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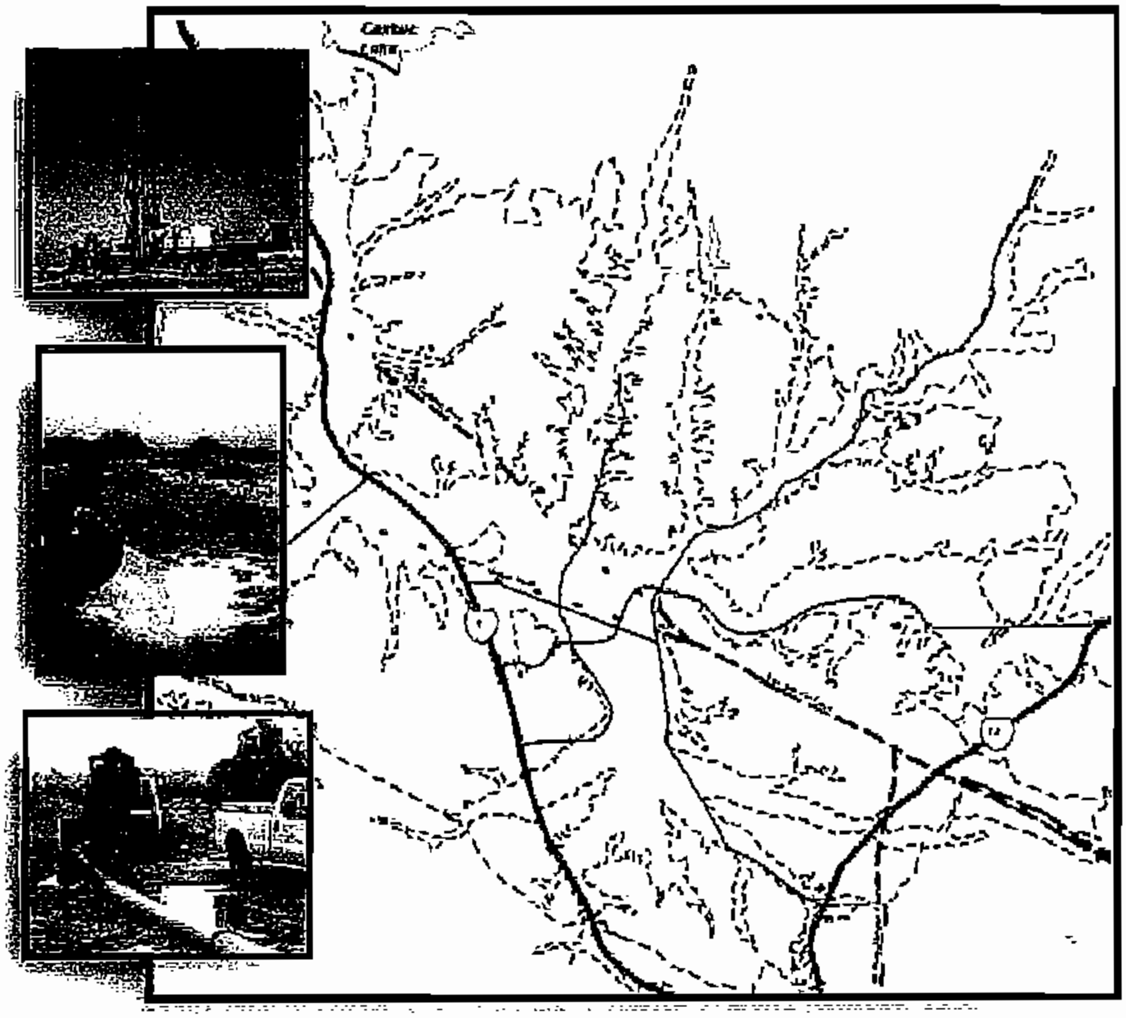
# 2001 UPDATE REPORT

# HYDROGEOLOGIC CONDITIONS IN THE ALLUVIAL AND SAUGUS FORMATION AQUIFER SYSTEMS



## VOLUME I - REPORT TEXT

PREPARED FOR
SANTA CLARITA VALLEY WATER PURVEYORS

JULY 2002

JOB NO. S9920

RCS

**RICHARD C. SLADE & ASSOCIATES LLC**
CONSULTING GROUNDWATER GEOLOGISTS

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August 20, 2002

Mr. Robert J. DiPrimio
c/o Santa Clarita Valley Water Purveyors
Valencia Water Company
24631 Avenue Rockefeller
Valencia, CA 91355

Subject: 2001 Update Report on the Hydrogeologic Conditions in the Alluvial and Saugus Formation Aquifer Systems — Job No. S9920

Dear Mr. DiPrimio:

This is to inform you that copies of the 2001 Update Report on the Hydrogeologic Conditions in the Alluvial and Saugus Formation Aquifer Systems in the Santa Clarita Valley area of Los Angeles County, California, Volumes I and II, have been distributed, per your request, as follows:

- Set Numbers 1 and 2 to: Valencia Water Company
- Set Numbers 3 and 4 to: Castaic Lake Water Agency
- Set Numbers 5 and 6 to: Newhall County Water District
- Set Numbers 7 and 8 to: Santa Clarita Water Company
- Set Number 9 to: Los Angeles County Water Works District #36
- Set Number 10 to: Richard C. Slade & Associates LLC

Additional copies of the report can be acquired through Mr. Ted Pollock of Glendale Blue Print Co., Inc. (818) 241-4181; they have all text, tables, figures, and plates in electronic format.

Very truly yours,
RICHARD C. SLADE & ASSOCIATES, LLC

Richard C. Slade

Richard C. Slade, President

July 7, 2002

Mr. Robert J. DiPrimio
c/o Santa Clarita Valley Water Purveyors
Valencia Water Company
24631 Avenue Rockefeller
Valencia, CA 91355

Subject: 2001 Update Report on the Hydrogeologic Conditions in the Alluvial and Saugus Formation Aquifer Systems — Job No. S9920

Dear Mr. DiPrimio:

We are pleased to present this 2001 Update Report on the Hydrogeologic Conditions in the Alluvial and Saugus Formation Aquifer Systems in the Santa Clarita Valley area of Los Angeles County, California. This project was undertaken to provide an update of our 1986 report of the alluvial aquifer system and our 1988 report on the Saugus Formation aquifer system.

This 2001 Update Report is provided as a two-volume set as follows:

- Volume I, which contains the Executive Summary, the report text in chapter format, and the supporting figures and tables.
- Volume II, which contains the report plates, in large-scale format, to support specific chapters of the report text; there are two sections to Volume II due to the large number of plates.

