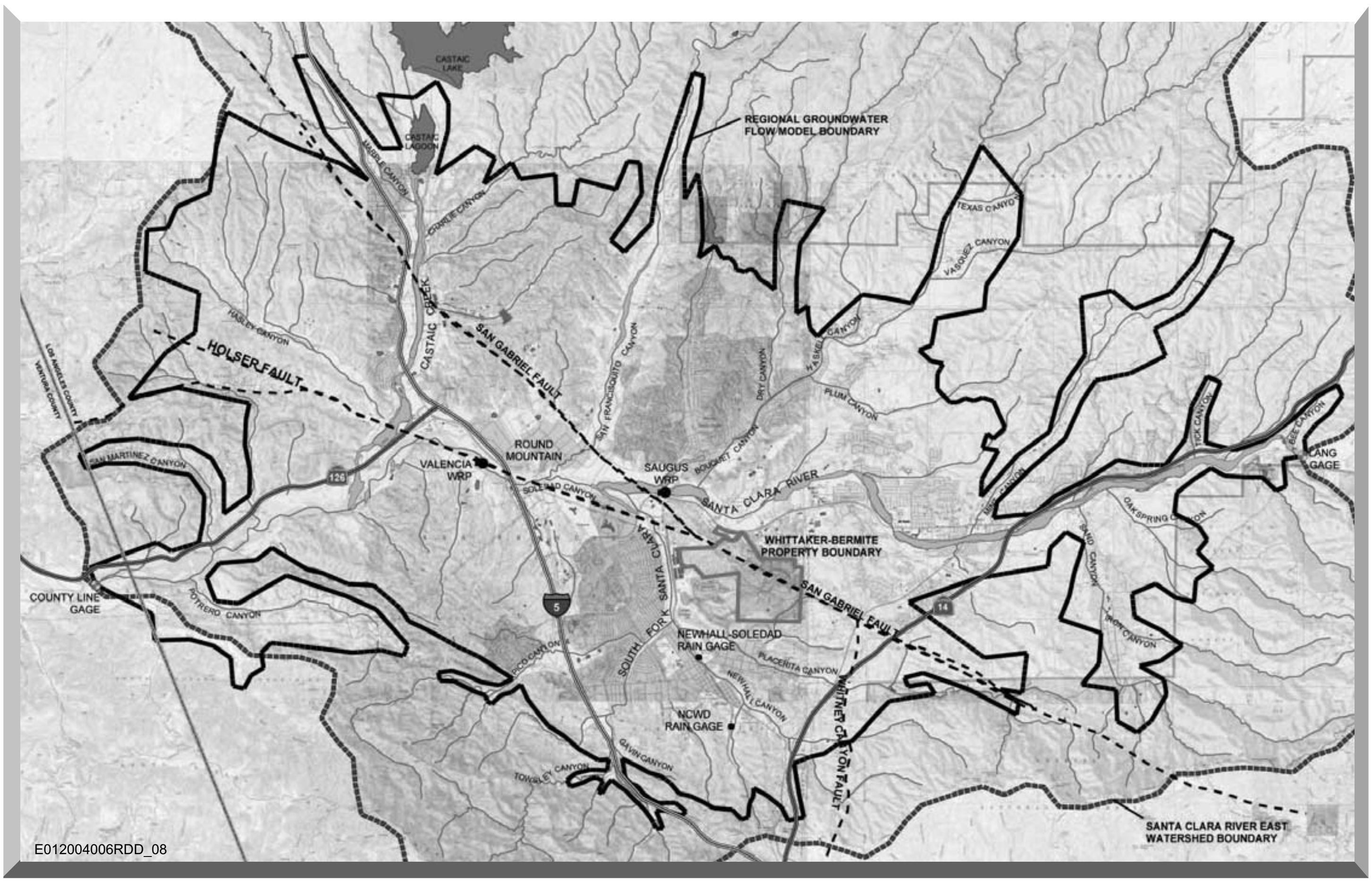
CH2MHill Final Report, Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, December 2004

FINAL REPORT

Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property

Prepared in Support of the 97-005 Permit Application



Prepared for

Upper Basin Water Purveyors:

Castaic Lake Water Agency (CLWA)

Newhall County Water District

Santa Clarita Water Division of CLWA

Valencia Water Company

CH2MHILL

Santa Clarita, California

December 2004

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Subject: Submittal of Final Report on Perchlorate Containment Analysis

Dear Mr. DiPrimio, Mr. Masnada, Mr. Manetta, and Mr. Cole:

CH2M HILL is pleased to submit the enclosed final report titled *Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California*. This report has been developed for the Upper Basin Water Purveyors and is the second of two reports that present and evaluate the strategy for containing perchlorate that is emanating from the Whittaker-Bermite site. This work has been performed as part of the Environmental Oversight Agreement with DTSC, which has approved both reports. The first report, dated April 2004, documented the construction and calibration of a groundwater flow model for the Santa Clarita Valley. The enclosed report presents a modeling analysis of the perchlorate containment plan and also discusses the general design of a sentinel monitoring plan that will be implemented in conjunction with the perchlorate containment plan (per the requirements of the Department of Health Services' 97-005 Policy).

It has been our pleasure to serve the Upper Basin Water Purveyors on this important project. Please feel free to call me at 503/235-5022, if you have any questions.

Sincerely,

CH2M HILL

John J. Porcello
Project Manager

Nathan R. Brown
Hydrogeologist

RDD/041620011(clr2739.doc)
Enclosures

Final

Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

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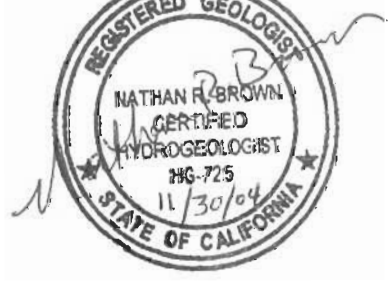

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CH2MHILL

Executive Summary

ES.1 Introduction

This report presents an analysis of a plan to contain perchlorate that is present in the Saugus Formation aquifer, which lies beneath a portion of the Santa Clarita Valley (located in northwestern Los Angeles County, California). The containment plan consists of pumping from two deep production wells (SCWC-Saugus1 and SCWC-Saugus2) that have not operated in several years because of elevated concentrations of perchlorate in groundwater. The SCWC-Saugus1 and SCWC-Saugus2 wells will be pumped on a nearly continual basis at a rate of 1,200 gallons per minute (gpm) at each well. A third impacted well, NCWD-11, might be pumped seasonally (during the summer) at 1,200 gpm if it is put back into service. However, this well is not needed to meet the containment objectives and might be destroyed. The groundwater that is pumped from these wells will then be treated at a central location to remove perchlorate prior to entering the potable water conveyance system. The treated water will be pumped to the Rio Vista Intake Pump Station (owned and operated by the Castaic Lake Water Agency [CLWA]) for subsequent distribution, to help meet water demands. In addition to these containment operations, one perchlorate-impacted production well (VWC-157) that lies downgradient of SCWC-Saugus1 and SCWC-Saugus2 will be destroyed, rather than being used for containment. Also, a network of sentinel monitoring wells will be used for performance monitoring of the containment plan and for providing early warning of any changes that might occur in groundwater quality upgradient of the containment wells.

The selected pumping plan has been designed to cause perchlorate, which is migrating in groundwater from the nearby Whittaker-Bermite property, to be captured by these wells, thereby controlling its movement toward other portions of the aquifer, where additional water supplies could otherwise be impacted. The operation of these wells is also designed to capture perchlorate-containing groundwater that is present just downgradient of these two wells. The pumping rates have been selected by considering the water supply needs of the valley and analyses of groundwater flow patterns that are expected under the pumping plan for these wells. The analyses of groundwater flow patterns have been performed using a numerical regional-scale groundwater flow model of the valley, which was developed by the local water purveyors (herein referred to as the Purveyors[1]) for use in managing the local groundwater resource. Figure ES-1 shows the study area, including the model boundaries (tables and figures are located at the end of this summary).

Returning perchlorate-impacted production wells to service with treatment requires the issuance of a permit by the California Department of Health Services (DHS) before the water can serve as a potable water supply. Before issuing a permit, DHS requires that formal studies and engineering work be performed to demonstrate that pumping these wells and

[1]The Purveyors, also referred to as the Upper Basin Water Purveyors, consist of the Castaic Lake Water Agency (CLWA), the Newhall County Water District, the Santa Clarita Water Division of CLWA, and the Valencia Water Company.

treating the water will be protective of human health for the users of the water[2]. To obtain a permit, the owner of the well must perform a detailed evaluation of the effects of returning the well to service. The process for conducting the evaluation is called the 97-005 process, named after the policy memo that describes the process (DHS, 1997). The policy memo also discusses the basic tenets under which the DHS Drinking Water Program evaluates proposals, establishes appropriate permit conditions, and approves returning an impacted well to service for direct potable use.

This report presents the modeling analysis of the Purveyors' preferred pumping plan for the Saugus Formation in the vicinity of the impacted Saugus production wells. This report also presents the objectives and general design of a groundwater quality monitoring program that will be implemented conjunctively with the pumping and treatment program, to identify any changes in groundwater quality that might adversely affect the treatment process. This monitoring program will include water level monitoring and groundwater modeling activities during startup of the long-term containment system, to verify that containment is being achieved and evaluate whether adjustments to the pumping program are warranted. This report has been prepared to support the source assessment and permitting process that the Purveyors are performing under the 97-005 Policy.

ES.2 Background

In 1997, two Saugus Formation production wells owned by the Santa Clarita Water Company (SCWC)[3] (wells SCWC-Saugus1 and SCWC-Saugus2), one Saugus Formation production well owned by the Newhall County Water District (NCWD) (well NCWD-11), and one Saugus Formation production well owned by Valencia Water Company (VWC) (well VWC-157) were shut down because perchlorate was detected in groundwater at these wells. In 2002, an Alluvial Aquifer production well owned by SCWC (well SCWC-Stadium) was shut down because of a perchlorate detection. The locations of the five impacted production wells and nearby nonimpacted production wells are shown on Figure ES-2, along with the locations of monitoring wells and exploratory borings that have been installed to investigate the extent of perchlorate contamination. Figure ES-2 also shows perchlorate concentrations at locations where perchlorate has been detected in groundwater. At each of the five production wells, the detected perchlorate concentrations exceeded the State of California's Action Level (AL) for perchlorate at the time of the detection[4].

Together, the four impacted production wells in the Saugus Formation pumped between 1,900 and 6,800 acre-feet per year (AF/yr) during the early and mid-1990s, prior to being shut down. The average pumping from these four wells was 4,186 AF/yr from 1991 through 1996, the 6 years preceding the perchlorate detections (see Table ES-1). The four wells have a combined instantaneous pumping capacity of 7,900 gpm. The Purveyors plan to return three of the four impacted Saugus Formation production wells to service (SCWC-Saugus1,

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[2]The Purveyors and DHS require that water provided to customers contain no detectable perchlorate.

[3]The SCWC was acquired by CLWA in 1999. It was formerly called the Santa Clarita Water Company and is now called the Santa Clarita Water Division of CLWA.

[4]The AL has varied over time. DHS initially established an AL of 18 micrograms per liter (μg/L) in 1997, at the same time the four impacted Saugus Formation production wells were taken offline. In 2002, DHS revised the AL to 4 μg/L based on studies by the U.S. Environmental Protection Agency (EPA). In March 2004, the AL was revised to 6 μg/L based on a public health goal published by the Office of Environmental Health Hazard Assessment. See the internet site http://www.dhs.ca.gov/ps/ddwem/chemicals/perchl/actionlevel.htm for further details.

SCWC-Saugus2, and NCWD-11) and to replace one well (VWC-157) with a newer well located in the western portion of the valley (west of the area shown on Figure ES-2).

ES-3 Objectives

In addition to meeting the requirements of the 97-005 Policy Memo (DHS, 1997), the Purveyors have identified the following objectives that must be met by the pumping plan for the impacted Saugus Formation production wells:

1. Hydraulically contain perchlorate that is migrating westward in the Saugus Formation from the Whittaker-Bermite property toward the impacted production wells.
2. Hydraulically contain perchlorate that is present at wells MP-5 and VWC-157, which are located downgradient of the impacted wells.
3. Protect downgradient production wells that are currently not impacted.
4. Restore the annual volumes of water that were pumped from the impacted wells before they were shut down.
5. Operate the impacted wells in a manner consistent with the Purveyors' operational plan for the groundwater resources in the Santa Clarita Valley[5].
6. If possible, pump one or more of the impacted Saugus Formation production wells in a manner that also contains perchlorate migrating in the Alluvial Aquifer from the northern portion of the Whittaker-Bermite property. Unlike the previous objectives, this is a secondary objective for operating the impacted Saugus Formation production wells, because other long-term remedies are being developed for the Alluvial Aquifer. Consequently, this objective is not the basis for selecting or rejecting any given pumping plan for the impacted Saugus Formation production wells.

The pumping plan that is developed and evaluated in this report for the impacted Saugus Formation production wells is an interim program that will operate throughout the period of evaluating, designing, and permitting long-term remedial actions for the Whittaker-Bermite property and nearby groundwater. It is anticipated that the pumping plan for the impacted Saugus Formation production wells will continue to be implemented after the long-term remedies are in place on the Whittaker-Bermite property, in part because the pumping plan is intended to meet the water supply needs of the Purveyors.

ES.4 Methodology

The containment evaluation for the impacted Saugus Formation production wells was performed using the regional groundwater flow model for the Santa Clarita Valley (Regional Model). The Regional Model's construction and calibration are discussed in detail in *Regional Groundwater Flow Model for the Santa Clarita Valley: Model Development and Calibration* (CH2M HILL, 2004a). The Regional Model simulates the temporal and spatial variations in groundwater flow patterns in three dimensions, including the recharge and

[5] This operational plan is described in the documents titled *Urban Water Management Plan 2000* (Black & Veatch, 2000) and *Santa Clarita Valley Water Report 2003* (Luhdorff & Scalmanini Consulting Engineers, 2004).

discharge rates of groundwater in the valley. The Regional Model covers the entire area underlain by the Saugus Formation, plus the portions of the Alluvial Aquifer that lie beyond the limits of the Saugus Formation. The Regional Model area largely coincides with the Santa Clara River Valley East Groundwater Subbasin, extending from the Lang stream gage at the eastern end of the valley to the County Line stream gage area in the west.

The process of designing a modeling analysis to evaluate perchlorate containment consisted of the following activities:

1. Refining the model grid in and around the areas where impacted wells are located
2. Selecting a period over which to simulate groundwater conditions resulting from various pumping configurations
3. Defining the pumping plan at the impacted wells and all other wells in the Santa Clarita Valley, considering the objectives above and the variability in pumping demands that occur due to cycles of drought and nondrought conditions and year-to-year variations in the availability of other water supplies
4. Defining the variation in local hydrology (rainfall, streamflows, and groundwater recharge) on a month-to-month basis throughout the simulation period
5. Running the model to calculate time-varying (monthly) groundwater elevations and groundwater discharge terms throughout the multi-year simulation period
6. Evaluating the modeling results, as follows:
    a. Examining forecasted time-series plots (hydrographs) of water budget terms and groundwater elevations to evaluate the effects of the pumping plan at the impacted Saugus Formation production wells and across the basin
    b. Analyzing forecasted groundwater flowpaths (using particle-tracking techniques) to identify the degree of containment provided by the pumping plan for the impacted Saugus Formation production wells
7. Performing two sets of sensitivity analyses to address the following questions concerning the selected pumping plan for the impacted Saugus Formation production wells:
    a. Can the containment objectives be met by using lower pumping rates at SCWC-Saugus1 and SCWC-Saugus2, rather than the rate of 1,200 gpm that has been selected for each well, based, in part, on the water supply needs of the valley?
    b. How would the model predictions change if the degree of connection between the Alluvial Aquifer and the Saugus Formation is less than the degree of connection that is simulated by the calibrated model?

Of importance to the analysis was not only the operation of the impacted wells, but also the operational pumping plan for other production wells in the Santa Clarita Valley. The operational plan for the Santa Clarita Valley's groundwater resources has been defined in the *Urban Water Management Plan 2000* (UWMP) for the Santa Clarita Valley (Black & Veatch, 2000) and in annual water reports that discuss the water demands, water supplies, and surface water and groundwater resources of the valley (including the *Santa Clarita*

Valley Water Report 2003 [Luhdorff & Scalmanini Consulting Engineers, 2004]). These reports provide ranges of values for groundwater extractions from the Alluvial Aquifer and the Saugus Formation during average/normal years and dry years. For the modeling analysis, the locations and temporal variation in pumping from the Alluvial Aquifer were defined from the operational plan and from historical records of the year-to-year variability in local hydrology. Simulated pumping from the Saugus Formation was defined from the operational plan, historical pumping records, and operational constraints and historical patterns of water supply availability for water supplies that are imported from the State Water Project (SWP). Pumping rates at individual wells were assigned using the recent and planned production schedules for each well and by evaluating the type of pumping plan that will meet the perchlorate containment objectives for the impacted wells.

The Regional Model was run using a synthetic 78-year period that was derived from historical records of year-to-year variations in both the local hydrology and the hydrology of the SWP system. The 78-year period simulates the following conditions:

1. Average rainfall during this period is similar to the long-term mean of approximately 18 inches per year, as measured at the Newhall-Soledad rain gage. The period includes long periods (i.e., on the order of decades) of relatively dry conditions and relatively wet conditions.
2. For the Saugus Formation, the simulation period includes 18 years of SWP drought and corresponding dry-year pumping during the 78-year period, including two droughts that last for 3 years and two droughts that last for 2 years. Dry-year pumping from the Saugus Formation ranges between 15,000 and 35,000 AF/yr, compared with 15,000 AF/yr or less in nondrought years (see Table ES-2).
3. For the Alluvial Aquifer, the 78-year period includes 24 years of dry-year pumping, which is approximately 5,000 AF/yr lower than the pumping that occurs during years of normal or above-normal rainfall and streamflows. This period includes one drought lasting for 4 years and two droughts that last 3 years.

Model results were evaluated as follows:

1. Time-series plots (hydrographs) of water budget terms and groundwater elevations were used to forecast the effects of the pumping plan at the impacted wells and across the basin.
2. Groundwater flowpaths were forecast using three-dimensional particle-tracking techniques to identify the degree to which pumping from the impacted Saugus Formation production wells contains perchlorate migrating westward toward these wells from the Whittaker-Bermite property.

ES.5 Conclusions from the Modeling Analysis

The major conclusions from the modeling analysis are as follows:

1. Operating production wells SCWC-Saugus1 and SCWC-Saugus2 at rates of 1,200 gpm each on a nearly continual basis will effectively contain perchlorate migrating westward in the Saugus Formation from the Whittaker-Bermite property, and will also contain perchlorate that is present at Saugus wells MP-5 and VWC-157. This is shown by Figure

ES-3, which displays groundwater flowpaths from MP-5, VWC-157, and the Whittaker-Bermite property; and by Figure ES-4, which displays the areas within the Saugus Formation where water is obtained by each of the impacted production wells and each of the nonimpacted production wells that are located downgradient of SCWC-Saugus1 and SCWC-Saugus2.

2. Operating production wells SCWC-Saugus1 and SCWC-Saugus2 at rates as low as 700 to 800 gpm each will not fully contain groundwater that is migrating westward from the Whittaker-Bermite property. Additionally, if these wells are operated at 1,000 gpm each, perchlorate that is present in the Saugus Formation at wells MP-5 and VWC-157 will not be captured, and will instead migrate to existing nonimpacted wells VWC-160 and VWC-205.

3. No new production wells are needed in the Saugus Formation to meet the perchlorate containment objectives.

4. Impacted well NCWD-11 is not a required component of the containment program.

5. Use of other water supplies in lieu of pumping at SCWC-Saugus1 and SCWC-Saugus2 will likely be detrimental to the long-term quality of groundwater in the Saugus Formation. Pumping at these two wells is necessary to prevent migration of perchlorate to other portions of the Saugus Formation.

6. The pumping plan for SCWC-Saugus1 and SCWC-Saugus2 may contain perchlorate that is migrating in the Alluvial Aquifer from the northern portion of the Whittaker-Bermite property, including perchlorate that has been detected in the Alluvial Aquifer at and south of Bouquet Junction.

7. The operational plan for the impacted production wells will not cause detrimental short-term or long-term effects to the groundwater and surface water resources of the Santa Clarita Valley. In particular, the modeling analysis indicates that short- and long-term variability in local rainfall and streamflows is the predominant cause of fluctuating groundwater elevations, river flows, and groundwater storage volumes. This is indicated by Figures ES-5 through ES-7, which together show that year-to-year changes in groundwater recharge volumes and groundwater storage volumes are much greater than year-to-year fluctuations in pumping. Compared to local hydrology, implementation of the operational pumping plan for the valley, including the planned use of wells SCWC-Saugus1 and SCWC-Saugus2, has much less influence on the water resources of the valley.

It is important to note that the model simulations described in this report distribute pumping in a manner that is based on current and projected uses of both the Alluvial Aquifer and the Saugus Formation. The conclusions presented in this report regarding containment of perchlorate-containing groundwater will potentially be different if the pumping plan for other Saugus Formation wells is significantly different than what was simulated. In particular, a significant change in the Saugus Formation pumping regime in the South Fork Santa Clara River area or near its mouth could potentially cause groundwater flow patterns and capture zones to be notably different from those described in this report. Changes that could appreciably alter groundwater flow patterns and capture zones could include the operation of new wells in that area, or notably greater instantaneous pumping rates or annual pumping volumes than those simulated by the Regional Model. Consequently, before a new well is sited in that area or a significant increase in pumping occurs from an existing wellfield in that area, it is recommended that an analysis first be conducted of the potential effects of the contemplated change on the perchlorate containment program.

ES.6 Sentinel Monitoring Program

DHS Policy Memo 97-005 requires the implementation of sentinel monitoring in groundwater upgradient of impacted wells to provide early warning of any unanticipated changes in groundwater quality. Based on this policy, the sentinel monitoring plan for the impacted Saugus Formation production wells is intended to provide advanced warning of concentration changes or the presence of additional contaminants in groundwater that might affect the perchlorate treatment processes. Additionally, groundwater elevation and pumping data will be collected under the sentinel monitoring plan to evaluate the effectiveness of the perchlorate containment plan that is described in this report.

As shown on Figure ES-8 and in Table ES-3, the monitoring well network for the sentinel monitoring program will monitor both the Alluvial Aquifer and the Saugus Formation upgradient of each production well. Monitoring will occur at eleven wells, seven of which do not yet exist. Well locations were selected according to the following considerations:

1. Locating sentinel wells sufficient distances from the production well to allow adequate time to respond to significant concentration changes
2. Using existing monitoring wells, to the degree possible
3. Locating new monitoring wells in areas where site access will not cause undue restrictions on drilling, installing, and monitoring new sentinel monitoring wells

Table ES-4 lists the chemical constituents to be monitored, and the frequency at which monitoring will occur as the operational plan for the impacted wells is implemented. The program will focus primarily on monitoring for perchlorate, volatile organic compounds, nitrate, and sulfate, which are the constituents most likely to affect the treatment system if present at concentrations greater than those observed to date. General minerals (anions and cations) will be sampled on a biannual basis to provide geochemical information that may be helpful for evaluating groundwater migration in the vicinity of each impacted production well. However, nitrate and sulfate will be analyzed annually because of their potential influence on the ion-exchange treatment system, which is the system likely to be selected for perchlorate treatment at SCWC-Saugus1, SCWC-Saugus2, and NCWD-11.

Performance monitoring of the pumping plan's ability to meet the containment objectives will be accomplished by monitoring groundwater levels and pumping rates during system startup and analyzing these data with the Regional Model. Water level monitoring will be conducted at each sentinel well that is completed in the Saugus Formation and at multi-port monitoring well MP-5, which is also completed in the Saugus Formation and is located downgradient of SCWC-Saugus1 and SCWC-Saugus2. Water levels will be measured at these wells during the start-up period for the containment system, as well as immediately prior to startup. The water level trends will then be compared with water level trends that are calculated from Regional Model simulations of the pumping at impacted and non-impacted wells during the initial startup period for the containment pumping plan. Together, the system monitoring data and the subsequent modeling analysis will used to draw conclusions concerning the effectiveness of the containment plan and whether adjustments to the pumping operations at SCWC-Saugus1 and SCWC-Saugus2 are warranted.

Tables

TABLE ES-1
Historical Pumping at Impacted Saugus Formation Production Wells
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Well Owner - Well Name	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
VWC-157	635	604	529	239	387	314	581	484	1,222	1,146	635	1,005	570	436	616	403	46	81	0	0	0
SCWC-Saugus1	0	0	0	0	0	0	0	0	31	0	0	1,690	437	1,226	1,333	0	410	451	0	0	0
SCWC-Saugus2	0	0	0	0	0	0	0	0	32	0	40	3,091	2,476	1,675	2,530	1,726	1,766	617	0	0	0
NCWD-11	729	870	715	754	1,159	1,278	2,209	2,371	1,265	1,280	1,252	1,034	428	730	614	522	353	81	14	0	0
Total	**1,364**	**1,474**	**1,244**	**993**	**1,546**	**1,592**	**2,790**	**2,855**	**2,550**	**2,426**	**1,927**	**6,820**	**3,911**	**4,067**	**5,093**	**2,651**	**2,575**	**1,230**	**14**	**0**	**0**

1991 through 1996 average = 4,186

Note:
All pumping volumes are listed in AF/yr.

TABLE ES-2
Annual Pumping Rates Specified by the Operational Plan for the Santa Clarita Valley's Groundwater Resources
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Aquifer	Normal Years	Dry Year 1	Dry Year 2	Dry Year 3
Operational Plan Pumping				
Alluvium	30,000 to 40,000	30,000 to 35,000	30,000 to 35,000	30,000 to 35,000
Saugus	7,500 to 15,000	7,500 to 25,000	21,000 to 25,000	21,000 to 35,000
Total	**37,500 to 55,000**	**37,500 to 60,000**	**51,000 to 60,000**	**51,000 to 70,000**
Modeled Pumping				
Alluvium	38,429	33,767	33,767	33,767
Saugus	10,679	15,760	24,346	34,096
Total	**49,108**	**49,527**	**58,113**	**67,863**

Notes:

All pumping volumes are listed in acre-feet.

The operational plan is defined in the documents titled *Urban Water Management Plan 2000* (Black & Veatch, 2000) and *Santa Clarita Valley Water Report 2003* (Luhdorff & Scalmanini Consulting Engineers, 2004).

In the model simulations, total pumping is different than listed in this table when dry-year pumping conditions in one aquifer coincide with normal-year pumping conditions in the other aquifer (due to differences in the timing of dry conditions locally versus reduced deliveries of water imports from the State Water Project).

TABLE ES-3

Well Network for Sentinel Groundwater Quality Monitoring

Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Production Well	Sentinel Monitoring Locations	New Monitoring Well Needed?	Actual or Target Depth Interval for Well Screen (ft bgs)	Well Name	TOT Distance from Production Well	Rationale, Comments
SCWC-Saugus1	Alluvium: New well in Magic Mountain Parkway north of Saugus1	Yes Yes	40-60 170-180	AL-12A AL-12B	1 year or less	Alluvial and Saugus HSU S-I monitoring is for a possible pathway to SCWC-Saugus1. Access constraints might require installation of these wells in the City of Santa Clarita right of way along Magic Mountain Parkway. There are currently no Saugus Formation monitoring wells within the delineated capture zone of SCWC-Saugus1. The Saugus wells for HSU S-III will be installed near the corner of San Fernando Road and Magic Mountain Parkway on land owned by the Newhall Land & Farming Company.
	Saugus (S-I unit): Adjacent to new alluvium well	Yes	230-250 (HSU S-I)	SG1-HSU1		
	Saugus (S-III unit): NLF land north of SCWC-Saugus1	Yes Yes Yes	490-520 (HSU S-III) 580-640 (HSU S-III) 750-770 (HSU S-III)	SG1-HSU3a SG1-HSU3b SG1-HSU3c		
SCWC-Saugus2	Alluvium: Existing well AL06	No	65-85	AL06	10 years	Alluvial monitoring is recommended to assess perchlorate near the SCWC-Saugus2 well. At MP-1, the port 2 screen correlates with the top of the screened intervals at SCWC-Saugus1 and SCWC-Saugus2. Port 4 is the uppermost port below a depth of 1,000 feet and below the zones containing perchlorate.
	Saugus: MP-1, ports 2 and 4	No No	391.4-401.4 (HSU S-III) 747.5-757.5 (HSU S-V)	MP-1 (port 2) MP-1 (port 4)		
NCWD-11	Alluvium: Existing well AL03	No	91-111	AL03	2 years	Alluvial monitoring is recommended because of the potential for the Alluvial Aquifer to be a pathway for perchlorate migration from the site to well NCWD-11. Additionally, movement within the Saugus Formation could be occurring from the site, which is the reason to install a Saugus sentinel well near the Alluvial sentinel well.
	Saugus: New well at AL03 location	Yes	280-320 (HSU S-III)	NC11-HSU3		

Notes:
TOT = time-of-travel
HSU = hydrostratigraphic unit (See *Draft Final Conceptual Hydrogeology Technical Memorandum for the Eastern Santa Clara Sub-basin Groundwater Study* [CH2M HILL, 2004b] for discussions of the locations and characteristics of the HSUs.)

TABLE ES-4
Chemical Constituents and Sampling Frequency for the 97-005 Sentinel Monitoring Program
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Analytical Parameters	EPA Method	Frequency			
		Initial	Semiannual	Annual	Biannual
Organic Constituents					
Perchlorate	314.0	X	X		
Volatile Organic Compounds	524.2[a]	X	X		
1,2,4-Trimethyl Benzene		X	X		
Methyl Tertiary Butyl Ether		X	X		
General Minerals (Cations and Anions)					
Aluminum	6010	X			X
Bicarbonate/Alkalinity	310.1	X			X
Calcium	6010	X			X
Chloride	300	X			X
Total Phosphorus	365.3	X			X
Potassium	7610	X			X
Iron	6010	X			X
Magnesium	6010	X			X
Manganese	6010	X			X
Sodium	7770	X			X
Sulfate	300	X		X	
Nitrate	352.1	X		X	
Ammonia	350.3	X			X

[a]Tentatively identified compounds will also be reported.

Figures

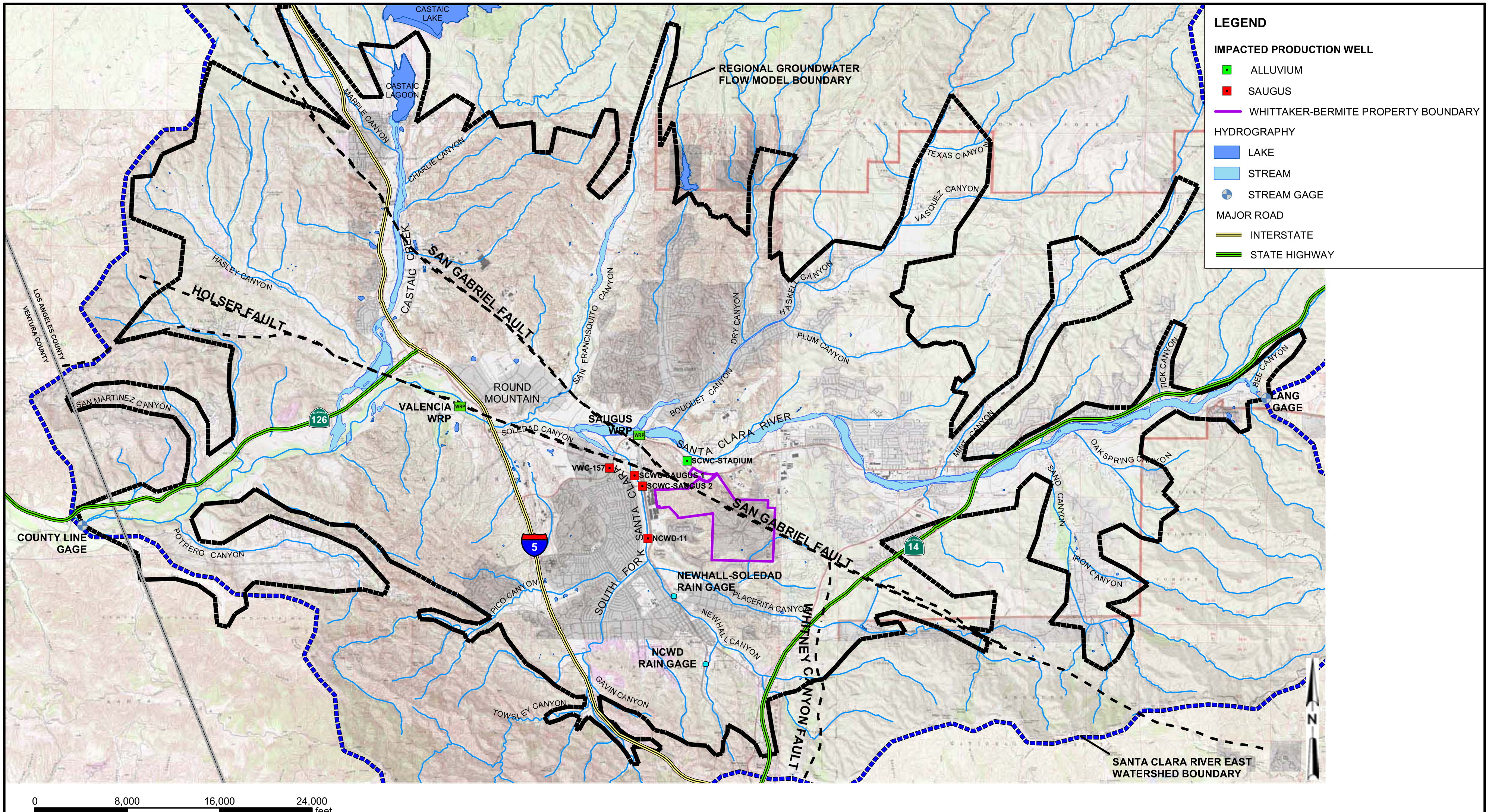

FIGURE ES-1
MAP OF STUDY AREA
ANALYSIS OF PERCHLORATE CONTAINMENT IN
GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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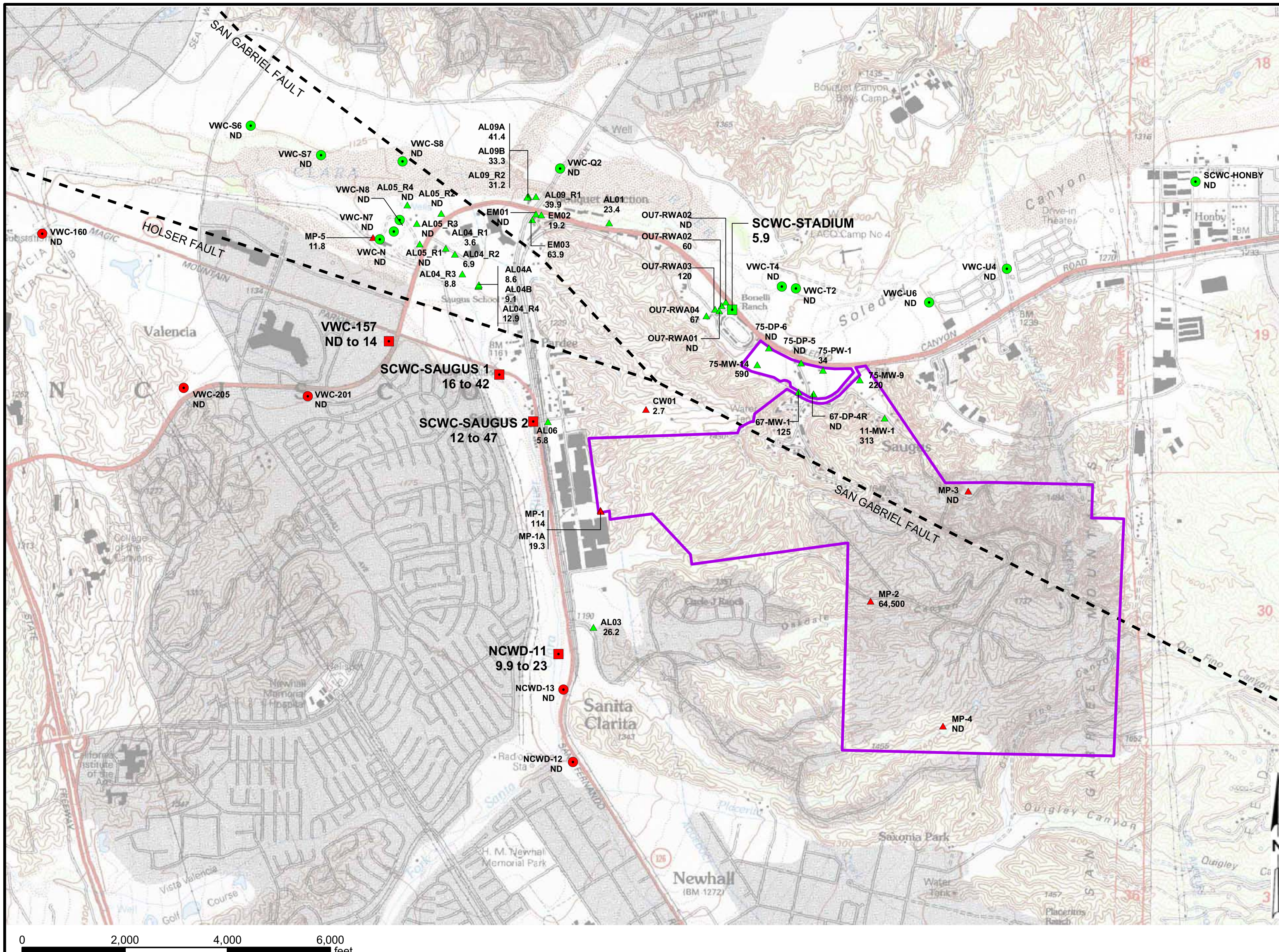

LEGEND

IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

NONIMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

MONITORING WELLS

- ALLUVIUM
- SAUGUS
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (μg/L).
2. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
3. μg/L = MICROGRAMS PER LITER.

FIGURE ES-2
WELL LOCATION MAP
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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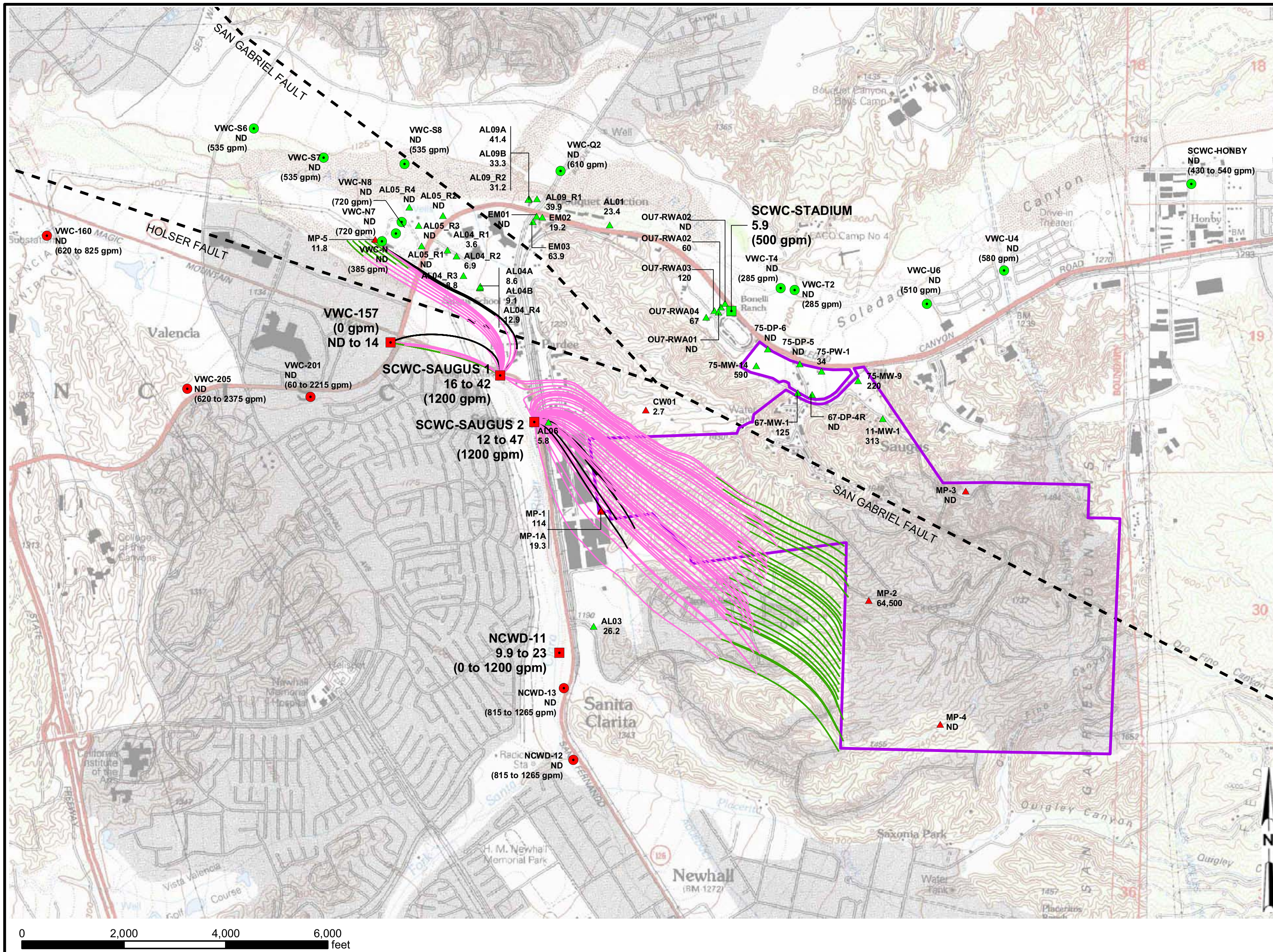

LEGEND

IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

MONITORING WELLS
- ALLUVIUM
- SAUGUS

GROUNDWATER FLOWPATH
- MODEL LAYER 1
- MODEL LAYER 2
- MODEL LAYER 3
- MODEL LAYER 4
- MODEL LAYER 5
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:
1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. FLOWPATHS AT VWC-157 AND MP-5 ARE INITIATED IN MODEL LAYERS 2, 3, 4, AND 5. FLOWPATHS AT THE WHITTAKER-BERMITE PROPERTY BOUNDARY ARE INITIATED IN MODEL LAYER 3.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.

