Suburban WD (Arcade)	129	ARC-050	08N/06E-06F01	data sheet*	
Sac Suburban WD (Arcade)	131	ARC-051	09N/06E-32F01	data sheet*	
Sac Suburban WD (Arcade)	892	ARC-056A		different from well Arcade well #56	
Sac Suburban WD (Arcade)	893	ARC-059A		different from well Arcade well #59	
Sac Suburban WD (Arcade)	828	ARC-063			
Sac Suburban WD (Arcade)	225	ARC-070			
Carmichael WD	232	CAR- Landis Ave			abandoned
Carmichael WD	815	CAR-Barrett			purveyor has data, MWH waiting to receive
Carmichael WD	226	CAR-Cottage			abandoned
Carmichael WD	230	CAR-Jan Drive			abandoned
Carmichael WD	233	CAR-Paddock			abandoned
Carmichael WD	526	CAR-Willow Park	09N/06E-09K01		purveyor has data, MWH waiting to receive
Citrus Heights WD	817	CHWD-009			dry hole drilled in 1990, no drillers report, have e-log
California American WC (Citizens- Antelope)	497	CIZ-ANT-Cook Riolo	10N/05E-22A02		
California American WC (Citizens- Lincoln Oaks)	272	CIZ-LO-Roseville Road	10N/06E-22A01		
California American WC (Citizens- Lincoln Oaks)	276	CIZ-LO-Sandalwood	10N/06E-32H01		
California American WC (Citizens- Lincoln Oaks)	279	CIZ-LO-Summerplace	10N/06E-14D01	data sheet*	
California American WC (Citizens- Lincoln Oaks)	281	CIZ-LO-Treelark	10N/06E-22B01	data sheet*	
California American WC (Citizens- Lincoln Oaks)	282	CIZ-LO-Twin Parks	10N/06E-22B01		
California American WC (Citizens- Lincoln Oaks)	283	CIZ-LO-Vanmaren	10N/06E-34F01	data sheet*	

Sac Suburban WD (Northridge)	62	NOR-003	09N/06E-18J01		
Sac Suburban WD (Northridge)	8	NOR-007	10N/06E-33N01	data sheet*	
Sac Suburban WD (Northridge)	822	NOR-013			
Sac Suburban WD (Northridge)	823	NOR-019			
Rio Linda/Elverta CWD	825	RLE-001			destroyed in 1990, no lithology info, located close to well #12
City of Sacramento	34	SAC-091	09N/05E-30D01	data sheet*	city only has the well data sheet
City of Sacramento	33	SAC-092	09N/05E-19M01	data sheet*	city only has the well data sheet
City of Sacramento	66	SAC-117	09N/05E-28C01	data sheet*	city did not have the drillers report
City of Sacramento	829	SAC-119			city did not have the drillers report
City of Sacramento	18	SAC-131	09N/05E-15D01	data sheet*	city only has the well data sheet
Sac County Water Agency	866	SCO-010		data sheet*	well not in service; well data not available
Sac County Water Agency	122	SCO-011	08N/05E-02J02 M	data sheet*	well not in service; well data not available

*We have the DWR well data sheet (different from Drillers Report), but it only contains name and location, and does not contain any lithology or well construction info