Volume I and the two sections of Volume II are separately bound.

It has been a pleasure to have worked on this investigation with you and the other Santa Clarita Valley Water Purveyors. This opportunity to have been of service is appreciated.

Very truly yours,
RICHARD C. SLADE & ASSOCIATES, LLC

Richard C. Slade, President

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# EXECUTIVE SUMMARY

This report presents our updated findings, conclusions and recommendations regarding the hydrogeologic conditions within the alluvial and Saugus Formation aquifer systems in the Santa Clarita Valley (Valley) of northern Los Angeles County, California. Figure ES-1 – Study Area Map – illustrates the approximate ground surface locations of the alluvial and Saugus Formation aquifer systems which are discussed herein. The report updates and expands upon two separate reports prepared by Richard C. Slade, Consulting Groundwater Geologist, on the alluvial and Saugus Formation aquifers, in 1986 and 1988, respectively. As such, this report supersedes those previous work products and is intended to provide the water purveyors in the Valley with a current assessment of the geologic and hydrogeologic conditions within the local groundwater basin.

The principal findings of this project include:

1. <u>Data Compilation and Review</u>

   Significant new data have been acquired that has greatly enhanced our understanding of the local groundwater basin. These new data cover a longer period of time, at a greater level of detail, and with more up-to-date information than previous data, and includes new types of information not previously available. The data are also representative of a broader geographic area of the Valley for both aquifer systems. These new data include information on water levels, water quality, downhole geophysical surveys (electric logs), driller's logs, flow meter surveys (spinner logs), depth specific water sampling, and injection and recovery testing.

   Historic and current data have been incorporated into a Geographic Information System (GIS) database, along with updated base maps and recent aerial photographs of the region.

2. <u>Santa Clara River</u>

   The Santa Clara River drains in a general east to west direction across the Valley. Annual runoff volumes within the river across the Valley have increased over time due to the increased use of imported water from the State Water Project (SWP water), and increased discharges from the two local water reclamation plants.

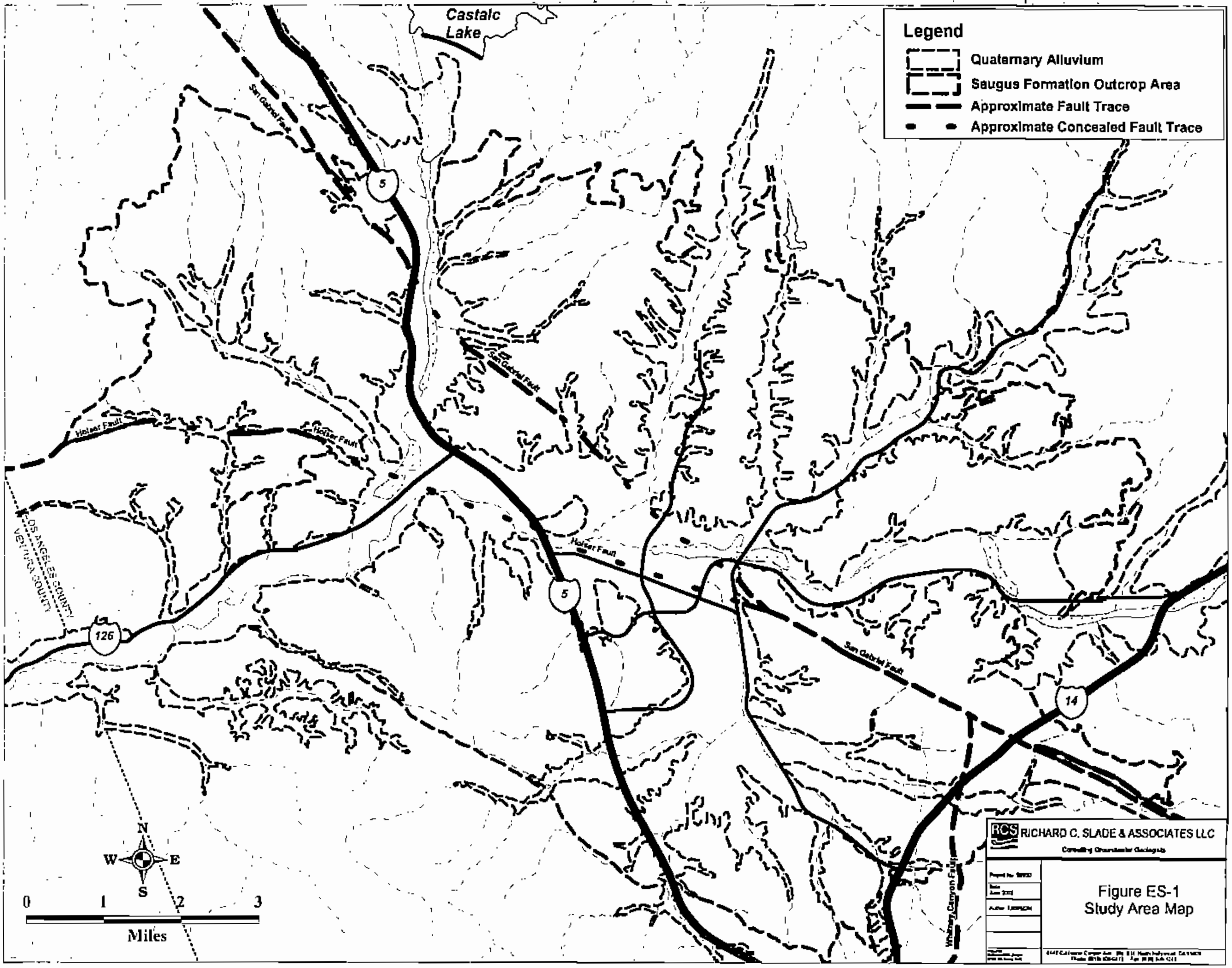


Figure ES-1
Study Area Map

Surface water runoff in the Santa Clara River drains into Ventura County at County line at the western end of the study area. This represents the only direct connection of surface water flow to Ventura County from the Santa Clarita Valley. The only direct connection of groundwater flow between the Valley and the downstream groundwater basins of Ventura County occurs at County line and only from subsurface outflow from the alluvium of the Santa Clara River.