FIGURE ES-3
GROUNDWATER FLOWPATHS IN THE SAUGUS FORMATION FROM VWC-157, MP-5, AND THE WESTERN BOUNDARY OF THE WHITTAKER-BERMITE PROPERTY
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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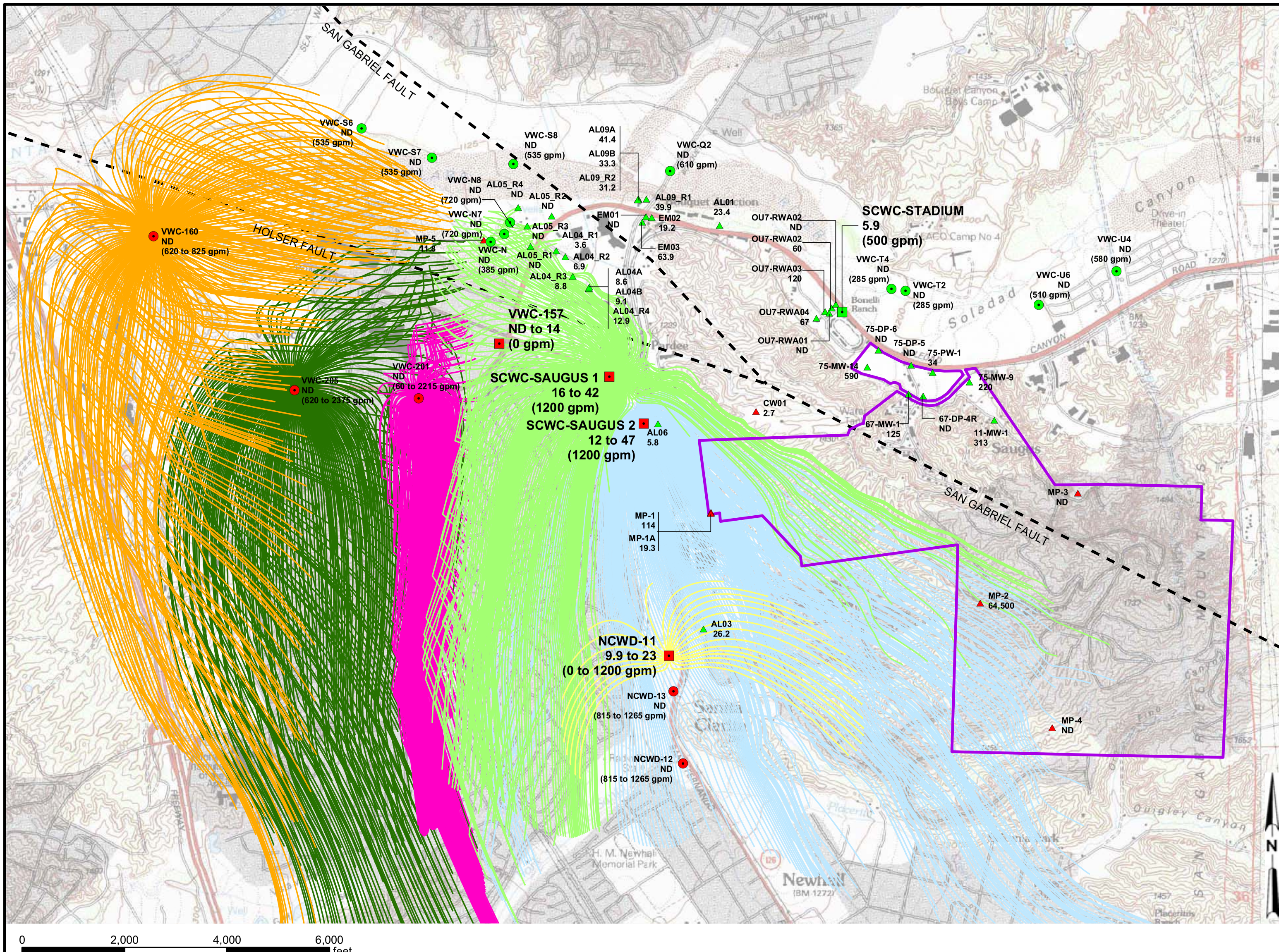

LEGEND

IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

MONITORING WELLS

- ALLUVIUM
- SAUGUS
- SCWC-SAUGUS 1
- SCWC-SAUGUS 2
- VWC-160
- VWC-201
- VWC-205
- NCWD-11
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. PARTICLES WERE INITIATED IN LAYERS 3, 4, AND 5. ALTHOUGH EACH WELL MAY DERIVE A PORTION OF ITS WATER FROM THE ALLUVIAL AQUIFER, PARTICLES THAT ARE TRACED INTO THE ALLUVIAL AQUIFER ARE NOT SHOWN ON THIS FIGURE BECAUSE THE INTENT OF THE FIGURE IS TO SHOW AREAS IN THE SAUGUS FORMATION THAT ARE CAPTURED BY EACH WELL.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.

FIGURE ES-4
SAUGUS FORMATION CAPTURE ZONES FOR IMPACTED AND NONIMPACTED PRODUCTION WELLS

ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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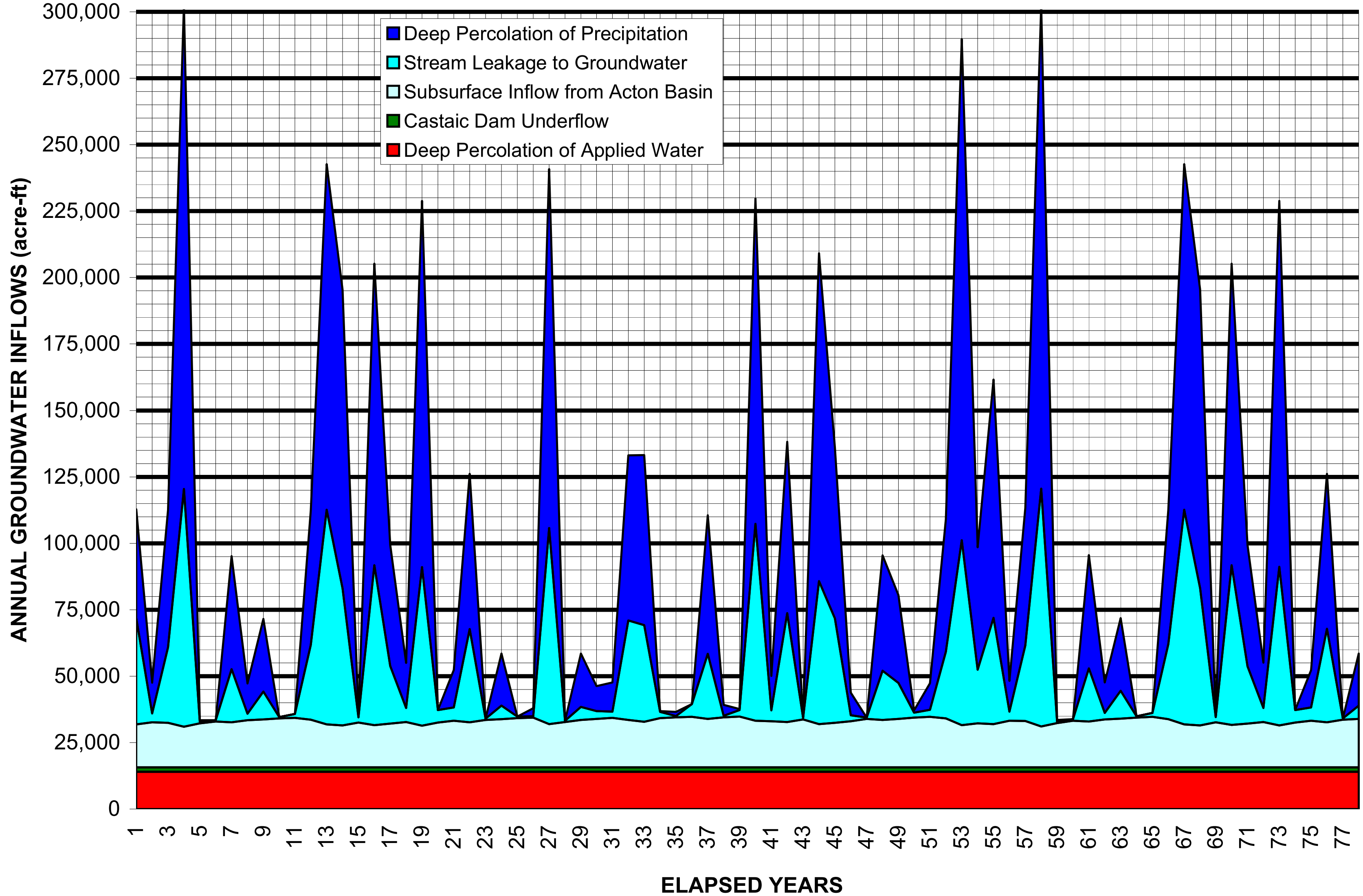

FIGURE ES-5

ANNUAL GROUNDWATER INFLOWS

ANALYSIS OF PERCHLORATE CONTAINMENT IN
GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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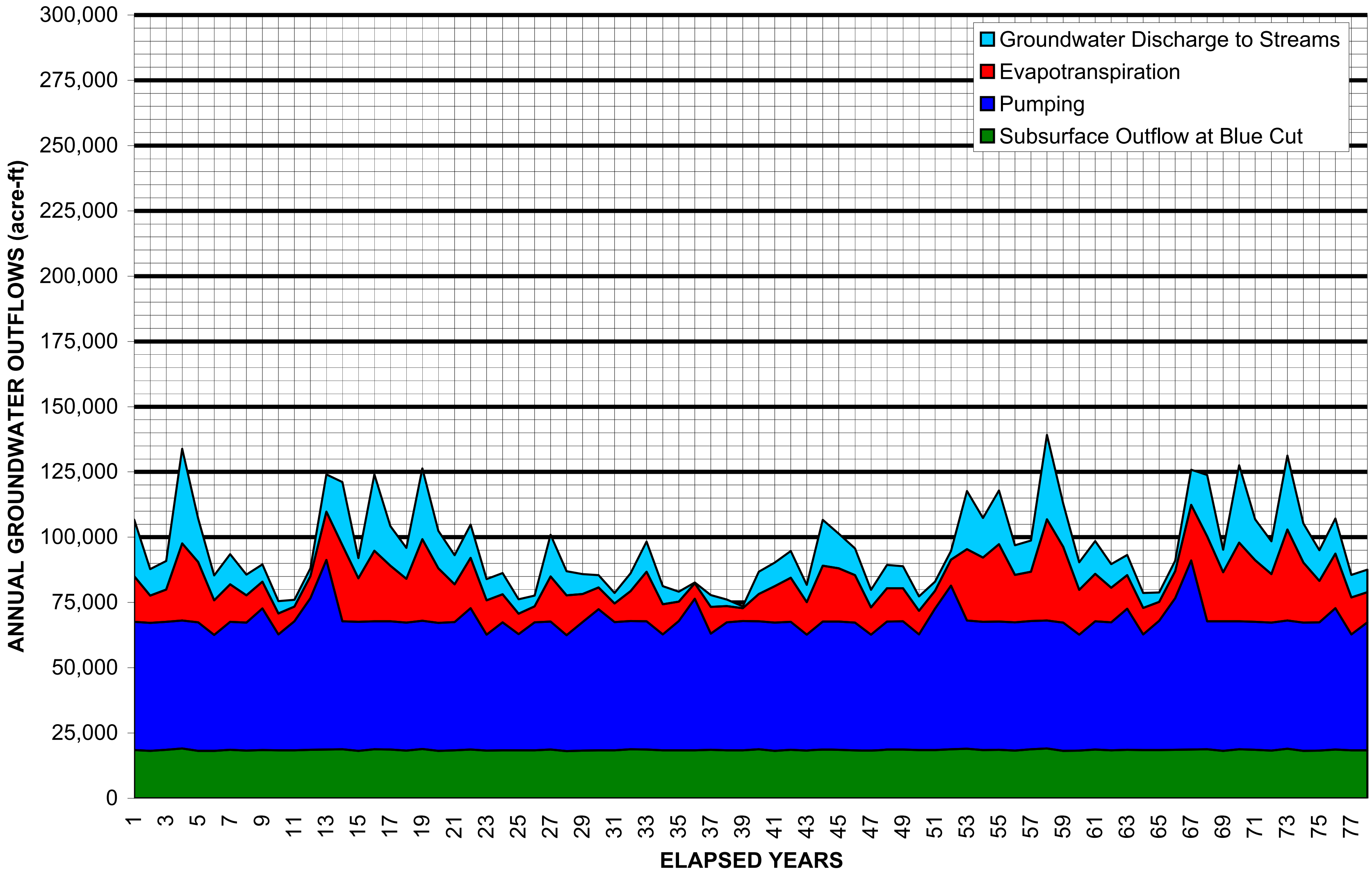

FIGURE ES-6
ANNUAL GROUNDWATER OUTFLOWS
ANALYSIS OF PERCHLORATE CONTAINMENT IN
GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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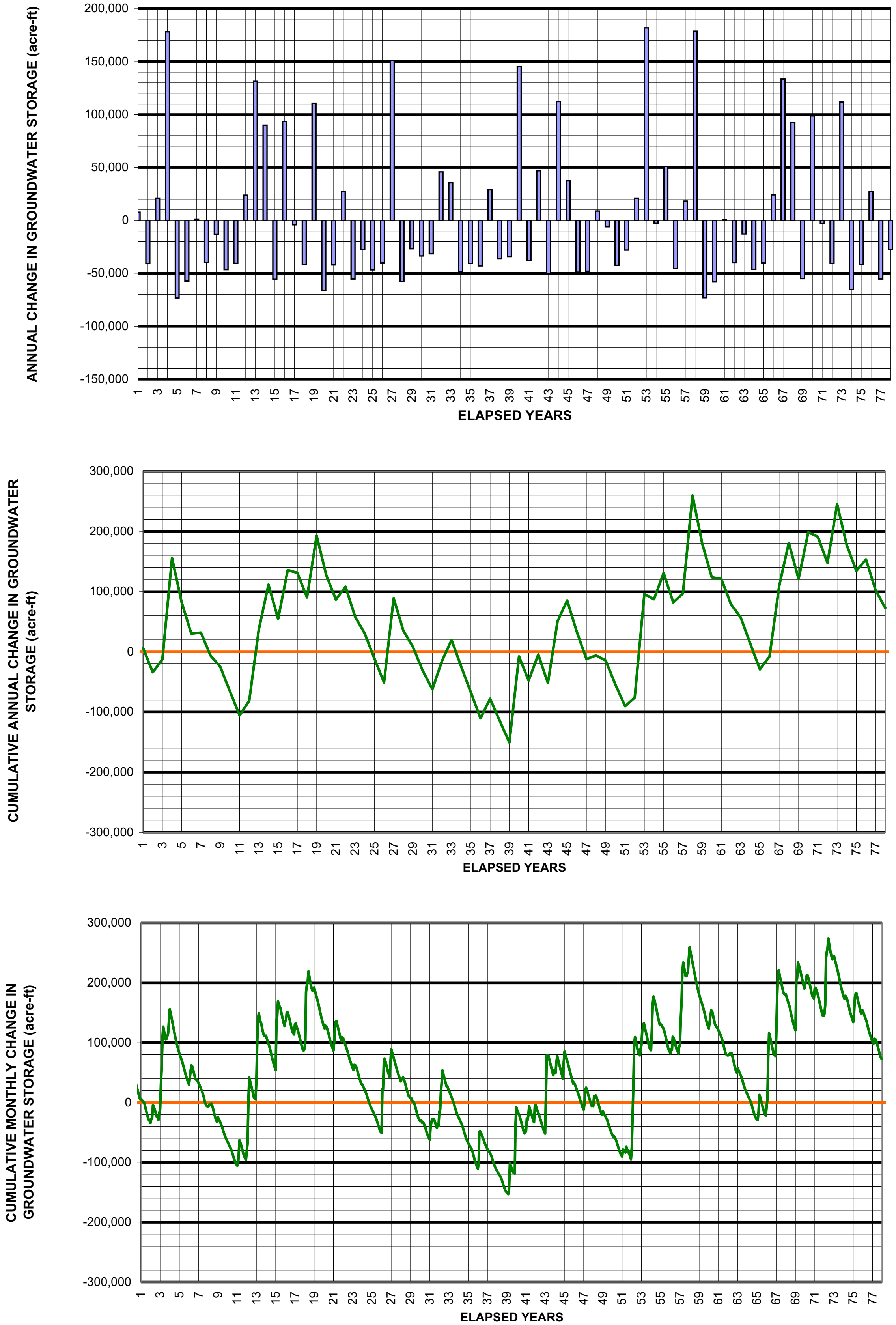

FIGURE ES-7
ANNUAL CHANGE AND CUMULATIVE CHANGE IN GROUNDWATER STORAGE
ANALYSIS OF PERCHLORATE CONTAINMENT IN
GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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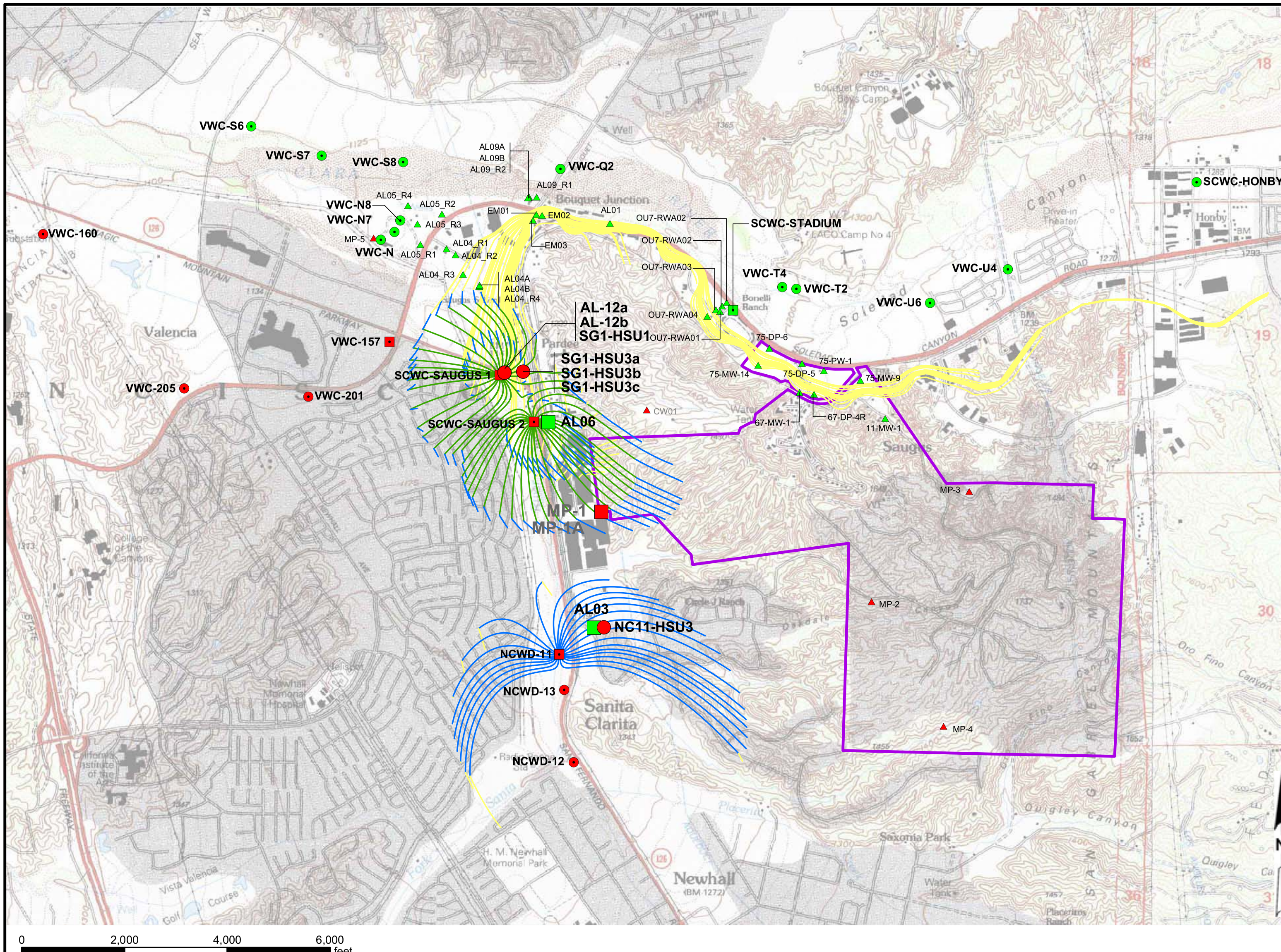

LEGEND

SENTINEL WELLS

EXISTING SENTINEL WELL
- ALLUVIUM
- SAUGUS

NEW SENTINEL WELL
- ALLUVIUM
- SAUGUS

PRODUCTION WELL

IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

OTHER MONITORING WELL
- ALLUVIUM
- SAUGUS

GROUNDWATER FLOWPATHS
- MODEL LAYER 1
- MODEL LAYER 2
- MODEL LAYER 3
- MODEL LAYER 4
- MODEL LAYER 5
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:
1. FLOWLINES STARTED THROUGHOUT MODEL LAYERS 2 AND 3 AND TRACED BACKWARDS FOR 20 YEARS.
2. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION. .

FIGURE ES-8
WELL LOCATIONS FOR SENTINEL MONITORING OF GROUNDWATER QUALITY
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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Contents

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Tables—Tables are located at the end of each section.

Contents, Continued

Figures—Figures are located at the end of each section.

Contents, Continued

Acronyms and Abbreviations

°F	degrees Fahrenheit
µg/L	micrograms per liter
AF	acre-feet
AF/yr	acre-feet per year
AL	State of California Action Level
ASR	aquifer storage and recovery
bgs	below ground surface
CIMIS	California Irrigation Management Information Service
CLWA	Castaic Lake Water Agency
DHS	California Department of Health Services
DMS	Development Monitoring System
DWR	California Department of Water Resources
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
ft/day	feet per day
ft^2/day	square feet per day
gpm	gallons per minute
HSU	hydrostratigraphic unit
I-5	Interstate 5
in/yr	inches per year
Kh	horizontal hydraulic conductivity
Kv	vertical hydraulic conductivity
LACFCD	Los Angeles County Flood Control District
LACSD	Los Angeles County Sanitation District
LACWWD	Los Angeles County Waterworks District
LADPW	Los Angeles County Department of Public Works
MCL	Maximum Contaminant Level
MP	multi-port monitoring well
NCWD	Newhall County Water District

NLF	Newhall Land & Farming Company
Purveyors	Upper Basin Water Purveyors
R	vertical anisotropy ratio (Kh:Kv)
Regional Model	Santa Clarita Valley Regional Groundwater Flow Model
SCWC	Santa Clarita Water Company
SWP	State Water Project
SWRM	Surface Water Routing Model
T	transmissivity
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
UWMP	*Urban Water Management Plan 2000*
VWC	Valencia Water Company
WHR	Wayside Honor Rancho
WRP	water reclamation plant
WY	water year

SECTION 1

Introduction

This report presents an analysis of a plan to contain perchlorate that is present in the Saugus Formation aquifer, which lies beneath a portion of the Santa Clarita Valley (located in northwestern Los Angeles County, California). The containment plan consists of pumping from two deep production wells that have not operated in several years because of elevated concentrations of perchlorate in groundwater. The selected pumping plan has been designed to cause perchlorate, which is migrating in groundwater from the nearby Whittaker-Bermite property, to be captured by these wells, thereby controlling its movement toward other portions of the aquifer, where additional water supplies could otherwise be impacted. The operation of these wells is also designed to capture perchlorate-containing groundwater that is present just downgradient of these two wells. The pumping rates have been selected by considering the water supply needs of the valley and analyses of groundwater flow patterns that are expected under the pumping plan for these wells. The analyses of groundwater flow patterns have been performed using a numerical regional-scale groundwater flow model of the valley, which was developed by the local water purveyors (herein referred to as the Purveyors[1]) for use in managing the local groundwater resource. Figure 1-1 shows the study area, including the model boundaries.

Following is background information on the impacted production wells and the presence of perchlorate, followed by a summary of the state regulatory program under which the evaluation work was conducted, and a summary of the purpose and content of this report.

1.1 Background

In 1997, two Saugus Formation production wells owned by the Santa Clarita Water Company (SCWC)[2] (wells SCWC-Saugus1 and SCWC-Saugus2), one Saugus Formation production well owned by the Newhall County Water District (NCWD) (well NCWD-11), and one Saugus Formation production well owned by Valencia Water Company (VWC) (well VWC-157) were shut down because perchlorate was detected in groundwater at these wells. In 2002, an Alluvial Aquifer production well owned by SCWC (well SCWC-Stadium) was shut down because of a perchlorate detection. The locations of the five impacted production wells and nearby nonimpacted production wells are shown on Figure 1-2, along with the locations of monitoring wells and exploratory borings that have been installed to investigate the extent of perchlorate contamination. Figure 1-2 also shows perchlorate concentrations at locations where perchlorate has been detected in groundwater. At each of

[1]The Purveyors, also referred to as the Upper Basin Water Purveyors, consist of the Castaic Lake Water Agency (CLWA), the Newhall County Water District, the Santa Clarita Water Division of CLWA, and the Valencia Water Company.

[2]The SCWC was acquired by CLWA in 1999. It was formerly called the Santa Clarita Water Company and is now called the Santa Clarita Water Division of CLWA.

the five production wells, the detected perchlorate concentrations exceeded the State of California's Action Level (AL) for perchlorate at the time of the detection[3].

The four production wells that were shut down in 1997 are constructed in the Saugus Formation, a deep aquifer system that underlies much of the Santa Clarita Valley. Wells SCWC-Saugus1 and SCWC-Saugus2 are screened from depths ranging between 490 and 1,620 feet below ground surface (ft bgs), and NCWD-11 well is screened from 200 to 1,075 ft bgs. Well VWC-157 is screened from 586 to 2,008 ft bgs. The production well that was shut down in 2002 (SCWC-Stadium) pumps groundwater from the Alluvial Aquifer, and is screened from 33 to 130 ft bgs.

Together, the four impacted production wells in the Saugus Formation pumped between 1,900 and 6,800 acre-feet per year (AF/yr) during the early and mid-1990s, prior to being shut down. The average pumping from these four wells was 4,186 AF/yr from 1991 through 1996, the 6 years preceding the perchlorate detections (see Table 1-1). The four wells have a combined instantaneous pumping capacity of 7,900 gallons per minute (gpm). The Purveyors plan to return three of the four impacted Saugus Formation production wells to service (SCWC-Saugus1, SCWC-Saugus2, and NCWD-11) and to replace one well (VWC-157) with a newer well located in the western portion of the valley (west of the area shown on Figure 1-2). The Purveyors have concluded that it is important to return these wells to service for the following reasons:

1. They are important sources of water supply to the valley, particularly in years of reduced availability of other water supplies.
2. Two of these wells (SCWC-Saugus1 and SCWC-Saugus2) are located in an area where they must be pumped to prevent perchlorate from migrating to currently nonimpacted areas in the Saugus Formation.

In addition, the Purveyors have established that the design of the operational plan for SCWC-Saugus1, SCWC-Saugus2, and NCWD-11 should be protective of human health as follows:

1. Implementation of the selected pumping plan for the impacted Saugus Formation production wells should minimize the risks to other water supply wells in the valley.
2. A sentinel monitoring program should be implemented to provide early warning of any changes in groundwater quality that could adversely affect the perchlorate treatment system or other water supplies.

Accordingly, the Purveyors have developed the following primary elements for the perchlorate containment plan:

1. Pumping and treating groundwater from wells SCWC-Saugus1, SCWC-Saugus2, and NCWD-11. The pumped groundwater will be treated at a central location to remove perchlorate prior to entering the potable water conveyance system. The treatment

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[3]The AL has varied over time. The California Department of Health Services (DHS) initially established an AL of 18 micrograms per liter (μg/L) in 1997, at the same time that the four impacted Saugus Formation production wells were taken offline. In 2002, DHS revised the Action Level to 4 μg/L based on studies by the U.S. Environmental Protection Agency (EPA). In March 2004, the Action Level was revised to 6 μg/L based on a public health goal (PHG) published by the Office of Environmental Health Hazard Assessment. See http://www.dhs.ca.gov/ps/ddwem/chemicals/perchl/actionlevel.htm for further details.

process will include the use of ion-exchange resins, followed by disinfection. The treatment system will be designed for a capacity of at least 2,400 gpm.

2. Pumping the treated groundwater to CLWA's Rio Vista Intake Pump Station for subsequent distribution, to help meet water demands.
3. Destroying one perchlorate-impacted production well (VWC-157) that lies downgradient of SCWC-Saugus1 and SCWC-Saugus2 and will not be used for containment.
4. Installing a network of sentinel monitoring wells for performance monitoring of the containment plan and sentinel water quality monitoring.

The pumping, treatment, and subsequent conveyance of water will be performed by CLWA for wells SCWC-Saugus1 and SCWC-Saugus2 and by NCWD for well NCWD-11.

1.2 State Regulatory Program

Returning perchlorate-impacted production to service with treatment requires the issuance of a DHS permit before the water can serve as a potable water supply. Before issuing a permit, DHS requires that formal studies and engineering work be performed to demonstrate that pumping these wells and treating the water will be protective of human health for the users of the water[4]. To obtain a permit, the owner of the well must perform a detailed evaluation of the effects of returning the well to service. The process for conducting the evaluation is called the 97-005 process, named after the policy memo that describes the process (DHS, 1997). The policy memo also discusses the basic tenets under which the DHS Drinking Water Program evaluates proposals, establishes appropriate permit conditions, and approves returning an impacted well to service for direct potable use.

1.3 Report Purpose and Content

Numerical modeling has been performed to forecast the degree of perchlorate containment in groundwater that is likely to be achieved by the pumping plan, and to assist in the selection of a monitoring well network for a sentinel monitoring program. This report presents a modeling analysis of the Purveyors' preferred pumping plan for the Saugus Formation in the vicinity of the impacted Saugus production wells. The modeling analysis was designed to evaluate the following aspects of the pumping plan:

1. Whether the existing impacted Saugus Formation production wells (SCWC-Saugus1, SCWC-Saugus2, and NCWD-11) could be used to contain perchlorate while meeting the water supply needs of the valley
2. Whether additional Saugus Formation production wells are needed in addition to, or instead of, these three impacted wells to meet the containment objectives
3. How the wells should be operated (i.e., the frequency and magnitude of pumping)
4. How operation of other wells in the valley might affect perchlorate containment

[4]The Purveyors and DHS require that water provided to customers contain no detectable perchlorate.

In addition to the modeling analysis, this report discusses the general design of a groundwater quality monitoring program that will be implemented conjunctively with the pumping and treatment program, to identify changes in groundwater quality that might adversely affect the treatment process. This monitoring program will include water level monitoring and groundwater modeling activities during the startup of the long-term containment system, to verify that containment is being achieved and evaluate whether adjustments to the pumping program are warranted.

Although the impacted Alluvial Aquifer production well (SCWC-Stadium) has remained shut down, it is not part of the focus of this analysis because pumping activities, and any necessary perchlorate treatment for this well, will resume only after containment pumping has begun in the Saugus Formation. The longer period for returning the SCWC-Stadium well to service arises from the dependence of this activity on the effectiveness of ongoing groundwater remediation activities being conducted by the Whittaker-Bermite Corporation. Consequently, the plan for the SCWC-Stadium well will be developed in the future, separately from the plan that is described in this report.

This report has been prepared to support the source assessment and permitting process that the Purveyors are performing under the 97-005 Policy. Section 2 of this report presents the analysis of perchlorate containment, including its relationship to the operational plan for Santa Clarita Valley groundwater resources. Section 3 presents the objectives and general design of the sentinel groundwater quality monitoring program, which includes identifying the network of existing and new wells that will be sampled under this program. Section 4 is the reference list.

Table

TABLE 1-1
Historical Pumping at Impacted Saugus Formation Production Wells
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Well Owner - Well Name	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
VWC-157	635	604	529	239	387	314	581	484	1,222	1,146	635	1,005	570	436	616	403	46	81	0	0	0
SCWC-Saugus1	0	0	0	0	0	0	0	0	31	0	0	1,690	437	1,226	1,333	0	410	451	0	0	0
SCWC-Saugus2	0	0	0	0	0	0	0	0	32	0	40	3,091	2,476	1,675	2,530	1,726	1,766	617	0	0	0
NCWD-11	729	870	715	754	1,159	1,278	2,209	2,371	1,265	1,280	1,252	1,034	428	730	614	522	353	81	14	0	0
Total	**1,364**	**1,474**	**1,244**	**993**	**1,546**	**1,592**	**2,790**	**2,855**	**2,550**	**2,426**	**1,927**	**6,820**	**3,911**	**4,067**	**5,093**	**2,651**	**2,575**	**1,230**	**14**	**0**	**0**

1991 through 1996 average = 4,186

Note:
All pumping volumes are listed in AF/yr.

Figures

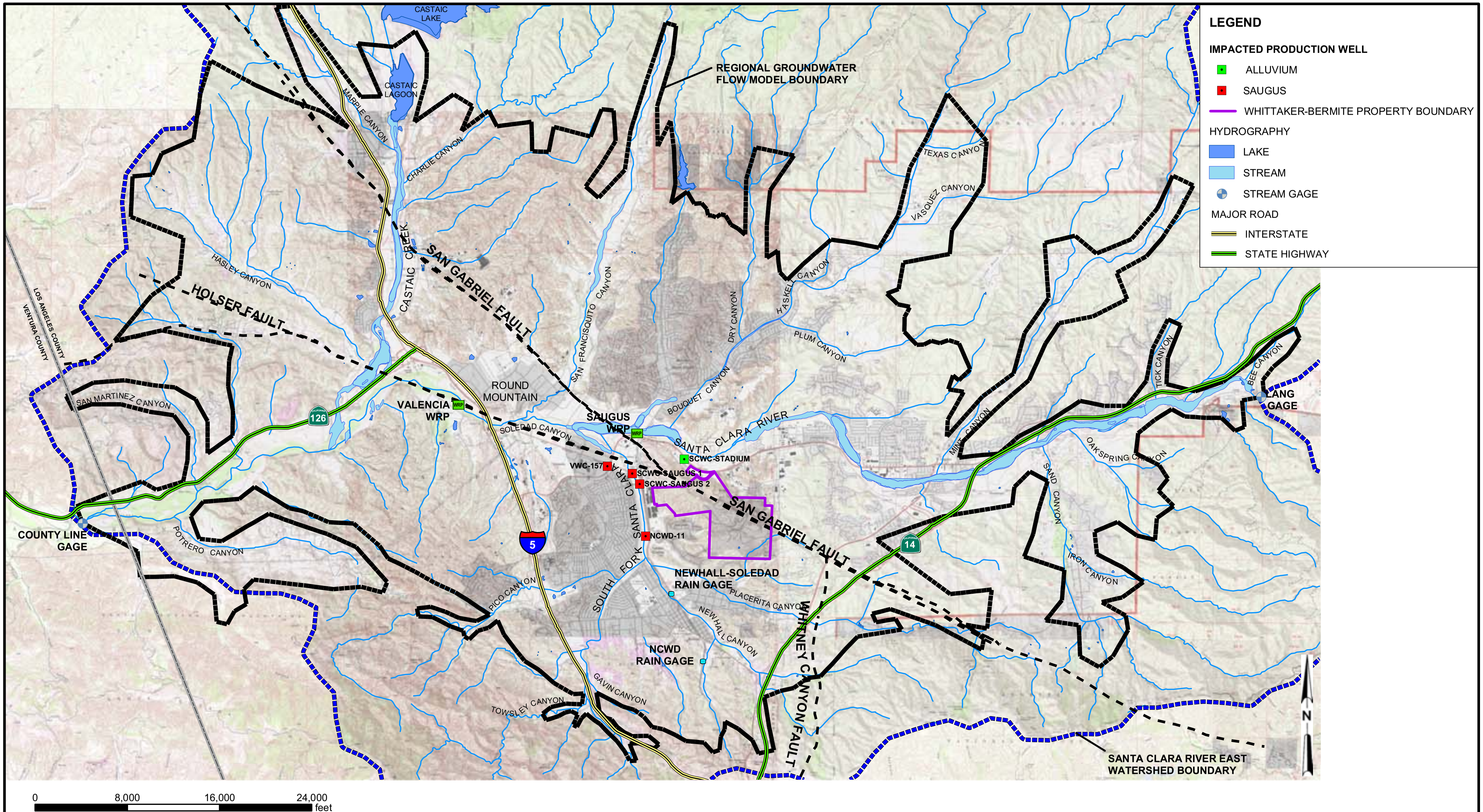

FIGURE 1-1
MAP OF STUDY AREA
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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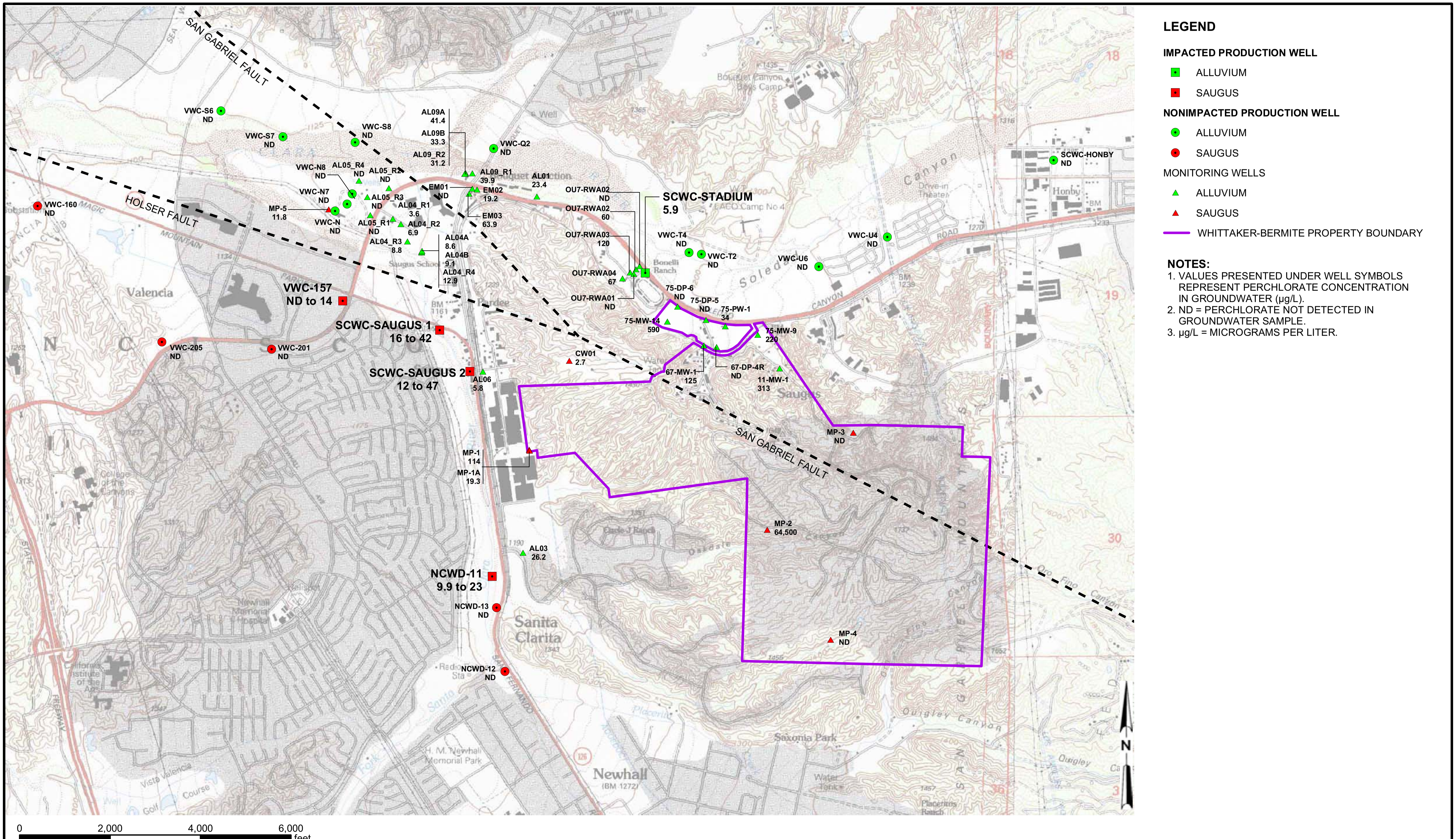

FIGURE 1-2
WELL LOCATION MAP
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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SECTION 2

Analysis of Perchlorate Containment

2.1 Objectives

In addition to meeting the requirements of the 97-005 policy memo (DHS, 1997), the Purveyors have identified the following objectives that must be met by the pumping plan for the impacted Saugus Formation production wells:

1. Hydraulically contain perchlorate that is migrating westward in the Saugus Formation from the Whittaker-Bermite property toward the impacted production wells.
2. Hydraulically contain perchlorate that is present at wells MP-5 and VWC-157, which are located downgradient of the impacted wells.
3. Protect downgradient production wells that are currently not impacted.
4. Restore the annual volumes of water that were pumped from the impacted wells before they were shut down.
5. Operate the impacted wells in a manner that is consistent with the Purveyors' operational plan for the groundwater resources in the Santa Clarita Valley[5].
6. If possible, pump one or more of the impacted Saugus Formation production wells in a manner that also contains perchlorate migrating in the Alluvial Aquifer from the northern portion of the Whittaker-Bermite property. Unlike the previous objectives, this is a secondary objective for operating the impacted Saugus Formation production wells, because other long-term remedies are being developed for the Alluvial Aquifer. Consequently, this objective is not the basis for selecting or rejecting any given pumping plan for the impacted Saugus Formation production wells.

The pumping plan that is developed and evaluated in this report for the impacted Saugus Formation production wells is an interim program that will operate throughout the period of evaluating, designing, and permitting long-term remedial actions for the Whittaker-Bermite property and nearby groundwater. It is anticipated that the pumping plan for the impacted Saugus Formation production wells will continue to be implemented after the long-term remedies are in place on the Whittaker-Bermite property, in part because the pumping plan is intended to meet the water supply needs of the Purveyors.

2.2 Methodology

The containment evaluation for the impacted Saugus Formation production wells was performed using the Regional Groundwater Flow Model for the Santa Clarita Valley (Regional Model). The Regional Model's construction and calibration are discussed in detail

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[5] This operational plan is described in the documents titled *Urban Water Management Plan 2000* (Black & Veatch, 2000) and *Santa Clarita Valley Water Report 2003* (Luhdorff & Scalmanini Consulting Engineers, 2004).

in *Regional Groundwater Flow Model for the Santa Clarita Valley: Model Development and Calibration* (CH2M HILL, 2004a). The Regional Model simulates the temporal and spatial variations in groundwater flow patterns in three dimensions, including the recharge and discharge rates of groundwater in the valley. Table 2-1 summarizes the components of the valley's hydrology that are simulated by the model. Figure 2-1 shows these processes schematically. Following are discussions of the Regional Model's design and the methods by which the model was used to evaluate the containment approach for the impacted Saugus Formation wells.

2.2.1 Regional Model Design

The Regional Model is a three-dimensional numerical model that uses the MicroFEM® finite-element software (Hemker and de Boer, 2003). The Regional Model covers the entire area underlain by the Saugus Formation, plus the portions of the Alluvial Aquifer that lie beyond the limits of the Saugus Formation. The Regional Model area largely coincides with the Santa Clara River Valley East Groundwater Subbasin, extending from the Lang stream gage at the eastern end of the valley to the County Line stream gage area in the west. The Regional Model is based on a finite-element mesh consisting of 7 layers, with 17,103 nodes and 32,496 elements in each layer. The upper model layer simulates the Alluvial Aquifer, or the upper portion of the Saugus Formation where the Alluvial Aquifer is not present. The underlying layers simulate the underlying freshwater Saugus Formation and the Sunshine Ranch Member. Figure 2-2 is a geologic map of the valley, including the boundaries of the Regional Model.

The boundary conditions in the model consist of the following:

1. Specified flux boundaries for:
    a. Precipitation
    b. Irrigation
    c. Recharge from ephemeral streams
    d. Pumping
    e. Underflow from beneath Castaic Dam
2. Head-dependent flux boundaries for:
    a. Groundwater discharges to the perennial reach of the Santa Clara River
    b. Residual drainage of groundwater to the Santa Clara River in the ephemeral reach under high water table conditions
    c. Evapotranspiration (ET) by phreatophyte plants, which extract groundwater from the shallow water table that lies along riparian river corridors

3. Constant-head boundaries for:
    a. Subsurface inflow to the valley in the Alluvial Aquifer at the eastern end of the valley, at the Lang gage[6]
    b. Subsurface outflow in the Alluvial Aquifer at the western end of the valley, at the County Line gage

Groundwater recharge rates are estimated using precipitation records; streamflow records; watershed maps; topographic maps; and aerial photography. These recharge rates are calculated using a detailed Surface Water Routing Model (SWRM) that was written specifically to provide time-dependent, spatially varying recharge rates as input to the Regional Model. The SWRM relies on historical records of rainfall and streamflow data from several sources. Rainfall data have been recorded since 1883 at the Newhall-Soledad gage (Station No. FC32CE), located at the Los Angeles County Department of Public Works (LADPW) Newhall-Soledad Division Headquarters office, on San Fernando Road in the community of Newhall. A second rain gage is located approximately 1.3 miles to the south, at the NCWD office. Figure 2-3 shows the annual rainfall at the Newhall-Soledad rain gage for calendar years 1950 through 2000 and at the NCWD gage from 1979 through 2000. Rainfall varies across the basin according to elevation differences and the locations of surrounding mountain ranges. Figure 2-4 shows lines of equal precipitation (rainfall isohyets) throughout the Santa Clara River East watershed, based on long-term mean annual precipitation data compiled from the U.S. Geological Survey (USGS), the California Department of Water Resources (DWR), and California Division of Mines and Geology maps and data.

The depths from which production wells obtain water are defined in the Regional Model from well construction records. The locations and rates of pumping are based on the Purveyors' pumping plan for the basin and on the surveyed location of each production well.

2.2.2 Design of Modeling Analysis

The process of designing a modeling analysis to forecast perchlorate containment consisted of the following activities:

1. Refining the model grid in and around the areas where impacted wells are located
2. Selecting a period over which to simulate groundwater conditions resulting from various pumping configurations
3. Defining the pumping plan at the impacted wells and all other wells in the Santa Clarita Valley, considering the objectives above and the variability in pumping demands that occur due to cycles of drought and nondrought conditions and year-to-year variations in the availability of other water supplies
4. Defining the variation in local hydrology (rainfall, streamflows, and groundwater recharge) on a month-to-month basis throughout the simulation period

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[6] A constant-head boundary was established in the model at this location based on recent field conditions that were observed after the model calibration report (CH2M HILL, 2004) was published. This change to the model improved the model's calibration in the Alluvial Aquifer in the upper reaches of Soledad Canyon and did not appreciably change the calibration quality elsewhere.

5. Running the model to calculate time-varying (monthly) groundwater elevations and groundwater discharge terms throughout the multi-year simulation period
6. Evaluating the modeling results, as follows:
   a. Examining forecasted time-series plots (hydrographs) of water budget terms and groundwater elevations to evaluate the effects of the pumping plan at the impacted Saugus Formation production wells and across the basin
   b. Analyzing forecasted groundwater flowpaths (using particle-tracking techniques) to identify the degree of containment provided by the pumping plan for the impacted Saugus Formation production wells
7. Performing two sets of sensitivity analyses to address the following questions concerning the selected pumping plan for the impacted Saugus Formation production wells:
   a. How large a factor of safety does the Purveyors' pumping plan for the impacted Saugus Formation wells provide for containment of Saugus groundwater migrating westward from the Whittaker-Bermite property, given that the plan is based, in part, on restoring groundwater pumping at the impacted production wells?
   b. How would the model predictions change if the degree of connection between the Alluvial Aquifer and the Saugus Formation is less than the degree of connection that is simulated by the calibrated model?

These activities are described in further detail below.

2.2.3 Grid Refinements

The Regional Model grid is shown on Figure 2-5. The Regional Model grid contains 17,103 nodes that are spaced 500 feet apart in the majority of the modeled area. However, the Regional Model contains finer node spacing (150 feet) along the Santa Clara River and its tributaries, to allow for improved resolution and precision in calculations of surface water/groundwater exchange rates. Nonetheless, it was deemed necessary to reduce the node spacing in the area around the impacted wells to increase the spatial resolution of the model, including its ability to calculate groundwater flowlines (groundwater particle traces) and hydraulic capture zones.

A node spacing of 75 feet was applied to an area of approximately 2,500 acres (approximately 4 square miles [mi^2]), which is approximately 3 percent of the 119-mi^2 area contained within the Regional Model's boundaries. This smaller node spacing was used within the northwestern portion of the Whittaker-Bermite property and adjacent areas to the north and west where perchlorate has been detected in groundwater. The 75-foot node spacing was used for all nodes in this area, including stream nodes. Figure 2-6 shows the refined finite-element grid in this localized area. The refinement of the grid caused the total number of nodes in the Regional Model to increase by 20,180 nodes per layer, for a total of 37,283 nodes per layer.

2.2.4 Simulation Period

The operational pumping plan for the Santa Clarita Valley's groundwater resources has been defined in the *Urban Water Management Plan 2000* (UWMP) for the Santa Clarita Valley (Black & Veatch, 2000) and in annual water reports that discuss the water demands, water supplies, and surface water and groundwater resources of the valley (including the *Santa Clarita Valley Water Report 2003* [Luhdorff & Scalmanini Consulting Engineers, 2004]). These reports provide ranges of values for groundwater extractions from the Alluvial Aquifer and the Saugus Formation during average/normal years and dry years. For the modeling analysis, the locations and temporal variation in pumping from the Alluvial Aquifer were defined from the operational plan and from historical records of the year-to-year variability in local hydrology. Simulated pumping from the Saugus Formation was defined from the operational plan, historical pumping records, and operational constraints and historical patterns of water supply availability for water supplies that are imported from the State Water Project (SWP).

Because the local pumping plan for the Saugus Formation is linked to the hydrology and operational constraints for the SWP system, the year-to-year variability in Saugus Formation pumping is, to a certain extent, dependent on the hydrology outside the valley (i.e., in northern California). As shown in Table 2-2, local hydrology is often not a good indicator of local pumping conditions in the Saugus Formation, because local droughts and SWP droughts frequently do not coincide with each other. The following are examples:

1. In 1955, dry conditions in the SWP system coincided with approximately 14 inches of rainfall at the Newhall-Soledad rain gage, which is similar to the long-term median rainfall recorded at this gage.
2. In 1976 and 1977, the SWP system hydrology was critical, while the local hydrology during those years was near normal (1976) and wetter than normal (1977).
3. In 1987 and 1988, the SWP system hydrology was dry (1987) and critical (1988), while the local hydrology during those years was near normal (1987) and wetter than normal (1988).
4. In 1991 and 1992, the SWP system hydrology was in its fifth and sixth consecutive years of dry or critical hydrology, while the local hydrology was wetter than normal both years.
5. In 2001, dry conditions in the SWP system coincided with wetter-than-normal local conditions.

Consequently, it was decided that the model would need to be run over several decades to capture the year-to-year variability in the hydrology of each system, as well as the less frequent times when both systems are experiencing similar hydrologic conditions (as occurred periodically during the 1960s and in 1994). Analyses of historical records were then conducted to identify a synthetic simulation period that would meet the following criteria:

1. The simulation time should be long enough to include an historical period that accounts for the year-to-year variations in local hydrology that have been observed in the past.
2. The period should be long enough to include longer-term (i.e., on the order of decades) periods of relatively dry conditions and relatively wet conditions.

3. The average rainfall during the simulation period should be similar to the average rainfall of 17.84 inches per year (in/yr) that was observed from 1950 through 2000 at the Newhall-Soledad gage.
4. The period should be sufficiently long to allow simulation of two occurrences of reduced SWP water supplies during the period 1990 through 1992, which corresponds to periods of increased pumping from the Saugus Formation under the valley's operational plan.
5. The frequency of dry-year occurrences in the SWP system, corresponding to increased pumping from the Saugus Formation, should be similar to the historical frequency.
6. If necessary to meet other criteria, the simulation should repeat parts of this sequence before and/or after the historical sequence.

Examination of historical local hydrology and independent simulations of SWP deliveries resulted in the selection of a 78-year period over which the model was run, with monthly time steps. Details regarding how the pumping conditions and local hydrology were defined during this period are described below in Section 2.2.5.

2.2.5 Assignment of Pumping Rates

Pumping rates were assigned in accordance with the operational plan for the Santa Clarita Valley, which defines ranges of valleywide annual pumping, given the water supply needs of the Purveyors. Pumping rates at individual wells were assigned using the recent and planned production schedules for each well and by evaluating the type of pumping plan that will meet the perchlorate containment objectives for the impacted wells. Details of pumping rate assignments are discussed below.

2.2.5.1 Description of Operational Plan for Groundwater Pumping

The operational plan for the Santa Clarita Valley's groundwater resources defines the ranges of annual groundwater pumping rates that are planned for the Alluvial Aquifer and the Saugus Formation under variable hydrologic conditions as follows (Black & Veatch, 2000; Luhdorff & Scalmanini Consulting Engineers, 2004):

1. Pumping from the Alluvial Aquifer in a given year is governed by local hydrologic conditions in the eastern Santa Clara River watershed. Under the operational plan, pumping ranges between 30,000 and 40,000 AF/yr during normal and above-normal rainfall years, but is reduced to between 30,000 and 35,000 AF/yr during locally dry years.
2. Pumping from the Saugus Formation in a given year is tied directly to the availability of other water supplies, particularly imported water from the SWP system. For the Saugus Formation, the operational plan consists of pumping between 7,500 and 15,000 AF/yr during average-year conditions within the SWP system. Planned dry-year pumping from the Saugus Formation ranges between 7,500 and 25,000 AF/yr during a drought year, and increases to between 21,000 and 25,000 AF/yr if SWP deliveries are reduced for longer than 1 year.

Table 2-3 summarizes the operational pumping plan for the Alluvial Aquifer and the Saugus Formation and compares this plan with the model-simulated valleywide pumping rates for each type of year (normal and above-normal years, dry year 1, dry year 2, and dry year 3). The selections of the simulated valleywide pumping rates are described below.

2.2.5.2 Variations in State Water Project Hydrology and Saugus Formation Pumping

CLWA has performed a statistical evaluation of SWP deliveries using the 2021B scenario from the CALSIM II model, which was developed by DWR for its SWP Delivery Reliability Report (DWR, 2002). The CALSIM II model and the SWP Delivery Reliability Report were developed to support (1) the preparation of urban water management plans by the water agencies that are SWP contractors, (2) analyses required to comply with Senate Bills 221 and 610, and (3) other water supply planning activities that include the SWP as a component of supply. The 2021B scenario simulates the anticipated deliveries of water to the 29 SWP contractors using an historical hydrologic record and anticipated operating and regulatory conditions for the SWP system in 2021. In addition to the CLWA evaluation (Kennedy/Jenks Consultants, 2003), the U.S. Bureau of Reclamation (USBR) has used CALSIM II to perform biological assessment studies for the Operating Criteria and Plan (OCAP) for the SWP (USBR, 2004). These studies, which were made public for review in February 2004, include evaluations of the role and function of an Environmental Water Account (EWA) that consists of water purchased to mitigate the water supply impacts of protection measures for endangered species. These CALSIM II simulations have been performed for the SWP system at a present-day level of development and for the anticipated level of development in 2020. Table 2-4 compares the municipal and industrial water use allocations calculated by CALSIM II for the SWP Reliability Report (DWR, 2002) and for the OCAP (USBR, 2004) for the hydrology that occurred from 1950 through 1993.

CLWA’s evaluation reached the following conclusions regarding the deliveries it will receive under this scenario (Kennedy/Jenks Consultants, 2003):

1. A regression analysis indicates that there is a weak relationship between the SWP delivery in a given year and the previous year’s delivery.
2. SWP deliveries will equal or exceed 70 percent of CLWA’s 95,200 AF/yr Table A Amount during approximately 75 percent of the simulated years. During the remaining years, the deliveries will vary between 20 and 70 percent.
3. A Monte Carlo analysis of projected deliveries during 73 consecutive years indicated that at a 95 percent confidence level, 4 years of a 7-year drought period in the SWP system (such as was observed from 1988 through 1994) will have sufficiently low deliveries to require short-term pumping of increased groundwater volumes to meet local water demands. This includes a period of 3 consecutive years of increased pumping.

As discussed in Sections 2.2.4 and 2.2.5.3, a 78-year period was simulated with the groundwater model. Table 2-5 shows the sequence of SWP droughts, SWP allocations, and resulting pumping volumes for the Saugus Formation that have been defined based on the CLWA and USBR analyses. The 78-year period contains the following:

1. Eighteen years of dry-year pumping from the Saugus Formation, or an average of 1 dry year approximately every 4 years

2. Two droughts lasting 3 years, plus (in both cases) a dry year that occurs 2 years before the beginning of each 3-year drought and another dry year that begins 1 year after each 3-year drought has ended
3. Two droughts lasting 2 years
4. Sixty years of normal-year pumping from the Saugus Formation

Pumping rates at specific wells were assigned for each type of year (normal, dry year 1, dry year 2, and dry year 3) using the operational plan for the valley and information on the capacity, recent and planned use, and location of each well. Figure 2-7 shows the locations of these wells and other wells in the valley. Table 2-6 summarizes the annual pumping volumes at each Saugus Formation well[7]. Significant aspects of the pumping rate selection at each well are as follows:

1. Two of the three impacted wells (SCWC-Saugus1 and SCWC-Saugus2) were assumed to operate on a continuous basis to contain perchlorate in this portion of the Saugus Formation. The modeling analysis simulated a continual pumping rate of 1,200 gpm at each well, consistent with the Purveyors' water supply needs from these wells. The analysis assumed each well will be offline 1 month each year for routine maintenance, but would otherwise operate on a continuous basis. The resulting simulated annual pumping volume was 1,772 AF at each of these two wells, for a combined annual pumping volume of 3,544 AF from both wells.
2. In contrast to the near-continuous operation of SCWC-Saugus1 and SCWC-Saugus2, modeling simulations showed that well NCWD-11 can operate on a seasonal basis without any adverse effects on the objective of containing perchlorate in the Saugus Formation east of this well. Consequently, well NCWD-11 was assumed to operate at a yield of 1,200 gpm for a period of 5 months during the peak-demand season, providing a volume of 811 acre-feet (AF) during this period. Consequently, total pumping from the three impacted Saugus Formation wells that will be returned to service (SCWC-Saugus1, SCWC-Saugus2, and NCWD-11) was simulated as 4,355 AF/yr.
3. Pumping from other existing Saugus Formation production wells was based on recent and planned use of these wells, as defined by the Purveyors. The simulation included increased dry-year pumping from the Saugus Formation in the western portion of the basin, where it is anticipated that future wells will be installed.

The pumping rates at each Saugus Formation well were also allocated in specific manners with respect to the pumping depth and the time of year. These allocations were as follows:

1. Except for one well (NCWD-13), each Saugus Formation production well has open intervals that are significantly longer in vertical extent than the thicknesses of the individual layers that represent the Saugus Formation in the Regional Model. Consequently, the pumping rates were assigned to multiple layers in the model by considering the depths of the open interval and the transmissivity of each model layer. Table 2-7 shows the allocation of pumping in each model layer for each Saugus

[7] Table 2-5 only lists wells that are anticipated to be operating in the future. Existing wells that are not listed in this table (including VWC-157) are currently not in service or pump very limited quantities of groundwater, and therefore are not expected to provide significant quantities of water in the future. Well VWC-157 has been replaced by new well VWC-206.

Formation production well, as well as the open intervals of each well and the model-simulated transmissivity in each layer at each well location.

2. Table 2-8 shows the allocation of pumping, by month, for agricultural and urban production wells in both the Saugus Formation and the Alluvial Aquifer. Separate distributions were used because agricultural demands are for exclusively outdoor uses, whereas urban demands are for both indoor and outdoor uses. As discussed in the model development report (CH2M HILL, 2004a), the monthly distribution of agricultural pumping was derived from crop consumptive use requirements published by the California Irrigation Management Information Service (CIMIS). The monthly distribution of urban demand was determined by examining historical monthly flow records for the two LACSD water reclamation plants (WRP) and monthly demand distributions recorded by VWC during the past several years.

2.2.5.3 Variations in Local Hydrology and Alluvial Aquifer Pumping

Annual rainfall records from 1950 through 2003 at the Newhall-Soledad rain gage (Station No. FC32CE) were inspected to identify dry years, wet years, and years of near-normal rainfall in the Santa Clarita Valley. For near-normal and wet years, the operational plan for the Valley's groundwater resources calls for Alluvial Aquifer pumping to range between 35,000 and 40,000 AF/yr. During locally dry years, groundwater elevations in eastern Soledad Canyon can decline several feet per year, and the historical record shows that multiple dry years can occur before sufficient rainfalls return to increase streamflows and groundwater recharge (see Section 2.6 of the Regional Model development and calibration report [CH2M HILL, 2004a]). Consequently, the operational plan calls for reducing pumping to between 30,000 and 35,000 AF/yr during dry years. As shown on Figure 2-8, the average rainfall from 1950 through 2000 at the Newhall-Soledad rain gage was 17.84 in/yr. To define pumping trends in the Alluvial Aquifer, the dry-year pumping rate was assigned to years when rainfall at the Newhall-Soledad rain gage is below 12 in/yr.

Figure 2-9 shows the year-to-year rainfall in the valley and the cumulative departure from average rainfall for each year during the 78-year simulation period. The figure also shows each simulation year's corresponding historical year. The cumulative departure from average rainfall is plotted to show the occurrence of relatively wet versus relatively dry periods. A year-to-year decline in the slope of the cumulative departure curve indicates conditions are dry, whereas a year-to-year increase indicates rainfall is above normal. Also plotted are the occurrences of SWP droughts. The figure shows the following:

1. The first 19 years of the simulation period are generally wet, as a whole, though a multi-year drought occurs in years 5 through 12 (1984 through 1991).

2. A prolonged dry period begins in year 20, as indicated by the downward slope in the cumulative departure curve. This period lasts through year 39, as the curve starts to slope upward to the right beginning in year 40[8]. This 20-year period of generally dry conditions corresponds to the historical period 1999 through 2003, followed by 1950 through 1964.

[8] Year 40 is equivalent to historical year 1965, when rainfall was over 32 inches, or 2.2 times the long-term median rainfall and 1.8 times the long-term average rainfall.

3. Rainfall was generally at or above normal from years 40 through 45 (historical years 1965 through 1970), before a drought ensued from years 46 through 51 (historical years 1971 through 1976).

4. Rainfall was then generally above normal during years 52 through 58 (1977 through 1983), followed by the drought years 59 through 66 (1984 through 1991), the wetter-than-normal years 67 through 76 (1992 through 2001), and dry years 77 and 78 (2002 and 2003).

Table 2-9 shows the sequence of local hydrologic conditions and resulting valleywide pumping volumes for the Alluvial Aquifer that have been defined from the operational pumping plan for the valley. The 78-year simulation period contains the following:

1. Twenty-four years of dry-year pumping, which is approximately 30 percent of the simulated 78-year period.

2. One drought consisting of 4 consecutive years of below-normal pumping (in years 34 through 37, based on historical hydrology from 1959 through 1962).

3. Two droughts consisting of 3 consecutive years of below-normal pumping (in years 10 through 12 and 64 through 66, both of which are based on historical hydrology from 1989 through 1991).

4. Three years (years 12, 37, and 66) when rainfall is near or above normal, but pumping is assigned at a dry-year rate because the year was preceded by a multi-year local drought.

Pumping rates at specific wells were assigned for normal and dry years using the operational plan and information on the capacity, recent and planned use, and location of each well. Figure 2-7 shows the locations of these wells and other wells in the valley. Table 2-10 compares recent annual pumping volumes at each Alluvial Aquifer well with the assumed future production rates at each well under normal and dry-year conditions. Significant aspects of the pumping rate selection at each well are as follows:

1. The SCWC-Stadium well was simulated as pumping 800 AF/yr. The Whittaker Corporation is developing plans to mitigate the source of perchlorate to the portion of the Alluvial Aquifer situated immediately north and downgradient of the Whittaker-Bermite property. The modeled pumping scenario simulates the possibility that the well will be returned to service in the future, and will pump at a rate similar to historical volumes, after source mitigation activities have reduced perchlorate concentrations to undetectable levels in the Alluvial Aquifer at and near this well.

2. As shown in Table 2-10, most Alluvial Aquifer wells were specified to operate at similar rates regardless of year type. However, there were two exceptions, as follows:

    a. Wells in the eastern portion of the basin (the NCWD-Pinetree wells, nine wells owned by SCWC, and the privately owned Robinson Ranch well) were assumed to have lower pumping capacities during dry years than nondrought years because of lower groundwater elevations during dry periods. This assumption was based on historical observations indicating that the eastern portion of the Alluvial Aquifer experiences declines in water levels, in contrast to other parts of the valley, during dry periods.

b. Pumping was also reduced at NCWD's three operating wells in Castaic Valley, in accordance with recent pumping records from those wells.

2.2.6 Simulation Method for Other Local Hydrologic Processes

In addition to groundwater pumping, infiltration from irrigation (from urban and agricultural lands), precipitation, and streamflows (stormwater and WRP discharges) were also modeled. These other local hydrologic processes were defined using the SWRM, which is described in Appendix C to the Regional Model development and calibration report (CH2M HILL, 2004a). Key aspects of the derivation of these terms are as follows:

1. **Urban Irrigation.** Under existing land use and water use conditions, the estimated long-term infiltration rates of applied irrigation water beneath urban areas, under full build-out conditions in the valley, were estimated to be 1.0 in/yr for industrial and retail lands, 2.2 in/yr for residential developments and parks, and 4.6 in/yr for golf courses. These rates were applied during each year (and each month) of the 78-year simulation period. The areas over which these rates were applied were larger than under current conditions. The areas were defined from existing land use data and from LACSD mapping of projected future land uses in the rest of the Santa Clarita Valley[9].

2. **Agricultural Irrigation.** As discussed in the *Newhall Ranch Updated Water Resources Impact Evaluation* (CH2M HILL, 2002), irrigation of lands owned by the Newhall Land & Farming Company results in existing agricultural return flows. The source of most irrigation water is groundwater pumping from the Alluvial Aquifer, with some limited pumping occurring from one Saugus Formation well (NLF-156). Under full valley build-out conditions, the currently irrigated lands will no longer be irrigated because their water source will be used as part of the water supply for Newhall Ranch. Therefore, under full build-out conditions, no agricultural irrigation will occur within the area simulated by the Regional Model.

3. **Precipitation.** Infiltration from direct precipitation within the Regional Model domain was defined using data from the two rain gages in the valley (the Newhall-Soledad and NCWD gages), an isohyet map of rainfall throughout the watershed, and a power-function equation developed by Turner (1986) that describes the relationship between annual rainfall and ET rates within the valley. Details concerning the derivation of precipitation infiltration rates from these data are contained in Appendix C to the Regional Model development and calibration report (CH2M HILL, 2004a). Table 2-11 lists the simulated monthly precipitation at the NCWD rain gage for the 78-year model period[10].

4. **Stormwater Flows in Streams.** For each month of the simulation, the SWRM calculated the amounts of stormwater flow and groundwater recharge in all streams, plus the

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[9] LACSD land use mapping indicates that, including Newhall Ranch, approximately 14,000 acres of currently undeveloped land will be urbanized in the future within the Regional Model simulation area. Additional urbanization will also occur in areas that are within the watershed, but outside the Regional Model's boundaries.

[10] The simulated monthly precipitation was defined from measurements at the NCWD gage from 1979 through 2003, as well as by combining the isohyet map with measurements at the Newhall-Soledad gage from 1950 through 1978.

amount of flow and groundwater recharge arising from projected future WRP discharges to the Santa Clara River. For the Santa Clara River, the volume of streamflow was defined from measured and estimated streamflow data at the Lang gage (Table 2-12). For Castaic Creek, the volume of streamflow was defined from historical DWR operations and consideration of the hydrologic year type (Table 2-13). For the remaining Santa Clara River tributaries, streamflow volumes were defined by the SWRM using monthly rainfall data and the Turner (1986) relationship between rainfall, ET, and the subsequent yield from each watershed.

5. **WRP Discharges to the Santa Clara River.** Under full valley build-out conditions, future flows into and from WRPs will be higher than historical flows because of increased development and the associated increase in indoor water use volumes. Additionally, a portion of the future treated water will be reclaimed. Future inflows to the Saugus and Valencia WRPs were estimated from projected future water demands and from comparisons of historical water use and measured inflows to both WRPs. Table 2-14 shows the derivation of urban water demands outside the Newhall Ranch development (which will be served by a new, separate WRP). Table 2-15 shows the total amount of treated water generated by the Saugus and Valencia WRPs, and the amount of this water that is reclaimed and discharged to the river. Table 2-15 shows this information by month, and the analysis assumes that the reclaimed water volume will be no more than 16,000 AF/yr, to maintain existing flow volumes in the Santa Clara River. For the Newhall Ranch WRP, discharges to the river will be 286 AF/yr, occurring primarily in December and January, when demands for reclaimed water are at their seasonal low. The total combined volumes of treated water discharged to the Santa Clara River under full valley build-out conditions (including Newhall Ranch) are summarized, by month, in Table 2-16. These rates were used in each year of the 78-year model run.

The month-by-month assignment of rates and locations of surface water infiltration to the underlying Alluvial Aquifer system was performed by the SWRM using the procedures described in Section C.8.5 of Appendix C to the Regional Model development and calibration report (CH2M HILL, 2004a). Streambed infiltration capacities were the same as those used in the calibrated model. For each of the 78 years in the model simulation, the streambed infiltration capacity values were selected by matching the year to one of the 20 years (1980 through 1999) from the model calibration runs, using rainfall and streamflow data to select the corresponding streambed infiltration rates.

The SWRM also tracked the volume of surface water in each simulated stream that does not infiltrate during each month because of gaining stream conditions (i.e., rejected stream leakage). This rejected stream leakage was calculated to remain as surface water in the Santa Clara River and to eventually exit the Regional Model at the west end of the valley at the County Line gage.

2.2.7 Running the Model

As discussed in the previous sections, the Regional Model was run with monthly time steps, in which pumping and recharge terms were varied each month. The model was run using a convergence criterion of 0.0001 foot for groundwater elevations, and a water budget convergence criterion of 1 cubic foot per day.

2.2.8 Evaluation Methods (Particle Tracking)

Model results were evaluated as follows:

1. Time-series plots (hydrographs) of water budget terms and groundwater elevations were used to evaluate the potential effects of the pumping plan at the impacted wells and across the basin; and
2. Groundwater flowpaths were calculated using three-dimensional particle-tracking techniques to identify the degree to which pumping from the impacted Saugus Formation production wells contains perchlorate migrating westward toward these wells from the Whittaker-Bermite property. Particle tracking was performed by first calculating the time-weighted average groundwater elevations at each node in each model layer, using the monthly elevations calculated by the model. The particle tracking was then performed in two manners:
   a. Forward in time. Particles traces were delineated forward in time, starting along the western boundary of the Whittaker-Bermite property. These traces were delineated to evaluate the degree to which perchlorate-containing groundwater moving west-ward from the Whittaker-Bermite property will be captured by the impacted wells. This evaluation also provided an indication of whether this groundwater could migrate to currently nonimpacted production wells.
   b. Backward in time. Particle traces were tracked backward in time from SCWC-Saugus1, SCWC-Saugus2, and NCWD-11 to delineate the groundwater capture zones of each well. The 2-year, 5-year, 10-year, and 20-year capture zones were defined for each of these wells, to support other 97-005 work activities (identifying contaminant sources and locating sentinel groundwater monitoring wells). The time-related capture zone delineations were based on an effective porosity of 0.10. Long-term particle tracking was also performed to define the size of the combined capture zone within the Saugus Formation that is created by pumping SCWC-Saugus1, SCWC-Saugus2, and NCWD-11. This included evaluating whether two wells with perchlorate detections to the northwest (former production well VWC-157 and Saugus monitoring well MP-5) would lie within the combined capture zone created by SCWC-Saugus1, SCWC-Saugus2, and NCWD-11.

2.2.9 Sensitivity Analyses

Two sets of sensitivity analyses were performed to address the following questions:

1. Can the containment objectives be met by using lower pumping rates at SCWC-Saugus1 and SCWC-Saugus2, rather than the rate of 1,200 gpm that has been selected for each well based, in part, on the water supply needs of the valley? This was evaluated by running the model several times to identify the pumping rates at the two wells (SCWC-Saugus1 and SCWC-Saugus2) that would potentially cause Saugus Formation groundwater to migrate to Saugus Formation wells that are not impacted by perchlorate. Particle-tracking analyses were performed for the entire 78-year simulation and for shorter periods within the 78-year period.
2. How would the model predictions change if the degree of connection between the Alluvial Aquifer and the Saugus Formation is less than the degree of connection that is

simulated by the calibrated model? This was evaluated by reducing the connection by a factor of 4, which corresponds to decreasing the vertical hydraulic conductivity of the Alluvial Aquifer and/or the uppermost beds of the Saugus Formation.

2.3 Results

This section presents and discusses the following analyses from the 78-year model runs:

1. Hydrographs of groundwater elevations and Santa Clara River flows. The purpose of the hydrographs is to show that the pumping plan at the impacted wells is consistent with the objective of operating the basin in a manner that maintains long-term stability in groundwater levels and river flows.
2. Maps of particle traces showing forecasted Saugus Formation groundwater flowpaths that leave the Whittaker-Bermite property.
3. A map of particle traces showing the area of forecasted hydraulic containment (capture) within the Saugus Formation that is achieved by pumping wells SCWC-Saugus1, SCWC-Saugus2, and NCWD-11 at the planned pumping rates described in Section 2.2.5.2 of this report.
4. Maps showing the forecasted 2-year, 5-year, 10-year, and 20-year capture zones for SCWC-Saugus1, SCWC-Saugus2, and NCWD-11.

2.3.1 Hydrographs

Hydrographs are displayed for different portions of the Alluvial Aquifer on Figures 2-10 through 2-14 and for different portions of the Saugus Formation on Figures 2-15 and 2-16. Each figure shows results for the 78-year model run to illustrate the potential effect of the operational plan for the Santa Clarita Valley, including the planned pumping at the impacted Saugus Formation production wells. These figures show that the spatial distribution and temporal variation of pumping are not expected to cause a long-term decline in groundwater levels in the Alluvial Aquifer or the Saugus Formation. The model simulates distinct multi-year periods of overall declining or overall increasing groundwater elevations, due to cycles of below-normal and above-normal rainfall periods. This variation is consistent with historical observations of the relationship between rainfall and groundwater level fluctuations (CH2M HILL, 2004). The model also simulates short-term declines in Saugus Formation groundwater elevations that arise from the increased Saugus pumping that occurs during the second and third years of a drought in the SWP system.

Figure 2-17 shows the total flows estimated by the model for the Santa Clara River at the County Line gage, which is located at the western end of the valley. The figure contains both a linear plot and a semi-logarithmic plot, to better illustrate the flows during low-flow periods. As shown by both plots, the total streamflows vary considerably over time at this location, due primarily to variations in rainfall.

The relative influences of local hydrology and the operational plan on the Santa Clara River are illustrated by Figure 2-18, which shows the model-calculated volumes of monthly groundwater discharge to the river. Groundwater discharges to the river occur along the river reach lying downstream of the mouth of San Francisquito Canyon. The figure shows that the groundwater discharges to the river also vary over time, both seasonally and over multi-year periods. Additionally, the figure shows a period of relatively low groundwater discharge to the river occurs from years 23 through 39 (historical years 2002 through 2003, followed by 1950 through 1964), which corresponds to the prevailing below-normal rainfall conditions in those years. The figure also shows higher volumes of groundwater discharge to the river in years of above-normal rainfall, particularly the very wet periods years 1 through 4, years 13 through 19, years 52 through 58, and years 67 through 72. The similarity between rainfall and groundwater discharges to the river indicates that local hydrology is the primary influence on these discharges. Additionally, the groundwater discharge hydrographs do not show any marked short-term declines in flows that coincide with the marked short-term declines in Saugus Formation groundwater levels when Saugus wells pump at drought-year rates. The model therefore indicates that the operational plan for the groundwater system is not expected to notably affect river flows.

Figures 2-19 and 2-20 show the variations in groundwater recharge and groundwater discharge, respectively, throughout the 78-year simulation period. These annual valleywide groundwater recharge and discharge rates are also listed in Table 2-17. Figure 2-21 shows the annual and cumulative changes in groundwater storage volumes. Figures 2-19 through 2-21 and Table 2-17 together show the following:

1. Groundwater recharge rates (Figure 2-19) are highly variable from year to year, due to variations in precipitation within the Regional Model domain, and precipitation and stormwater generation in the watersheds lying upstream of the aquifer system. In contrast, total groundwater discharge (Figure 2-20) is much less variable from year to year, with the more limited variations arising from increased pumping during drought years and increased ET and groundwater discharge to the Santa Clara River during wet years.

2. Year-to-year and cumulative changes in groundwater storage during the 78-year simulation period (Figure 2-21) provide insights as to the manner in which the basin is functioning hydrologically under the operational pumping plan for the Valley. The cumulative change in groundwater storage is a measure of the longer-term trends in the amount of groundwater in storage, and is plotted on a monthly basis. Table 2-17 tabulates the annual water budget for each year of the 78-year simulation, and shows the cumulative change on an annual basis (in contrast to the monthly basis shown on Figure 2-21). Figure 2-21 and Table 2-17 together show the following:

   a. The cumulative change in total groundwater storage volume, which measures the continuous change in storage since the beginning of the simulation, ranges between approximately a 150,000 AF decline and a 260,000 AF increase. The change in groundwater storage during a single year ranges from approximately an 80,000 AF/yr decline to a 170,000 AF/yr increase.

   b. A nearly 20-year period of overall decline in the cumulative groundwater storage volume occurs between years 19 and 39, as shown on Figure 2-21. Beginning in year 40, the cumulative change in storage shows a generally upward trend, with occasional downward trends during specific drought periods.

   c. The Regional Model estimates that the total volume of groundwater in storage above a depth of 2,500 feet is approximately 5 million AF[11]. Consequently, the cumulative declines and increases in groundwater storage represent 5 percent or less of the volume of groundwater in storage.

3. Implementation of the operational pumping plan, including operation of the impacted Saugus Formation production wells, will have no significant effect on long-term groundwater conditions. This is shown by the forecasted recovery of groundwater storage volumes after periods of continued decline, such as the 20-year period of groundwater declines that occurs during years 19 through 39.

4. Based on the previous observations, changes in groundwater storage volumes, particularly over a period of many years, are governed primarily by local hydrologic conditions, not by the operational pumping plan. Local precipitation and streamflows are the most important influences on the year-to-year and longer-term changes in groundwater storage volumes.

The curves presented on Figures 2-10 through 2-21 provide a general indication of the types of fluctuations in groundwater conditions that could be expected to occur in the future in the Santa Clarita Valley over a period of many years. However, these curves have been derived using an assumed sequence of local hydrologic conditions that is based on the sequence of rainfall and streamflow volumes that were measured during the past several decades. In the future, the volumes and year-to-year trends in rainfall and streamflow could vary from those observed in the past. Consequently, the most significant conclusion from the 78-year simulations is that local hydrologic conditions, rather than the operational pumping plan and the use of the impacted Saugus Formation production wells, will be the predominant influence on the water resources (groundwater and river flows) of the Santa Clarita Valley.

2.3.2 Hydraulic Containment

As discussed previously in Section 2.2.5.2, the combined pumping volume from the three impacted wells was modeled as 4,355 AF/year. Figures 2-22 and 2-23 show the long-term average groundwater elevations in the Alluvial Aquifer and the Saugus Formation, respectively, in the vicinity of the Whittaker-Bermite property and the impacted production wells[12]. These groundwater elevations were used to delineate three-dimensional ground-water flowpaths using the MicroFEM® model's particle-tracking routines. The flowpaths were used to forecast the degree of hydraulic containment in the Saugus Formation that will arise from the pumping plan at wells SCWC-Saugus1, SCWC-Saugus2, and NCWD-11.

Figure 2-24 shows the traces of groundwater particles (1) migrating westward in the Saugus Formation from the Whittaker-Bermite property and (2) migrating away from Saugus wells

[11]This calculation excludes groundwater deeper than 2,500 feet and shallower groundwater residing in the Sunshine Ranch Member of the Saugus Formation. The calculation also assumes a specific yield of 0.15 for the Alluvial Aquifer and 0.065 for the Saugus Formation, which are similar to values used by Richard C. Slade and Associates, LLC (2002), for similar calculations of the volume of groundwater in storage. The model-based calculations estimate that the groundwater storage volumes are 1 million AF of groundwater in the Alluvial Aquifer and 4 million AF in the Saugus Formation. Richard C. Slade and Associates, LLC, estimated these volumes to be 0.16 million AF and 1.65 million AF, respectively. Robson (1972) estimated this volume to be 6 million AF based on a specific yield of 0.10 and a Saugus Formation thickness of 3,500 feet.

[12]Figure 2-23 shows the average groundwater elevations in the fourth layer of the model, which represents the depth interval from 1,000 to 1,500 ft bgs.

MP-5 and VWC-157. The figure uses different colors for the flowpaths to illustrate the depths in the Saugus Formation from which the wells derive their water. The flowpaths extending westward from the Whittaker-Bermite property were initiated at depths between 500 and 1,000 ft bgs, and the flowpaths migrating from MP-5 and VWC-157 were initiated at depths between 150 and 1,500 ft bgs. Three principal observations about the flowpaths are as follows:

1. Each flowpath initiated at these depths along the Whittaker-Bermite property's western boundary on Figure 2-24 ends at wells SCWC-Saugus1 and SCWC-Saugus2. This includes flowpaths originating near multi-port monitoring well MP-2, which end at well SCWC-Saugus2. Groundwater sampling results at MP-2 indicate that perchlorate is present as deep as approximately 800 ft bgs (CH2M HILL, 2003).
2. None of the groundwater particles migrate to nonimpacted production wells lying downgradient (west and northwest) of the three impacted wells that are closest to the Whittaker-Bermite property (SCWC-Saugus1, SCWC-Saugus2, and NCWD-11). Consequently, no new production wells are needed in the area around SCWC-Saugus1, SCWC-Saugus2, and NCWD-11 to control groundwater migrating from the Whittaker-Bermite property.
3. None of the flowpaths end at NCWD-11, which indicates that the pumping plan for SCWC-Saugus1 and SCWC-Saugus2 alone will contain groundwater migrating from areas on the Whittaker-Bermite property where perchlorate has been detected in groundwater, south and west of the San Gabriel Fault.
4. Saugus Formation groundwater at wells MP-5 and VWC-157 is captured by containment pumping at SCWC-Saugus1.

Figure 2-25 shows the area of hydraulic containment within the Saugus Formation that will be achieved by the planned pumping for SCWC-Saugus1, SCWC-Saugus2, and NCWD-11. The figure shows groundwater flowpaths that have been traced backward from these three wells to delineate the horizontal extent of the capture zone in the Saugus Formation created by pumping from these wells. Capture zones are also shown for three nearby nonimpacted Saugus Formation production wells (VWC-160, VWC-201, and VWC-205) that lie downgradient of SCWC-Saugus1, SCWC-Saugus2, and NCWD-11. The flowpaths were drawn by placing imaginary groundwater particles through the entire open interval of each well and tracing the flowpaths in a backward direction to delineate the full extent of the capture zones created in the Saugus Formation for each well[13] (see Table 2-7 for the depths of the open intervals at each Saugus Formation production well). Figure 2-25 shows the following:

1. The capture zones for SCWC-Saugus1 and SCWC-Saugus2 occupy a large volume of the Saugus Formation, extending as far east as the Whittaker-Bermite property and as far northwest as wells VWC-157 and MP-5, which have historical detections of perchlorate.
2. The capture zones for VWC-160, VWC-201, and VWC-205 lie west of, and generally do not overlap, the capture zones for SCWC-Saugus1 and SCWC-Saugus2.

[13]For clarity, flowlines that were delineated to the base of the Alluvial Aquifer were stopped at that location so Figure 2-25 would show capture zones only in the Saugus Formation, which is the focus of the containment evaluation.

3. The capture zones for VWC-160, VWC-201, and VWC-205 do not extend to the locations of other Saugus Formation wells that have historical perchlorate detections (VWC-157 and MP-5).

In summary, Figures 2-24 and 2-25 together indicate that the pumping plan for production wells SCWC-Saugus1 and SCWC-Saugus2 will likely meet the objectives of (1) containing perchlorate that is migrating westward in the Saugus Formation from the Whittaker-Bermite property, (2) containing perchlorate that is present in the Saugus Formation at wells MP-5 and VWC-157, and (3) preventing perchlorate migration to nonimpacted Saugus Formation wells located farther west in the Santa Clarita Valley. Additionally, pumping at NCWD-11 is not necessary for meeting these objectives. These conclusions are further reinforced by the results of sensitivity analyses that are described in Section 2.3.4.

2.3.3 Time-related Capture Zones

Delineations of the 2-year, 5-year, 10-year, and 20-year capture zones of the impacted wells have been developed at DHS' request, for use in conducting the contaminant source inventory that is required by DHS Policy Memo 97-005. These capture zones are shown on Figures 2-26 through 2-29 respectively. As shown by the color scheme for the flowlines in each figure, the hydraulic capture zones lie not only in the Saugus Formation, but also in portions of the Alluvial Aquifer. The particle traces indicate that a portion of the yield to the impacted Saugus Formation production wells comes from downward leakage of groundwater from the Alluvial Aquifer to the Saugus Formation. This finding is consistent with the understanding of the basinwide and localized hydrogeology, which is discussed in the Regional Model development and calibration report (CH2M HILL, 2004a) and is based on drilling records, well-yield data, aquifer tests, streamflow data, and long-term monitoring of pumping rates and groundwater elevations across the basin. These data together indicate SCWC-Saugus1, SCWC-Saugus2, and NCWD-11 lie in a regional groundwater recharge area where the Saugus Formation is recharged by the Alluvial Aquifer, which in turn receives recharge from rainfall and streamflows. Figure 2-30 shows where the Saugus Formation is recharged by the Alluvial Aquifer.

Figures 2-26 through 2-29 also show that the portion of the Alluvial Aquifer that would contain groundwater migrating toward production well SCWC-Saugus1 lies within an area where perchlorate has been detected in the Alluvial Aquifer, north of this well and south of the Santa Clara River. In this area, perchlorate detections in Alluvial Aquifer monitoring wells have ranged from as little as 3.6 μg/L (well AL04_R1) to as high as 40 μg/L (well AL09_R1) and 64 μg/L (well EM03). The flowpaths suggest that the Alluvial Aquifer monitoring wells with perchlorate detections contain groundwater that will eventually migrate to SCWC-Saugus1, and thereby be contained by the near-continuous pumping activity that is planned for SCWC-Saugus1. This conclusion is supported by recent groundwater elevation data from the Alluvial Aquifer that show higher groundwater elevations exist at the AL09 series wells than at the AL04 series wells (see Figure 2-31). These data indicate that under the nonpumping conditions that have existed in the Saugus Formation in this area since 1997, the groundwater flow direction in the Alluvial Aquifer in this area is from north and northeast to south and southwest. This observation is consistent with water budget analyses that indicate significantly greater flow rates of surface water and Alluvial Aquifer groundwater occur along the Santa Clara River than along the South

Fork Santa Clara River. Because the Saugus Formation is recharged by the Alluvial Aquifer in this area, this hydraulic connection between the two aquifers means that implementation of Saugus Formation pumping could gradually increase the rate of downward leakage from the Alluvial Aquifer over a long period of time. This, in turn, could potentially help reduce the migration of Alluvial Aquifer groundwater farther west from the area around monitoring wells AL04 and AL06. This is evaluated in further detail in the sensitivity analysis, which is discussed below.

2.3.4 Sensitivity Analysis

As discussed in Section 2.2.9, sensitivity analyses were performed to further evaluate the likelihood that implementation of the Purveyors' pumping plan for the impacted Saugus Formation production wells will meet the containment objectives, particularly the objective of preventing movement of perchlorate to nonimpacted Saugus Formation wells located farther downgradient (to the west of the impacted wells). A model run was performed to evaluate each of the following questions:

1. **Can the containment objectives be met by using lower pumping rates at SCWC-Saugus1 and SCWC-Saugus2, rather than the rate of 1,200 gpm that has been selected for each well based, in part, on the water supply needs of the valley?** The purpose of this simulation was to evaluate whether the pumping plan for SCWC-Saugus1 and SCWC-Saugus2 does either of the following:
   a. Involves more pumping than is necessary for containment reasons alone
   b. Provides a high degree of certainty that groundwater migrating westward from the western boundary of the Whittaker-Bermite property will be prevented from moving farther west to wells that are not currently impacted by perchlorate
2. **How would the model predictions change if the degree of connection between the Alluvial Aquifer and the Saugus Formation is less than the degree of connection that is simulated by the calibrated model?** The purpose of this simulation was to evaluate whether uncertainty in the degree of hydraulic connection would notably affect the Regional Model's prediction that Alluvial Aquifer groundwater north of this well will migrate to this well, rather than migrating westward in the Alluvial Aquifer. This was evaluated by reducing the hydraulic connection by a factor of 4, which corresponds to decreasing the vertical hydraulic conductivity (Kv) of the Alluvial Aquifer and/or the uppermost beds of the Saugus Formation.

The sensitivity analyses showed the following:

1. Containment of Saugus groundwater migrating westward from the Whittaker-Bermite property will not be completely achieved if the two wells are operated at 800 gpm each or lower. Figure 2-32 compares groundwater flowpaths initiated at the western boundary of the Whittaker-Bermite property for the base model run and the sensitivity run that models a pumping rate of 700 gpm at each of these two wells. The figure shows that for the lower pumping rate, the southern end of the western property boundary will not lie within the capture zone of SCWC-Saugus1 and SCWC-Saugus2. At monitoring wells MP-2 and MP-4, which are both located on the Whittaker-Bermite property, Saugus groundwater migrates northwest and lies within the capture zones of

SCWC-Saugus1 and SCWC-Saugus2 for both sets of pumping rates (1,200 gpm per well and 700 gpm per well).

2. Although Figure 2-32 shows that pumping rates of 800 gpm per well or higher will capture most of the Saugus groundwater moving west from the Whittaker-Bermite property, pumping rates below 1,200 gpm will not completely capture perchlorate and groundwater that are present in the Saugus Formation at wells MP-5 and VWC-157. This is illustrated on Figure 2-32 by the blue flowpaths, which were generated using a pumping rate of 1,000 gpm per well at SCWC-Saugus1 and SCWC-Saugus2. At MP-5, groundwater above a depth of 1,000 feet migrates to SCWC-Saugus1 and to nonimpacted well VWC-205, while groundwater at and below 1,000 feet migrates to nonimpacted well VWC-160. At VWC-157, groundwater within the well's open interval migrates to SWC-Saugus1 and nonimpacted well VWC-205. Consequently, because these lower pumping rates are unable to fully contain perchlorate that is present at MP-5 and VWC-157, the containment plan will consist of pumping SCWC-Saugus1 and SCWC-Saugus2 at 1,200 gpm each.

3. The continuous pumping of wells SCWC-Saugus1 and SCWC-Saugus2 will likely capture much of the Alluvial Aquifer groundwater north of these wells that has historically contained perchlorate detections (see Figure 2-33, which compares the 20-year capture zones for the base model run and the sensitivity run). Modeling analyses indicate that if the vertical anisotropy[14] is as high as 200:1 in the upper beds of the Saugus Formation, it is still possible to contain Alluvial Aquifer groundwater from this area.