3. Geologic Setting

The two principal aquifers in the Valley are (see Figure ES-1):

a) The blanket of unconsolidated alluvium of Quaternary geologic age deposited by the Santa Clara River and its tributaries, which covers the floor of the main river valley to a maximum thickness of approximately 200 ft. The alluvial aquifer consists of complexly interlayered and interfingered beds of gravel, sand, silt, and clay, which, due to their unconsolidated to poorly consolidated nature, and their lack of cementation, tend to have a relatively high permeability and porosity.

b) The considerably thicker, somewhat more consolidated sediments of the geologically older Saugus Formation (Pliocene to Pleistocene geologic age) that underlie the Quaternary Alluvium. The Saugus Formation can be subdivided into two stratigraphic units. The upper portion of the Saugus Formation is up to 5,000 ft thick and contains numerous coarse-grained sand and gravel beds that form the potential aquifer units. The lower portion of the formation, known as the Sunshine Ranch Member, is up to 3,500 ft thick, and does not contain groundwater in sufficient quantity or of adequate quality for municipal-supply purposes because it contains an abundance of fine-grained sediments of low permeability. The Saugus Formation has been deformed by folding and by faulting along the Holser and San Gabriel fault zones.

   A new geologic cross-section through the Saugus Formation has identified and correlated an important stratigraphic zone of coarse-grained sediments encountered in several existing water wells. This correlatable zone (informally termed the Santa Clarita Aquifer Zone), can be identified on electric logs over a wide area of the Valley. The Saugus Formation water wells with the highest pumping rates generally tend to produce groundwater from within and stratigraphically above the Santa Clarita Aquifer Zone.

4. Local Groundwater Sub-basin

In recent years, the California Department of Water Resources (DWR) has begun a process of updating the official names and locations of groundwater basins throughout the State, including the region along the Santa Clara River between the Santa Clarita Valley and the Pacific Ocean. Currently, the alluvial and

Saugus Formation aquifer systems in the study area are considered to lie within the Santa Clara River Valley East Groundwater Subbasin (East Subbasin) of the Santa Clara River Valley Groundwater Basin.

The western boundary of this local East Subbasin is currently taken at County line where it meets the adjoining (downstream) Piru Subbasin of Ventura County. The eastern boundary of the local East Subbasin occurs at a narrows near Lang Station.

## 5. Alluvial Aquifer System

### A. *Groundwater Levels*

Groundwater in the alluvial aquifer occurs under unconfined (water table) conditions. In the western end of the East Subbasin, west of I-5, long-term water levels have remained generally constant over time in large part because of the naturally occurring upward flow of groundwater from the Saugus Formation into the overlying alluvium in this area. This provides a fairly consistent source of recharge that is relatively independent of annual rainfall trends.

In the central portion of the basin, between I-5 and the South Fork of the Santa Clara River, long-term water levels have become increasingly stable and now appear to be relatively insensitive to variations in annual rainfall. This is due in large part to the increased recharge provided to the alluvium from the two local water reclamation plants (WRPs) owned by the Sanitation Districts of Los Angeles County.

In the eastern portion of the alluvial aquifer (east of the South Fork of the Santa Clara River) water levels continue to display a much stronger correlation with annual rainfall totals than wells in the central or western parts of the Valley. Water levels decline temporarily during dry periods, but quickly recover to their pre-drought highs upon a return to wetter or even more normal climatic conditions.

Overall, there is no evidence of a long-term, continuous or permanent decline in water levels in any alluvial aquifer well, and thus no evidence that the alluvial aquifer is being pumped beyond its sustainable capacity (i.e. the aquifer is not in overdraft). While water levels in the alluvial aquifer do fluctuate over time, there is no continued and progressive decline in groundwater levels, leading to a permanent loss of groundwater in storage, which would be indicative of overdraft.

### B. *Groundwater in Storage*

The alluvial aquifer contained an estimated 200,000 acre-feet of water in storage at its historical high in 1945, as reported by Slade in the original 1986 report on the alluvial aquifer system (Slade 1986 Report). In the spring of 2000, the total volume of groundwater in storage in the alluvial aquifer was approximately 161,000 AF. Over time, groundwater levels and associated groundwater storage in the alluvial aquifer have fluctuated, typically in response to wet and dry conditions as they affect water levels and storage in the eastern portion of the alluvial aquifer. However, there has been no long-term, progressive decline in the amount of alluvial groundwater storage that could be considered illustrative of overdraft conditions.

### C. *Groundwater Production and Operational Yield*

Since the mid-1940s, annual groundwater production from the alluvium has ranged from a low of approximately 20,000 acre feet per year (AF/yr) in 1983, to a high of at least 44,000 AF/yr in 1955. The historically largest alluvial extractions occurred between 1951 and 1960, and between 1991 and 2000 (both are 10-year periods, during which the average annual pumpage was approximately 37,000 AF/yr and 35,000 AF/yr, respectively.

The annual groundwater production from the alluvial aquifer over the last ten years has averaged approximately 35,000 AF/yr, about 10 percent higher then the "practical or perennial yield" of 31,600 to 32,600 AF/yr calculated in the Slade 1986 Report. However, this increase in average production has occurred without any onset of undesirable conditions such as lowered water levels that might be indicative of overdraft. The primary reason that the alluvial aquifer has been able to supply groundwater in volumes that are well in excess of its previously estimated perennial yield for the past ten years is that imports of SWP water into the Valley have risen from approximately 1,100 AF/yr in 1980 to over 32,000 AF/yr in 2000. Much of this additional water is returned to the alluvial aquifer in the form of discharge from the two WRPs located along the Santa Clara River.

One of the disadvantages of utilizing perennial yield as a basis for managing the pumpage from an aquifer system is that it represents a long-term average value for annual yield. There is a potential for the perennial yield value to be interpreted as a "not-to-exceed" volume, with a related potential for pumpage above the perennial yield value in any given year to be incorrectly interpreted as "overdraft". A recently advanced concept intended to deal with such misinterpretations is that of operational yield. Operational yield can be defined as a fluctuating value of pumpage that may be above or below the perennial (or average) yield in any given year, and that varies as a function of the availability of other water supplies. The basic intent of the operational yield value is that it should not exceed the perennial yield of the groundwater basin over multi-year wet and dry cycles.

The operational yield concept includes flexibility of groundwater use by allowing increased pumping during dry periods and increased recharge (direct or in-lieu) with supplemental water when it is available in wet/normal rainfall periods. The operational yield protects the aquifer by helping to assure that groundwater supplies are adequately replenished on a long-term basis from one wet/dry cycle to the next. In the Valley, historical groundwater data demonstrate that the alluvium has been, and continues to be developed within its long-term sustainability (i.e. no continuous lowering of water levels, no notable trend toward degradation of groundwater quality, etc.).

It is evident from observation of the response of the alluvial aquifer system to average pumping over the last several decades, and response to pumping in individual years, that pumping from the alluvium can be performed at a higher average pumping rate and over a wide range of yearly pumping rates without inducing undesirable conditions that would be indicative of overdraft, i.e., long-term continuous and progressive decline in water levels and storage. This observation is particularly evident since the initiation of supplemental SWP water deliveries in 1980. As a result, the operational yield of the alluvial aquifer, or the yearly yield for operating purposes, could range from an individual annual pumping volume as low as about 20,000 AF to an individual annual pumping volume as high as about 45,000 AF. The ultimate goals would be to avoid short-term adverse impacts as a result of year-to-year fluctuations in pumping, and to avoid long-term adverse impacts such as continuously lowered water levels and reduced amounts of groundwater in storage.

Recognition of the historical response of the alluvium to the wide range of annual pumping and the higher average rate of pumping in recent years has led to the following two plans regarding operation of this aquifer system: 1) development of an Urban Water Management Plan (UWMP) in 2000 that includes water supply from the alluvial aquifer within both the long-term yearly operational range and the recent (last ten years) average pumping capacity; and 2) commitment via a Memorandum of Understanding (MOU) process between the Santa Clarita Valley Water Purveyors, Castaic Lake Water Agency (CLWA), and the downstream United Water Conservation District to develop a numerical groundwater flow model in order to analyze in greater detail how the alluvium can be operated in the future to optimize its yield without adverse impact to either the aquifer (avoidance of depressed water levels and depleted storage) or the environment associated with this aquifer (avoidance of decreased stream flows, avoidance of depleting riparian vegetation, etc.).

In summary, the combination of historical observations and current planning has led to the present conclusion that the alluvial aquifer system can be operated over a wide range of pumping volumes in any given year. As summarized in the 2000 UWMP, the operation of the alluvial aquifer will typically be in the 30,000 to 40,000 AF/yr range for most wet and normal rainfall years, with an expected reduction into the range of 30,000 to 35,000 AF/yr in dry years.

Given that the rate of alluvial groundwater extraction over the past ten years has averaged approximately 35,000 AF/yr and no long-term or permanent decline in water levels or groundwater in storage has occurred, the range of pumping proposed for the alluvial aquifer in the most recent UWMP is well within the operational yield of the aquifer.

### D. *Water Quality*

The overall character of groundwater within the alluvial aquifer changes gradually from a calcium bicarbonate to a calcium sulfate character as the groundwater moves from east to west across the Valley. Alluvial groundwater in the tributary canyons in the western part of the area also tends to have a calcium sulfate character.

Concentrations of nitrate and total dissolved solids (TDS) in the groundwater within the alluvial aquifer system show measurable changes as one moves from the eastern to the western end of the Valley. In the eastern and central portions of alluvial aquifer (east of I-5) nitrate levels range from 14 to 27 milligrams per liter (mg/l), while west of I-5 they drop to less than 10 mg/l. TDS concentrations average approximately 550 to 660 mg/l in the eastern and central portions of the alluvial aquifer. TDS concentrations are highest in the alluvial groundwater west of I-5, averaging approximately 1000 mg/l TDS. Neither nitrate nor TDS concentrations exceed their respective State Primary or Secondary Maximum Contaminant Levels (MCLs) in any samples. Groundwater extracted in the area west of I-5 is used solely for agricultural irrigation, and not for municipal-supply purposes.

Between 1985 and 2000, even though some low levels of volatile organic compounds (VOCs) were detected in a few alluvial municipal-supply wells in the Valley, none of these VOCs was encountered at concentrations exceeding its respective MCL. There has been no detection of perchlorate ($ClO_4$, a component of rocket fuel) in any alluvial, municipal-supply water well in the Valley.

## 6. Saugus Formation Aquifer System

### A. *Groundwater Levels*

Groundwater in the Saugus Formation occurs under semi-confined to confined conditions in the central part of the Valley, but is likely unconfined near the lateral margins of the Saugus Formation outcrop area. Historic static water levels in the Saugus Formation have typically fluctuated over time: the magnitude of these historic fluctuations varies from well to well, but has generally ranged from a minimum of 50 ft to a maximum of 175 ft; these water level conditions are for wells that typically range in total depth between 750 to 2000 ft. Long-term water level records show no evidence of a long-term or continuous decline in water levels in any Saugus Formation water well, and like the alluvial aquifer, the Saugus Formation aquifer is not in a condition of overdraft.

*B.* Groundwater in Storage

The amount of groundwater in storage in the Saugus Formation was calculated to be approximately 1.41 million AF, using an upper limit of 500 ft below ground surface (bgs) as part of the calculations, as reported by Slade in the original 1988 Report on the Saugus Formation aquifer system (Slade 1988 Report). More recent information on the thickness of the alluvium and the degree of potential drawdown interference between adjacent Saugus Formation and alluvial water wells has led us to adjust this upper limit from 500 ft bgs to 300 ft bgs. Updated calculations of groundwater in storage reveal a value of approximately 1.65 million AF, an increase of about 18% more than the 1.41 million AF calculated in the original Slade 1988 Report. This increase is due almost entirely to raising the upper limit of our depth zone for calculations from 500 ft to 300 ft bgs.

*C.* *Groundwater Production and Operational Yield*

Groundwater production from the Saugus Formation has averaged approximately 8,600 AF/yr from 1991 to 2000, with the highest ever historical production of approximately 15,000 AF/yr occurring in 1991, towards the end of a multi-year drought. No long-term continuous or permanent decline in either water levels or the amount of groundwater in storage has occurred under this historical range of pumping. In summary, the combination of historical observations and current planning has led to the present conclusion that the Saugus Formation aquifer system can be operated on a long-term average basis in the range of 7,500 to 15,000 AF/yr. Infrequently, during dry periods of one to three years, pumping extractions from the Saugus Formation can be ramped up from 15,000 to 25,000 AF/yr, and ultimately to 35,000 AF/yr if dry conditions continue. These latter increases would be temporary and would return to or below the historical range of 7,500 to 15,000 AF/yr once rainfall patterns returned to normal.