2.4 Conclusions

Analyses using a locally scaled version of the Regional Model of Santa Clarita Valley's groundwater resources indicate that the Purveyors' pumping plan for the impacted Saugus Formation production wells will meet the following objectives that have been defined by the Purveyors:

1. Hydraulically contain perchlorate migrating westward in the Saugus Formation from the Whittaker-Bermite property toward the impacted wells.
2. Hydraulically contain perchlorate that is present at wells MP-5 and VWC-157, which are located downgradient of the impacted wells.
3. Protect downgradient production wells that are currently not impacted.
4. Restore the annual volumes of water that were pumped from the impacted wells before they were shut down because of perchlorate detections.
5. Operate the impacted wells in a manner that is consistent with the Purveyors' operational plan for the Santa Clarita Valley's groundwater resources.

[14] The vertical anisotropy of a geologic unit is the ratio of its horizontal hydraulic conductivity (Kh) to its vertical hydraulic conductivity (Kv). In the Saugus Formation, the vertical anisotropy of 50:1 in the Regional Model was revised upward to 200:1 for this sensitivity analysis.

6. If possible, pump one or more of the impacted Saugus Formation production wells in a manner that also contains perchlorate migrating in the Alluvial Aquifer from the northern portion of the Whittaker-Bermite property.

The major conclusions from the modeling analysis are as follows:

1. Operating production wells SCWC-Saugus1 and SCWC-Saugus2 at rates of 1,200 gpm each on a nearly continual basis will effectively contain perchlorate migrating westward in the Saugus Formation from the Whittaker-Bermite property and will also contain perchlorate that is present at Saugus wells MP-5 and VWC-157. This is shown by Figure 2-24, which displays groundwater flowpaths from MP-5, VWC-157, and the Whittaker-Bermite property; and by Figure 2-25, which displays the areas within the Saugus Formation where water is obtained by each of the impacted production wells and each of the nonimpacted production wells that are located downgradient of SCWC-Saugus1 and SCWC-Saugus2.
2. Operating production wells SCWC-Saugus1 and SCWC-Saugus2 at rates as low as 700 to 800 gpm each will not fully contain groundwater that is migrating westward from the Whittaker-Bermite property. Additionally, if these wells are operated at 1,000 gpm each, perchlorate that is present in the Saugus Formation at wells MP-5 and VWC-157 will not be captured and will instead migrate to existing nonimpacted wells VWC-160 and VWC-205. (See Figure 2-32.)
3. No new production wells are needed in the Saugus Formation to meet the perchlorate containment objective.
4. Impacted well NCWD-11 is not a required component of the containment program.
5. Use of other water supplies in lieu of pumping at SCWC-Saugus1 and SCWC-Saugus2 will likely be detrimental to the long-term quality of groundwater in the Saugus Formation. Pumping at these two wells is necessary to prevent migration of perchlorate to other portions of the Saugus Formation.
6. The pumping plan for SCWC-Saugus1 and SCWC-Saugus2 might contain perchlorate that is migrating in the Alluvial Aquifer from the northern portion of the Whittaker-Bermite property, including perchlorate that has been detected in the Alluvial Aquifer at and south of Bouquet Junction.
7. Planned operation of the impacted production wells will not cause detrimental short-term or long-term effects to the groundwater and surface water resources of the Santa Clarita Valley. In particular, the modeling analysis indicates that short- and long-term variability in local rainfall and streamflows is the predominant cause of fluctuating groundwater elevations, river flows, and groundwater storage volumes. Compared to local hydrology, implementation of the operational pumping plan for the valley, including the planned use of wells SCWC-Saugus1 and SCWC-Saugus2, has much less influence on the water resources of the valley.

It is important to note that the model simulations described in this report distribute pumping in a manner that is based on current and projected uses of both the Alluvial Aquifer and the Saugus Formation. The conclusions presented in this report regarding containment of perchlorate-containing groundwater will potentially be different if the pumping plan for other Saugus Formation wells is significantly different than what was simulated. In particular, a significant change in the Saugus Formation pumping regime in the South Fork Santa Clara River area or near its mouth could potentially cause ground-water flow patterns and capture zones to be notably different from those described in this report. Changes that could appreciably alter groundwater flow patterns and capture zones could include the operation of new wells in that area, or notably greater instantaneous pumping rates or annual pumping volumes than those simulated by the Regional Model. Consequently, before a new well is sited in that area or a significant increase in pumping occurs from an existing wellfield in that area, it is recommended that an analysis first be conducted of the potential effects of the contemplated change on the perchlorate containment program.

Tables

TABLE 2-1
Recharge and Discharge Components of the Hydrologic Cycle in the Upper Santa Clara River Basin
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Recharge	Discharge
Surface Water	
Direct runoff of precipitation	Evapotranspiration of precipitation
Precipitation runoff from upstream watershed areas	Santa Clara River flow to Ventura County
Castaic Lake/Lagoon releases into Castaic Creek	Streamflow seepage to the Alluvial Aquifer
WRP discharges into the Santa Clara River	Evapotranspiration of applied irrigation water
Groundwater seepage into the Santa Clara River	
Irrigation return flows (agricultural and urban)	
Groundwater	
Infiltration of precipitation	Pumping
Infiltration of outdoor applied water (agricultural and urban)	Evapotranspiration of Alluvial Aquifer groundwater by riparian vegetation
Alluvial Aquifer subsurface inflow (Castaic Dam, Lang gage)	Alluvial Aquifer subsurface outflow (western study area boundary)
Streamflow seepage to Alluvial aquifer	Groundwater seepage into the Santa Clara River

Notes:

The two sources of water for agricultural and municipal water uses in the basin are groundwater pumping and imported water from the SWP.

Because SWP water is stored in Castaic Lake, which is outside the limits of the Alluvial and Saugus aquifers, it is not considered a part of the valley's hydrologic cycle while it is still in storage. However, SWP water that is land-applied or that is discharged from a WRP qualifies as a component of the hydrologic cycle. In addition, subsurface groundwater flow occurs into the Santa Clarita Valley beneath Castaic Creek through water seepage beneath Castaic Dam.

TABLE 2-2
Historical Hydrology in Northern California and the Santa Clarita Valley, 1950 through 2003
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	Northern California Hydrology[a]	Local Rainfall[b]
1950	Below Normal	6.84
1951	Above Normal	12.42
1952	Wet	34.19
1953	Wet	4.88
1954	Above Normal	15.82
1955	Dry	13.91
1956	Wet	14.21
1957	Above Normal	22.85
1958	Wet	23.14
1959	Below Normal	9.81
1960	Dry	11.64
1961	Dry	8.82
1962	Below Normal	21.22
1963	Wet	12.79
1964	Dry	10.09
1965	Wet	32.28
1966	Below Normal	14.57
1967	Wet	23.23
1968	Below Normal	6.90
1969	Wet	32.42
1970	Wet	23.19
1971	Wet	13.75
1972	Below Normal	4.15
1973	Above Normal	19.79
1974	Wet	18.04
1975	Wet	10.92
1976	Critical	14.02
1977	Critical	20.87
1978	Above Normal	42.17
1979	Below Normal	21.47
1980	Above Normal	27.00
1981	Dry	13.42
1982	Wet	20.20
1983	Wet	39.07
1984	Wet	12.86

TABLE 2-2
Historical Hydrology in Northern California and the Santa Clarita Valley, 1950 through 2003
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	Northern California Hydrology[a]	Local Rainfall[b]
1985	Dry	8.37
1986	Wet	18.02
1987	Dry	14.45
1988	Critical	16.92
1989	Dry	7.56
1990	Critical	6.98
1991	Critical	17.21
1992	Critical	32.03
1993	Above Normal	32.72
1994	Critical	10.27
1995	Wet	29.15
1996	Wet	15.88
1997	Wet	13.35
1998	Wet	30.73
1999	Wet	8.96
2000	Above Normal	14.04
2001	Dry	22.24
2002	Dry	7.90
2003	Above Normal	15.70

[a]Defined by water year, using DWR's Sacramento Valley Unimpaired Runoff Index: wet = wettest; critical = driest.

[b]Records are for the Newhall-Soledad rain gage (Station No. FC32CE), in inches. As shown on Figure 2-3, the median and average rainfall at this gage from 1950 through 2002 were 14.57 in/yr and 17.84 in/yr, respectively.

TABLE 2-3
Annual Pumping Rates Specified by the Operational Plan for the Santa Clarita Valley's Groundwater Resources
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Aquifer	Normal Years	Dry Year 1	Dry Year 2	Dry Year 3
Operational Plan Pumping				
Alluvium	30,000 to 40,000	30,000 to 35,000	30,000 to 35,000	30,000 to 35,000
Saugus	7,500 to 15,000	7,500 to 25,000	21,000 to 25,000	21,000 to 35,000
Total	**37,500 to 55,000**	**37,500 to 60,000**	**51,000 to 60,000**	**51,000 to 70,000**
Modeled Pumping				
Alluvium	38,429	33,767	33,767	33,767
Saugus	10,679	15,760	24,346	34,096
Total	**49,108**	**49,527**	**58,113**	**67,863**

Notes:

All pumping volumes are listed in acre-feet.

The operational plan is defined in the documents titled *Urban Water Management Plan 2000* (Black & Veatch, 2000) and *Santa Clarita Valley Water Report 2003* (Luhdorff & Scalmanini Consulting Engineers, 2004).

In the model simulations, total pumping is different than listed in this table when dry-year pumping conditions in one aquifer coincide with normal-year pumping conditions in the other aquifer (due to differences in the timing of dry conditions locally versus reduced deliveries of water imports from the State Water Project).

TABLE 2-4

CALSIM II Calculated State Water Project Municipal and Industrial Allocations

Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	OCAP Current EWA[a]	OCAP Future EWA[a]	2020 SWP Reliability[b]
1950	0.88	0.91	0.79
1951	1.00	1.00	0.96
1952	1.00	1.00	1.00
1953	1.00	1.00	0.95
1954	1.00	1.00	0.96
1955	0.44	0.45	0.43
1956	1.00	1.00	1.00
1957	0.94	0.91	0.75
1958	1.00	1.00	1.00
1959	0.84	0.88	0.83
1960	0.51	0.55	0.56
1961	0.68	0.72	0.76
1962	0.93	0.98	0.87
1963	1.00	1.00	1.00
1964	0.84	0.74	0.73
1965	0.87	0.81	0.77
1966	1.00	1.00	0.92
1967	1.00	1.00	1.00
1968	0.89	0.90	0.85
1969	1.00	1.00	1.00
1970	1.00	1.00	0.95
1971	1.00	1.00	1.00
1972	0.76	0.75	0.65
1973	1.00	1.00	0.91
1974	1.00	1.00	1.00
1975	1.00	1.00	1.00
1976	0.78	0.75	0.65
1977	0.03	0.04	0.20
1978	1.00	1.00	1.00
1979	1.00	0.94	0.89
1980	1.00	0.91	0.85
1981	0.90	0.92	0.84
1982	1.00	1.00	1.00
1983	1.00	1.00	1.00
1984	0.66	1.00	0.99
1985	0.97	0.91	0.83
1986	0.74	0.70	0.78
1987	0.70	0.77	0.71
1988	0.12	0.17	0.23
1989	0.96	0.95	0.83
1990	0.24	0.27	0.28
1991	0.24	0.29	0.25
1992	0.39	0.43	0.29
1993	1.00	1.00	1.00

[a]Source: USBR, 2004

[b]Source: DWR, 2002

Notes:

EWA = Environmental Water Account
OCAP = Operating Criteria and Plan

TABLE 2-5
State Water Project Allocations and Corresponding Saugus Formation Pumping for the 78-year Simulation
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	SWP Hydrology[a]	SWP Allocations[b] (%)	Simulated Saugus Pumping Conditions (AF/yr)
1	Above Normal	90	Normal (7,500-15,000)
2	Dry	90	Normal (7,500-15,000)
3	Wet	100	Normal (7,500-15,000)
4	Wet	100	Normal (7,500-15,000)
5	Wet	100	Normal (7,500-15,000)
6	Dry	95	Normal (7,500-15,000)
7	Wet	70	Normal (7,500-15,000)
8	Dry	75	Normal (7,500-15,000)
9	Critical	15	Dry Year 1 (15,000)
10	Dry	95	Normal (7,500-15,000)
11	Critical	25	Dry Year 1 (15,000)
12	Critical	30	Dry Year 2 (25,000)
13	Critical	45	Dry Year 3 (35,000)
14	Above Normal	100	Normal (7,500-15,000)
15	Critical	50	Dry Year 1 (15,000)
16	Wet	80	Normal (7,500-15,000)
17	Wet	100	Normal (7,500-15,000)
18	Wet	100	Normal (7,500-15,000)
19	Wet	100	Normal (7,500-15,000)
20	Wet	100	Normal (7,500-15,000)
21	Above Normal	90	Normal (7,500-15,000)
22	Dry	39	Dry Year 1 (15,000)
23	Dry	70	Normal (7,500-15,000)
24	Above Normal	90	Normal (7,500-15,000)
25	Below Normal	90	Normal (7,500-15,000)
26	Above Normal	100	Normal (7,500-15,000)
27	Wet	100	Normal (7,500-15,000)
28	Wet	100	Normal (7,500-15,000)
29	Above Normal	100	Normal (7,500-15,000)
30	Dry	45	Dry Year 1 (15,000)
31	Wet	100	Normal (7,500-15,000)
32	Above Normal	90	Normal (7,500-15,000)
33	Wet	100	Normal (7,500-15,000)
34	Below Normal	85	Normal (7,500-15,000)
35	Dry	55	Dry Year 1 (15,000)
36	Dry	70	Dry Year 2 (25,000)
37	Below Normal	95	Normal (7,500-15,000)
38	Wet	100	Normal (7,500-15,000)
39	Dry	75	Dry Year 1 (15,000)
40	Wet	80	Normal (7,500-15,000)
41	Below Normal	100	Normal (7,500-15,000)
42	Wet	100	Normal (7,500-15,000)
43	Below Normal	90	Normal (7,500-15,000)

TABLE 2-5
State Water Project Allocations and Corresponding Saugus Formation Pumping for the 78-year Simulation
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	SWP Hydrology[a]	SWP Allocations[b] (%)	Simulated Saugus Pumping Conditions (AF/yr)
44	Wet	100	Normal (7,500-15,000)
45	Wet	100	Normal (7,500-15,000)
46	Wet	100	Normal (7,500-15,000)
47	Below Normal	75	Normal (7,500-15,000)
48	Above Normal	100	Normal (7,500-15,000)
49	Wet	100	Normal (7,500-15,000)
50	Wet	100	Normal (7,500-15,000)
51	Critical	75	Dry Year 1 (15,000)
52	Critical	4	Dry Year 2 (25,000)
53	Above Normal	100	Normal (7,500-15,000)
54	Below Normal	95	Normal (7,500-15,000)
55	Above Normal	90	Normal (7,500-15,000)
56	Dry	90	Normal (7,500-15,000)
57	Wet	100	Normal (7,500-15,000)
58	Wet	100	Normal (7,500-15,000)
59	Wet	100	Normal (7,500-15,000)
60	Dry	95	Normal (7,500-15,000)
61	Wet	70	Normal (7,500-15,000)
62	Dry	75	Normal (7,500-15,000)
63	Critical	15	Dry Year 1 (15,000)
64	Dry	95	Normal (7,500-15,000)
65	Critical	25	Dry Year 1 (15,000)
66	Critical	30	Dry Year 2 (25,000)
67	Critical	45	Dry Year 3 (35,000)
68	Above Normal	100	Normal (7,500-15,000)
69	Critical	50	Dry Year 1 (15,000)
70	Wet	80	Normal (7,500-15,000)
71	Wet	100	Normal (7,500-15,000)
72	Wet	100	Normal (7,500-15,000)
73	Wet	100	Normal (7,500-15,000)
74	Wet	100	Normal (7,500-15,000)
75	Above Normal	90	Normal (7,500-15,000)
76	Dry	39	Dry Year 1 (15,000)
77	Dry	70	Normal (7,500-15,000)
78	Above Normal	90	Normal (7,500-15,000)

[a]Defined by water year, using DWR's Sacramento Valley Unimpaired Runoff Index: wet = wettest; critical = driest. SWP = State Water Project.

[b]Defined from simulations performed by CLWA (Kennedy/Jenks Consultants, 2003) and USBR (2004) using the CALSIM II model. This condition is for the year 2020 level of development. In any given year, the allocation may be made up, in part, of carryover water from the prior year.

TABLE 2-6
Simulated Annual Groundwater Pumping from the Saugus Formation
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Owner	Well Name	Normal Years	Dry Year 1	Dry Year 2	Dry Year 3
NCWD	11	811	811	811	811
	12	1,315	2,044	2,044	2,044
	13	1,315	2,044	2,044	2,044
Total Pumping (NCWD)		**3,441**	**4,899**	**4,899**	**4,899**
NLF	156	369	369	369	369
Total Pumping (NLF)		**369**	**369**	**369**	**369**
SCWC	Saugus1	1,772	1,772	1,772	1,772
	Saugus2	1,772	1,772	1,772	1,772
Total Pumping (SCWC)		**3,544**	**3,544**	**3,544**	**3,544**
VWC	159	50	50	50	50
	160 (Municipal)	500	830	830	830
	160 (Val. Ctry Club)	500	500	500	500
	201	100	100	3,577	3,577
	205	1,000	2,734	3,827	3,827
	206	1,175	2,734	3,500	3,500
Total Pumping (VWC)		**3,325**	**6,948**	**12,284**	**12,284**
To Be Determined	Future #1	0	0	3,250	3,250
	Future #2	0	0	0	3,250
	Future #3	0	0	0	3,250
	Future #4	0	0	0	3,250
Total Pumping (Future)		**0**	**0**	**3,250**	**13,000**
Total Saugus Formation Pumping		**10,679**	**15,760**	**24,346**	**34,096**

Notes:

All pumping volumes are listed in acre-feet.

Wells VWC-157 and NCWD-7, 8, 9, and 10 are assumed to no longer operate in the future.

NCWD = Newhall County Water District
NLF = Newhall Land and Farming Company
SCWC = Santa Clarita Water Company
VWC = Valencia Water Company
Val. Ctry Club = Valencia Country Club

TABLE 2-7
Allocation of Pumping by Layer for Wells Completed in the Saugus Formation
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Well Owner - Well Name	Model Layer	Depth to Open Interval (feet) Top	Depth to Open Interval (feet) Bottom	Length of Open Interval in Model Layer (feet)	Kh (ft/day)	T in Open Interval (ft^2/day)	Percentage of Yield from Model Layer
NCWD-11	2	200	1,075	300	10	3,000	72.3
	3			500	2	1,000	24.1
	4			75	2	150	3.6
NCWD-12	2	485	1,280	15	10	150	8.8
	3			500	2	1,000	58.5
	4			280	2	560	32.7
NCWD-13	2	420	750	80	10	800	61.5
	3			250	2	500	38.5
NLF-156	2	320	1,800	180	10	1,800	21.8
	3			500	6.5	3,250	39.4
	4			500	4	2,000	24.2
	5			300	4	1,200	14.5
SCWC-Saugus1	2	490	1,620	10	10	100	1.8
	3			500	6.5	3,250	59.9
	4			500	4	2,000	36.8
	5			20	4	80	1.5
SCWC-Saugus2	2	490	1,591	10	10	100	1.7
	3			500	6.5	3,250	56.9
	4			500	4	2,000	35.0
	5			91	4	364	6.4
VWC-159	3	662	1,900	338	0.025	8.45	27.3
	4			500	0.025	12.5	40.4
	5			400	0.025	10	32.3
VWC-160	3	950	2,000	50	6.5	325	7.6
	4			500	4	2,000	46.2
	5			500	4	2,000	46.2
VWC-201	3	540	1,670	460	6.5	2,990	52.7
	4			500	4	2,000	35.3
	5			170	4	680	12.0
VWC-205	3	820	1,930	180	6.5	1,170	23.9
	4			500	4	2,000	40.9
	5			430	4	1,720	35.2
VWC-206	3	500	2,000	500	6.5	3,250	44.8
	4			500	4	2,000	27.6
	5			500	4	2,000	27.6

TABLE 2-7
Allocation of Pumping by Layer for Wells Completed in the Saugus Formation
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Well Owner - Well Name	Model Layer	Depth to Open Interval (feet) Top	Depth to Open Interval (feet) Bottom	Length of Open Interval in Model Layer (feet)	Kh (ft/day)	T in Open Interval (ft^2/day)	Percentage of Yield from Model Layer
Future Wells	3	820	1,930	180	6.5	1,170	23.9
Near VWC-206	4			500	4	2,000	40.9
(Assumed)	5			430	4	1,720	35.2

Notes:

Wells VWC-157 and NCWD-7, 8, 9, and 10 are assumed to no longer operate in the future.

Kh = horizontal hydraulic conductivity
T = transmissivity
ft/day = feet per day
ft^2/day = square feet per day

TABLE 2-8
Allocation of Pumping by Month for Agricultural and Urban Production Wells
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Month	Percent of Annual Water Use, Agricultural	Percent of Annual Water Use, Urban	Percent of May through October Water Use, Urban
January	3.75	5.2	
February	5.10	3.7	
March	6.60	5.2	
April	9.10	6.6	
May	10.55	8.7	13.2
June	11.40	10.4	15.8
July	14.10	13.0	19.7
August	12.95	13.6	20.6
September	10.20	10.9	16.6
October	7.50	9.3	14.1
November	5.00	7.1	
December	3.75	6.3	
Total	**100.0**	**100.0**	**100.0**

TABLE 2-9
Local Hydrology and Corresponding Pumping from the Alluvial Aquifer for the 78-year Simulation
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Model Year	Based on Historical Year	Local Rainfall[a]	Alluvial Aquifer Pumping under the Operational Pumping Plan (AF/yr)[b,c]
1	1980	27.00	35,000-40,000
2	1981	13.42	35,000-40,000
3	1982	20.20	35,000-40,000
4	1983	39.07	35,000-40,000
5	1984	12.86	35,000-40,000
6	1985	8.37	30,000-35,000
7	1986	18.02	35,000-40,000
8	1987	14.45	35,000-40,000
9	1988	16.92	35,000-40,000
10	1989	7.56	30,000-35,000
11	1990	6.98	30,000-35,000
12	1991	17.21	30,000-35,000
13	1992	32.03	35,000-40,000
14	1993	32.72	35,000-40,000
15	1994	10.27	30,000-35,000
16	1995	29.15	35,000-40,000
17	1996	15.88	35,000-40,000
18	1997	13.35	35,000-40,000
19	1998	30.73	35,000-40,000
20	1999	8.96	30,000-35,000
21	2000	14.04	35,000-40,000
22	2001	22.24	35,000-40,000
23	2002	7.90	30,000-35,000
24	2003	15.70	35,000-40,000
25	1950	6.84	30,000-35,000
26	1951	12.42	35,000-40,000
27	1952	34.19	35,000-40,000
28	1953	4.88	30,000-35,000
29	1954	15.82	35,000-40,000
30	1955	13.91	35,000-40,000
31	1956	14.21	35,000-40,000
32	1957	22.85	35,000-40,000
33	1958	23.14	35,000-40,000
34	1959	9.81	30,000-35,000
35	1960	11.64	30,000-35,000
36	1961	8.82	30,000-35,000
37	1962	21.22	30,000-35,000
38	1963	12.79	35,000-40,000
39	1964	10.09	30,000-35,000
40	1965	32.28	35,000-40,000
41	1966	14.57	35,000-40,000
42	1967	23.23	35,000-40,000
43	1968	6.90	30,000-35,000

TABLE 2-9
Local Hydrology and Corresponding Pumping from the Alluvial Aquifer for the 78-year Simulation
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Model Year	Based on Historical Year	Local Rainfall[a]	Alluvial Aquifer Pumping under the Operational Pumping Plan (AF/yr)[b,c]
44	1969	32.42	35,000-40,000
45	1970	23.19	35,000-40,000
46	1971	13.75	35,000-40,000
47	1972	4.15	30,000-35,000
48	1973	19.79	35,000-40,000
49	1974	18.04	35,000-40,000
50	1975	10.92	30,000-35,000
51	1976	14.02	35,000-40,000
52	1977	20.87	35,000-40,000
53	1978	42.17	35,000-40,000
54	1979	21.47	35,000-40,000
55	1980	27.00	35,000-40,000
56	1981	13.42	35,000-40,000
57	1982	20.20	35,000-40,000
58	1983	39.07	35,000-40,000
59	1984	12.86	35,000-40,000
60	1985	8.37	30,000-35,000
61	1986	18.02	35,000-40,000
62	1987	14.45	35,000-40,000
63	1988	16.92	35,000-40,000
64	1989	7.56	30,000-35,000
65	1990	6.98	30,000-35,000
66	1991	17.21	30,000-35,000
67	1992	32.03	35,000-40,000
68	1993	32.72	35,000-40,000
69	1994	10.27	30,000-35,000
70	1995	29.15	35,000-40,000
71	1996	15.88	35,000-40,000
72	1997	13.35	35,000-40,000
73	1998	30.73	35,000-40,000
74	1999	8.96	30,000-35,000
75	2000	14.04	35,000-40,000
76	2001	22.24	35,000-40,000
77	2002	7.90	30,000-35,000
78	2003	15.70	35,000-40,000

[a]From records at Newhall-Soledad rain gage (Station No. FC32CE).

[b]Alluvial pumping rates listed in this column are the rates that will occur under the operational plan for the Valley if the 1950 through 2003 local hydrology repeats itself in the future.

[c]Alluvial pumping is set at the dry-year rate in years 12, 37, and 66 because each of these years is the first nondrought year that occurs after a multi-year drought ends.

TABLE 2-10
Recent and Simulated Future Annual Groundwater Pumping Volumes from the Alluvial Aquifer
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

		Historical Pumping			UWMP Pumping	
Well Name	**Location**	**2001**	**2002**	**2003**	**Normal Years**	**Dry Years**
NCWD-Castaic 1	Castaic Valley	345	385	561	385	345
NCWD-Castaic 2	Castaic Valley	166	0	123	166	125
NCWD-Castaic 3	Castaic Valley	0	0	0	0	0
NCWD-Castaic 4	Castaic Valley	100	47	56	100	45
NCWD-Pinetree 1	Mint Canyon	164	0	0	164	0
NCWD-Pinetree 2	Mint Canyon	0	0	0	0	0
NCWD-Pinetree 3	Mint Canyon	566	544	525	545	525
NCWD-Pinetree 4	Mint Canyon	300	5	0	300	0
NCWD Total		**1,641**	**981**	**1,265**	**1,660**	**1,040**
NLF-161	Downstream of Valencia WRP	496	485	2,021	485	485
NLF-B10	Downstream of Valencia WRP	1,240	534	344	344	344
NLF-B11	Downstream of Valencia WRP	205	232	271	232	232
NLF-B5	Downstream of Valencia WRP	1,680	2,280	1,582	1,582	1,582
NLF-B6	Downstream of Valencia WRP	1,312	2,175	1,766	1,766	1,766
NLF-B7	Downstream of Valencia WRP	474	584	402	584	584
NLF-C	Downstream of Valencia WRP	1,319	1,720	1,373	1,373	1,373
NLF-C3	Downstream of Valencia WRP	93	192	186	192	192
NLF-C4	Downstream of Valencia WRP	1,028	809	764	809	809
NLF-C5	Downstream of Valencia WRP	680	850	622	850	850
NLF-C6	Downstream of Valencia WRP	231	241	108	241	241
NLF-C7	Downstream of Valencia WRP	741	866	443	866	866
NLF-C8	Downstream of Valencia WRP	286	593	408	594	594
NLF-C9	Downstream of Valencia WRP	7	1	0	0	0
NLF-E	Castaic Valley	1,691	16	28	16	16
NLF-E2	Castaic Valley	141	55	14	55	55
NLF-E4	Downstream of Valencia WRP	0	0	0	0	0
NLF-E5	Downstream of Valencia WRP	172	679	537	679	679
NLF-E9	Downstream of Valencia WRP	238	814	47	814	814
NLF-G45	Downstream of Valencia WRP	291	283	60	283	283
NLF-S3	Downstream of Valencia WRP	0			0	0
NLF-W4	San Francisquito Canyon	46	1	0	0	0
NLF-W5	San Francisquito Canyon	276	104	23	107	107
NLF-X3	Downstream of Valencia WRP	12	0	0	0	0
NLF Total		**12,659**	**13,514**	**10,999**	**11,872**	**11,872**
SCWD-Clark	Bouquet Canyon	696	782	712	782	700
SCWD-Guida	Bouquet Canyon	1,047	1,320	1,230	1,320	1,230
SCWD-Honby	Above Saugus WRP	721	696	874	696	870
SCWD-Lost Canyon 2	Mint Canyon	741	730	644	741	640
SCWD-Lost Canyon 2A	Mint Canyon	1,034	905	593	1,034	590
SCWD-Mitchell #5A	Mint Canyon	407	143	19	0	0
SCWD-Mitchell #5B	Mint Canyon	0	150	0	557	0
SCWD-N. Oaks Central	Mint Canyon	822	1,646	1,641	822	1,640
SCWD-N. Oaks East	Mint Canyon	1,234	448	485	1,234	485
SCWD-N. Oaks West	Mint Canyon	898	1,123	31	898	0
SCWD-Sand Canyon	Mint Canyon	930	705	195	930	195
SCWD-Sierra	Mint Canyon	846	87	0	846	0
SCWD-Stadium	Above Saugus WRP	565	778	0	800	800
SCWD Total		**9,941**	**9,513**	**6,424**	**10,660**	**7,150**

TABLE 2-10
Recent and Simulated Future Annual Groundwater Pumping Volumes from the Alluvial Aquifer
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

		Historical Pumping			UWMP Pumping	
Well Name	**Location**	**2001**	**2002**	**2003**	**Normal Years**	**Dry Years**
VWC-D	Castaic Valley	645	772	687	690	690
VWC-I	San Francisquito Canyon	0	0	0	0	0
VWC-K2	Downstream of Saugus WRP	669	955	364	0	0
VWC-L2	Downstream of Saugus WRP	349	490	71	0	0
VWC-N	Downstream of Saugus WRP	591	700	622	620	620
VWC-N3	Downstream of Saugus WRP	226	857	255	0	0
VWC-N4	Downstream of Saugus WRP	458	909	248	0	0
VWC-N7	Downstream of Saugus WRP				1,160	1,160
VWC-N8	Downstream of Saugus WRP				1,160	1,160
VWC-Q2	Downstream of Saugus WRP	923	1,167	1,451	985	985
VWC-S6	Downstream of Saugus WRP	1,490	1,320	2,134	865	865
VWC-S7	Downstream of Saugus WRP	564	419	1,095	865	865
VWC-S8	Downstream of Saugus WRP	327	190	409	865	865
VWC-T2	Above Saugus WRP	900	696	1,014	460	460
VWC-T4	Above Saugus WRP	690	831	799	460	460
VWC-U3	Above Saugus WRP	956	572	823	0	0
VWC-U4	Above Saugus WRP	942	796	934	935	935
VWC-U6	Above Saugus WRP	0	0	0	825	825
VWC-W10	San Francisquito Canyon	182	0		0	0
VWC-W11	San Francisquito Canyon	806	939	764	600	600
VWC-W6	San Francisquito Canyon	0	0	36	865	865
VWC-W9	San Francisquito Canyon				350	350
VWC Total		**10,718**	**11,613**	**11,706**	**11,705**	**11,705**
Robinson Ranch	Mint Canyon				932	400
WHR (All Wells)	Castaic Valley	1,604	1,602	2,273	1,600	1,600
Total Alluvial Aquifer Pumping		**36,563**	**37,223**	**32,667**	**38,429**	**33,767**

Notes:

All pumping volumes are listed in AF/yr.

Wells that are not listed are assumed to not be pumping in the future.

NCWD = Newhall County Water District
NLF = Newhall Land and Farming Company
SCWC = Santa Clarita Water Company
VWC = Valencia Water Company
WHR = Wayside Honor Rancho, owned by LACWWD

TABLE 2-11

Simulated Monthly Precipitation at the Newhall County Water District Rain Gage

Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	10.36	14.63	4.84	0.36	0.40	0.00	0.00	0.00	0.00	0.00	0.00	1.36	31.95
2	4.76	1.66	5.50	0.46	0.00	0.00	0.00	0.00	0.00	0.58	3.62	0.22	16.80
3	3.33	1.21	9.50	1.09	0.13	0.00	0.00	0.00	1.02	0.25	5.34	2.95	24.82
4	8.67	6.85	13.07	4.61	0.20	0.00	0.00	1.17	1.85	1.74	5.04	5.13	48.33
5	0.00	0.00	0.27	0.07	0.00	0.00	0.00	0.00	0.05	0.16	3.87	8.13	12.55
6	0.78	1.20	1.04	0.14	0.07	0.00	0.06	0.00	0.12	0.54	5.11	0.70	9.76
7	5.84	6.65	5.39	0.88	0.00	0.00	0.05	0.00	1.78	0.68	1.55	0.24	23.06
8	2.10	0.61	1.69	0.14	0.00	0.00	0.09	0.02	0.00	3.47	3.84	4.80	16.76
9	3.27	3.39	1.16	3.98	0.09	0.00	0.00	0.00	0.10	0.00	0.92	7.14	20.05
10	0.89	4.13	1.30	0.30	0.00	0.00	0.00	0.00	0.62	0.86	0.37	0.00	8.47
11	2.89	4.23	0.22	0.48	0.88	0.00	0.00	0.00	0.00	0.00	0.63	0.01	9.34
12	1.11	5.72	11.33	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	5.95	24.61
13	3.28	16.64	9.73	0.15	0.34	0.00	0.30	0.00	0.00	1.55	0.00	7.25	39.24
14	17.11	11.73	4.27	0.00	0.00	0.65	0.00	0.00	0.00	0.57	0.75	1.00	36.08
15	0.48	5.31	2.33	0.42	0.00	0.00	0.00	0.00	0.00	0.78	0.71	1.94	11.97
16	21.98	1.93	8.30	0.72	0.26	0.76	0.00	0.00	0.00	0.00	0.00	2.33	36.28
17	2.97	6.73	2.08	0.13	0.68	0.00	0.00	0.00	0.00	1.30	1.06	8.70	23.65
18	6.67	0.23	0.00	0.00	0.00	0.00	0.05	0.00	0.53	0.00	3.73	6.72	17.93
19	3.49	22.00	3.98	2.28	5.50	0.06	0.00	0.00	0.21	0.33	1.36	1.39	40.60
20	2.08	0.65	3.00	3.78	0.00	0.48	0.00	0.00	0.01	0.00	0.00	0.05	10.05
21	1.21	9.43	3.15	2.10	0.00	0.00	0.00	0.31	0.00	1.13	0.00	0.00	17.33
22	5.96	9.79	3.70	1.88	0.00	0.00	0.00	0.00	0.00	0.36	3.33	1.08	26.10
23	1.08	1.10	0.26	0.05	0.05	0.00	0.00	0.00	0.01	0.00	2.48	4.25	9.27
24	0.00	9.88	2.73	2.42	0.05	0.00	0.00	0.00	0.09	0.10	0.63	2.57	18.47
25	2.58	1.69	1.27	0.86	0.01	0.00	0.00	0.00	0.32	0.36	0.73	0.21	8.03
26	2.96	0.93	1.16	1.69	0.09	0.00	0.00	0.05	0.00	0.49	1.33	5.88	14.57
27	17.68	0.61	10.30	1.80	0.00	0.00	0.00	0.00	0.12	0.00	4.52	5.09	40.12
28	0.80	0.02	0.21	1.64	0.69	0.00	0.00	0.00	0.00	0.00	2.32	0.04	5.73
29	6.38	3.36	4.86	0.12	0.00	0.00	0.00	0.00	0.00	0.00	2.38	1.47	18.56
30	5.69	1.69	0.21	3.38	1.91	0.00	0.00	0.00	0.00	0.00	1.43	2.01	16.32
31	7.55	1.00	0.00	5.90	1.82	0.00	0.11	0.00	0.00	0.15	0.00	0.15	16.68
32	7.22	2.71	3.05	1.16	1.06	0.25	0.00	0.00	0.00	2.68	0.40	8.30	26.81
33	2.11	10.42	5.82	7.18	0.00	0.00	0.00	0.00	0.04	1.35	0.23	0.00	27.15
34	3.70	5.47	0.00	0.59	0.00	0.00	0.00	0.00	0.08	0.00	0.00	1.68	11.51
35	4.17	2.21	0.20	2.05	0.00	0.00	0.00	0.00	0.00	0.00	4.96	0.07	13.66
36	1.88	0.00	0.76	0.33	0.09	0.00	0.07	0.00	0.11	0.00	4.12	2.99	10.35
37	3.86	19.44	1.53	0.00	0.02	0.00	0.00	0.00	0.00	0.05	0.00	0.00	24.90
38	0.99	3.63	4.10	2.23	0.06	0.43	0.00	0.00	0.77	0.50	2.29	0.01	15.01
39	2.95	0.00	1.88	2.41	0.04	0.12	0.00	0.00	0.00	0.52	1.47	2.48	11.84
40	0.25	0.07	1.65	9.14	0.00	0.02	0.26	0.16	0.95	0.00	17.49	7.89	37.88
41	1.42	1.55	0.33	0.00	0.09	0.00	0.00	0.00	0.09	0.11	7.56	5.95	17.10

TABLE 2-11
Simulated Monthly Precipitation at the Newhall County Water District Rain Gage
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
42	6.76	0.22	3.23	5.41	0.19	0.00	0.00	0.00	0.50	0.00	9.36	1.58	27.26
43	0.86	0.93	2.91	0.97	0.07	0.00	0.00	0.38	0.00	0.39	0.35	1.24	8.10
44	19.53	13.89	0.82	1.16	0.05	0.05	0.18	0.00	0.00	0.00	2.32	0.05	38.04
45	0.94	6.63	4.33	0.00	0.00	0.00	0.00	0.00	0.00	0.13	8.86	6.33	27.21
46	1.23	1.41	0.48	0.94	0.15	0.00	0.00	0.00	0.47	0.50	0.38	10.57	16.14
47	0.00	0.12	0.00	0.02	0.05	0.05	0.00	0.06	0.00	0.05	3.45	1.08	4.87
48	5.19	11.74	3.29	0.00	0.00	0.00	0.00	0.00	0.00	0.15	1.83	1.03	23.22
49	10.58	0.02	4.30	0.06	0.00	0.00	0.02	0.00	0.00	1.17	0.12	4.89	21.17
50	0.28	3.02	6.04	2.96	0.00	0.00	0.00	0.00	0.00	0.39	0.04	0.09	12.81
51	0.00	7.39	1.47	0.46	0.15	0.35	0.01	0.00	3.40	0.22	2.09	0.90	16.45
52	5.75	0.12	2.15	0.00	5.27	0.00	0.00	2.68	0.02	0.05	0.06	8.40	24.49
53	10.74	13.23	17.10	2.72	0.00	0.00	0.00	0.00	1.23	0.01	2.70	1.76	49.49
54	12.44	3.20	6.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.89	1.19	23.75
55	10.36	14.63	4.84	0.36	0.40	0.00	0.00	0.00	0.00	0.00	0.00	1.36	31.95
56	4.76	1.66	5.50	0.46	0.00	0.00	0.00	0.00	0.00	0.58	3.62	0.22	16.80
57	3.33	1.21	9.50	1.09	0.13	0.00	0.00	0.00	1.02	0.25	5.34	2.95	24.82
58	8.67	6.85	13.07	4.61	0.20	0.00	0.00	1.17	1.85	1.74	5.04	5.13	48.33
59	0.00	0.00	0.27	0.07	0.00	0.00	0.00	0.00	0.05	0.16	3.87	8.13	12.55
60	0.78	1.20	1.04	0.14	0.07	0.00	0.06	0.00	0.12	0.54	5.11	0.70	9.76
61	5.84	6.65	5.39	0.88	0.00	0.00	0.05	0.00	1.78	0.68	1.55	0.24	23.06
62	2.10	0.61	1.69	0.14	0.00	0.00	0.09	0.02	0.00	3.47	3.84	4.80	16.76
63	3.27	3.39	1.16	3.98	0.09	0.00	0.00	0.00	0.10	0.00	0.92	7.14	20.05
64	0.89	4.13	1.30	0.30	0.00	0.00	0.00	0.00	0.62	0.86	0.37	0.00	8.47
65	2.89	4.23	0.22	0.48	0.88	0.00	0.00	0.00	0.00	0.00	0.63	0.01	9.34
66	1.11	5.72	11.33	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	5.95	24.61
67	3.28	16.64	9.73	0.15	0.34	0.00	0.30	0.00	0.00	1.55	0.00	7.25	39.24
68	17.11	11.73	4.27	0.00	0.00	0.65	0.00	0.00	0.00	0.57	0.75	1.00	36.08
69	0.48	5.31	2.33	0.42	0.00	0.00	0.00	0.00	0.00	0.78	0.71	1.94	11.97
70	21.98	1.93	8.30	0.72	0.26	0.76	0.00	0.00	0.00	0.00	0.00	2.33	36.28
71	2.97	6.73	2.08	0.13	0.68	0.00	0.00	0.00	0.00	1.30	1.06	8.70	23.65
72	6.67	0.23	0.00	0.00	0.00	0.00	0.05	0.00	0.53	0.00	3.73	6.72	17.93
73	3.49	22.00	3.98	2.28	5.50	0.06	0.00	0.00	0.21	0.33	1.36	1.39	40.60
74	2.08	0.65	3.00	3.78	0.00	0.48	0.00	0.00	0.01	0.00	0.00	0.05	10.05
75	1.21	9.43	3.15	2.10	0.00	0.00	0.00	0.31	0.00	1.13	0.00	0.00	17.33
76	5.96	9.79	3.70	1.88	0.00	0.00	0.00	0.00	0.00	0.36	3.33	1.08	26.10
77	1.08	1.10	0.26	0.05	0.05	0.00	0.00	0.00	0.01	0.00	2.48	4.25	9.27
78	0.00	9.88	2.73	2.42	0.05	0.00	0.00	0.00	0.09	0.10	0.63	2.57	18.47

TABLE 2-12

Simulated Monthly Streamflows in the Santa Clara River at the Lang Gage

Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	1,310	7,449	1,213	568	218	78	6	0	37	274	467	553	12,175
2	594	98	339	240	107	18	18	12	338	321	258	394	2,739
3	333	1,420	785	283	238	0	0	0	0	95	178	855	4,188
4	1,922	16,971	2,755	2,576	958	523	639	512	0	0	0	0	26,855
5	0	596	405	240	143	166	228	411	154	220	904	578	4,044
6	483	461	274	215	77	0	0	0	12	179	221	301	2,224
7	483	1,138	488	283	107	6	0	12	6	12	80	129	2,744
8	117	117	65	31	12	0	0	0	0	0	258	516	1,116
9	222	209	506	117	77	68	0	0	0	0	12	25	1,236
10	50	111	60	25	6	0	0	0	102	94	34	18	499
11	212	276	230	46	46	5	0	0	0	27	36	147	1,025
12	162	775	879	736	145	142	14	0	45	69	62	263	3,291
13	336	534	429	398	117	84	16	5	108	144	498	1,446	4,115
14	14,709	5,336	1,194	530	239	110	54	10	64	145	264	281	22,937
15	388	493	497	319	163	80	20	7	37	102	193	941	3,239
16	1,211	1,421	954	802	268	156	62	8	6	1	27	189	5,104
17	666	896	730	315	151	46	7	0	54	154	307	510	3,836
18	517	346	140	85	33	5	4	50	66	240	566	809	2,859
19	18,997	8,508	3,837	961	667	347	81	91	70	139	190	186	34,074
20	92	85	204	224	197	107	80	46	52	54	31	80	1,252
21	117	117	65	31	12	0	0	0	0	0	258	516	1,116
22	333	1,420	785	283	238	0	0	0	0	95	178	855	4,188
23	50	111	60	25	6	0	0	0	102	94	34	18	499
24	666	896	730	315	151	46	7	0	54	154	307	510	3,836
25	83	198	184	126	105	83	51	54	56	53	43	42	1,078
26	49	40	66	91	98	84	79	72	57	71	47	53	807
27	9,629	636	7,091	2,114	895	326	153	138	86	97	178	313	21,656
28	300	282	271	237	165	134	102	86	85	83	74	68	1,888
29	145	278	404	356	181	108	110	99	91	90	80	75	2,017
30	103	156	157	128	153	99	78	76	74	68	66	62	1,220
31	69	85	130	137	139	98	86	80	77	76	67	69	1,113
32	67	55	78	90	93	80	78	78	76	79	66	71	910
33	66	329	743	4,550	825	283	130	108	95	145	146	116	7,536
34	246	351	189	127	111	92	84	86	83	69	68	68	1,575
35	68	67	70	69	70	68	65	65	60	58	316	164	1,140
36	124	91	38	38	36	32	28	33	22	19	19	119	597
37	139	1,904	791	449	329	169	97	82	80	84	82	82	4,287
38	85	142	145	131	104	86	79	74	66	65	62	58	1,096
39	69	50	51	62	66	54	53	53	54	45	43	41	640
40	30	23	25	46	43	36	31	34	37	35	1,305	3,300	4,944
41	1,765	1,014	778	450	308	115	68	54	45	63	91	523	5,274