As summarized in the 2000 UWMP, the operation of the Saugus Formation aquifer system will typically be in the 7,500 to 15,000 AF/yr range for most years of normal or wet conditions, with possible short-term increases in dry periods into the 15,000 to 35,000 AF/yr range. It is recommended that a program of enhanced water level and water quality monitoring accompany this incremental temporary "ramp-up" in groundwater production from the Saugus Formation. However, such a temporary increase in pumping over and above historic levels is unlikely to have an adverse impact on the Saugus Formation aquifer system, and in particular is unlikely to induce a permanent loss of groundwater from storage or a decline in water quality.

D. *Groundwater Quality*

Groundwater in the Saugus Formation varies in character from calcium-bicarbonate ($Ca\text{-}HCO_3$) along the South Fork of the Santa Clara River, to calcium-sulfate ($Ca\text{-}SO_4$) in the central part of the Valley, to sodium-bicarbonate ($Na\text{-}HCO_3$) further west within the central fault block. The TDS concentration of Saugus Formation groundwater typically ranges from 500 to 900 mg/l, which is below the maximum State Secondary MCL for TDS of 1000 mg/l. We have performed a recent re-examination of water quality data for possible historical trends in TDS concentrations in the Saugus Formation. This revealed that although there has been a slight increase in TDS concentrations in most Saugus Formation wells in the past 40 years, this increase could not be correlated with increased groundwater production. On the contrary, there is evidence that TDS concentrations have actually decreased during periods of increased Saugus Formation groundwater production.

VOCs generally have not been detected in Saugus Formation groundwater, with the exception of four Saugus Formation water wells in the eastern part of the Valley. In these few wells, certain VOCs (primarily TCE) and the inorganic compound perchlorate have been encountered. None of the four impacted wells has been used for municipal-supply purposes since perchlorate was first detected in each of these wells in 1997. Results of ongoing laboratory testing of the other eight active Saugus Formation municipal-supply wells have all shown non-detection of perchlorate. Steps are currently being taken by the water purveyors to safely restore the capacity of the four impacted wells.

7. Artificial Recharge

Temporary fluctuations in water levels in the alluvial aquifer east of Bouquet Canyon create temporary groundwater storage capacity that could potentially be refilled faster than occurs naturally through a program of artificial recharge via spreading basins adjacent to the Santa Clara River. Excess flood flows in the Santa Clara River that would otherwise flow out of the Valley could be diverted to spreading basins where the water would percolate into and provide additional groundwater recharge to the alluvial aquifer. The purveyors may want to consider a range of recharge programs to augment the management of groundwater in the Valley.

In the Saugus Formation, recent field testing and groundwater modeling has demonstrated that Aquifer Storage and Recovery (ASR) using deep injection wells is feasible and potentially advantageous in terms of overall groundwater management for the local sub-basin. An ASR project of a scope beyond that envisioned for the Newhall Ranch development may provide further benefits to the Saugus Formation, including increased volume of groundwater in storage, more rapid post-drought recovery of water levels, a possible improvement in the groundwater quality in the Saugus Formation (depending on the source of the injection water), and greater flexibility in the operations and management of the local groundwater sub-basin by the local water purveyors.

8. Groundwater Monitoring

Although a specific basin monitoring program has not been developed as part of this update report, it is expected that the database developed for this report will become the basis for the evolution of historical data collection and recording into a formal program of monitoring, data collection, and database maintenance. These monitoring efforts have actually begun in a cooperative and integrated manner along the entire Santa Clara River as a result of the MOU between the Santa Clarita Valley Water Purveyors and United Water Conservation District.

Data to be collected and interpreted in the MOU process, as part of ongoing groundwater management, should include:

a) Static and pumping water level monitoring in wells in both the alluvial and Saugus Formation aquifers.

b) Water quality data monitoring from wells in both aquifers and for surface water in the Santa Clara River and its major tributaries.

c) Rainfall records.

d) Annual groundwater production volumes by individual wells from all of the major water users, including private and agricultural users.

e) Detailed well construction information for new and existing wells.

f) Records of any well destruction activities, including the dates and methods used.

g) Historic data on aquifer parameters, as well as newer data acquired during well construction and testing.

h) Information on potential groundwater contamination sites obtained from available government and/or private databases and publications.

i) Discharge volume and water quality data for existing and future WRPs.

j) Other relevant data, such as major changes in land use.

9. Conjunctive Use and Management of the Alluvial and Saugus Formation Aquifers

Conjunctive use refers to the coordinated management and operation of multiple water supplies to achieve improved reliability of the water supply. In this aspect, the Santa Clarita Valley is fortunate to have two local aquifers that can be conjunctively used with imported SWP water to provide the Valley with a reliable supply of potable drinking water.

Since beginning to import a supplemental surface water supply in 1980, the Santa Clarita Valley Water Purveyors have been conjunctively utilizing that imported surface water with local groundwater from the alluvial and Saugus Formation aquifer systems. These conjunctive use efforts have allowed increasing water demands to be met while maintaining groundwater production within a range that precludes either aquifer from being in overdraft. A similar, but expanded, conjunctive use program, as described in detail in the 2000 UWMP, is expected to integrate additional supplemental sources of water supply in order to meet further projected increases in water demand while maintaining both aquifer systems within long-term sustainable yield, i.e. no overdraft.

A conjunctive use strategy for the Santa Clarita Valley could include:

a) Utilizing a combination of imported SWP water and groundwater from the alluvial aquifer during periods of average or above average rainfall (normal and wet years).

b) Increased pumping of the Saugus Formation during periods of lower than average rainfall in the valley (dry years), or during periods of decreased SWP water availability.

c) Enhancing the recovery of water levels and storage volume in the Saugus Formation through a program of artificial recharge, via injection, whenever additional water supplies are available.

d) Increasing the available storage capacity of the alluvial aquifer through increased pumping in the area east of Bouquet Canyon. This would serve to enhance both the natural recharge to the aquifer, and the effectiveness of an artificial recharge program using surface spreading basins in the same area.

## SECTION 1

# INTRODUCTION

Presented in this 2001 update report are our findings, conclusions and recommendations regarding the hydrogeologic conditions within the alluvial and Saugus Formation aquifer systems in the Santa Clarita River Valley of northern Los Angeles County, California. As shown on Figure 1.1 – Location Map – the area covered by this report is centered near the City of Santa Clarita, and extends roughly 21 miles from the Los Angeles – Ventura County Line on the west, to the town of Lang on the east. In a north-south direction, the study area extends approximately 13 miles from the intersection of Interstate 5 (I-5) and State Highway 14 on the south, to Castaic Dam on the north.

### Purpose and Scope of Services

This hydrogeologic study has been undertaken to update and expand upon two previous reports which were originally prepared for the Upper Santa Clara Water Committee (USCWC) by Richard C. Slade, Consulting Groundwater Geologist: the December 1986 report entitled *Hydrogeologic Investigation, Perennial Yield and Artificial Recharge Potential of the Alluvial Sediments in the Santa Clarita River Valley of Los Angeles County, California* [known as the Slade 1986 Report]; and the February 1988 report entitled *Hydrogeologic Assessment of the Saugus Formation in the Santa Clara Valley of Los Angeles County, California* [known as the Slade 1988 Report]. Specifically addressed in this 2001 update report are: updated geology and aquifer parameters; groundwater levels and groundwater quality in both the alluvial and Saugus Formation aquifer systems; an updated calculation of groundwater in storage in both aquifer systems; a discussion of the operational yield of both aquifer systems; and general considerations for conducting ongoing monitoring of both aquifers in the future, including data collection and management.

This project has been conducted for the water purveyors operating in the Santa Clarita Valley. These purveyors include four retail purveyors of domestic water and the Castaic Lake Water Agency (CLWA), which has a contract with the State of California to obtain water from the State Water Project (SWP) and which furnishes SWP water to these four retail purveyors. The four retail purveyors of domestic water are: Los Angeles County Water

Works District (LACWWD) No. 36 – Val Verde the Newhall County Water District (NCWD), the Santa Clarita Water Company (SCWC), a Division of CLWA, and the Valencia Water Company (VWC).

A summary of the hydrogeologic work tasks undertaken for this report is as follows:

Task 1 Acquisition of Basic Data

A. Recent geologic and hydrogeologic data and reports.
B. Precipitation data.
C. Water level data for alluvial and Saugus Formation water wells
D. Water quality data for alluvial and Saugus Formation wells.
E. Annual groundwater production data for alluvial and Saugus Formation wells.
F. Well construction and pump installation details for alluvial and Saugus Formation wells.
G. Accurate locations and wellhead elevations for alluvial and Saugus Formation wells.
H. Electric logs for new water wells and for additional wildcat oil wells.

Task 2 Production of Geographic Information System (GIS) Base Map and Digital Database

A. Acquisition of base map components including digital street data, topographic contours, rivers, etc.
B. Digital aerial photographs for land use evaluation.
C. Compile, verify and input data from Task 1 into electronic database and/or GIS format.
D. Import Global Positioning System (GPS) survey results of water well locations for the major purveyors in the Valley into GIS format (GPS survey carried out by others).
E. Update and digitize selected information from maps presented in the Slade 1986 Report and the Slade 1988 Report, and import into the new GIS format.

Task 3 Field Reconnaissance

A. Field reconnaissance of selected alluvial-supply water wells to collect non-pumping water levels.

B. Field reconnaissance of selected Saugus Formation water wells to collect non-pumping water levels.

Task 4 Current Land Use Patterns

Using aerial photography and the GIS system, identify and digitize the general location and extent of various land use types.

Task 5 Hydrogeologic Analysis

A. Identify local groundwater basins.

B. Discuss basic geologic conditions.

C. Review and re-define (as needed) key parameters for the alluvium and/or Saugus Formation, including thickness, extent, and depth to the base of fresh water, based on drilling and electric log data acquired since the mid-1980s.

D. Reinterpret existing and newly acquired electric logs from the Saugus Formation to identify key intraformational stratigraphic marker units.

E. Update existing geologic cross-sections, and construct new cross-sections.

F. Prepare and evaluate updated water level hydrographs (where possible) for selected municipal- and irrigation-supply wells.

G. Prepare and evaluate updated rainfall graphs.

H. Prepare and evaluate updated graphs of specific capacity (where possible) for selected municipal- and agricultural-supply wells.

I. Prepare updated water level elevation contour maps for both the alluvium and the Saugus Formation.

J. Re-assess aquifer transmissivity values for the alluvial and the Saugus Formation aquifer systems.

K. Update calculations of groundwater in storage for the alluvial aquifer and the Saugus Formation.

L. Provide recommendations for areas in the alluvial aquifer where artificial recharge projects might be considered.

M. Re-assess the Slade 1986 Report estimate of the operational yield of the alluvial aquifer.

N. Re-assess the Slade 1988 Report estimate of potential groundwater extractions that might be possible for the Saugus Formation on both short- and long-term periods.

O. Develop a program for groundwater monitoring within the Valley.

Task 6 Report Preparation

Prepare the updated hydrogeologic report, including large-format maps and a digital GIS-compatible database.

Task 7 Meetings

Prepare for and attend meetings with the local water purveyors.

**Sources of Data**

One of the most ambitious goals of this project has been the research and compilation of a digital dataset that brings together available information pertaining to groundwater in the Valley. Included in this dataset are details of water well construction, annual groundwater extractions, historic groundwater levels and groundwater quality, and both surface and subsurface geology, all in a format compatible with commonly available GIS software.

This unified digital dataset provides a number of significant benefits, in that it:

- Serves as a common, easily accessible source of information and data on groundwater in the Valley.
- Facilitates the cooperative and ongoing management of groundwater resources among the various purveyors.
- Reduces the time required to prepare future annual water reports.
- Facilitates planning and siting of new wells, and the destruction of old ones.
- Simplifies the analysis of wellhead protection/vulnerability studies.
- Greatly simplifies the distribution of data to consultants retained by the member water agencies.
- Facilitates detailed, accurate and rapid analysis of groundwater and geologic data.
- Allows new data to be rapidly incorporated into existing datasets.
- Permits the transfer of data to and from groundwater modeling software.
- Allows groundwater maps be created, updated and printed in hours instead of days or weeks.

Previous Studies

Because the study area overlies several producing and former oil fields, there exist numerous published and unpublished geologic reports and maps dealing with surface and subsurface geologic conditions in the hills and mountains surrounding the Valley. The earliest works date from the period 1902 to 1924 (importantly, Kew, 1924) and document the initial efforts at naming and mapping the surface exposures of the stratigraphic units and geologic structure in the region.

With the discovery of larger oil fields between the late-1930s and the late-1940s, there was a renewed interest in the geology and the potential for additional petroleum development. Mapping by such workers as Bailey (1954) and Crowell (1954) added considerable detail to the known stratigraphy and to major geologic structures like the San Gabriel fault. Other particularly significant geologic reports include those by Winterer and Durham for the U. S. Geological Survey (1962) and by Oakeshott (1958) for the California Division of Mines and Geology. More recent studies include university theses by Nelligan (1978) and by Stitt (1980).