TABLE 2-12

Simulated Monthly Streamflows in the Santa Clara River at the Lang Gage

Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
42	757	489	1,028	2,295	1,880	729	212	104	89	73	255	487	8,397
43	300	247	276	180	72	32	32	30	25	133	208	851	2,384
44	13,797	2,856	1,005	489	320	147	98	98	46	318	392	399	19,966
45	461	550	1,168	465	290	169	74	60	58	27	501	1,338	5,161
46	614	524	556	397	262	167	70	25	5	30	200	420	3,270
47	332	250	131	90	50	22	32	6	0	0	11	58	983
48	153	1,717	950	471	226	71	18	12	8	3	8	44	3,679
49	608	229	392	190	129	49	17	6	0	3	19	87	1,728
50	53	90	228	181	104	31	15	3	0	0	0	0	704
51	0	110	63	39	33	12	0	0	1	0	0	0	258
52	28	7	28	19	60	5	0	0	0	0	0	0	147
53	744	9,486	11,412	1,696	2,736	1,154	418	209	101	264	422	86	28,730
54	1,254	433	1,113	506	246	190	178	111	125	90	120	558	4,925
55	1,310	7,449	1,213	568	218	78	6	0	37	274	467	553	12,175
56	594	98	339	240	107	18	18	12	338	321	258	394	2,739
57	333	1,420	785	283	238	0	0	0	0	95	178	855	4,188
58	1,922	16,971	2,755	2,576	958	523	639	512	0	0	0	0	26,855
59	0	596	405	240	143	166	228	411	154	220	904	578	4,044
60	483	461	274	215	77	0	0	0	12	179	221	301	2,224
61	483	1,138	488	283	107	6	0	12	6	12	80	129	2,744
62	117	117	65	31	12	0	0	0	0	0	258	516	1,116
63	222	209	506	117	77	68	0	0	0	0	12	25	1,236
64	50	111	60	25	6	0	0	0	102	94	34	18	499
65	212	276	230	46	46	5	0	0	0	27	36	147	1,025
66	162	775	879	736	145	142	14	0	45	69	62	263	3,291
67	336	534	429	398	117	84	16	5	108	144	498	1,446	4,115
68	14,709	5,336	1,194	530	239	110	54	10	64	145	264	281	22,937
69	388	493	497	319	163	80	20	7	37	102	193	941	3,239
70	1,211	1,421	954	802	268	156	62	8	6	1	27	189	5,104
71	666	896	730	315	151	46	7	0	54	154	307	510	3,836
72	517	346	140	85	33	5	4	50	66	240	566	809	2,859
73	18,997	8,508	3,837	961	667	347	81	91	70	139	190	186	34,074
74	92	85	204	224	197	107	80	46	52	54	31	80	1,252
75	117	117	65	31	12	0	0	0	0	0	258	516	1,116
76	333	1,420	785	283	238	0	0	0	0	95	178	855	4,188
77	50	111	60	25	6	0	0	0	102	94	34	18	499
78	666	896	730	315	151	46	7	0	54	154	307	510	3,836

TABLE 2-13
Simulated Monthly Water Releases from Castaic Lagoon to Castaic Creek
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	0	0	0	0	0	834	1,052	919	0	0	0	0	2,805
2	105	0	0	1,490	46	0	0	0	0	0	0	0	1,641
3	0	0	0	0	0	667	842	735	0	0	0	0	2,244
4	0	0	0	0	0	1,168	1,473	1,287	0	0	0	0	3,928
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	105	0	0	1,490	46	0	0	0	0	0	0	0	1,641
8	105	0	0	1,490	46	0	0	0	0	0	212	0	1,853
9	0	0	809	341	900	0	0	0	0	0	0	0	2,050
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	66	66
13	0	0	580	3,052	667	127	24	0	0	0	0	0	4,450
14	0	140	186	3,031	1,901	635	341	337	813	0	0	341	7,725
15	210	0	0	2,979	93	0	0	0	0	0	0	0	3,282
16	0	0	0	0	0	1,668	2,104	1,839	0	0	0	0	5,611
17	0	0	0	4,961	671	0	0	0	0	0	0	0	5,632
18	0	0	8,701	873	0	0	0	0	0	0	0	310	9,884
19	1,186	19,545	10,747	4,566	7,561	47	1,370	436	464	302	652	926	47,802
20	612	691	0	3,187	1,191	149	0	0	0	0	0	0	5,830
21	0	660	855	0	2,087	3,484	0	0	0	0	0	0	7,086
22	0	0	0	0	0	667	842	735	0	0	0	0	2,244
23	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	4,961	671	0	0	0	0	0	0	0	5,632
25	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	140	186	3,031	1,901	635	341	337	813	0	0	341	7,725
28	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	4,961	671	0	0	0	0	0	0	0	5,632
30	105	0	0	1,490	46	0	0	0	0	0	0	0	1,641
31	105	0	0	1,490	46	0	0	0	0	0	212	0	1,853
32	0	0	0	0	0	667	842	735	0	0	0	0	2,244
33	0	0	0	0	0	667	842	735	0	0	0	0	2,244
34	210	0	0	2,979	93	0	0	0	0	0	0	0	3,282
35	0	0	0	0	0	0	0	0	0	0	0	0	0
36	612	691	0	3,187	1,191	149	0	0	0	0	0	0	5,830
37	0	0	0	0	0	667	842	735	0	0	0	0	2,244
38	0	0	0	0	0	0	0	0	0	0	0	0	0
39	210	0	0	2,979	93	0	0	0	0	0	0	0	3,282
40	0	0	580	3,052	667	127	24	0	0	0	0	0	4,450
41	105	0	0	1,490	46	0	0	0	0	0	212	0	1,853

TABLE 2-13
Simulated Monthly Water Releases from Castaic Lagoon to Castaic Creek
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
42	0	0	0	0	0	667	842	735	0	0	0	0	2,244
43	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	140	186	3,031	1,901	635	341	337	813	0	0	341	7,725
45	0	0	0	0	0	667	842	735	0	0	0	0	2,244
46	105	0	0	1,490	46	0	0	0	0	0	0	0	1,641
47	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	667	842	735	0	0	0	0	2,244
49	105	0	0	1,490	46	0	0	0	0	0	0	0	1,641
50	210	0	0	2,979	93	0	0	0	0	0	0	0	3,282
51	105	0	0	1,490	46	0	0	0	0	0	212	0	1,853
52	0	0	0	0	0	667	842	735	0	0	0	0	2,244
53	0	0	0	0	0	1,168	1,473	1,287	0	0	0	0	3,928
54	0	0	0	0	0	667	842	735	0	0	0	0	2,244
55	0	0	0	0	0	834	1,052	919	0	0	0	0	2,805
56	105	0	0	1,490	46	0	0	0	0	0	0	0	1,641
57	0	0	0	0	0	667	842	735	0	0	0	0	2,244
58	0	0	0	0	0	1,168	1,473	1,287	0	0	0	0	3,928
59	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
61	105	0	0	1,490	46	0	0	0	0	0	0	0	1,641
62	105	0	0	1,490	46	0	0	0	0	0	212	0	1,853
63	0	0	809	341	900	0	0	0	0	0	0	0	2,050
64	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	66	66
67	0	0	580	3,052	667	127	24	0	0	0	0	0	4,450
68	0	140	186	3,031	1,901	635	341	337	813	0	0	341	7,725
69	210	0	0	2,979	93	0	0	0	0	0	0	0	3,282
70	0	0	0	0	0	1,668	2,104	1,839	0	0	0	0	5,611
71	0	0	0	4,961	671	0	0	0	0	0	0	0	5,632
72	0	0	8,701	873	0	0	0	0	0	0	0	310	9,884
73	1,186	19,545	10,747	4,566	7,561	47	1,370	436	464	302	652	926	47,802
74	612	691	0	3,187	1,191	149	0	0	0	0	0	0	5,830
75	0	660	855	0	2,087	3,484	0	0	0	0	0	0	7,086
76	0	0	0	0	0	667	842	735	0	0	0	0	2,244
77	0	0	0	0	0	0	0	0	0	0	0	0	0
78	0	0	0	4,961	671	0	0	0	0	0	0	0	5,632

TABLE 2-14
Water Demands and Indoor Water Use under Full Build-out Conditions (Excluding Newhall Ranch)
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year 2000 Actual (AF/yr)	Full Build-out Conditions (AF/yr)	Comments
Annual Urban Water Use Outside Newhall Ranch		
60,988	123,038	Year 2000 value is retail purveyor demand plus other demands in Tables III-6 and IV-1 of the *Santa Clarita Valley Water Report 2000* (Luhdorff & Scalmanini Consulting Engineers, 2001). Year 2045 value is from Table 2.5-4 of the *Newhall Ranch Draft Additional Analysis* (Impact Sciences, Inc., 2001). Consists of 89,805 AF/yr Development Monitoring System (DMS)[a] demand, plus 55,995 AF/yr additional urban demand, minus 14,480 AF/yr conservation, minus 5,193 AF/yr agricultural uses and 3,089 AF/yr "other" uses. Does not include 4,500 AF/yr for aquifer storage and recovery (ASR) or the 17,680 AF/yr demand for the Newhall Ranch Specific Plan.
Annual Indoor Water Use Outside Newhall Ranch (Equal to LACSD WRP Influent Volumes)		
18,723	40,313 (average year)	The year 2000 volume is from the Saugus and Valencia WRPs for the period January 2000 through December 2000. The long-term current generated effluent volume is based on the influent volume estimated from water balance calculations performed for the chloride mass balance analysis. The effluent volume is 32.8 percent of the total urban water production of 123,038 AF/yr, which includes other uses.

[a]DMS water demands are demands associated with future build-out of developments identified in Los Angeles County's DMS for the Santa Clarita Valley.

TABLE 2-15

Treated Water Discharges from the Saugus and Valencia WRPs to the Santa Clara River under Full Build-out Conditions

Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Month	Treated Water Volume (2000)[a]	Treated Water Volume (Full Build-out Conditions)[b]	Percent of Annual Outdoor Demand	Reclaimed Volume under Full Build-out Conditions (Before Maintaining Existing Streamflows)	Reclaimed Volume under Full Build-out Conditions (After Maintaining Existing Streamflows)	WRP Discharges to River under Full Build-out Conditions[c]	Month
January	1,503	3,237	3.75	637	637	2,600	January
February	1,443	3,106	5.10	867	867	2,239	February
March	1,528	3,290	6.60	1,122	1,122	2,168	March
April	1,505	3,240	9.10	1,547	1,547	1,693	April
May	1,569	3,379	10.55	1,794	1,794	1,585	May
June	1,543	3,322	11.40	1,938	1,781	1,541	June
July	1,606	3,459	14.10	2,397	1,854	1,605	July
August	1,649	3,550	12.95	2,202	1,902	1,648	August
September	1,593	3,430	10.20	1,734	1,734	1,696	September
October	1,631	3,512	7.50	1,275	1,275	2,237	October
November	1,546	3,329	5.00	850	850	2,479	November
December	1,607	3,459	3.75	637	637	2,822	December
Total Annual	**18,723**	**40,313**	**100.0**	**17,000**	**16,000**	**24,313**	**Total Annual**

[a]Values shown are the actual volume of treated water discharged to the Santa Clara River from the Saugus and Valencia WRPs during calendar year 2000. (See also Table 2-14.)

[b]Values shown are the combined treated water volumes estimated to be produced by the Saugus and Valencia WRPs for full build-out conditions in the Santa Clarita Valley. These values do not include the future Newhall Ranch WRP, which will be operated by LACSD.

[c]Values shown do not include discharges of treated water to the river from the future Newhall Ranch WRP. These volumes are 10 AF in November, 138 AF in December, and 138 AF in January. During the other nine months of the year, this WRP will not discharge treated water to the river (see the *Newhall Ranch Draft Additional Analysis* [Impact Sciences, Inc., 2001] for further details). The combined total discharge from the Saugus, Valencia, and Newhall Ranch WRPs is summarized in Table 2-16 of this report.

Note:
All units are in acre-feet, unless otherwise indicated.

TABLE 2-16
Simulated Monthly Treated Wastewater Discharges from Santa Clarita Valley WRPs under Full Build-out Conditions
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

WRP	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Saugus	493	487	500	490	503	466	457	508	586	555	514	596	6,155
Valencia	2,107	1,752	1,668	1,203	1,082	1,075	1,148	1,140	1,110	1,682	1,965	2,226	18,158
Newhall	138	0	0	0	0	0	0	0	0	0	10	138	286
Total	**2,738**	**2,239**	**2,168**	**1,693**	**1,585**	**1,541**	**1,605**	**1,648**	**1,696**	**2,237**	**2,489**	**2,960**	**24,599**

Note:

Wastewater discharge volumes are listed in acre-feet.

TABLE 2-17
Simulated Annual Groundwater Budget
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year			Precipitation Infiltration	Infiltration of Applied Water	Streambed Infiltration	Subsurface Inflow	Total Recharge	Pumping	Groundwater Discharge to Streams	ET	Subsurface Outflow at County Line	Total Discharge	Change in Groundwater Storage	Cumulative Change in Groundwater Storage
0	to	1	41,053	13,970	39,953	17,871	112,847	49,119	21,649	17,524	18,464	106,756	6,091	6,091
1	to	2	11,601	13,970	3,373	18,632	47,576	49,035	10,147	10,469	18,136	87,788	-40,212	-34,120
2	to	3	51,672	13,970	28,415	18,444	112,501	49,035	10,925	12,319	18,585	90,863	21,638	-12,483
3	to	4	181,820	13,970	89,448	16,985	302,223	49,035	36,265	29,506	19,056	133,861	168,361	155,879
4	to	5	687	13,970	527	18,253	33,437	49,119	16,665	23,150	18,225	107,158	-73,721	82,158
5	to	6	2	13,970	535	18,927	33,434	44,372	9,497	13,286	18,171	85,326	-51,891	30,266
6	to	7	42,574	13,970	19,998	18,619	95,161	49,035	11,479	14,376	18,568	93,458	1,703	31,969
7	to	8	11,415	13,970	2,484	19,419	47,288	49,035	7,923	10,419	18,277	85,654	-38,366	-6,397
8	to	9	27,363	13,970	10,507	19,743	71,583	54,214	6,664	10,234	18,507	89,618	-18,036	-24,433
9	to	10	0	13,970	523	20,113	34,606	44,372	4,739	8,041	18,359	75,510	-40,904	-65,336
10	to	11	0	13,970	1,472	20,347	35,789	49,446	2,584	5,612	18,354	75,996	-40,208	-105,544
11	to	12	50,580	13,970	28,173	19,613	112,336	58,025	3,061	8,476	18,563	88,125	24,211	-81,334
12	to	13	130,074	13,970	80,760	17,850	242,654	72,600	14,234	18,462	18,728	124,024	118,630	37,296
13	to	14	112,433	13,970	51,561	17,509	195,472	49,035	24,221	29,084	18,797	121,137	74,335	111,632
14	to	15	414	13,970	1,979	18,575	34,939	49,446	7,788	16,616	18,157	92,007	-57,068	54,563
15	to	16	113,543	13,970	60,100	17,636	205,250	49,035	29,255	26,983	18,745	124,018	81,232	135,795
16	to	17	45,609	13,970	21,594	18,204	99,376	49,119	15,122	21,342	18,635	104,218	-4,842	130,954
17	to	18	16,967	13,970	5,320	18,758	55,015	49,035	11,851	16,757	18,242	95,885	-40,870	90,084
18	to	19	137,727	13,970	59,717	17,397	228,810	49,035	27,143	31,249	18,923	126,350	102,460	192,544
19	to	20	13	13,970	4,717	18,586	37,286	49,035	14,305	20,865	18,200	102,405	-65,119	127,425
20	to	21	14,095	13,970	4,962	19,294	52,321	49,119	11,194	14,485	18,342	93,139	-40,818	86,607
21	to	22	58,364	13,970	35,154	18,639	126,127	54,116	12,710	19,337	18,655	104,818	21,309	107,917
22	to	23	0	13,970	523	19,557	34,050	44,372	8,105	13,129	18,311	83,916	-49,866	58,051
23	to	24	19,602	13,970	5,065	19,867	58,504	49,035	8,138	10,710	18,375	86,258	-27,754	30,297
24	to	25	0	13,970	524	20,258	34,752	44,441	5,486	7,896	18,418	76,240	-41,489	-11,192
25	to	26	3,053	13,970	518	20,406	37,947	49,035	4,033	6,132	18,386	77,587	-39,639	-50,832
26	to	27	135,033	13,970	73,747	18,014	240,763	49,035	16,024	17,254	18,639	100,951	139,812	88,980
27	to	28	0	13,970	536	18,764	33,270	44,372	9,238	15,229	18,125	86,963	-53,693	35,287
28	to	29	20,048	13,970	4,960	19,518	58,496	49,119	7,646	10,808	18,326	85,898	-27,402	7,885
29	to	30	9,397	13,970	2,999	19,929	46,296	54,116	4,726	8,252	18,339	85,433	-39,138	-31,253
30	to	31	11,022	13,970	2,348	20,308	47,647	49,035	4,024	7,140	18,409	78,609	-30,962	-62,215
31	to	32	62,138	13,970	37,429	19,568	133,105	49,035	6,854	11,497	18,820	86,205	46,900	-15,315
32	to	33	63,939	13,970	36,375	18,890	133,174	49,119	11,471	19,025	18,678	98,293	34,881	19,566
33	to	34	244	13,970	2,395	20,199	36,808	44,372	6,943	11,585	18,375	81,275	-44,466	-24,900
34	to	35	1,555	13,970	524	20,530	36,579	49,446	3,767	7,507	18,404	79,124	-42,545	-67,445
35	to	36	32	13,970	4,852	20,690	39,543	58,025	303	5,882	18,401	82,610	-43,067	-110,512
36	to	37	52,098	13,970	24,510	19,931	110,509	44,441	4,564	10,236	18,620	77,860	32,648	-77,864
37	to	38	4,170	13,970	616	20,483	39,239	49,035	2,503	6,237	18,378	76,152	-36,913	-114,777
38	to	39	362	13,970	2,463	20,816	37,610	49,446	719	4,966	18,418	73,549	-35,938	-150,716
39	to	40	122,459	13,970	74,037	19,276	229,741	49,035	8,546	10,468	18,766	86,814	142,927	-7,789
40	to	41	12,997	13,970	4,096	19,066	50,129	49,119	8,998	13,953	18,220	90,290	-40,161	-47,950
41	to	42	64,499	13,970	40,945	18,797	138,210	49,035	10,243	16,890	18,577	94,745	43,465	-4,484
42	to	43	0	13,970	536	19,752	34,258	44,372	6,577	12,461	18,301	81,711	-47,454	-51,938
43	to	44	123,377	13,970	53,751	18,022	209,121	49,035	17,543	21,442	18,640	106,660	102,461	50,523
44	to	45	64,250	13,970	39,379	18,423	136,022	49,119	13,271	20,449	18,544	101,383	34,639	85,163
45	to	46	8,541	13,970	2,217	19,103	43,830	49,035	10,232	18,196	18,249	95,712	-51,882	33,281
46	to	47	0	13,970	533	19,897	34,399	44,372	6,746	10,372	18,334	79,823	-45,424	-12,143

TABLE 2-17
Simulated Annual Groundwater Budget
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Year	Precipitation Infiltration	Infiltration of Applied Water	Streambed Infiltration	Subsurface Inflow	Total Recharge	Pumping	Groundwater Discharge to Streams	ET	Subsurface Outflow at County Line	Total Discharge	Change in Groundwater Storage	Cumulative Change in Groundwater Storage
47 to 48	43,414	13,970	18,560	19,505	95,448	49,035	8,927	12,755	18,638	89,355	6,094	-6,050
48 to 49	32,966	13,970	13,527	19,953	80,416	49,119	8,497	12,634	18,666	88,916	-8,499	-14,549
49 to 50	839	13,970	1,856	20,451	37,117	44,372	5,528	8,992	18,434	77,326	-40,209	-54,758
50 to 51	9,990	13,970	2,645	20,684	47,289	54,116	3,517	6,845	18,455	82,933	-35,643	-90,401
51 to 52	49,961	13,970	25,027	20,153	109,112	62,702	3,319	9,913	18,755	94,689	14,423	-75,978
52 to 53	188,493	13,970	69,633	17,584	289,679	49,119	22,292	27,398	18,933	117,742	171,937	95,959
53 to 54	46,125	13,970	20,155	18,290	98,539	49,035	15,148	24,661	18,522	107,366	-8,827	87,132
54 to 55	89,718	13,970	39,953	17,979	161,620	49,035	20,589	29,655	18,624	117,903	43,716	130,848
55 to 56	11,601	13,970	3,373	19,267	48,211	49,035	11,347	18,242	18,316	96,940	-48,729	82,119
56 to 57	51,672	13,970	28,415	19,203	113,260	49,119	11,982	18,862	18,806	98,769	14,491	96,610
57 to 58	181,820	13,970	89,448	17,106	302,343	49,035	32,399	38,747	19,048	139,229	163,114	259,725
58 to 59	687	13,970	527	18,350	33,534	49,035	16,623	29,046	18,213	112,917	-79,383	180,342
59 to 60	2	13,970	535	19,266	33,773	44,372	10,576	17,223	18,266	90,437	-56,664	123,678
60 to 61	42,574	13,970	19,998	18,987	95,529	49,119	12,553	18,152	18,704	98,527	-2,998	120,680
61 to 62	11,415	13,970	2,484	19,754	47,622	49,035	9,005	13,268	18,366	89,674	-42,052	78,628
62 to 63	27,363	13,970	10,507	20,014	71,853	54,116	7,752	12,812	18,539	93,219	-21,366	57,262
63 to 64	0	13,970	523	20,416	34,909	44,372	5,755	10,119	18,437	78,683	-43,774	13,488
64 to 65	0	13,970	1,472	20,680	36,121	49,522	3,569	7,254	18,475	78,820	-42,698	-29,210
65 to 66	50,580	13,970	28,173	19,854	112,576	58,025	4,004	10,335	18,623	90,989	21,588	-7,622
66 to 67	130,074	13,970	80,760	17,898	242,702	72,452	13,502	21,223	18,686	125,863	116,839	109,216
67 to 68	112,433	13,970	51,561	17,536	195,499	49,035	23,462	32,532	18,803	123,833	71,667	180,883
68 to 69	414	13,970	1,979	18,661	35,024	49,522	8,596	18,842	18,226	95,186	-60,162	120,721
69 to 70	113,543	13,970	60,100	17,647	205,261	49,035	29,552	30,176	18,761	127,523	77,737	198,459
70 to 71	45,609	13,970	21,594	18,166	99,339	49,035	15,740	23,534	18,602	106,911	-7,572	190,886
71 to 72	16,967	13,970	5,320	18,777	55,034	49,035	12,551	18,552	18,264	98,402	-43,368	147,518
72 to 73	137,727	13,970	59,717	17,442	228,856	49,119	28,296	34,847	19,001	131,263	97,592	245,111
73 to 74	13	13,970	4,717	18,592	37,292	49,035	14,986	23,059	18,220	105,299	-68,007	177,103
74 to 75	14,095	13,970	4,962	19,254	52,281	49,035	11,783	15,930	18,311	95,059	-42,779	134,324
75 to 76	58,364	13,970	35,154	18,654	126,142	54,116	13,385	20,958	18,673	107,132	19,010	153,334
76 to 77	0	13,970	523	19,646	34,139	44,441	8,624	14,082	18,380	85,527	-51,388	101,946
77 to 78	19,602	13,970	5,065	19,899	58,536	49,035	8,607	11,515	18,393	87,550	-29,014	72,932
Minimum	0	13,970	518	16,985	33,270	44,372	303	4,966	18,125	73,549	-79,383	-150,716
Maximum	188,493	13,970	89,448	20,816	302,343	72,600	36,265	38,747	19,056	139,229	171,937	259,725
Average	42,498	13,970	21,480	19,092	97,040	49,823	11,520	16,262	18,498	96,105	935	44,866
Median	19,602	13,970	5,193	19,153	58,500	49,035	9,822	14,430	18,446	92,573	-28,384	36,292

Note:
All flow volumes are listed in AF/yr.

Figures

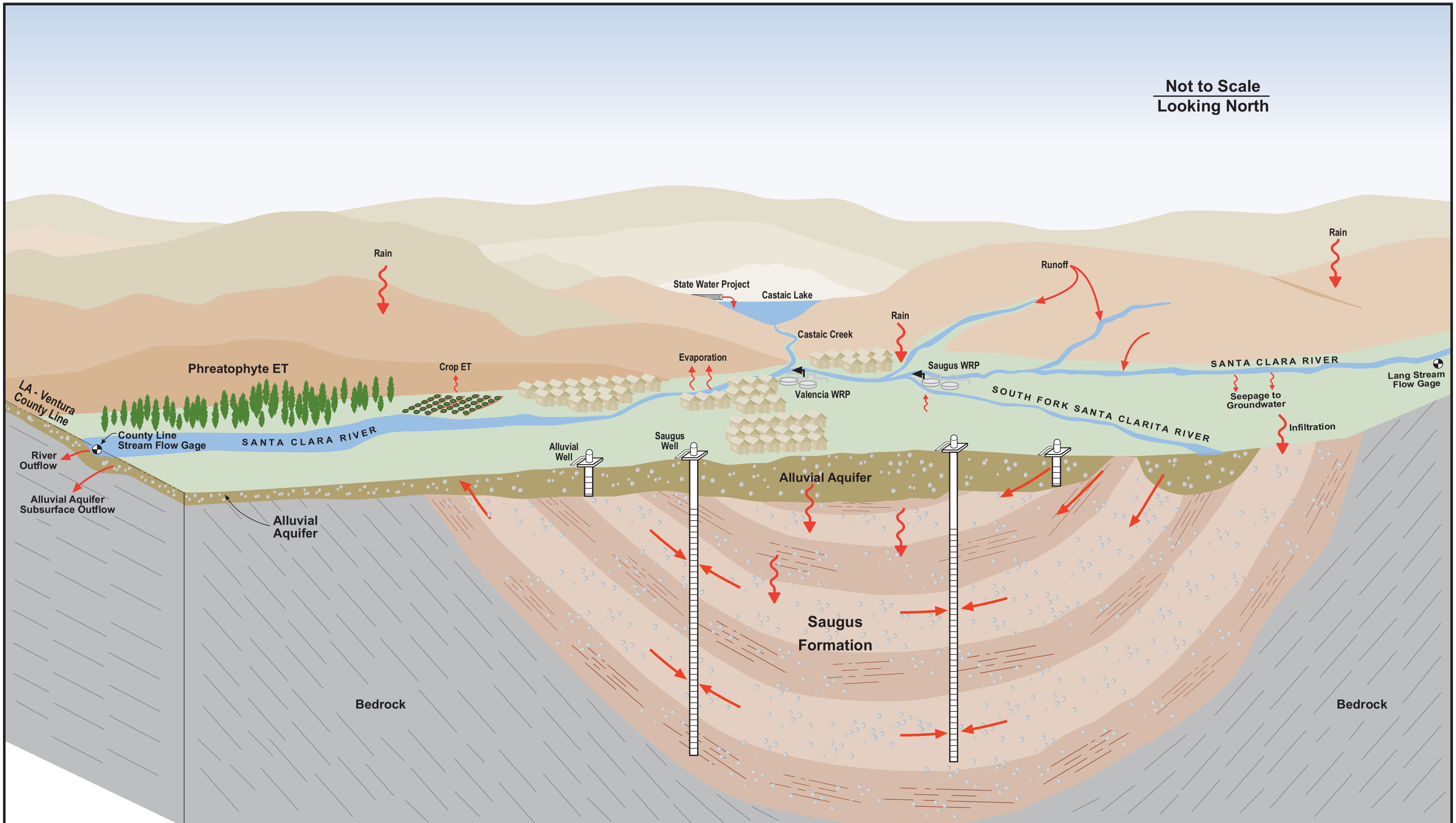

FIGURE 2-1
SANTA CLARITA VALLEY HYDROLOGY
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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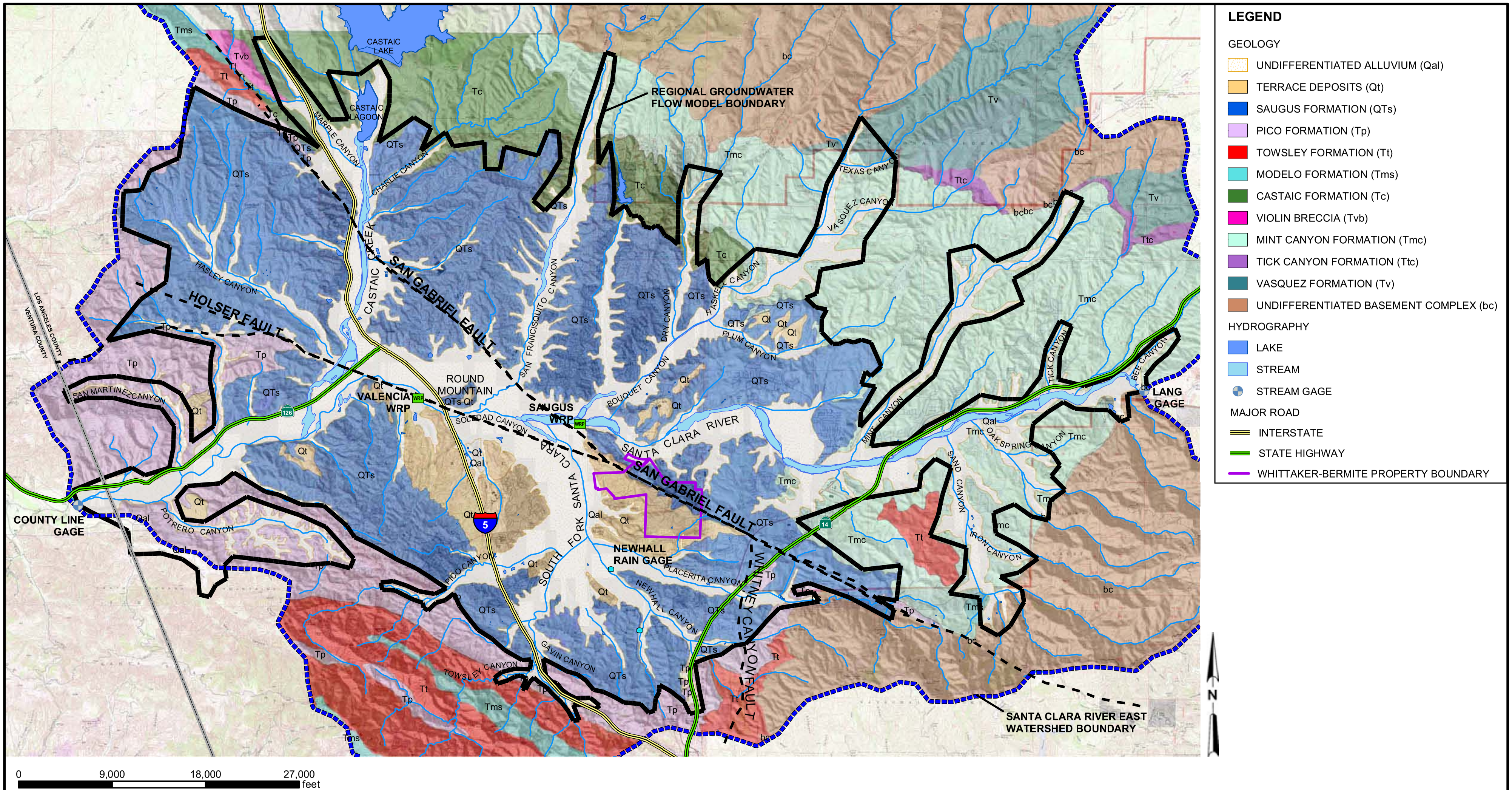

FIGURE 2-2
BASIN GEOLOGIC MAP
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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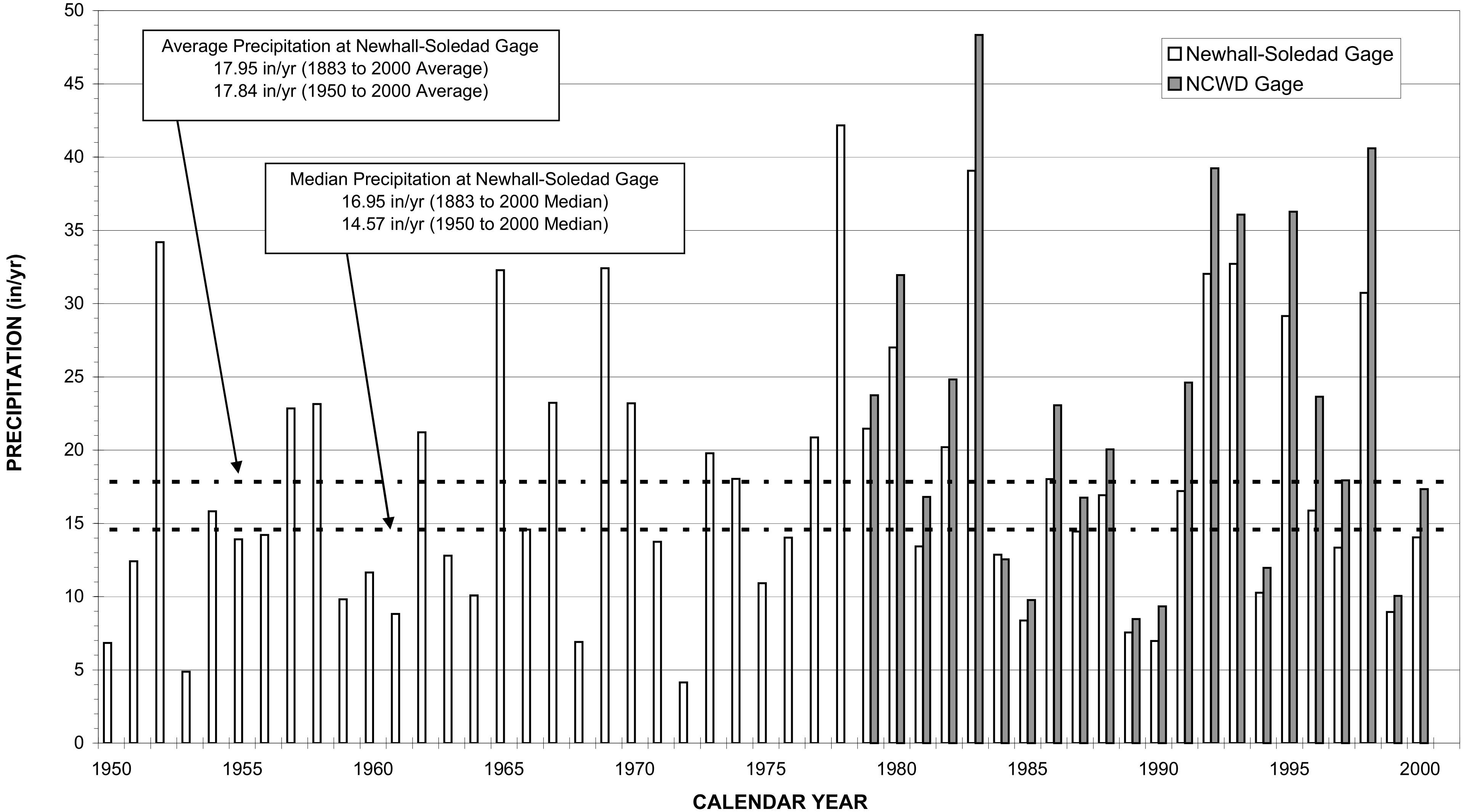
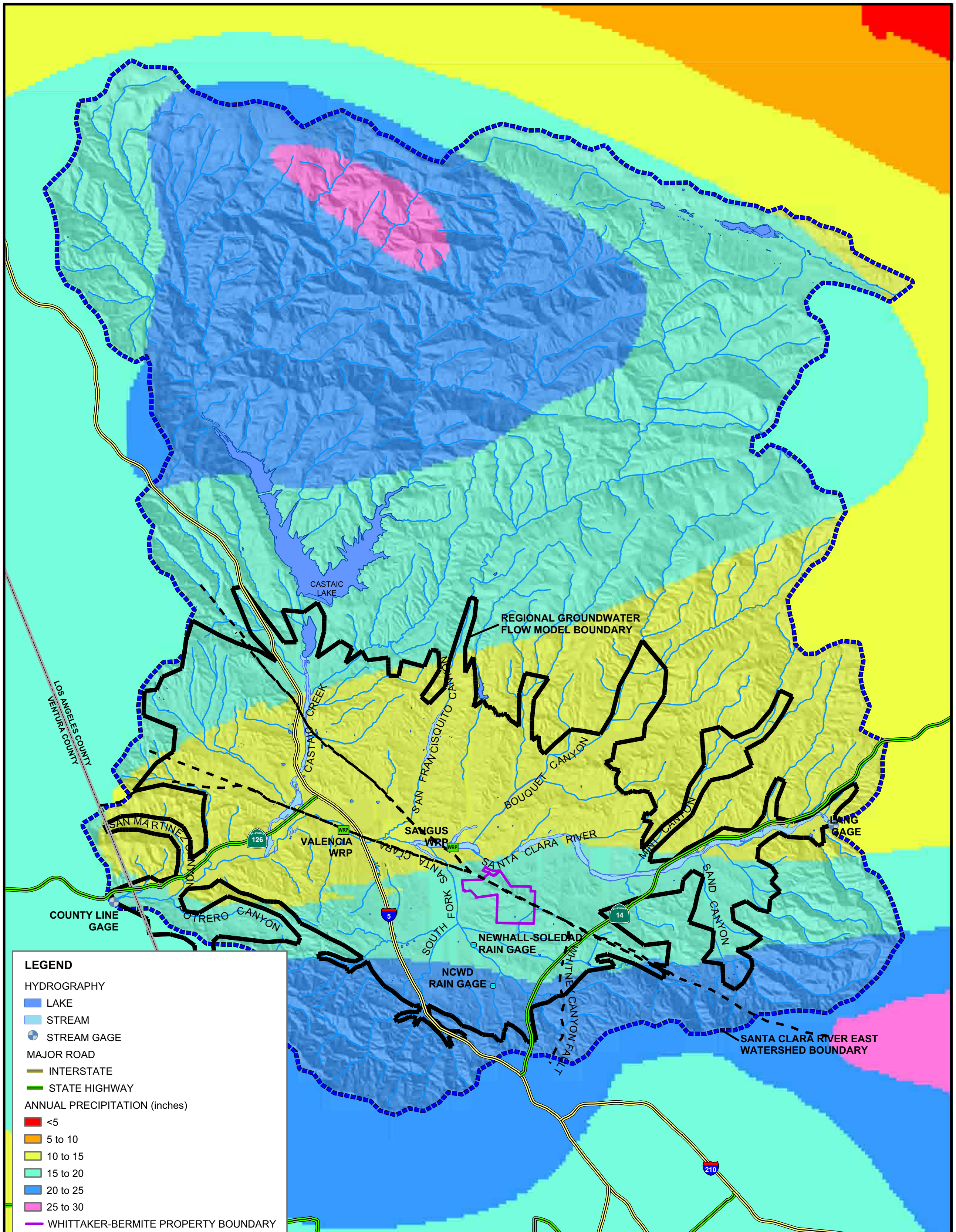


FIGURE 2-3
ANNUAL PRECIPITATION AT THE NEWHALL-SOLEDAD AND NCWD RAIN GAGES SINCE 1950
ANALYSIS OF PERCHLORATE CONTAINMENT IN
GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL

178973-P2-3.xls\Fig 2-3



SOURCE: SEE THE INTERNET SITE HTTP://GIS.CA.GOV/META.EPL?OID=286 FOR MORE INFORMATION.