Considerable information is available to document the history of oil field development in the greater Santa Clarita Valley region. The majority of these reports have been published by the California Division of Oil and Gas. From its Ventura office, the Division of Oil and Gas maintains comprehensive files on the well histories and geophysical electric logs for the large number of existing and former wildcat and producing oil wells in the region.

In contrast to the geology and oil well data, published hydrogeologic and hydrologic information for the region is not nearly as abundant. With the exception of the Slade 1986 Report, the Slade 1988 Report, and the Los Angeles County Flood Control District (LACFCD) annual maps of the region showing water level data for key wells, there have been no previously published studies detailing aquifer characteristics, water well construction and testing, water level elevation fluctuations, or water quality variations in water wells throughout the region.

Previous assessments of the local hydrogeologic conditions are limited to those by: Robson (1972) for the U.S. Geological Survey, which provided the results of an analog computer model of the Saugus-Newhall area; the 1979 State Department of Water Resources (DWR) report, which provided a reconnaissance-level evaluation of the potential for storing excess water from the SWP within the several groundwater basins located along the Santa Clara River in Los Angeles and Ventura counties; the Department of Water Resources (DWR, 1975 and 1980) which identified the boundaries of the various groundwater basins in the region; and numerous maps by the LACFCD which provided water level elevations contour maps for various years.

Many of the references listed above are cited in the Slade 1986 Report and/or the Slade 1988 Saugus Report. Key references specifically cited in this 2001 update report are provided herein in Section 7 – References Reviewed.

*Water Wells*

Well construction details were obtained from a variety of sources, including the Slade 1986 Report, the Slade 1988 Report, other in-house reports and files for other projects by this investigator subsequent to 1988 for the area, the local major Santa Clarita Valley Water Purveyors, and from State water well completion reports. In some cases, particularly with older or privately-owned wells, information on well construction details was often unavailable.

As of 2001, a total of 30 deep Saugus Formation water wells had been drilled and constructed for municipal-supply and/or irrigation-supply purposes in the Valley. Of these wells, 13 have been abandoned and/or destroyed, whereas the remaining 17 either have remained in operation or are on inactive or standby status. Also as of January 2001, there were 61 currently active alluvial water wells in the Valley; of this number, 37 were used for municipal-supply purposes and 24 were used for irrigation-supply by the Newhall Land & Farming Company (NLF), the largest agricultural user of groundwater in the Valley. The number, usage, viability and location of small, individual, domestic-supply water wells in the alluvial and Saugus Formation aquifer systems in the region are unknown.

Electric logs (e-logs) are available for nearly all of the currently active Saugus Formation water wells, as well as for a number of the currently active municipal-supply alluvial water wells.

An attempt was made to determine the correct and/or complete State Well numbers (SW Nos.) and Los Angeles County Flood Control District numbers (LACFCD Nos.) for wells owned by the major purveyors in the study area. It was hoped this would permit the use of water level records maintained by these agencies together with those maintained by the U.S. Geological Survey (USGS) and LACFCD. Unfortunately, the database of SW Nos.

maintained by the DWR is incomplete and in some cases contradicts other sources of information. The LACFCD records are equally lacking, and although a few SW Nos. and LACFCD Nos. have been updated, there are still numerous wells for which these data remain incomplete. As a result, we are relying in this report solely on the well name or well number designated by its owner for each well discussed in this report.

One major improvement in data collection reflected in this report has been the accurate surveying of the locations of the known Santa Clarita Valley Water Purveyor water wells, as well as a number of other important wells in the area. The surveying program was carried out in December 1999 by Penfield and Smith Engineers & Surveyors, Inc. using a GPS receiver. A total of 99 wells were surveyed.

The GPS receiver used for this study was a Trimble Pathfinder Pro/XRS, and the locations were differentially corrected to a theoretical horizontal accuracy of ±1 meter horizontally and ±2 to 3 meters vertically. Well locations were stored in a Microsoft Access 2000 database in latitude/longitude coordinates, NAD83 datum, and random field checking of these locations by us and others, has revealed them to be accurate for the purposes of this project. However, in reviewing the positional data, errors in the vertical elevation of several wells were discovered because certain wellhead elevations derived from the GPS survey did not agree with the elevation of the ground surface as shown on the USGS 1:24,000 scale topographic contour maps. In these cases, the well elevations were adjusted to match the published USGS digital elevation map.

The positions of historic wells that were destroyed prior to 2000 were digitized from the original Mylar maps that were used in publishing the Slade 1986 Report and the Slade 1988 Report. The locations shown on the current maps for these historic wells are only approximate.

### *Groundwater Extractions*

For the period from 1947 to 1984, groundwater extraction data were available only as a yearly value for each purveyor. Although the database of groundwater production contains some individual well data prior to 1984, those data should not be used to calculate total production figures. The total groundwater production from 1947 to 1966 is a minimum figure, because the only complete production records for this early period are those from NLF; during that period, NLF–owned water wells extracted the majority of the groundwater production from the local aquifer systems.

From 1984 to the present, groundwater production data are generally available for the individual municipal-supply wells on a yearly basis. The acre-feet per year (AF/yr) values for the NCWD, SCWC and VWC wells are from metered production at each well. For the NLF wells, the reported extractions were estimated from kilowatts of power consumed converted to AF/yr by reference to the results of annual Edison efficiency tests. For the Wayside Honor Rancho (WHR) wells, the actual quantity of water pumped is not known because the individual wells at that facility are not metered. Instead, the annual extractions reported for WHR are based on their estimated water consumption using an estimated number of prisoners and staff using the facilities.

### *Water Levels*

Static water level data supplied by the water purveyors for this project vary considerably in quality and completeness. In some cases, static water levels have been measured on a consistent, once-per-month basis and stored in a regularly updated digital database. In other cases, water level measurements have been taken sporadically or not at all, and data gaps of a few months to several years in duration may exist in the historical records. For this report, available pumping and static water level data for wells in both the alluvial and Saugus Formation aquifer systems have been entered into a Microsoft Access database. In addition, customized queries and reports have been written to provide tables of water level data, and to prepare water level hydrographs for individual wells.