N

0 2.5 5 miles

FIGURE 2-4
ISOHYETAL MAP SHOWING AVERAGE ANNUAL PRECIPITATION PATTERN FROM 1900 TO 1960
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL

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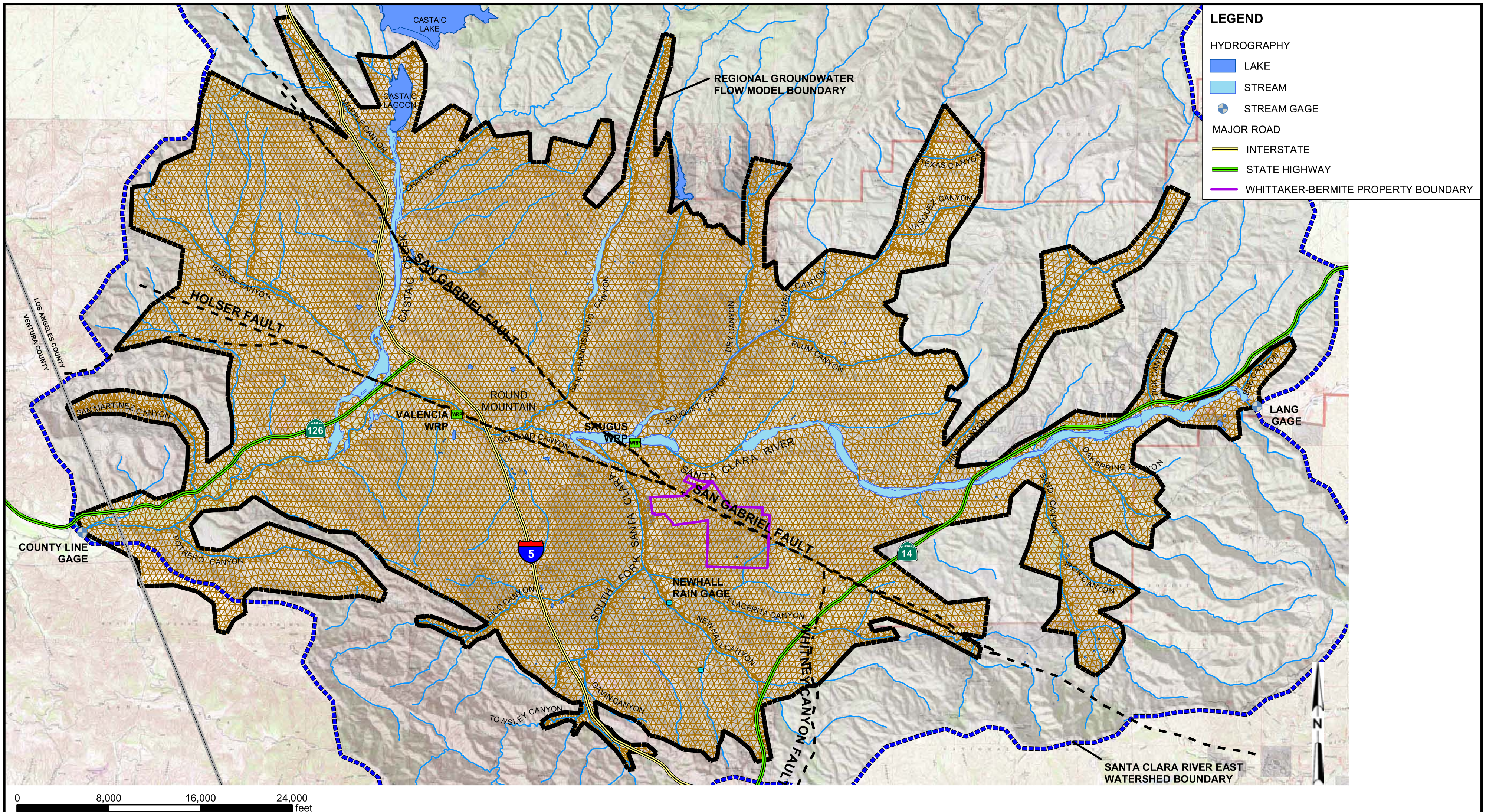

FIGURE 2-5
REGIONAL MODEL GRID
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL

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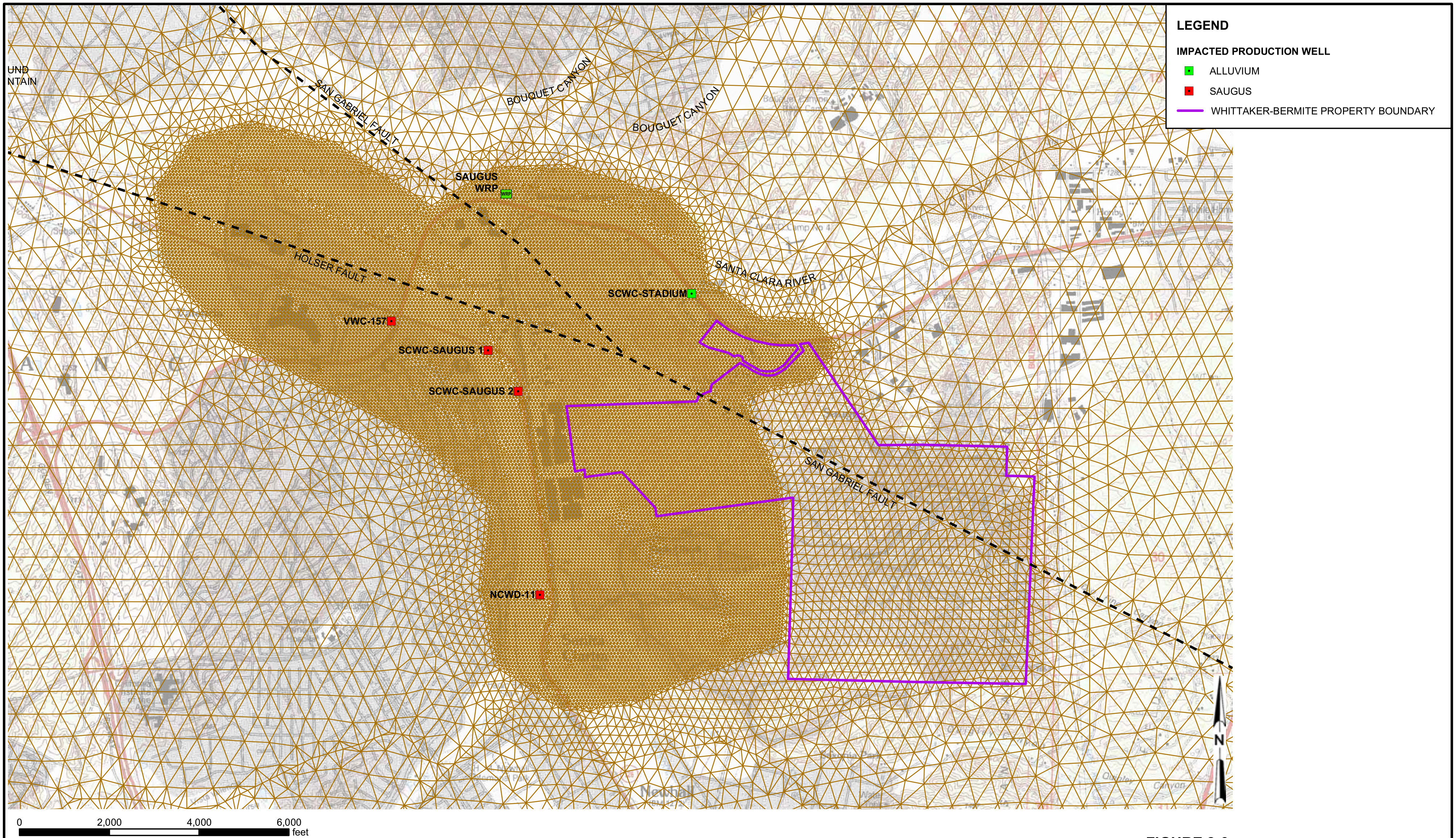

FIGURE 2-6
LOCAL MODEL GRID
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL

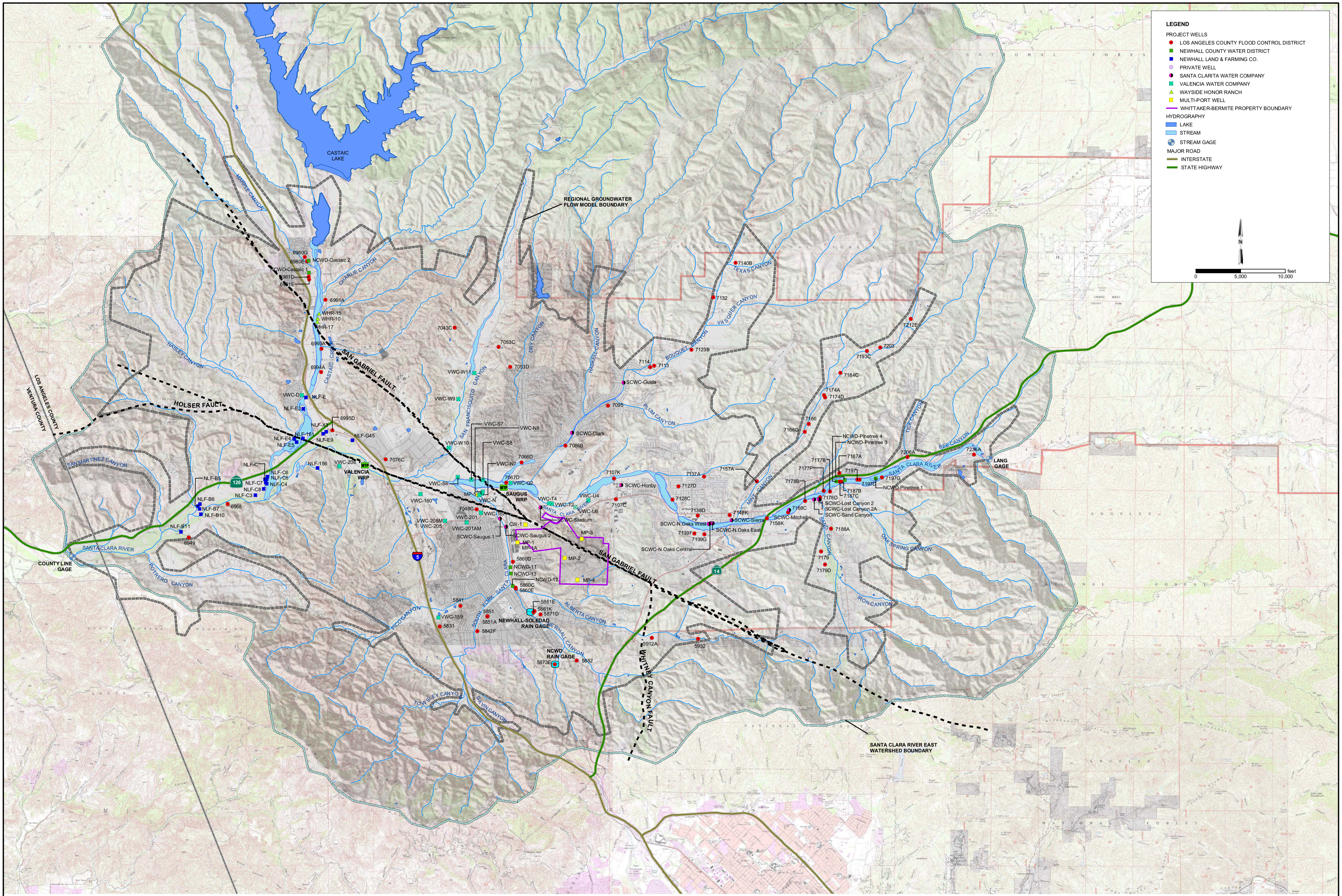

FIGURE 2-7
REGIONAL WELL LOCATION MAP
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL

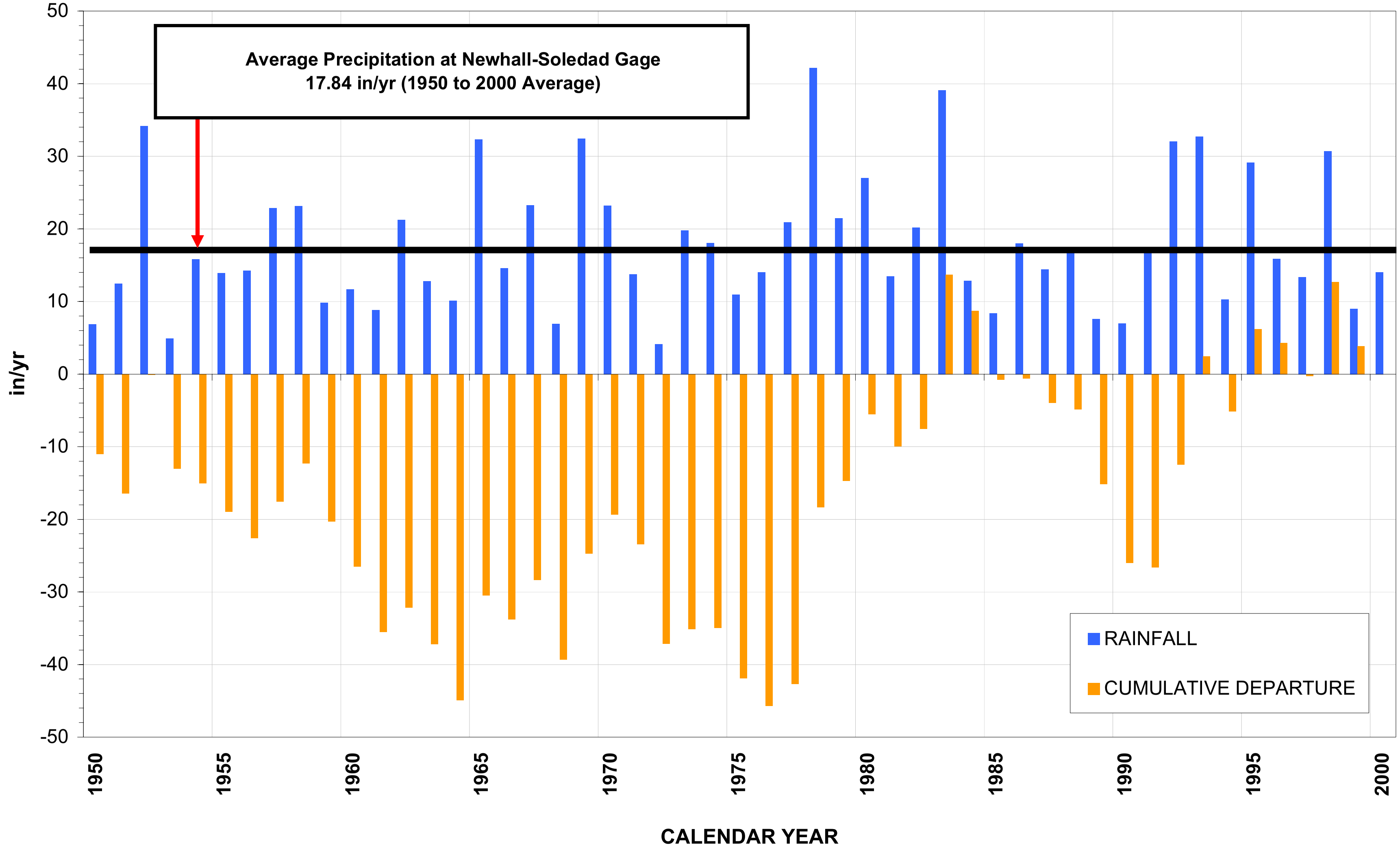

FIGURE 2-8
ANNUAL PRECIPITATION AND CUMULATIVE DEPARTURE FROM THE 1950 THROUGH 2000 AVERAGE AT THE NEWHALL-SOLEDAD RAIN GAGE
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

178973-P2-8_9.xls/FIG2-8

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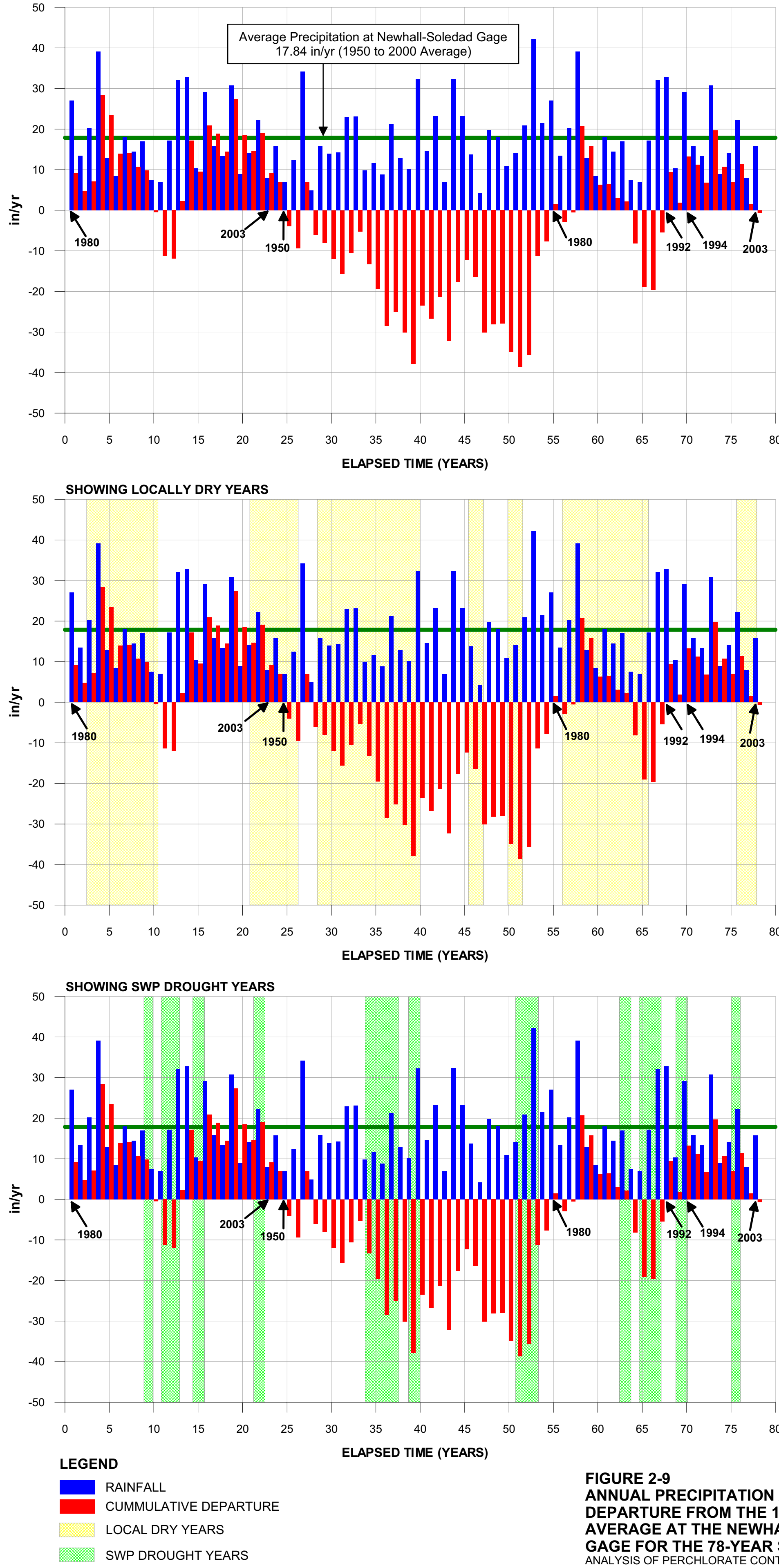

FIGURE 2-9
ANNUAL PRECIPITATION AND CUMULATIVE DEPARTURE FROM THE 1950 THROUGH 2000 AVERAGE AT THE NEWHALL-SOLEDAD RAIN GAGE FOR THE 78-YEAR SIMULATION PERIOD
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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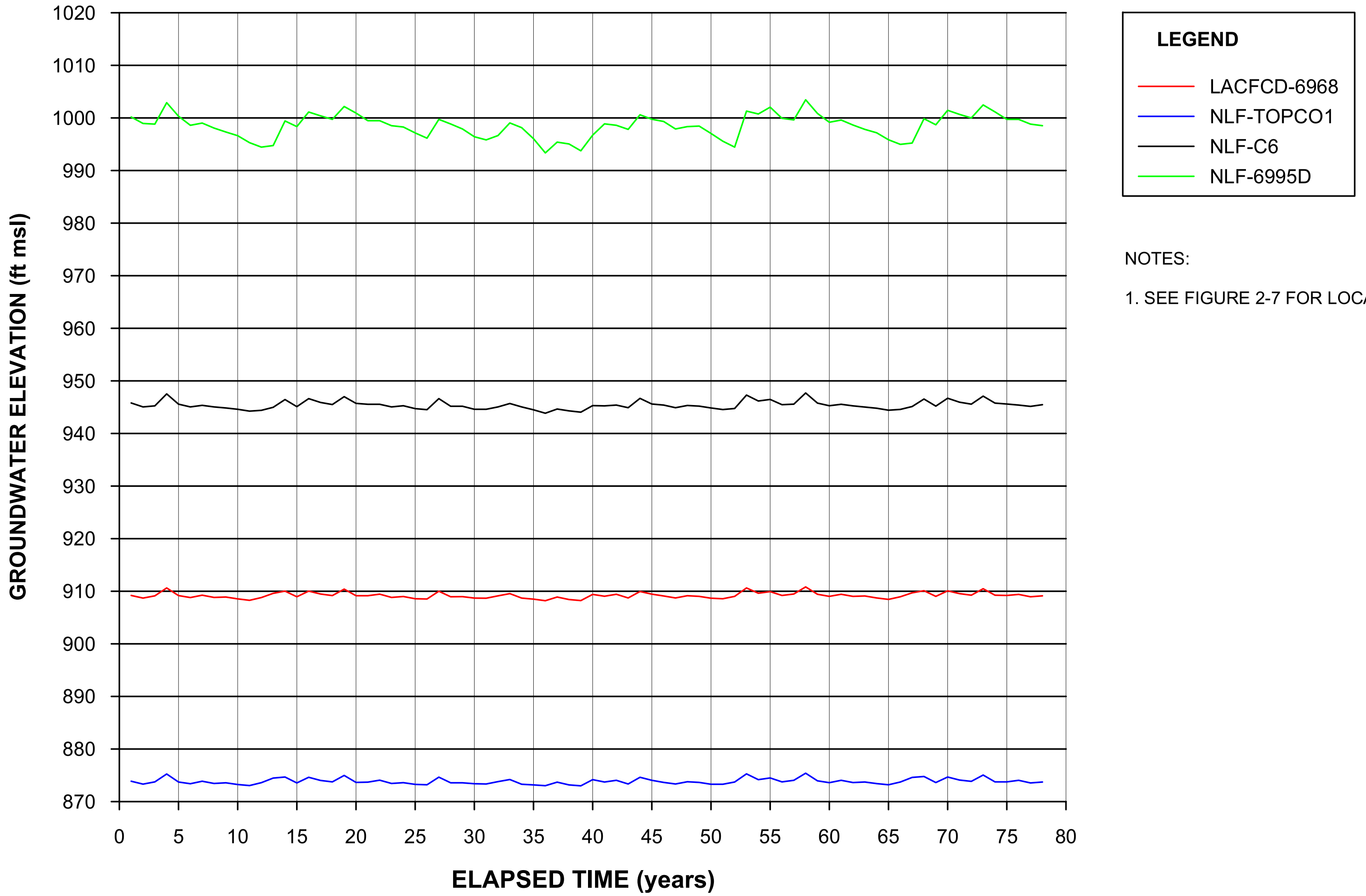

NOTES:

1. SEE FIGURE 2-7 FOR LOCATIONS OF WELLS.

FIGURE 2-10
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER WEST OF INTERSTATE 5
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

178973-346.GRF

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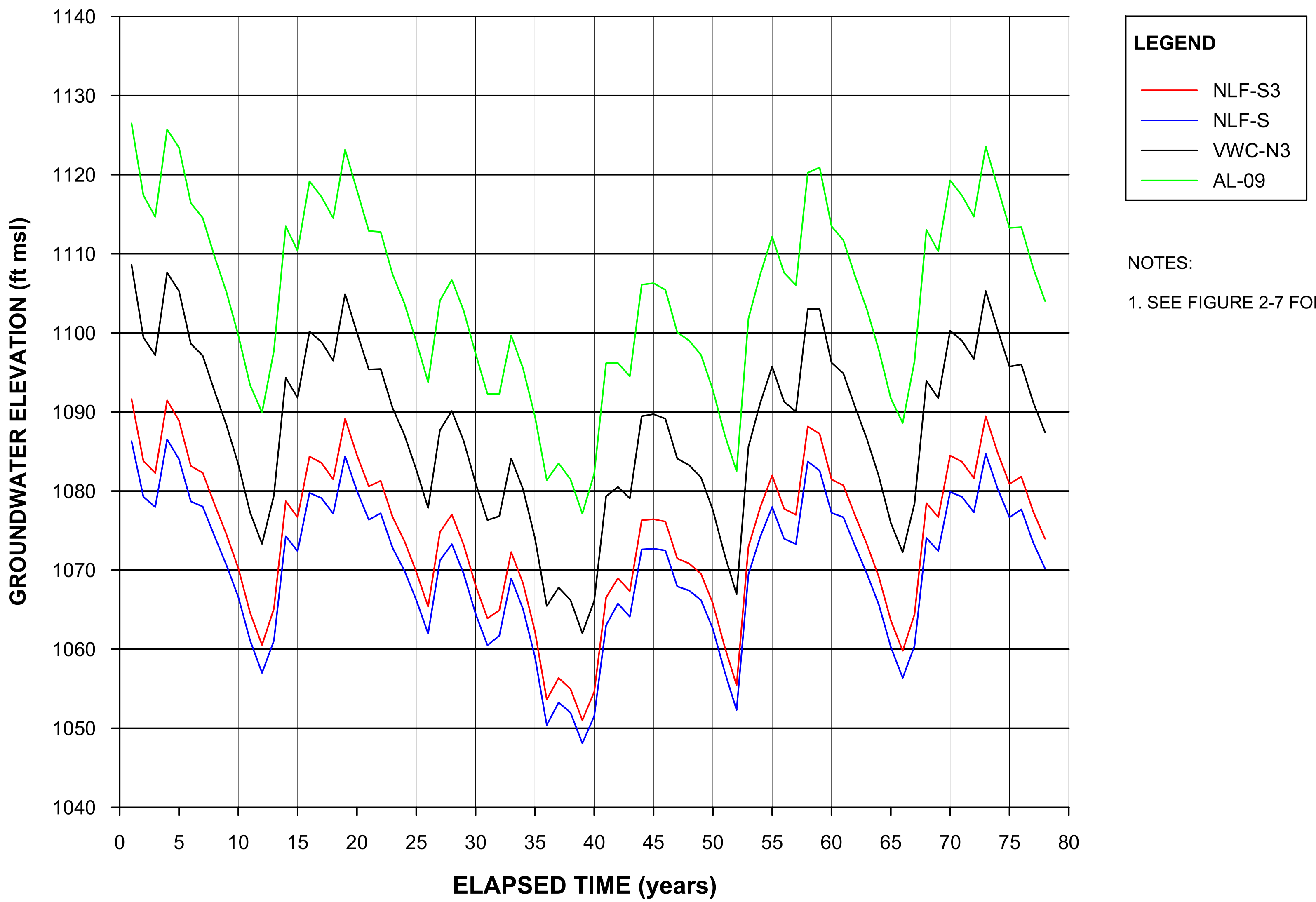

NOTES:

1. SEE FIGURE 2-7 FOR LOCATIONS OF WELLS.

FIGURE 2-11
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER EAST OF INTERSTATE 5

ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

178973-347.GRF

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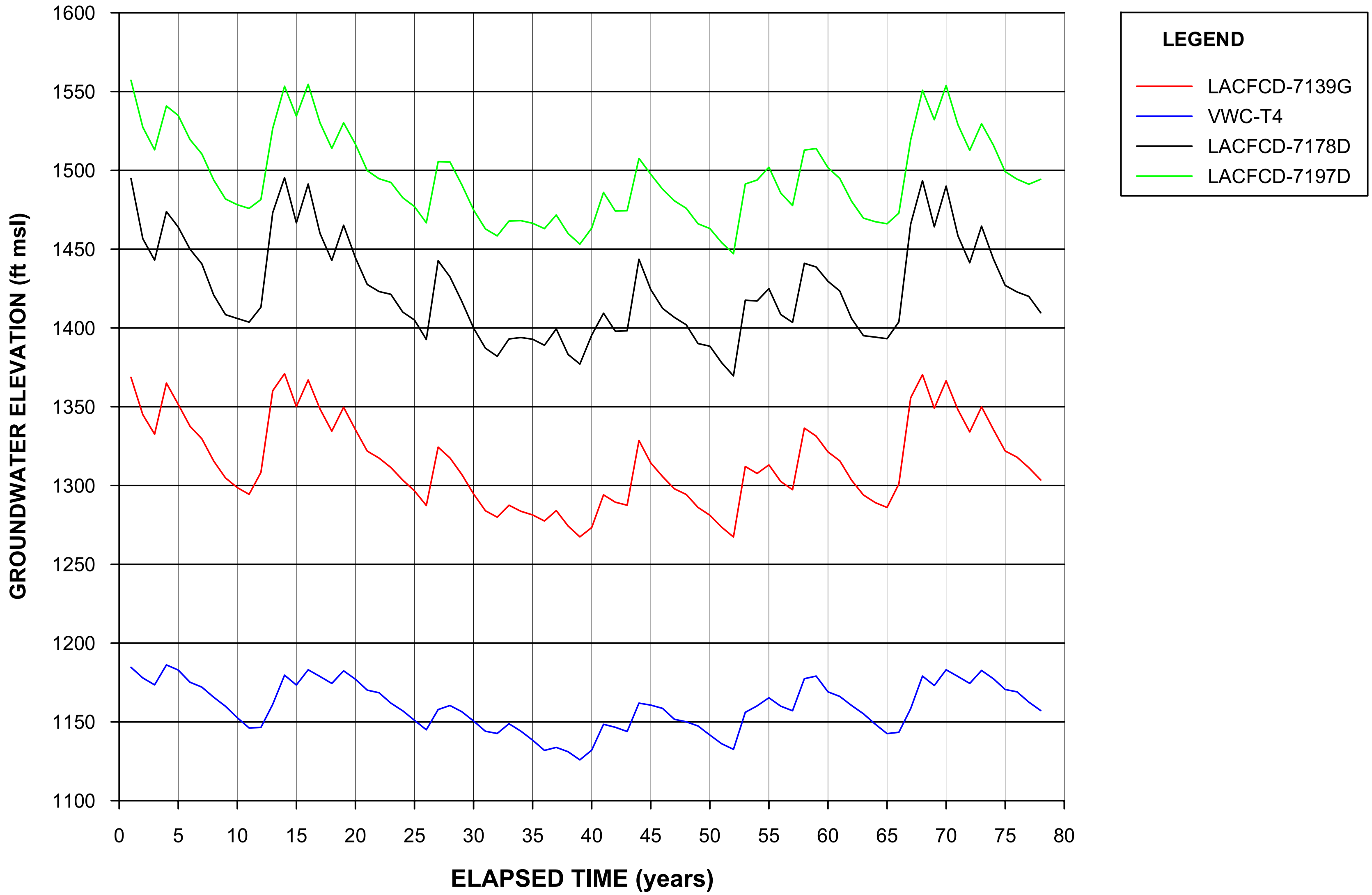

NOTES:

1. SEE FIGURE 2-7 FOR LOCATIONS OF WELLS.
2. LOWEST HISTORICAL GROUNDWATER ELEVATIONFOR VWC- T4 = 1101 ft msl
   ALLUVIUM BOTTOM ELEVATION ~1050 TO 1065 ft msl.
3. LOWEST HISTORICAL GROUNDWATER ELEVATION FOR LACFCD-7139G = 1289 ft msl
   ALLUVIUM BOTTOM ELEVATION ~1256 ft msl OR LOWER.
4. LOWEST HISTORICAL GROUNDWATER ELEVATION FOR LACFCD-7178D = 1463 ft msl
   ALLUVIUM BOTTOM ELEVATION ~1398 TO 1425 ft msl.
5. LOWEST HISTORICAL GROUNDWATER ELEVATION FOR LACFCD-7197D = 1474 ft msl
   ALLUVIUM BOTTOM ELEVATION ~1423 TO 1447 ft msl.

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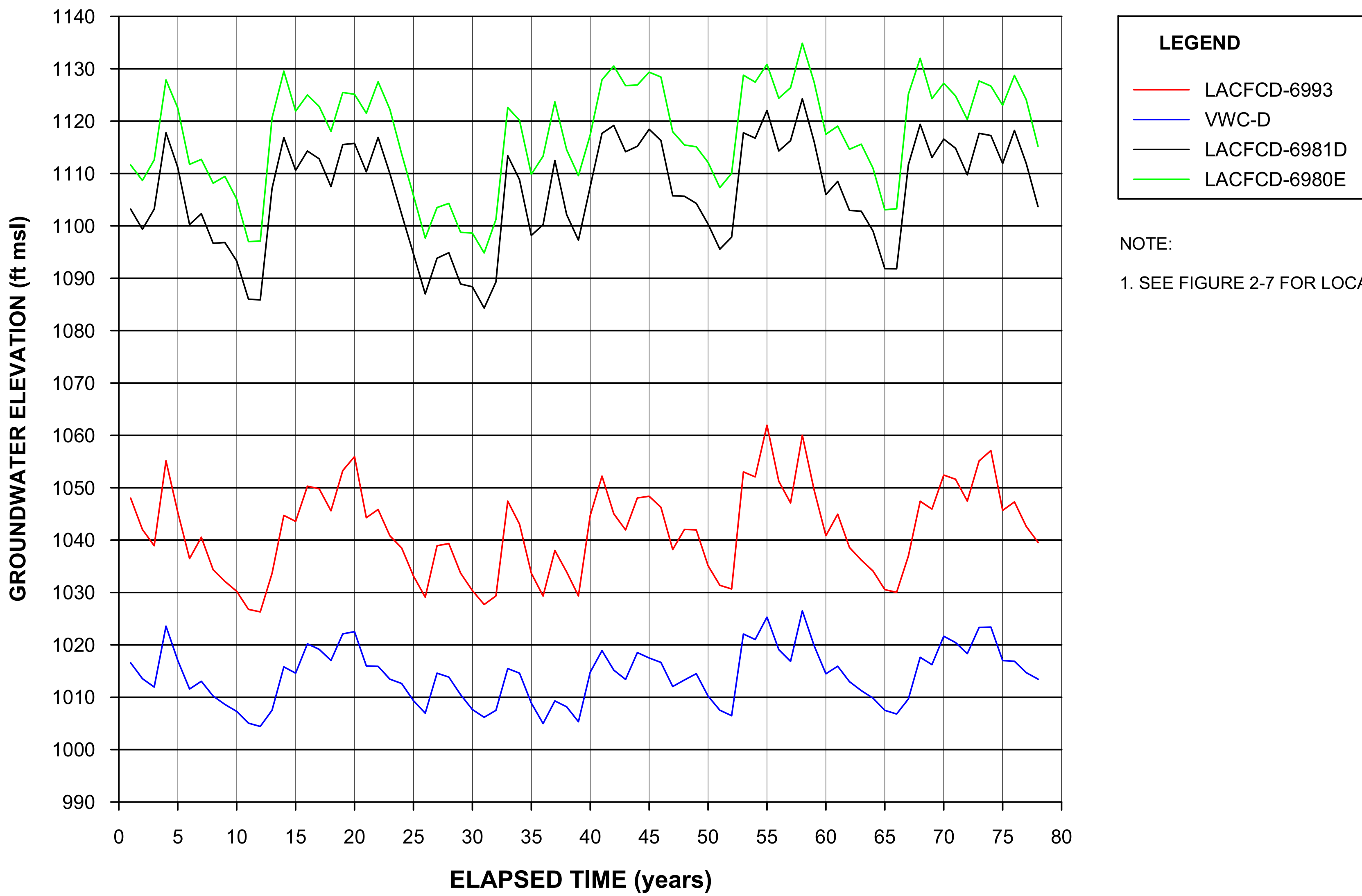
FIGURE 2-12
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER IN SOLEDAD CANYON
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL



NOTE:

1. SEE FIGURE 2-7 FOR LOCATIONS OF WELLS.

FIGURE 2-13
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER ALONG CASTAIC CREEK
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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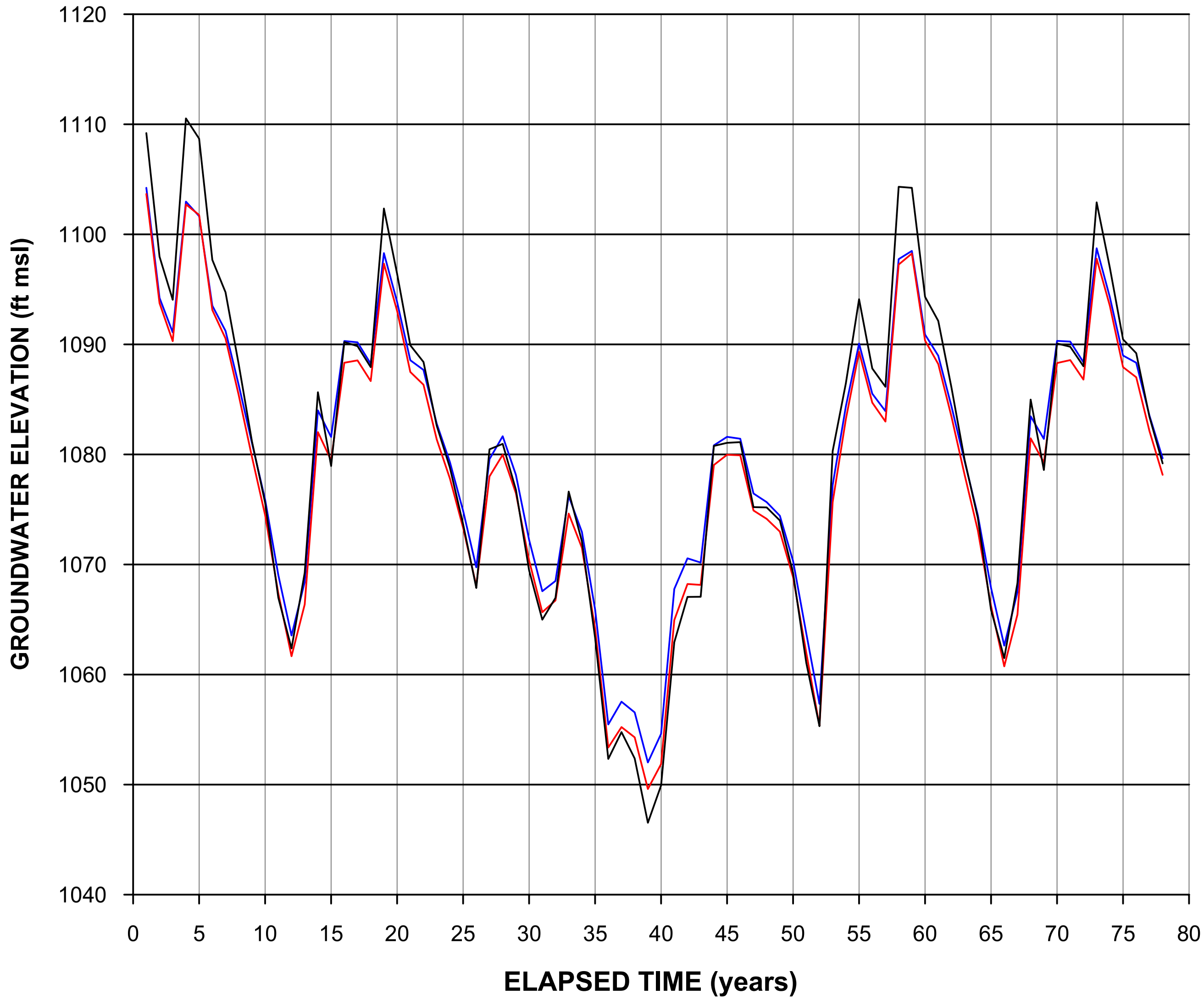

NOTE:

1. SEE FIGURE 2-7 FOR LOCATIONS OF WELLS.

FIGURE 2-14
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER AT IMPACTED SAUGUS WELLS
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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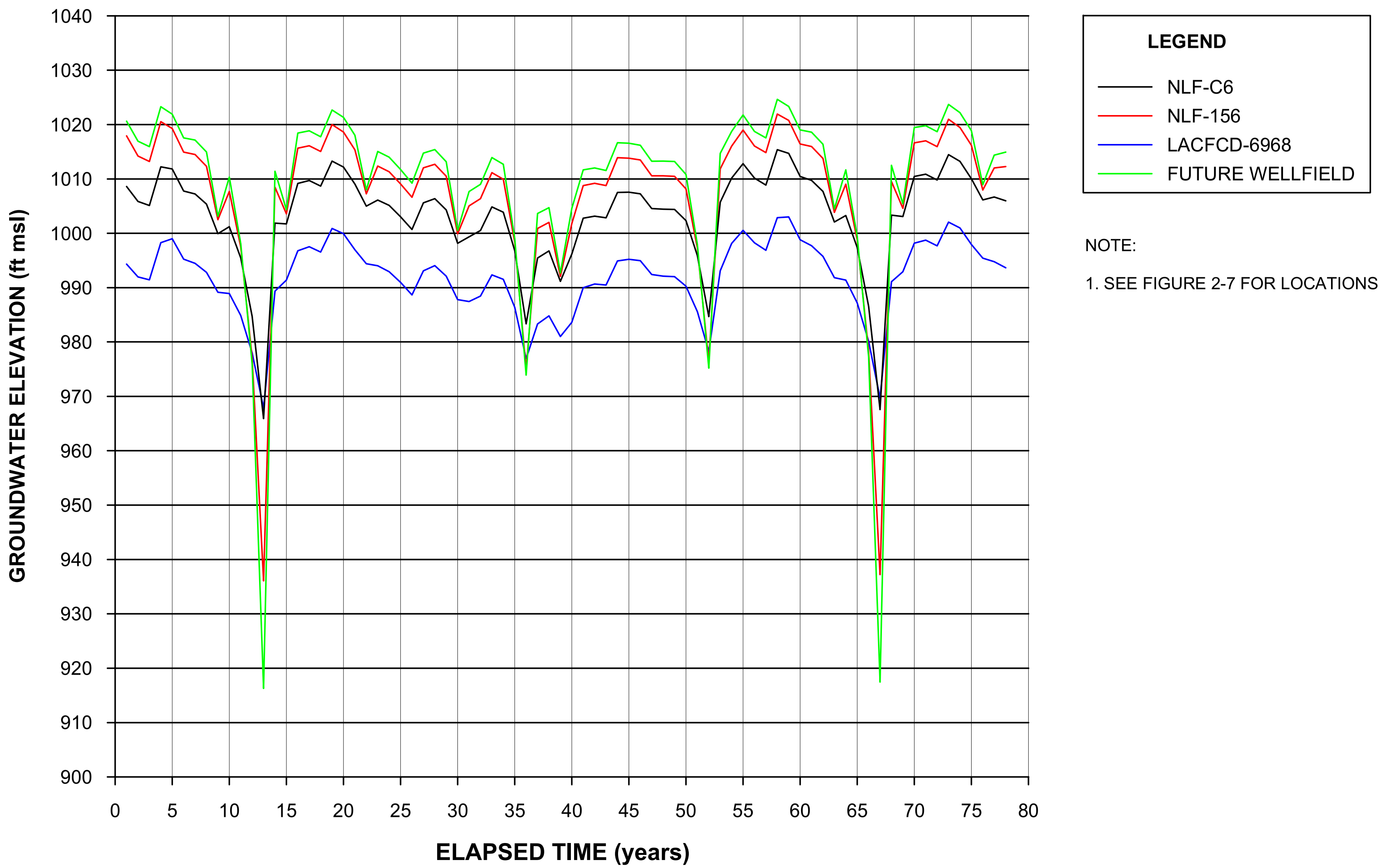

NOTE:

1. SEE FIGURE 2-7 FOR LOCATIONS OF WELLS.

FIGURE 2-15
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE SAUGUS FORMATION WEST OF INTERSTATE 5
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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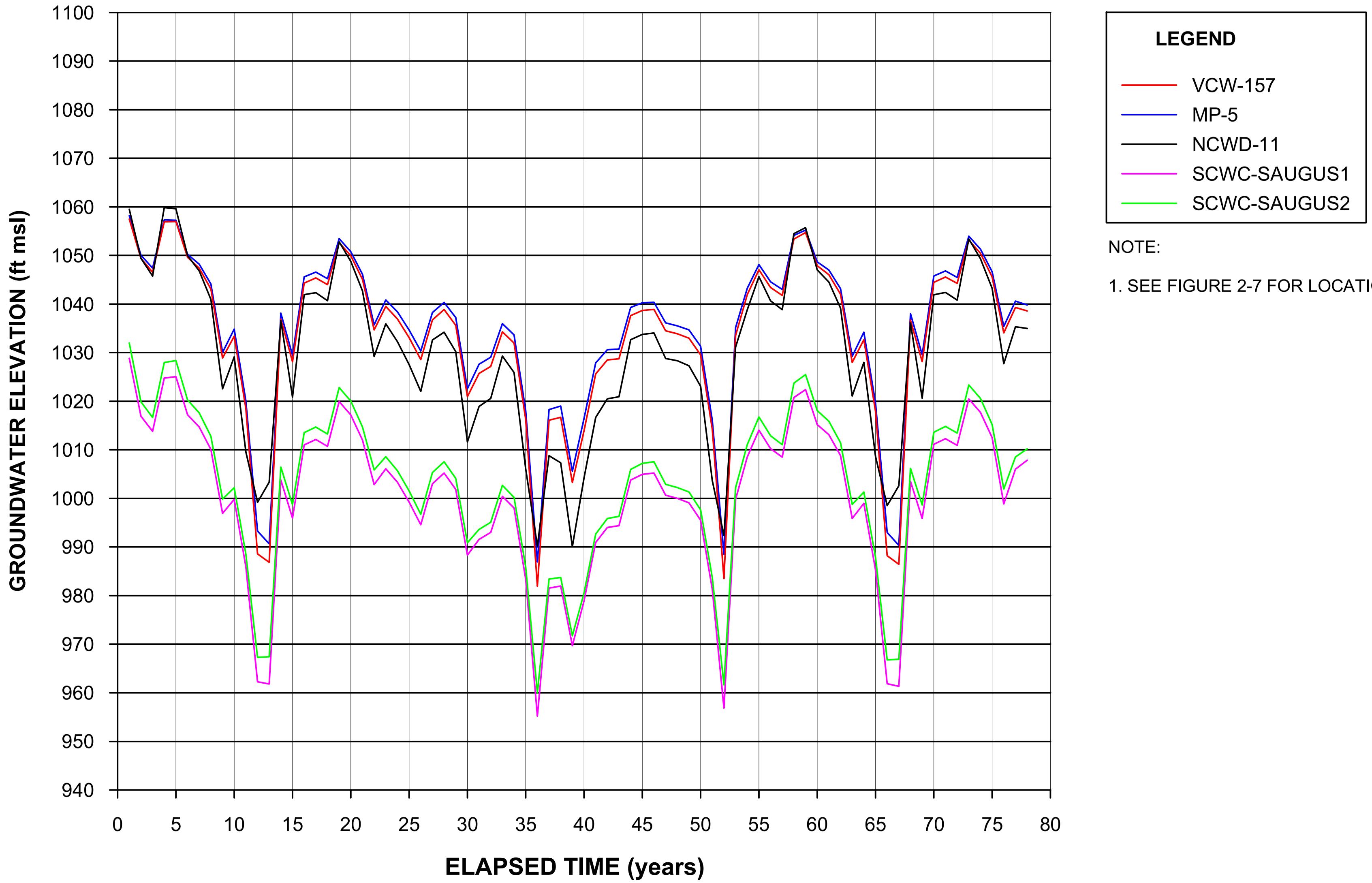

NOTE:

1. SEE FIGURE 2-7 FOR LOCATIONS OF WELLS.

FIGURE 2-16
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE SAUGUS FORMATION EAST OF INTERSTATE 5
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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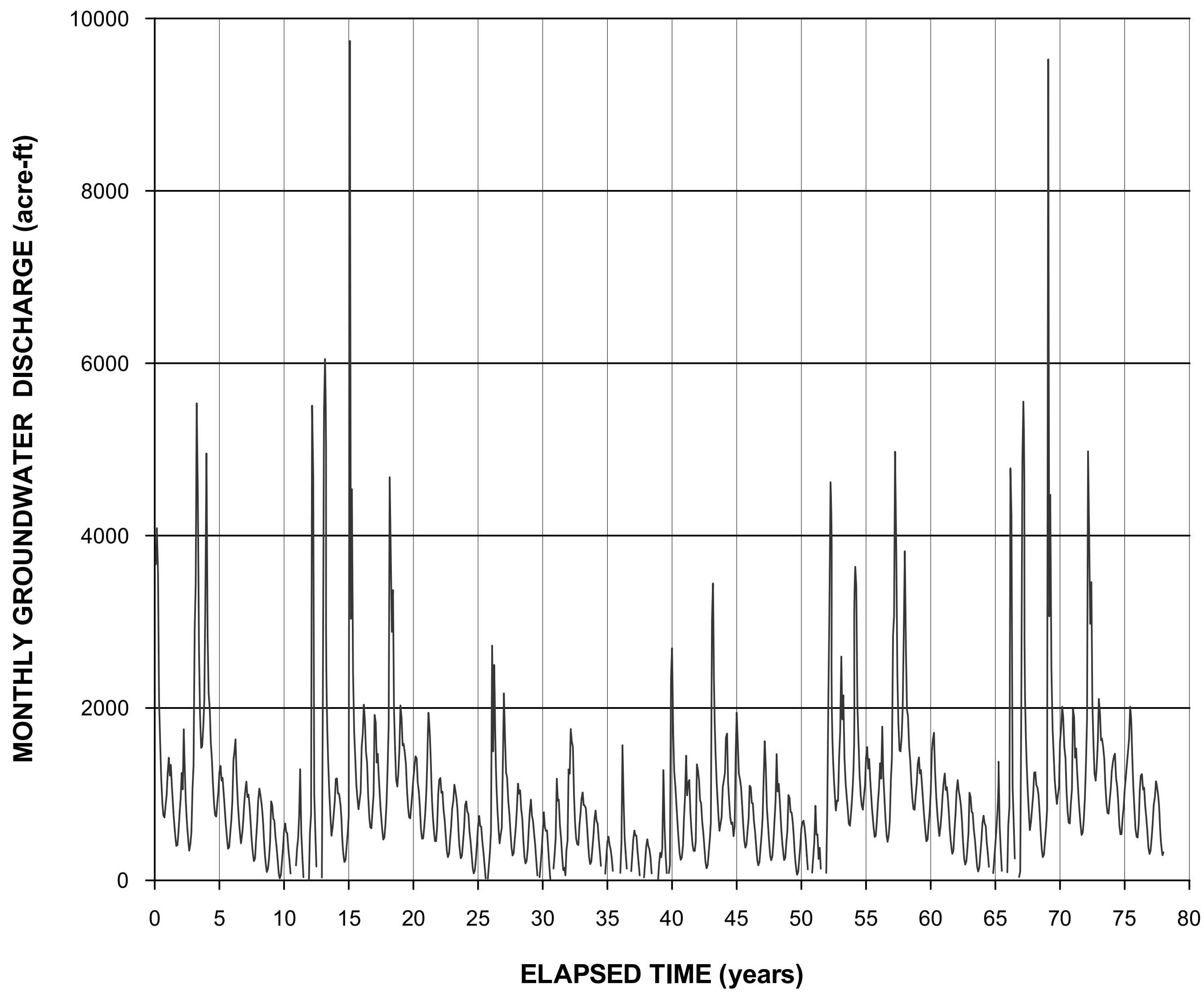

FIGURE 2-18
SIMULATED GROUNDWATER DISCHARGE TO SANTA CLARA RIVER
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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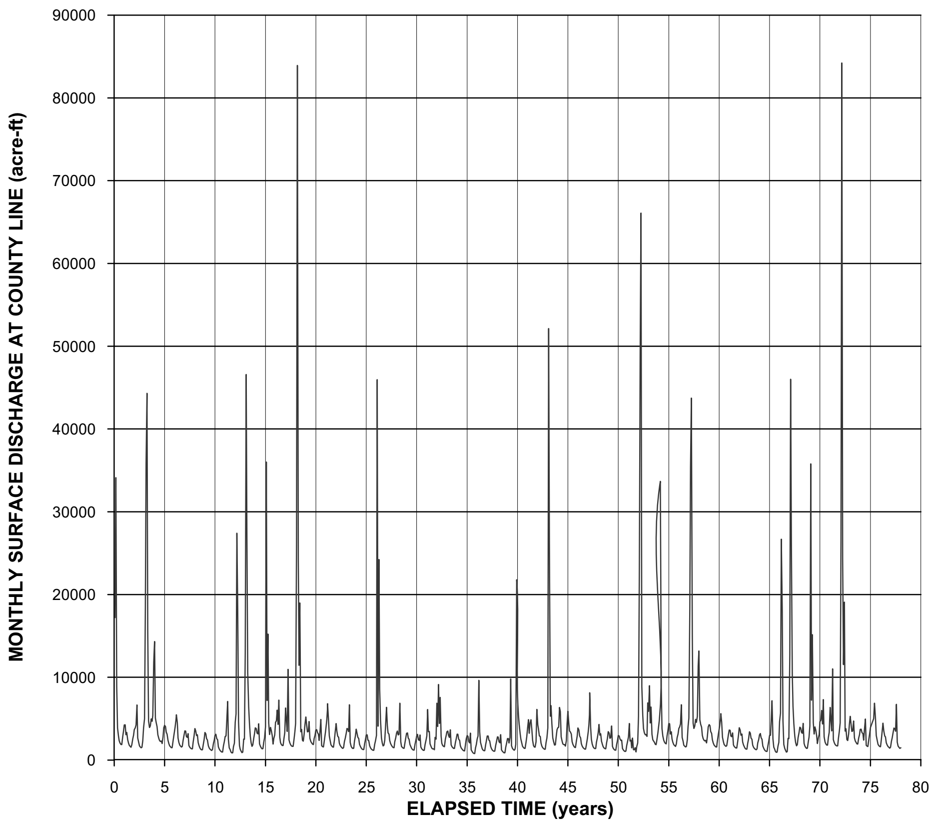

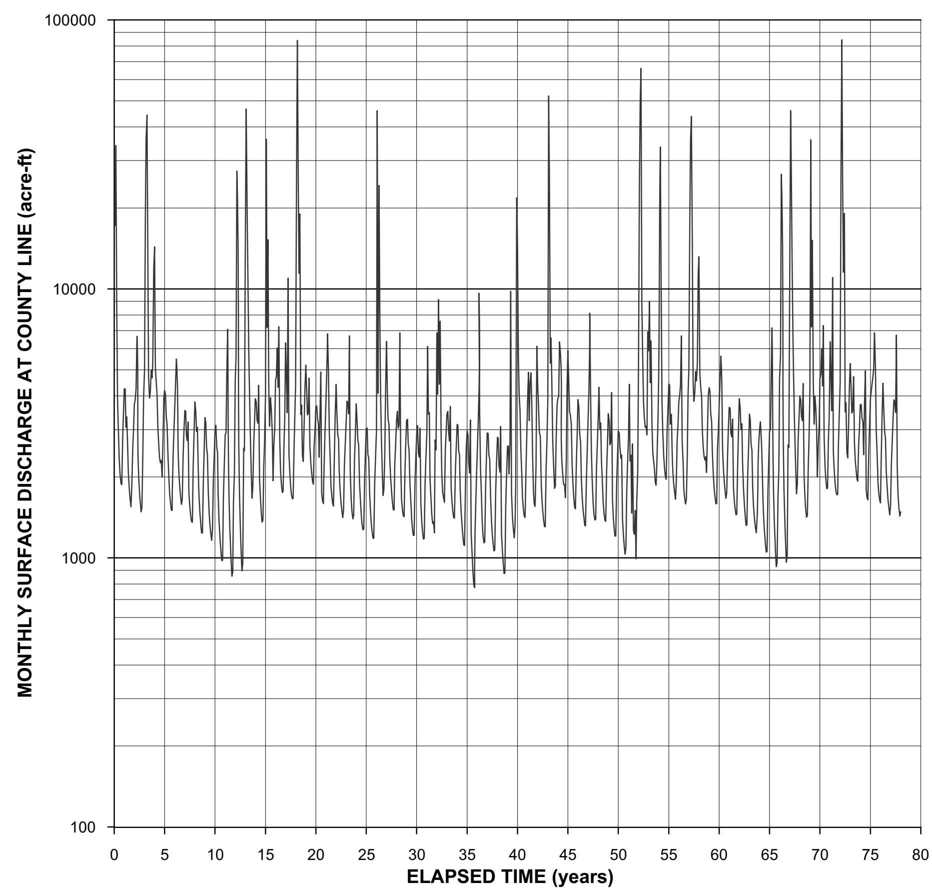

FIGURE 2-17
SIMULATED SANTA CLARA RIVER FLOW AT COUNTY LINE
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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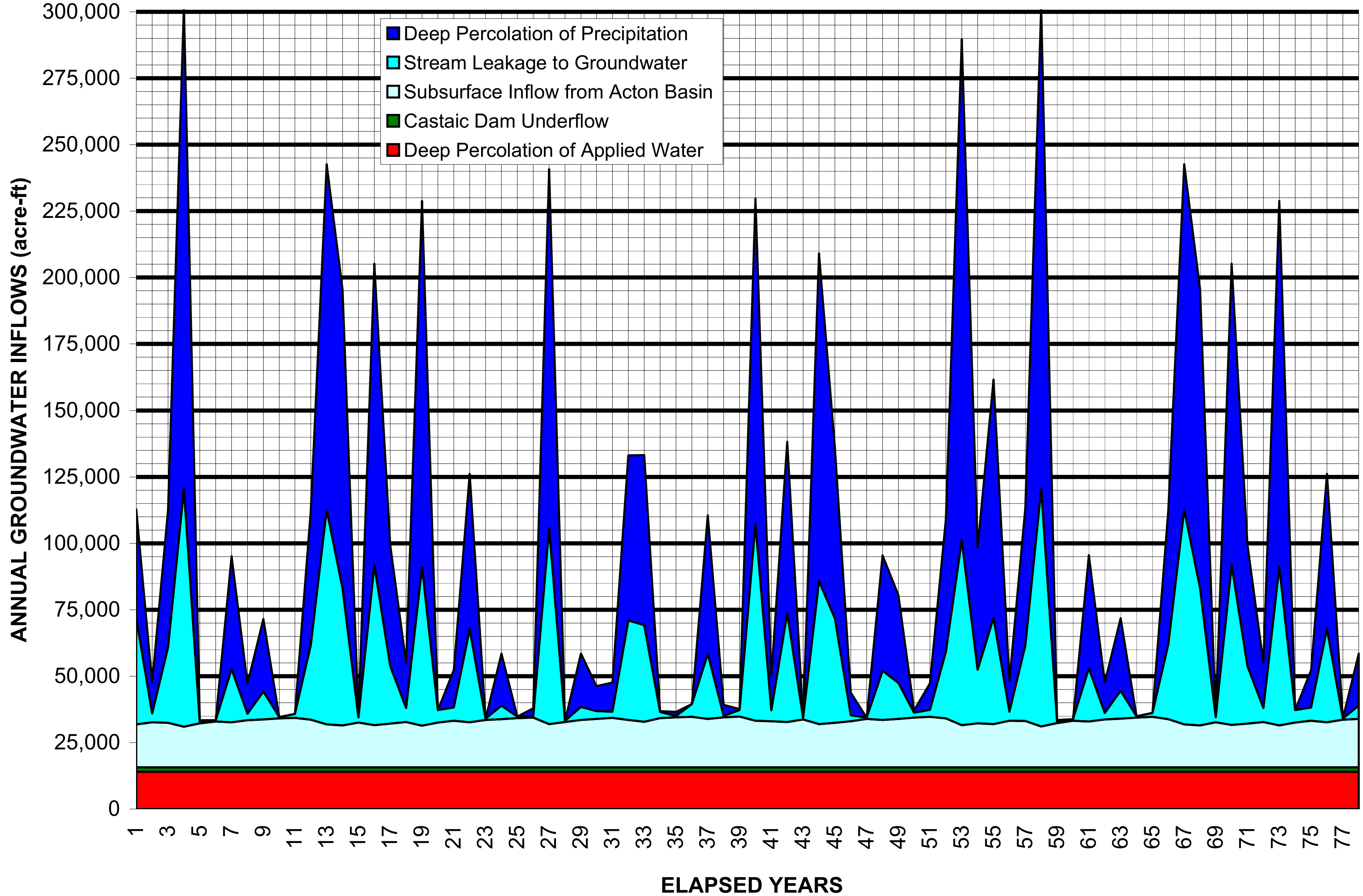

FIGURE 2-19
ANNUAL GROUNDWATER INFLOWS
ANALYSIS OF PERCHLORATE CONTAINMENT IN
GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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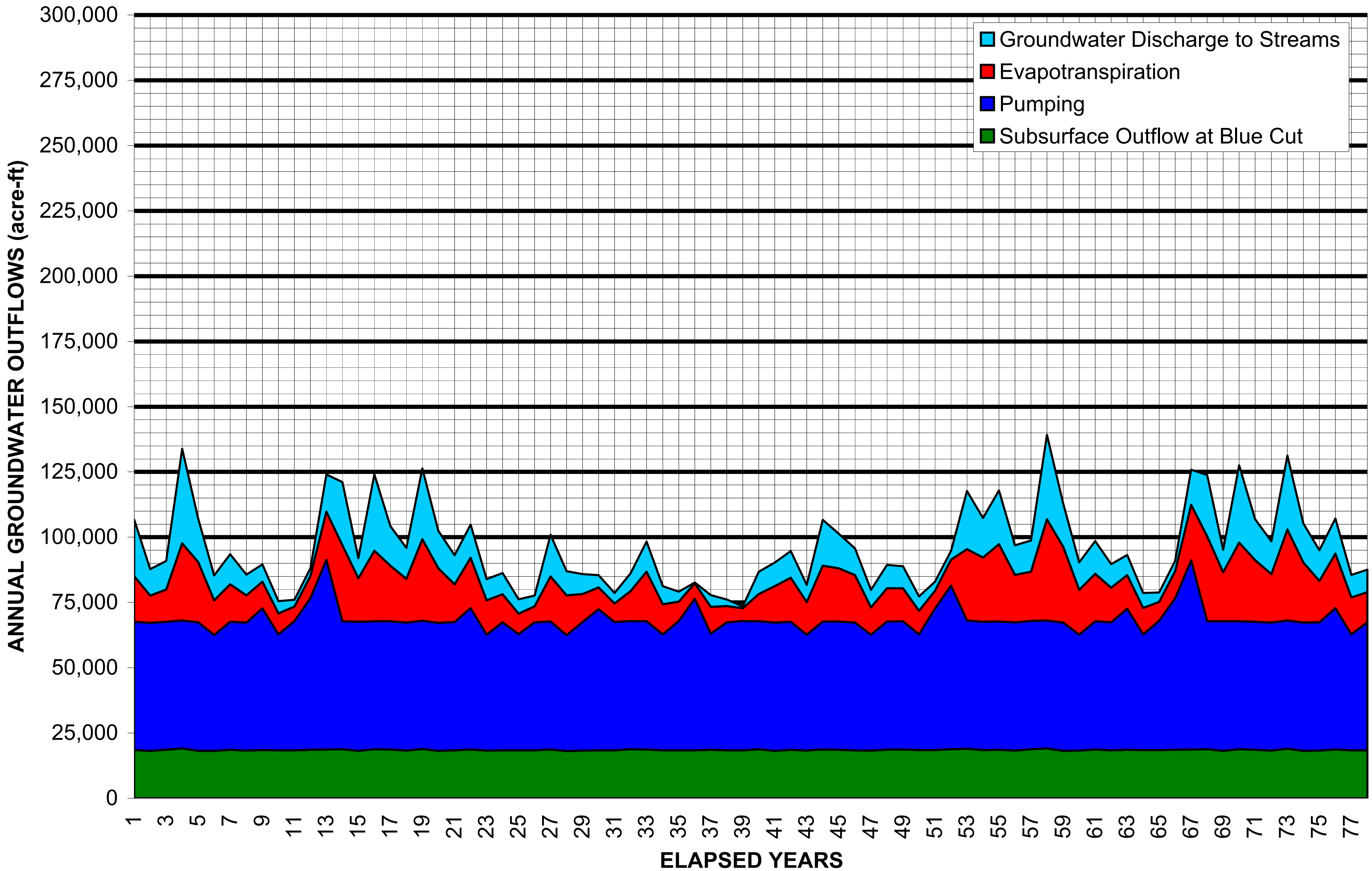

FIGURE 2-20
ANNUAL GROUNDWATER OUTFLOWS
ANALYSIS OF PERCHLORATE CONTAINMENT IN
GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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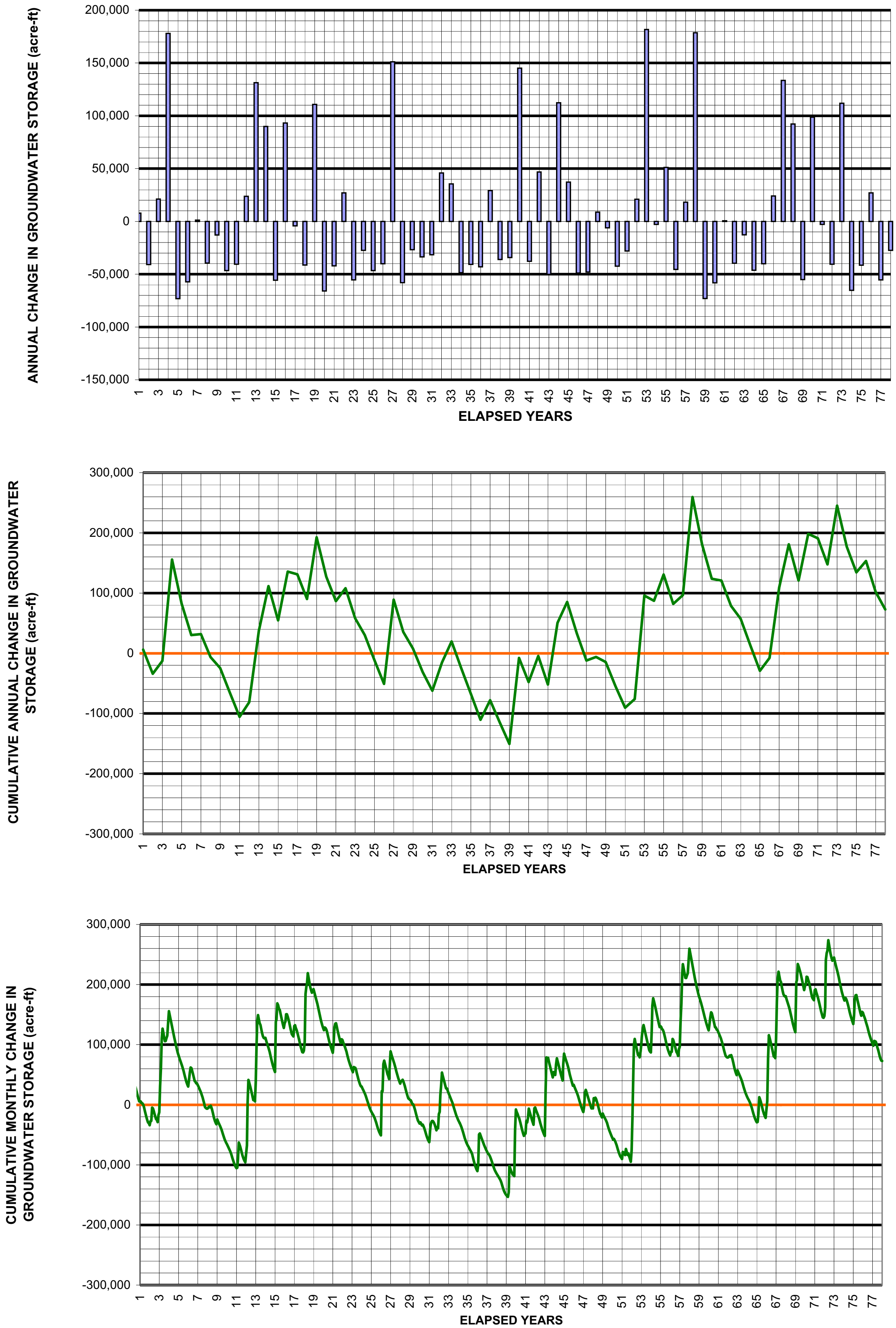

FIGURE 2-21
ANNUAL CHANGE AND CUMULATIVE CHANGE IN GROUNDWATER STORAGE
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

178973-Figures_2-19thru2-21.xls/Fig 2-21

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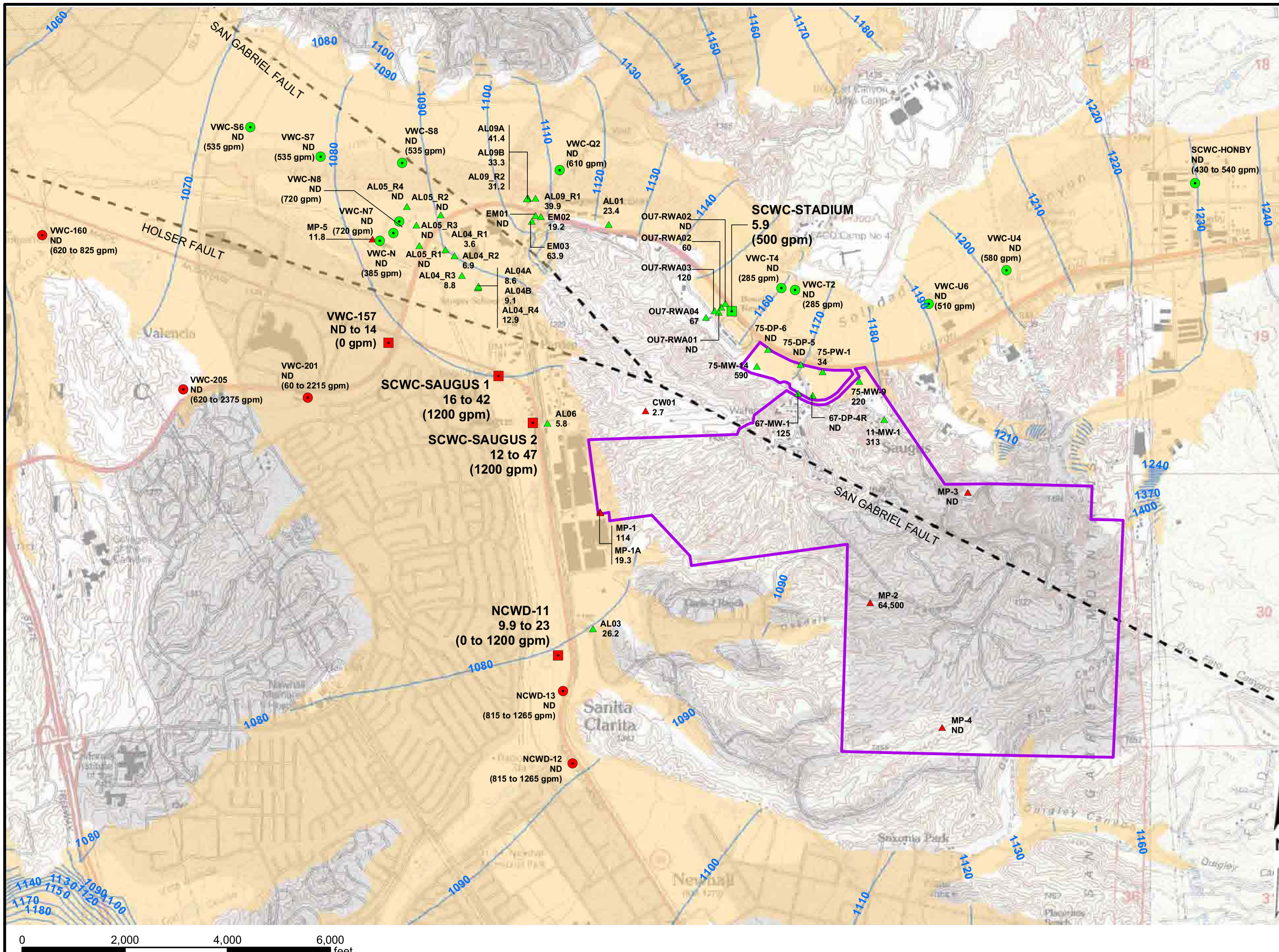

LEGEND

IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

NONIMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

MONITORING WELLS

- ALLUVIUM
- SAUGUS

- SIMULATED GROUNDWATER ELEVATION (ft MSL)
- ALLUVIUM
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE

FIGURE 2-22
SIMULATED AVERAGE GROUNDWATER ELEVATION CONTOURS FOR ALLUVIAL AQUIFER

ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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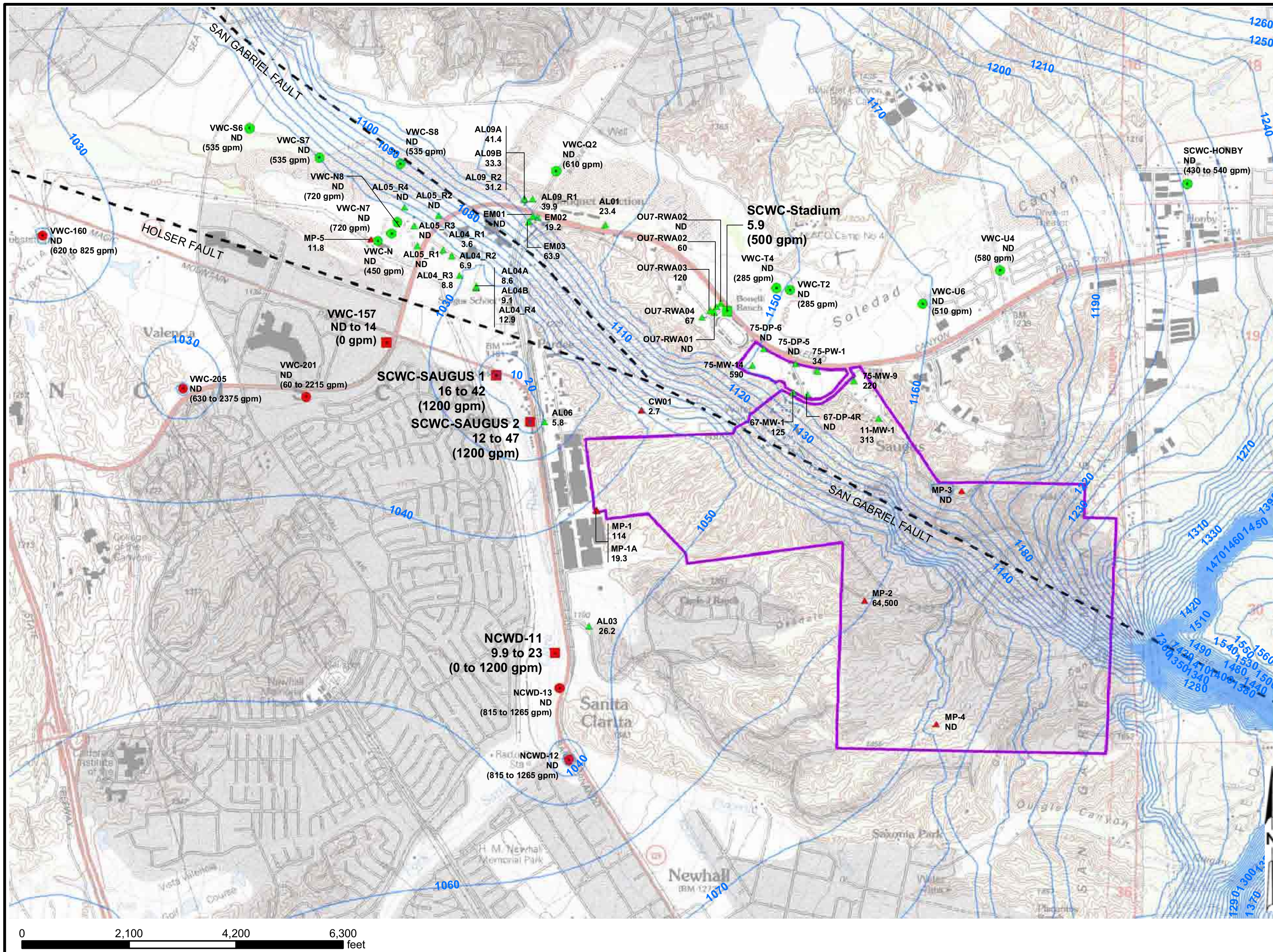

LEGEND

- SIMULATED GROUNDWATER ELEVATION (ft MSL)

IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

NONIMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

MONITORING WELLS
- ALLUVIUM
- SAUGUS

- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:
1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE

FIGURE 2-23
SIMULATED AVERAGE GROUNDWATER ELEVATION CONTOURS FOR SAUGUS FORMATION
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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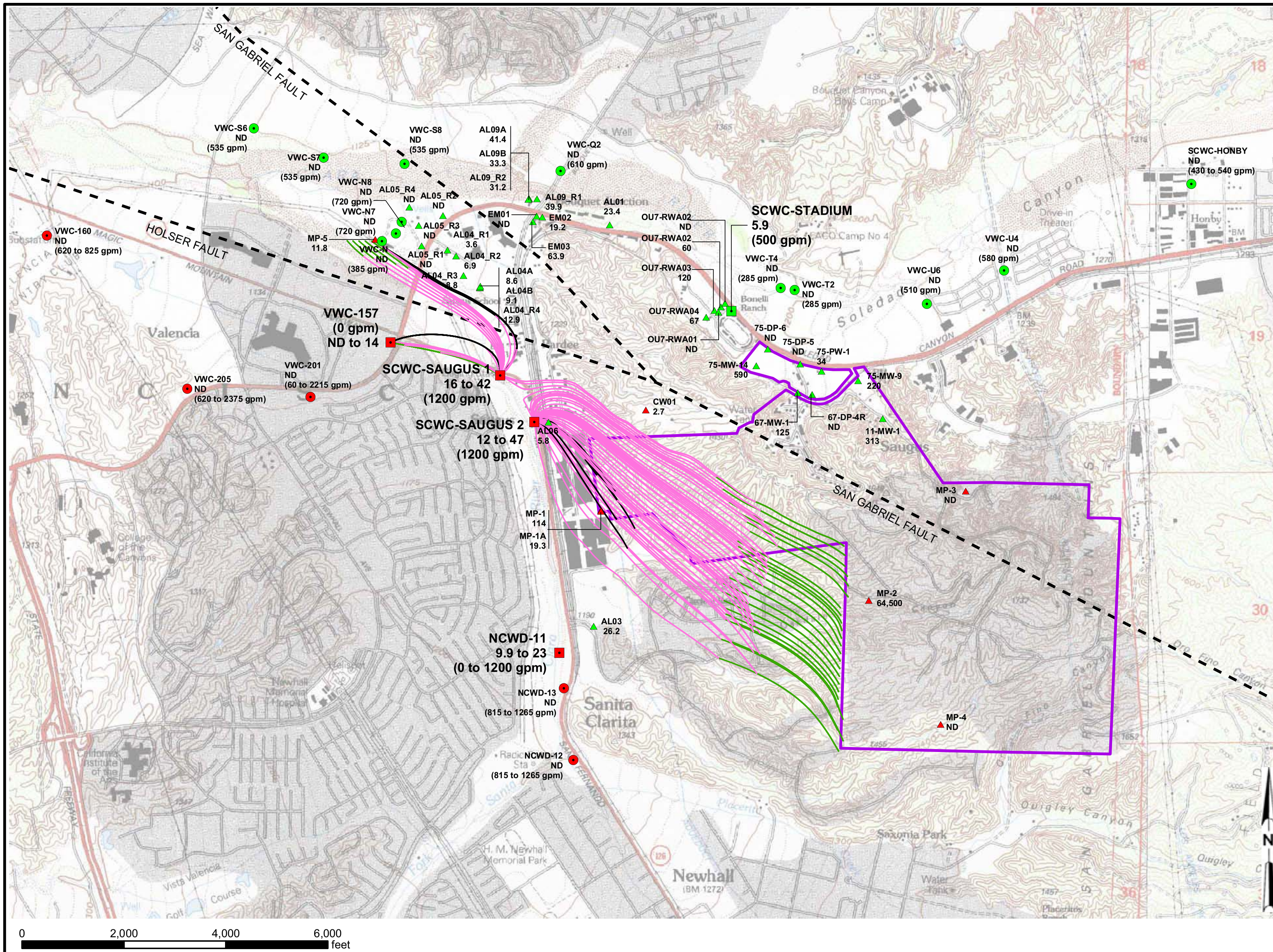


LEGEND

IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

MONITORING WELLS

- ALLUVIUM
- SAUGUS

GROUNDWATER FLOWPATH

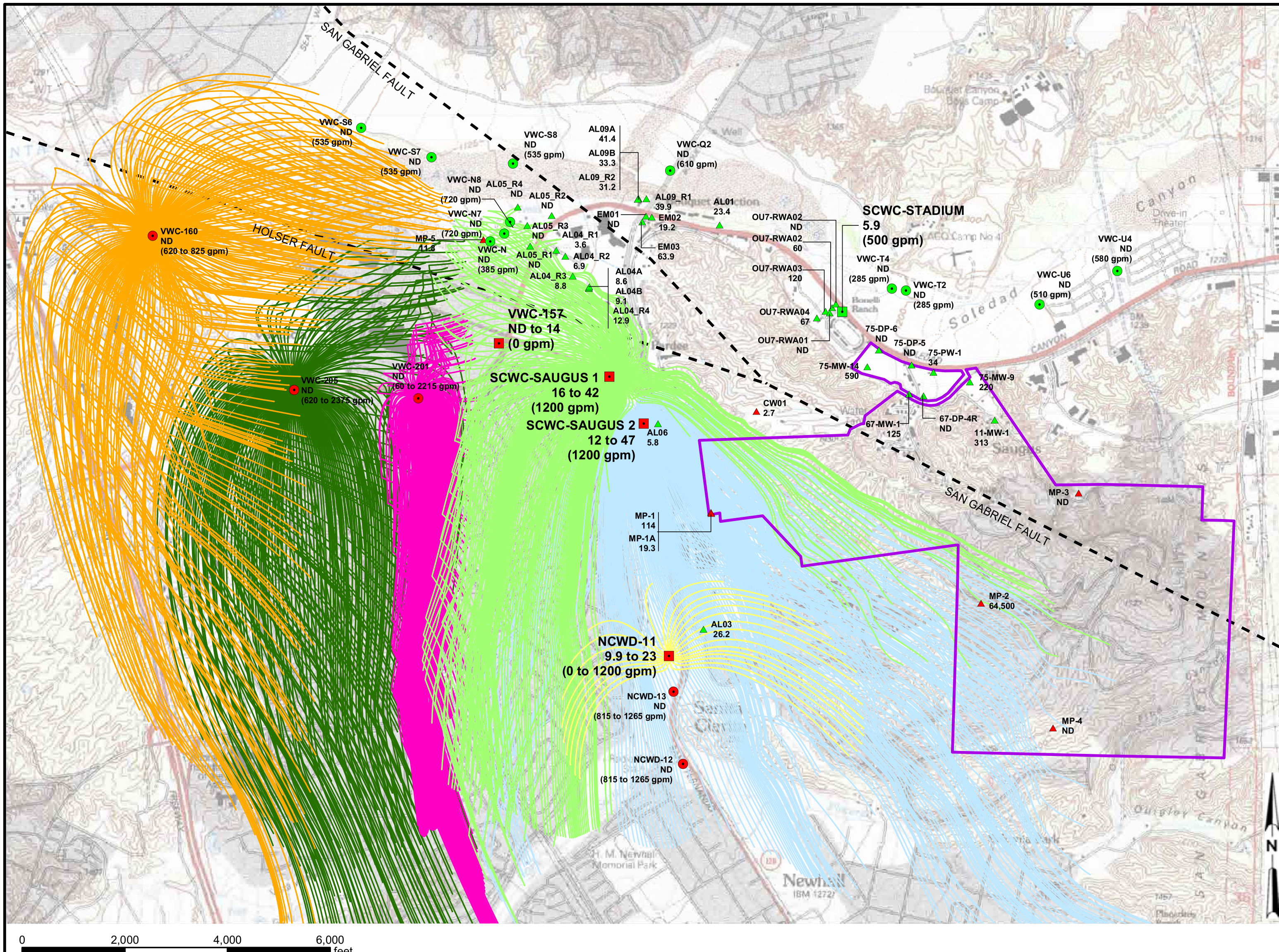
- MODEL LAYER 1
- MODEL LAYER 2
- MODEL LAYER 3
- MODEL LAYER 4
- MODEL LAYER 5
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. FLOWPATHS AT VWC-157 AND MP-5 ARE INITIATED IN MODEL LAYERS 2, 3, 4, AND 5. FLOWPATHS AT THE WHITTAKER-BERMITE PROPERTY BOUNDARY ARE INITIATED IN MODEL LAYER 3.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.

FIGURE 2-24
GROUNDWATER FLOWPATHS IN THE SAUGUS FORMATION FROM VWC-157, MP-5, AND THE WESTERN BOUNDARY OF THE WHITTAKER-BERMITE PROPERTY
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL



LEGEND

IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

MONITORING WELLS
- ALLUVIUM
- SAUGUS

- SCWC-SAUGUS 1
- SCWC-SAUGUS 2
- VWC-160
- VWC-201
- VWC-205
- NCWD-11
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:
1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. PARTICLES WERE INITIATED IN LAYERS 3, 4, AND 5. ALTHOUGH EACH WELL MAY DERIVE A PORTION OF ITS WATER FROM THE ALLUVIAL AQUIFER, PARTICLES THAT ARE TRACED INTO THE ALLUVIAL AQUIFER ARE NOT SHOWN ON THIS FIGURE BECAUSE THE INTENT OF THE FIGURE IS TO SHOW AREAS IN THE SAUGUS FORMATION THAT ARE CAPTURED BY EACH WELL.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.

FIGURE 2-25
SAUGUS FORMATION CAPTURE ZONES FOR IMPACTED AND NONIMPACTED PRODUCTION WELLS
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL

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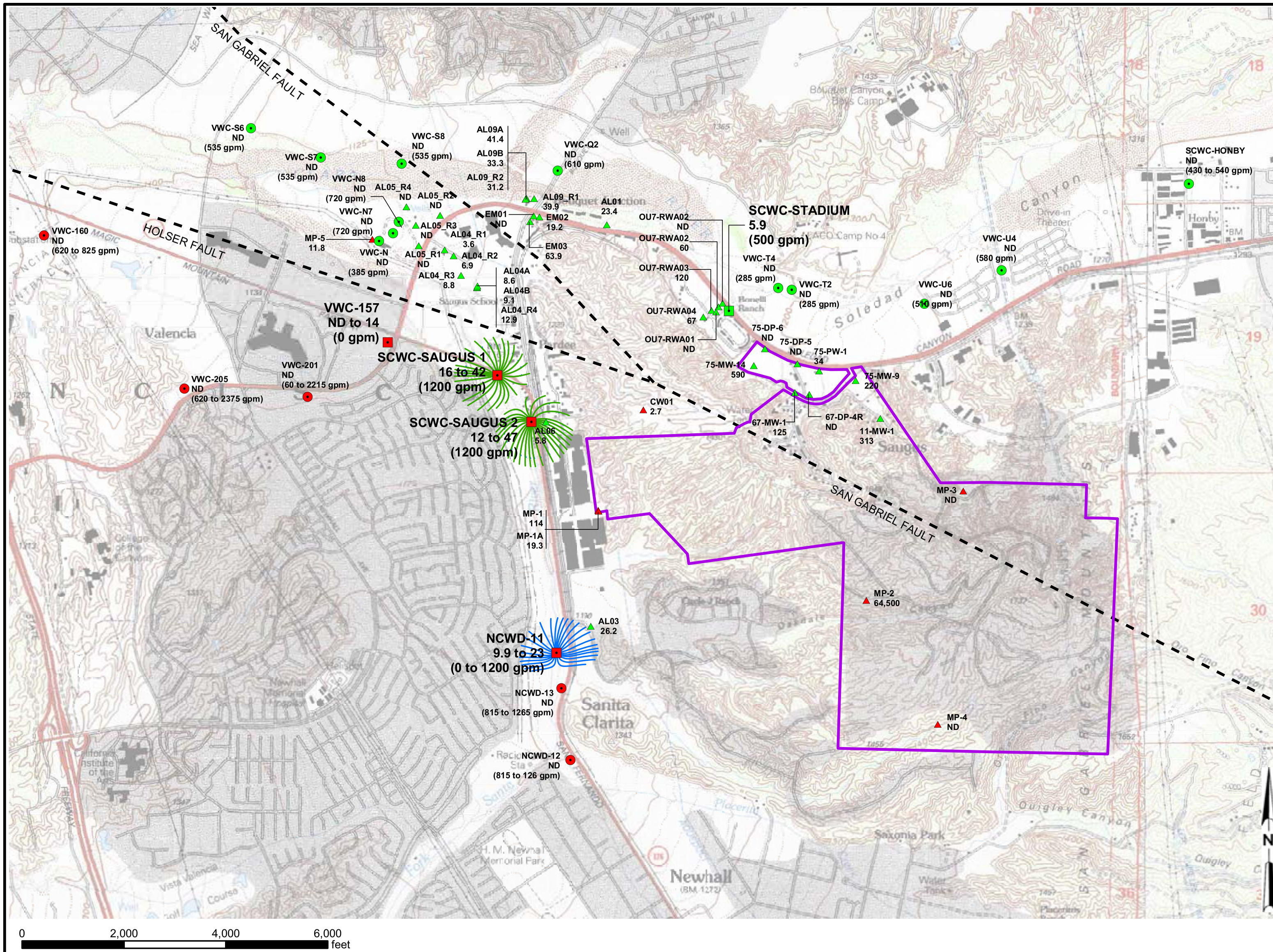

LEGEND

IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

MONITORING WELLS

- ALLUVIUM
- SAUGUS

GROUNDWATER FLOWPATH

- MODEL LAYER 1
- MODEL LAYER 2
- MODEL LAYER 3
- MODEL LAYER 4
- MODEL LAYER 5
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. PARTICLES WERE INITIATED IN LAYER 2 AT NCWD-11, AND LAYER 3 AT SCWC-SAUGUS 1 AND SCWC-SAUGUS 2.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.

FIGURE 2-26
TWO-YEAR CAPTURE ZONES FOR WELLS SCWC-SAUGUS 1, SCWC-SAUGUS 2, AND NCWD-11

ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL

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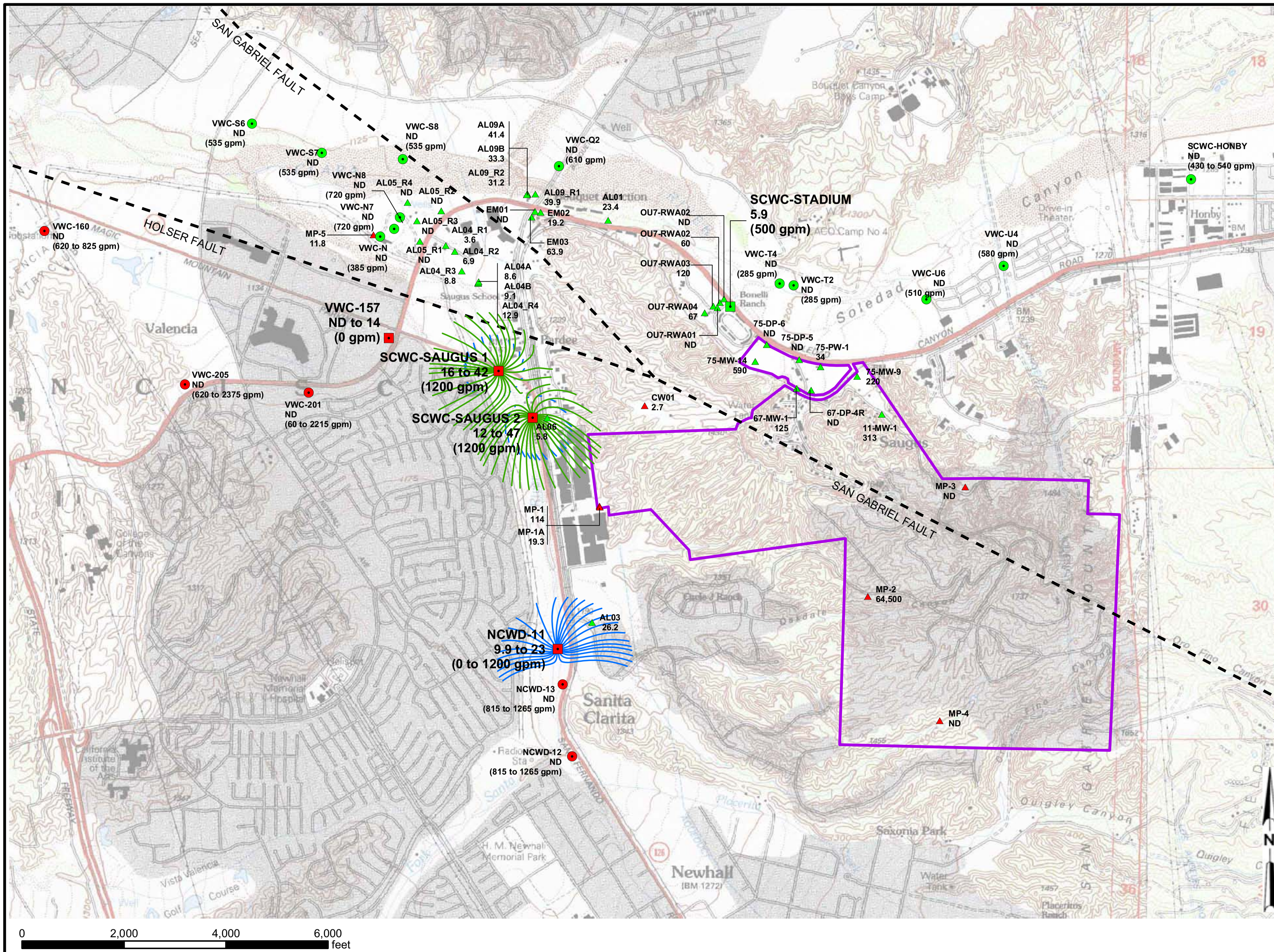
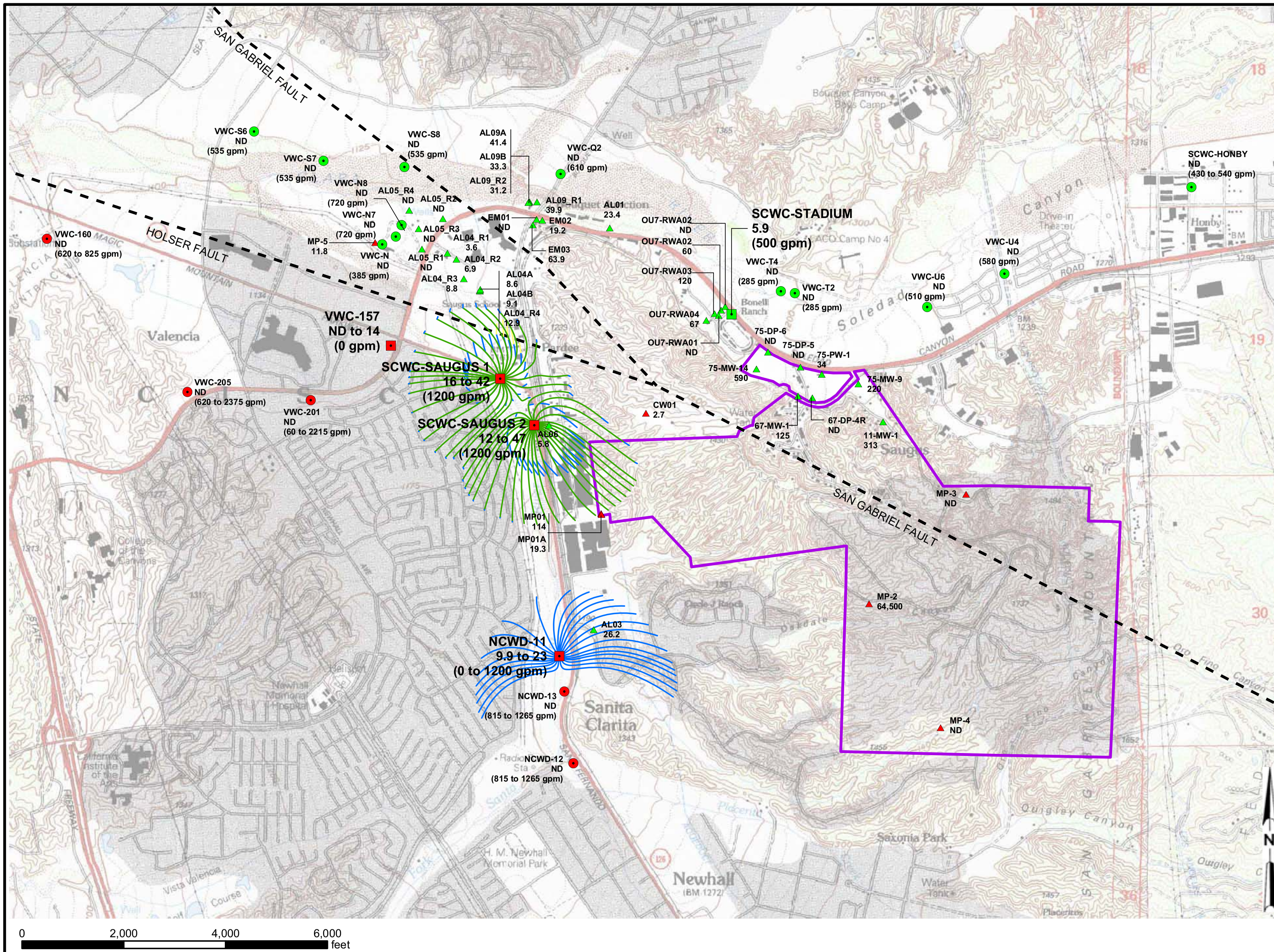


NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (μg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. μg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. PARTICLES ARE INITIATED IN LAYER 2 AT NCWD-11, AND LAYER 3 AT SCWC-SAUGUS 1 AND SCWC-SAUGUS 2.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.

FIGURE 2-27
FIVE-YEAR CAPTURE ZONES FOR WELLS SCWC-SAUGUS 1, SCWC-SAUGUS 2, AND NCWD-11
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL



LEGEND

IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

MONITORING WELLS

- ALLUVIUM
- SAUGUS

GROUNDWATER FLOWPATHS

- MODEL LAYER 1
- MODEL LAYER 2
- MODEL LAYER 3
- MODEL LAYER 4
- MODEL LAYER 5
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (μg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. μg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. PARTICLES ARE INITIATED IN LAYER 2 AT NCWD-11, AND LAYER 3 AT SCWC-SAUGUS 1 AND SCWC-SAUGUS 2.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.

FIGURE 2-28
TEN-YEAR CAPTURE ZONES FOR WELLS SCWC-SAUGUS 1, SCWC-SAUGUS 2, AND NCWD-11
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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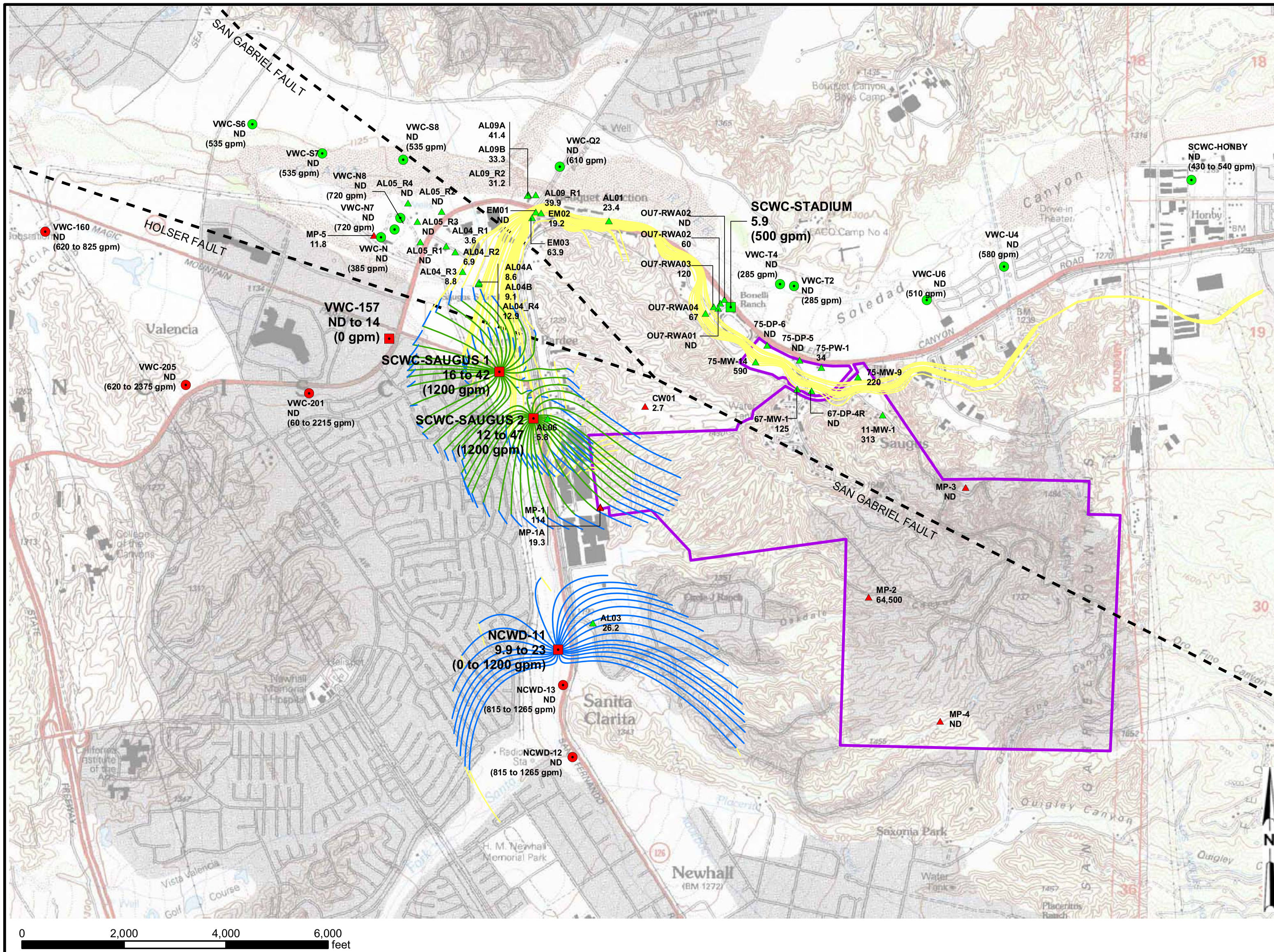

LEGEND

IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

MONITORING WELLS
- ALLUVIUM
- SAUGUS

GROUNDWATER FLOWPATHS
- MODEL LAYER 1
- MODEL LAYER 2
- MODEL LAYER 3
- MODEL LAYER 4
- MODEL LAYER 5
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:
1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. PARTICLES ARE INITIATED IN LAYER 2 AT NCWD-11, AND LAYER 3 AT SCWC-SAUGUS 1 AND SCWC-SAUGUS 2.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.

FIGURE 2-29
TWENTY-YEAR CAPTURE ZONES FOR WELLS SCWC-SAUGUS 1, SCWC-SAUGUS 2, AND NCWD-11

ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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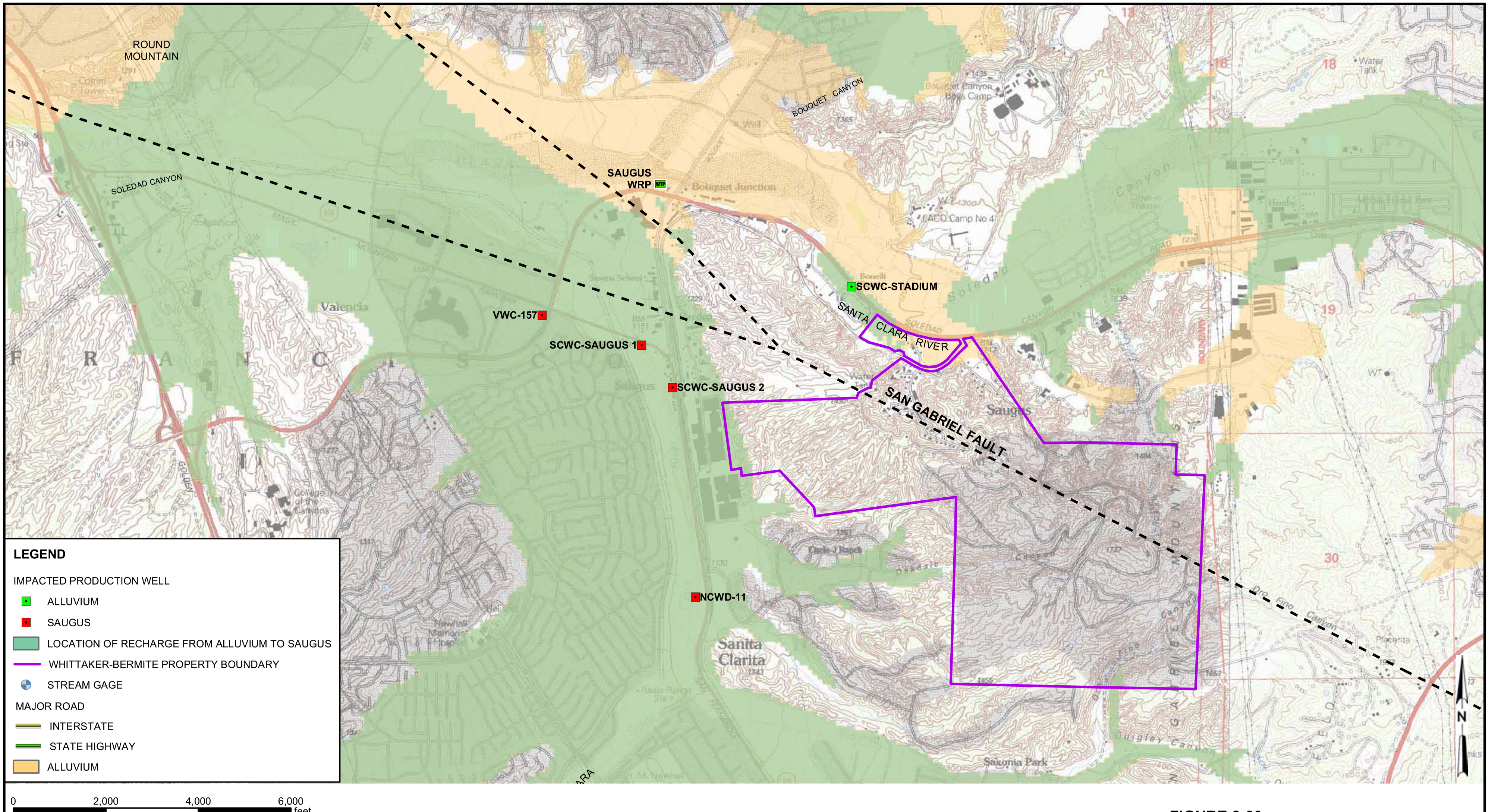

FIGURE 2-30
LOCATIONS OF SAUGUS FORMATION RECHARGE FROM THE ALLUVIAL AQUIFER IN THE VICINITY OF THE WHITTAKER-BERMITE PROPERTY
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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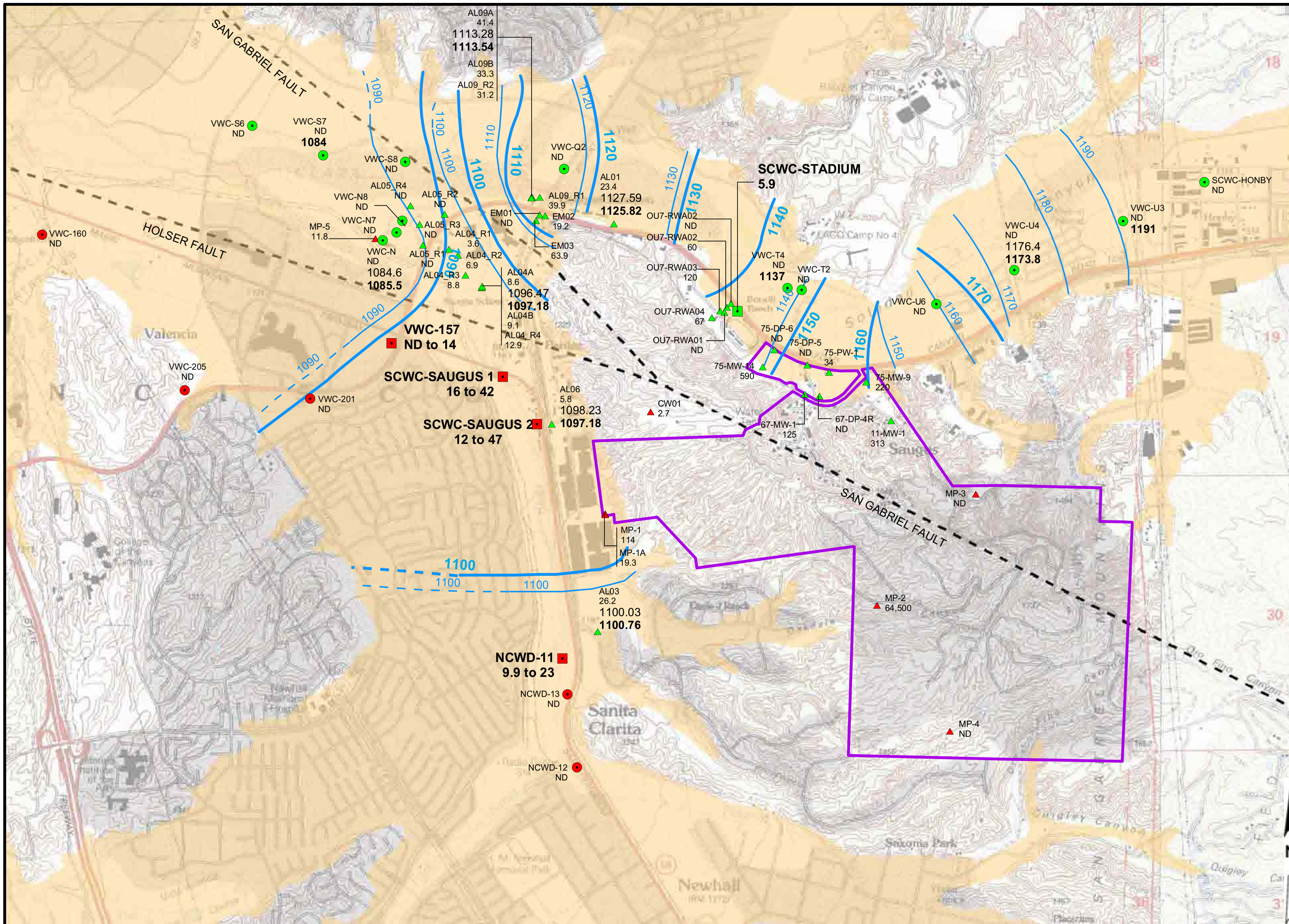

LEGEND

IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

NONIMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

GROUNDWATER ELEVATION CONTOURS (ft MSL)

- OCTOBER 2003 (DASHED WHERE INFERRED)
- DECEMBER 2003 (DASHED WHERE INFERRED)
- ALLUVIUM
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER
5. 1100.03 = OCTOBER 2003 GROUNDWATER ELEVATION (ft MSL)
6. **1097.18 = DECEMBER 2003 GROUNDWATER ELEVATION (ft MSL)**

FIGURE 2-31
MEASURED ALLUVIAL AQUIFER GROUNDWATER ELEVATIONS IN THE VICINITY OF THE WHITTAKER-BERMITE PROPERTY
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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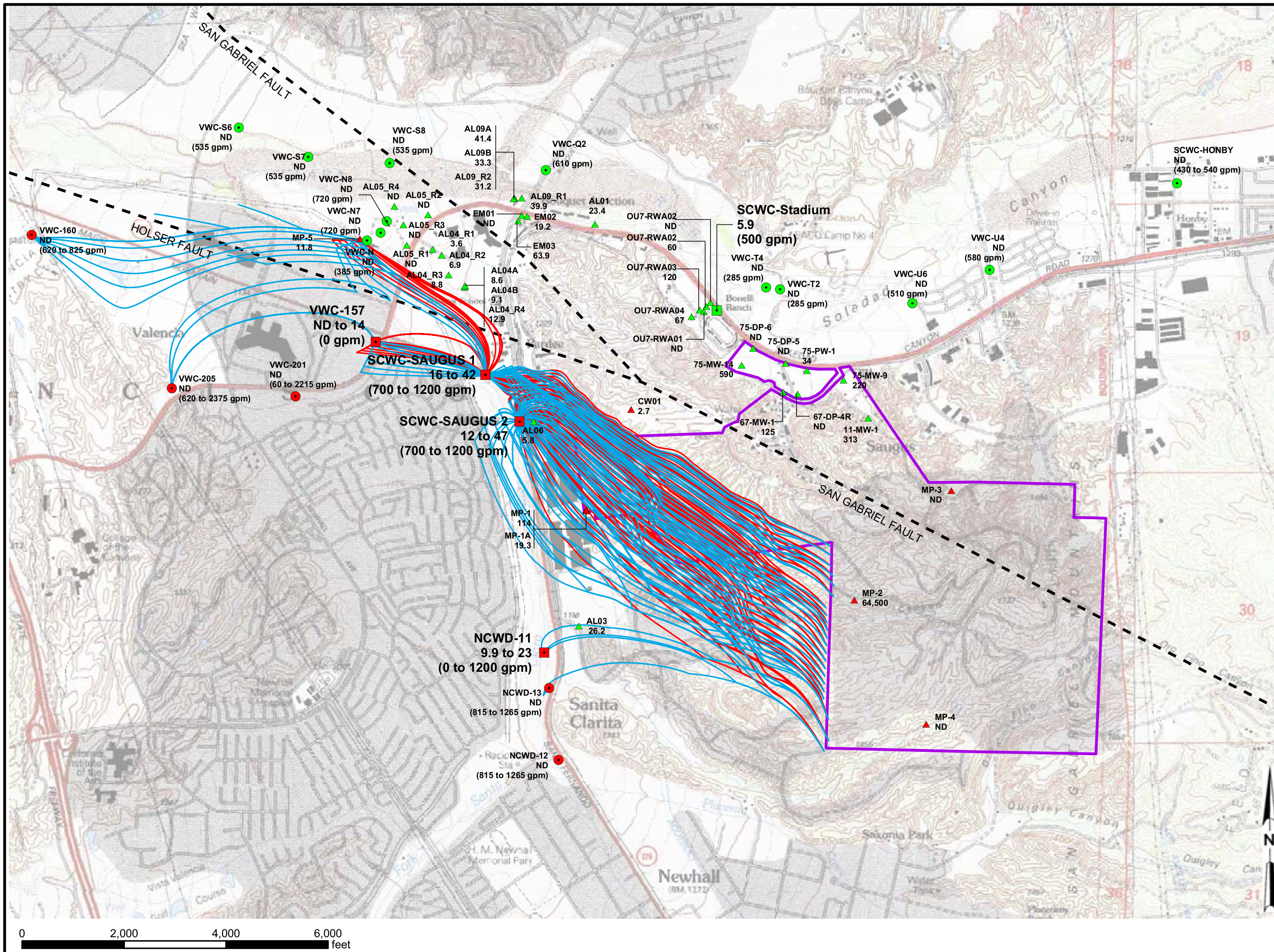

LEGEND

IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

MONITORING WELLS

- ALLUVIUM
- SAUGUS

GROUNDWATER FLOWPATHS

- PUMPING RATE 1200 gpm
- PUMPING RATE 700 and 1000 gpm
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. FLOWPATHS AT VWC-157 AND MP-5 ARE INITIATED IN MODEL LAYERS 2, 3, 4, AND 5. FLOWPATHS AT THE WHITTAKER-BERMITE PROPERTY BOUNDARY ARE INITIATED IN MODEL LAYER 3.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.

FIGURE 2-32
SENSITIVITY OF FLOWPATHS IN THE SAUGUS FORMATION TO LOWER PUMPING RATES AT SCWC-SAUGUS1 AND SCWC-SAUGUS2

ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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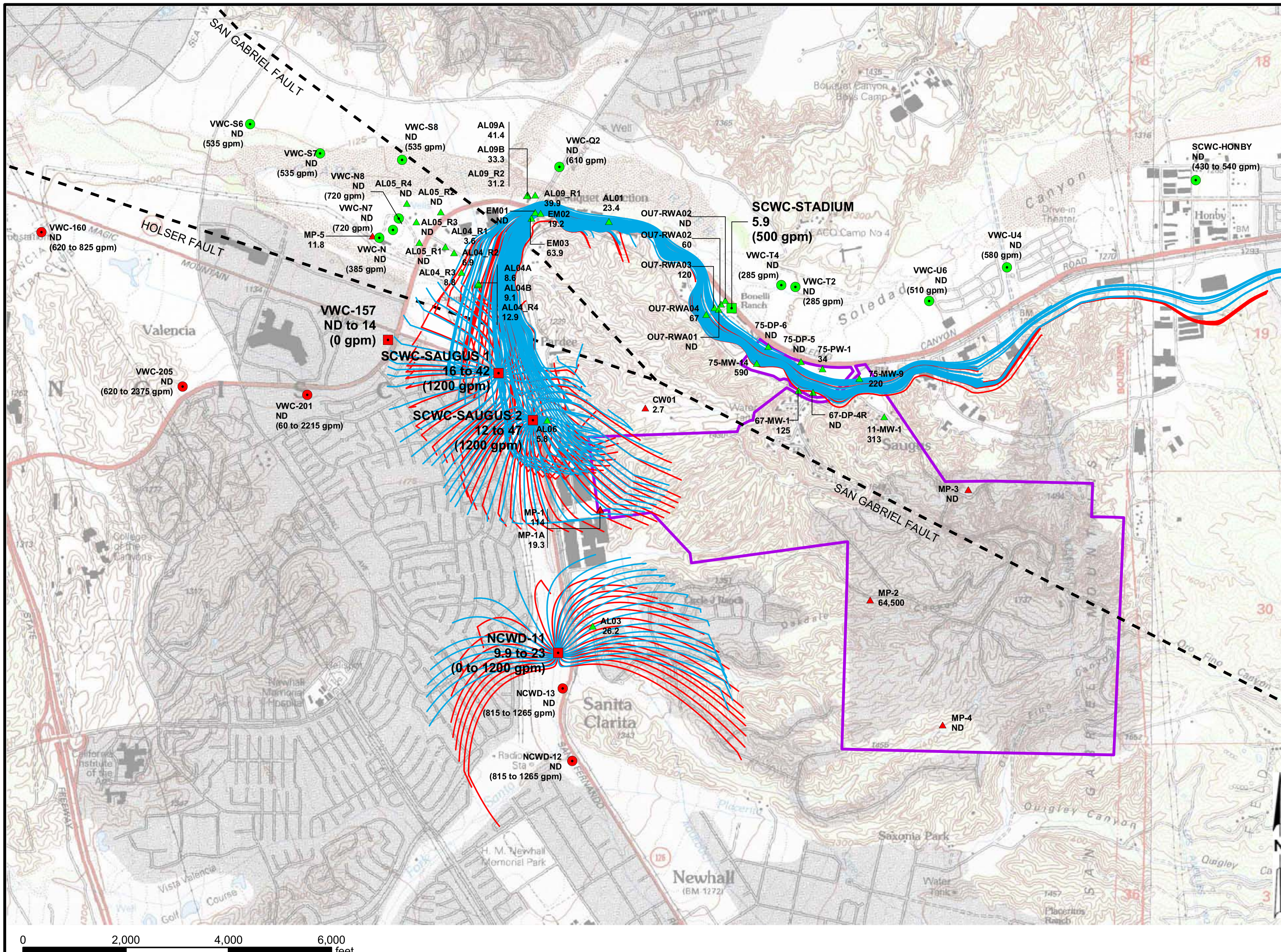


LEGEND

IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL

- ALLUVIUM
- SAUGUS

MONITORING WELLS

- ALLUVIUM
- SAUGUS

GROUNDWATER FLOWPATHS

- BASE CASE RUN (Kh:Kv = 50:1)
- SENSITIVITY RUN (Kh:Kv = 200:1)

NOTES:

1. VALUES PRESENTED UNDER WELL SYMBOLS REPRESENT PERCHLORATE CONCENTRATION IN GROUNDWATER (µg/L).
2. INDICATED PUMPING RATES REPRESENT INSTANTANEOUS RATES WHEN THE WELL OPERATES.
3. ND = PERCHLORATE NOT DETECTED IN GROUNDWATER SAMPLE.
4. µg/L = MICROGRAMS PER LITER; gpm = GALLONS PER MINUTE
5. PARTICLES ARE INITIATED IN LAYER 2 AT NC-11, AND LAYER 3 AT SCWC-SAUGUS1 AND SCWC-SAUGUS2.
6. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION.
7. Kh:Kv = RATIO OF HORIZONTAL HYDRAULIC CONDUCTIVITY TO VERTICAL HYDRAULIC CONDUCTIVITY.

FIGURE 2-33
SENSITIVITY OF 20-YEAR CAPTURE ZONES FOR WELLS SCWC-SAUGUS1, SCWC-SAUGUS2, AND NCWD-11 TO LOWER SIMULATED HYDRAULIC CONNECTION BETWEEN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION

ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

CH2MHILL

SECTION 3

Sentinel and Performance Monitoring Programs

This section of the report discusses the objectives and design of the sentinel and performance monitoring programs that will be implemented for the impacted Saugus Formation production wells as part of the permitting process for returning them to service. The sentinel monitoring program is designed to provide early warning of any changes that might occur in groundwater quality. The scope of this discussion is limited to the ambient groundwater quality monitoring that will be performed upgradient of each impacted well (SCWC-Saugus1, SCWC-Saugus2, and NCWD-11). Monitoring of raw and/or treated water produced by the wells will be addressed in separate documents describing the selection and implementation of the planned perchlorate treatment process at each well. The performance monitoring program evaluates whether containment is being achieved by the containment pumping plan.

3.1 Objectives

DHS Policy Memo 97-005 requires the implementation of sentinel monitoring in groundwater upgradient of impacted wells to provide early warning of unanticipated changes in groundwater quality. This monitoring program is described under the source protection element of the evaluation process for returning an impacted well to service. Based on this policy, the sentinel monitoring plan for the impacted Saugus Formation production wells is intended to provide advanced warning of concentration changes or the presence of additional contaminants in groundwater that might affect the perchlorate treatment processes.

Additionally, groundwater elevation and pumping data will be collected under the sentinel monitoring plan to evaluate the effectiveness of the perchlorate containment plan that is described in this report. Specifically, these data will be evaluated to verify that the containment objectives of the containment pumping plan are being achieved and identify any changes to the operations of the containment wells that might be warranted.

3.2 Monitoring Network

As shown on Figure 3-1 and in Table 3-1, the monitoring well network for the sentinel monitoring program will provide access to both the Alluvial Aquifer and the Saugus Formation upgradient of each production well. Monitoring will occur at the following locations:

1. Two new Alluvial Aquifer monitoring wells and four new Saugus Formation monitoring wells (for monitoring upgradient of production well SCWC-Saugus1)
2. One existing Alluvial Aquifer monitoring well and two screens in existing Saugus Formation multi-port monitoring well MP-2 (for monitoring upgradient of production well SCWC-Saugus2)

3. One existing Alluvial Aquifer monitoring well and one new Saugus Formation monitoring well (for monitoring upgradient of production well NCWD-11)

This program will require the installation of seven new monitoring wells (six near SCWC-Saugus1, and one near NCWD-11).

The rationale for the well locations is provided in Table 3-1. Well locations were selected according to the following considerations:

1. Locating sentinel wells sufficient distances from the production well to allow adequate time to respond to significant concentration changes
2. Using existing monitoring wells, to the degree possible
3. Locating new monitoring wells in areas where site access will not cause undue restrictions on drilling, installing, and monitoring new sentinel monitoring wells

The shape of the SCWC-Saugus1 capture zone requires that sentinel wells be located north of SCWC-Saugus1. However, site access restrictions in this area are significant. Consequently, sentinel monitoring wells can only be located just north of SCWC-Saugus1, at locations that might provide only 1 year of warning and response time. At SCWC-Saugus2, the sentinel wells are anticipated to provide as much as 10 years of warning and response time. At NCWD-11, the sentinel wells are anticipated to provide approximately 2 years of warning and response time.

Alluvial Aquifer monitoring is planned near each production well because of the potential for groundwater containing perchlorate to migrate downward into the Saugus Formation and move toward each impacted production well. The *Draft Final Conceptual Hydrogeology Technical Memorandum for the Eastern Santa Clara Sub-basin Groundwater Study* (CH2M HILL, 2004b) has identified a potential pathway for perchlorate migration to production well NCWD-11, consisting of stormwater runoff from Oakdale Canyon that infiltrates into shallow groundwater and migrates vertically into the Saugus Formation due to ambient or induced (by pumping) hydraulic gradients. This pathway has been identified from the hydrogeologic data in this area and the detection of perchlorate in monitoring well AL03, which is located downstream of Oakdale Canyon near production well NCWD-11. In addition, perchlorate detections in Alluvial Aquifer monitoring well AL06, located near SCWC-Saugus2, are consistent with the conceptual pathway involving stormwater runoff influence on the Alluvial Aquifer. This impacted Alluvial Aquifer groundwater is likely to be in direct contact with the upper Saugus Formation, thereby warranting monitoring of the Alluvial Aquifer, and not just the Saugus Formation.

3.3 Chemical Constituents and Monitoring Frequency

Table 3-2 lists the chemical constituents to be monitored, and the frequency at which monitoring will occur as the operational plan for the impacted Saugus Formation production wells is implemented. The following are key aspects of the program's design:

1. The program will focus primarily on monitoring for perchlorate, VOCs, nitrate, and sulfate, which are the constituents most likely to affect the treatment system if present at concentrations greater than those observed to date at the impacted Saugus Formation

production wells. Perchlorate concentrations would need to increase by a factor of approximately 10 or higher above concentrations measured to date before the treatment systems (which will use ion-exchange resins) would be unable to function as necessary.

2. General minerals (anions and cations) will be sampled on a biannual basis to provide geochemical information that may be helpful for evaluating groundwater migration in the vicinity of each impacted production well. However, nitrate and sulfate will be analyzed annually because of their potential influence on the ion-exchange treatment system.

3. The monitoring frequency will be the same for Alluvial Aquifer sentinel wells as for Saugus Formation sentinel wells.

4. Laboratory-quality-assured analytical data will be submitted to DHS after each monitoring event. Additionally, an annual report will be prepared that summarizes the sentinel monitoring results and identifies any recommended changes to the scope of the monitoring program. Proposed changes will also consider treatment operations and analytical data for the production wells being monitored. Changes to the sentinel well monitoring program that are recommended in the annual reports will be implemented after DHS has reviewed and approved the proposed changes.

The sentinel monitoring program will coincide with a long-term groundwater monitoring program occurring at various locations to the east on the Whittaker-Bermite property. That program will consist of monitoring for the constituents above, plus other constituents that can be associated with perchlorate presence, but which have not been detected in groundwater beneath the site to date.

3.4 Evaluating Capture Zone Effectiveness

As discussed in Sections 1.1 and 2.2.5.2 of this report, CLWA will operate SCWC-Saugus1 and SCWC-Saugus2 on a nearly continual basis at a combined rate of 2,400 gpm to provide hydraulic containment of perchlorate that is moving westward in the Saugus Formation from the Whittaker-Bermite property. Groundwater level monitoring and additional groundwater modeling will be conducted to evaluate whether the containment plan is meeting its intended objectives.

Water level monitoring will be conducted at each sentinel well that is completed in the Saugus Formation and at multi-port monitoring well MP-5, which is also completed in the Saugus Formation and is located downgradient of SCWC-Saugus1 and SCWC-Saugus2. Water levels will be measured at these wells during the startup period for the containment system, as well as immediately prior to startup. Additionally, detailed records of groundwater extraction rates, and the timing of those extractions, will be maintained for SCWC-Saugus1 and SCWC-Saugus2 and the other nearby Saugus Formation production wells (VWC-160, VWC-201, VWC-205, NCWD-11, NCWD-12, and NCWD-13).

The water level trends will then be compared with water level trends that are calculated from Regional Model simulations of the pumping at impacted and nonimpacted wells during the initial startup period for the containment pumping plan. If the comparison of simulated and measured water level trends indicates that adjustments are warranted to the assignment of Saugus Formation aquifer properties in the model, those adjustments will be made and the capture zone evaluations presented on Figure 2-24 of this report will be re-evaluated. Regardless of the need for changes to the model, the information that is obtained from this field data collection program and the subsequent modeling analysis will be used to draw conclusions concerning the effectiveness of the containment plan and whether adjustments to the pumping operations at SCWC-Saugus1 and SCWC-Saugus2 are warranted. These conclusions will be presented in a separate report to DHS.

Tables

TABLE 3-1

Well Network for Sentinel Groundwater Quality Monitoring

Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

Production Well	Sentinel Monitoring Locations	New Monitoring Well Needed?	Actual or Target Depth Interval for Well Screen (ft bgs)	Well Name	TOT Distance from Production Well	Rationale, Comments
SCWC-Saugus1	Alluvium: New well in Magic Mountain Parkway north of Saugus1	Yes	40-60	AL-12A	1 year or less	Alluvial and Saugus HSU S-I monitoring is for a possible pathway to SCWC-Saugus1. Access constraints might require installation of these wells in the City of Santa Clarita right of way along Magic Mountain Parkway. There are currently no Saugus Formation monitoring wells within the delineated capture zone of SCWC-Saugus1. The Saugus wells for HSU S-III will be installed near the corner of San Fernando Road and Magic Mountain Parkway on land owned by the Newhall Land & Farming Company.
		Yes	170-180	AL-12B		
	Saugus (S-I unit): Adjacent to new alluvium well	Yes	230-250 (HSU S-I)	SG1-HSU1		
	Saugus (S-III unit): NLF land north of SCWC-Saugus1	Yes	490-520 (HSU S-III)	SG1-HSU3a		
		Yes	580-640 (HSU S-III)	SG1-HSU3b		
		Yes	750-770 (HSU S-III)	SG1-HSU3c		
SCWC-Saugus2	Alluvium: Existing well AL06	No	65-85	AL06	10 years	Alluvial monitoring is recommended to assess perchlorate near the SCWC-Saugus2 well. At MP-1, the port 2 screen correlates with the top of the screened intervals at SCWC-Saugus1 and SCWC-Saugus2. Port 4 is the uppermost port below a depth of 1,000 feet and below the zones containing perchlorate.
	Saugus: MP-1, ports 2 and 4	No	391.4-401.4 (HSU S-III)	MP-1 (port 2)		
		No	747.5-757.5 (HSU S-V)	MP-1 (port 4)		
NCWD-11	Alluvium: Existing well AL03	No	91-111	AL03	2 years	Alluvial monitoring is recommended because of the potential for the Alluvial Aquifer to be a pathway for perchlorate migration from the site to well NCWD-11. Additionally, movement within the Saugus Formation could be occurring from the site, which is the reason to install a Saugus sentinel well near the Alluvial sentinel well.
	Saugus: New well at AL03 location	Yes	280-320 (HSU S-III)	NC11-HSU3		

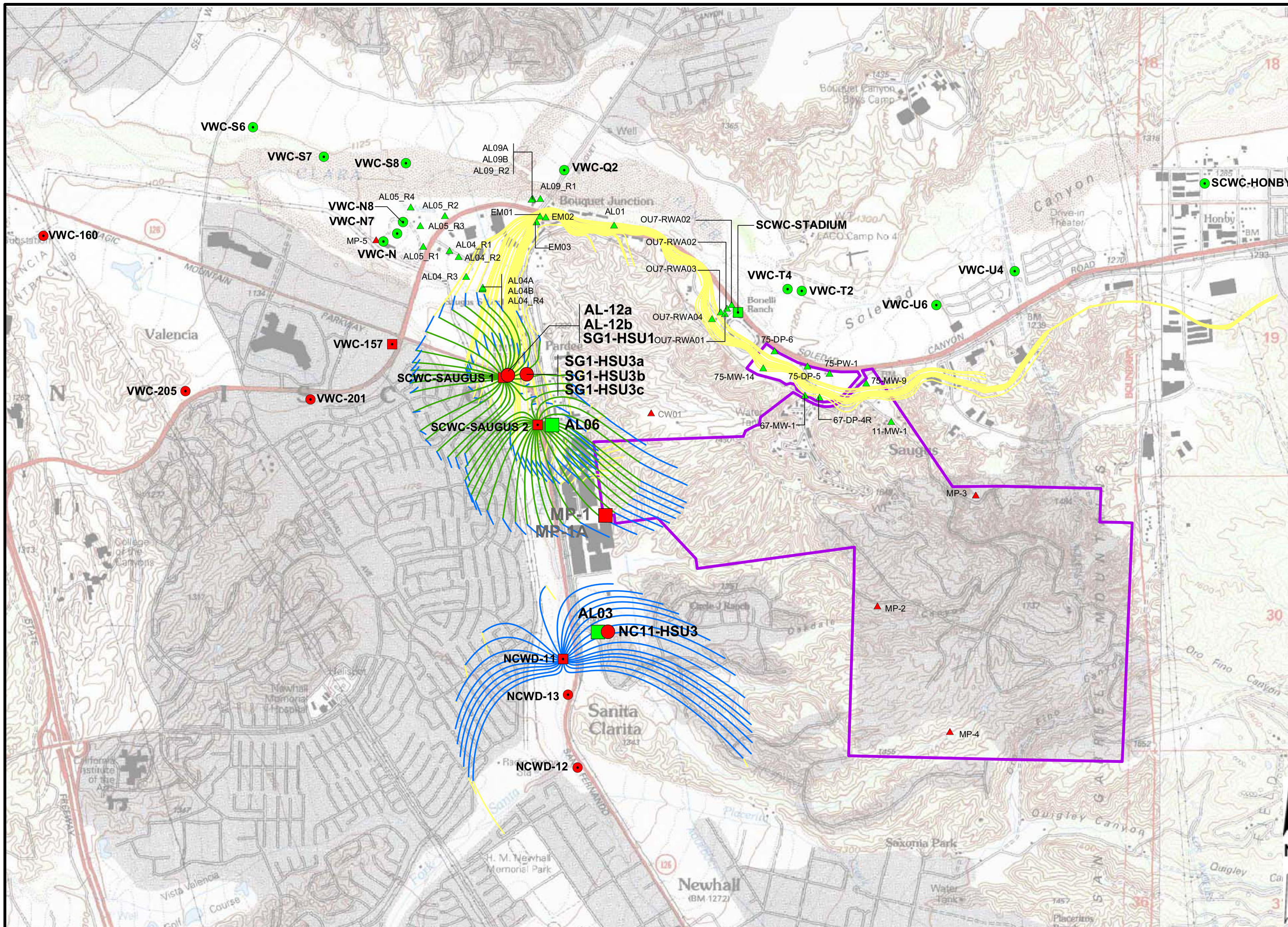
Notes:
TOT = time-of-travel
HSU = hydrostratigraphic unit (See *Draft Final Conceptual Hydrogeology Technical Memorandum for the Eastern Santa Clara Sub-basin Groundwater Study* [CH2M HILL, 2004b] for discussions of the locations and characteristics of the HSUs.)

TABLE 3-2
Chemical Constituents and Sampling Frequency for the 97-005 Sentinel Monitoring Program
Analysis of Perchlorate Containment in Groundwater Near the Whittaker-Bermite Property, Santa Clarita, California

		Frequency			
Analytical Parameters	**EPA Method**	**Initial**	**Semiannual**	**Annual**	**Biannual**
Organic Constituents					
Perchlorate	314.0	X	X		
Volatile Organic Compounds	524.2[a]	X	X		
1,2,4-Trimethyl Benzene		X	X		
Methyl Tertiary Butyl Ether		X	X		
General Minerals (Cations and Anions)					
Aluminum	6010	X			X
Bicarbonate/Alkalinity	310.1	X			X
Calcium	6010	X			X
Chloride	300	X			X
Total Phosphorus	365.3	X			X
Potassium	7610	X			X
Iron	6010	X			X
Magnesium	6010	X			X
Manganese	6010	X			X
Sodium	7770	X			X
Sulfate	300	X		X	
Nitrate	352.1	X		X	
Ammonia	350.3	X			X

[a]Tentatively identified compounds will also be reported.

Figure



LEGEND

SENTINEL WELLS

EXISTING SENTINEL WELL
- ALLUVIUM
- SAUGUS

NEW SENTINEL WELL
- ALLUVIUM
- SAUGUS

PRODUCTION WELL

IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

NON-IMPACTED PRODUCTION WELL
- ALLUVIUM
- SAUGUS

OTHER MONITORING WELL
- ALLUVIUM
- SAUGUS

GROUNDWATER FLOWPATHS
- MODEL LAYER 1
- MODEL LAYER 2
- MODEL LAYER 3
- MODEL LAYER 4
- MODEL LAYER 5
- WHITTAKER-BERMITE PROPERTY BOUNDARY

NOTES:
1. FLOWLINES STARTED THROUGHOUT MODEL LAYERS 2 AND 3 AND TRACED BACKWARDS FOR 20 YEARS.
2. FLOWPATHS ARE DELINEATED USING AN EFFECTIVE POROSITY OF 0.10 IN THE ALLUVIAL AQUIFER AND THE SAUGUS FORMATION. .

FIGURE 3-1
WELL LOCATIONS FOR SENTINEL MONITORING OF GROUNDWATER QUALITY
ANALYSIS OF PERCHLORATE CONTAINMENT IN GROUNDWATER NEAR THE WHITTAKER-BERMITE PROPERTY
SANTA CLARITA, CALIFORNIA

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SECTION 4

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