For the alluvial aquifer, the extent of available water level data is as follows:

- A dataset for thirteen of the SCWC wells for the period from 1973 to the present.
- A dataset for eight of the NCWD wells covering the period from the early 1980s to the present.
- A dataset for the fifteen currently active VWC wells, from the early 1990s to present. In addition, some data exist for these same wells from the 1950s to the mid-1980s.
- Finally, for NLF wells, some data exist from the mid-1950s to the early-1980s, little or no data are available for the latter part of the 1980s, and data collected from

Edison Company well efficiency test records (which typically include a static water level data point) were obtained for the period from approximately 1990 to the present.

The alluvial aquifer water level data described above were compiled from our in-house files, purveyor water level records, and available Edison test datasheets. Recorded static water levels in some cases may represent partially recovered, post-pumping water levels, especially for active NCWD wells.

For the Saugus Formation, the extent of available water level data can be summarized as follows:

- A dataset for six of NCWD's Saugus Formation wells from the mid-1980s to the present.
- A dataset for the two SCWC Saugus Formation wells from their construction in the late-1980s to the present.
- A dataset for VWC Well Nos. 157 and 160 from the early-1950s to the present
- Limited available information on water levels for VWC Well No. 159 from 1992 to the present.
- A dataset for VWC Well No. 201 from 1990 to the present.
- For NLF Well No. 156, some data exist from the mid-1950s to the early-1980s, little or no data are available for the latter part of the 1980s, and a few once-per-year Edison test records were obtained for the period from approximately 1990 to the present.

The Saugus Formation water level data described above were compiled from our company files, purveyor water level records, and available Edison test datasheets. Water levels in some cases may represent partially recovered, post-pumping water levels, especially for active NCWD wells.

*Water Quality*

Water quality data, including general mineral chemistry data on common dissolved cations and anions, as well as inorganics (metals), VOCs, and perchlorate, were obtained primarily from the local water purveyors. Some additional data were derived from our company files, and from the databases maintained by the California Department of Health Services (DHS) and DWR.

Because various agencies, including the DHS, require that drinking water sources such as water wells be tested on a regular basis, water quality data are readily available for the wells used by the various purveyors for municipal-supply purposes in the Valley. Considerably fewer water quality data are available for the NLF wells, because these are used only for agricultural-supply purposes.

Further groundwater quality data are available from a recent re-examination of available TDS data from Saugus Formation water wells in the Valley; this re-examination was carried out as part of a May 2000 presentation by our firm to the California Public Utilities Commission (PUC) on behalf of VWC. The original laboratory data were used to re-calculate TDS concentrations using a more standard, additive method described in a USGS report by Hem (1985). These data were then compared to historic pumping and water level records to look for possible trends in TDS concentrations over time, and to examine if these trends were related to changes in groundwater production.

### *Surface Geology*

The geology of the study area was originally compiled from published sources and presented in the Slade 1986 Report and the Slade 1988 Report for the alluvial aquifer system and the Saugus Formation aquifer system, respectively. For this current update, the original geological units and features shown in those reports were digitized, and in some cases updated using newer published sources (for example, Dibblee, 1996). No major changes have been made to the original geologic maps, although some minor adjustments have been made to the boundaries of the alluvium unit, and to the degree of certainty attached to the mapped location of a portion of the Holser fault across a portion of the Valley.

### *Subsurface Geology*

For the Slade 1988 Report, the subsurface geology of the Saugus Formation was compiled from published reports and from an examination of a few hundred e-logs from oil industry exploration and production wells. The locations of approximately 140 of these oil wells are shown on several maps in that Slade 1988 Report, along with various subsurface geologic contours (depth to the base of fresh water, the thickness of sand units in the Saugus Formation, etc.).

For this 2001 updated report, we have re-examined and re-interpreted the e-logs for each of the 140 oil wells depicted in the Slade 1988 Report (plus approximately 30 additional wells) in order to obtain more detailed subsurface geologic information for the Saugus Formation. The location of each of these wells has been digitized from the original 1988 report map, for use in the GIS system. From each of these approximately 170 e-logs, total sand thicknesses were re-calculated for the depth zone between 300 ft and 2500 ft below ground surface (bgs), or to the base of fresh water, whichever was shallower. Also re-calculated for each of these ±170 wells were the depth to the base of fresh water, the total Saugus Formation thickness, and the depth to the top of a prominent e-log marker bed unit within the Saugus Formation (herein termed the Santa Clarita Aquifer Zone). In addition, a new geologic cross-section Z-Z' (see Plate 3.3 in Section 3 of this report) that parallels the Santa Clara River has been completed across the area from east to west.

**GIS Compilation**

Data acquired and compiled for this report have been formatted for use with GIS software. This was done to facilitate the updating of maps with newly acquired or corrected data, and to utilize the powerful data manipulation abilities of GIS packages. To accomplish this objective, we first constructed a useable base map of the Valley, combining data from a wide variety of sources as described below.

Topographic contours for the base map were derived from USGS 1:24,000 scale digital elevation models, using TopoDepot, a commercially available software package produced by Sylvan Ascent Inc. of New Mexico. Although they vary slightly in detail from the contours found on printed USGS 1:24,000 topographic quadrangle sheets, the TopoDepot contours are considered to provide sufficiently accurate elevation data for the project area.

Hydrographic features for the base map (streams, reservoirs, etc.), and the Public Lands Survey System (PLSS) features (sections, townships & ranges) were taken from publicly available USGS Digital Line Graph (DLG) files downloaded from the USGS web site. The hydrographic features were digitized by the USGS from 1:100,000 scale topographic maps, and therefore tend to be somewhat generalized in appearance.

The PLSS data are much more accurate, but some caution must be exercised regarding their use with water well and oil well data provided by the State of California. The PLSS sections depicted on the maps supplied with this report include large blank areas where the PLSS system ends at the boundaries of the large historic Spanish land grants. Both the DWR and the Department of Oil and Gas have created artificial section lines that project across these land grant areas in order to assign State Well Numbers to water wells and oil wells. However, these different projections frequently fail to accurately line up with one another, and are therefore not compatible or interchangeable.

The road and freeway network in the Valley was obtained from the Los Angeles County Public Works Department (LACPWD) GIS system. The original data were accurate with respect to location, but contained numerous errors in attribute coding which required our firm to perform extensive editing and correction before use in our base map.

In order to review current land use patterns and distribution, high-resolution seamless color aerial photography covering the entire study area was obtained from Eagle Aerials Ltd. This photography is in digital format with an approximate 1 meter ground resolution, and was flown in June, 2000. Approximate land use polygons were digitized from the aerial photography, although the actual land use categories were not verified by field checking.

## SECTION 2

# AREA OF INVESTIGATION

### Study Area

As shown on Figure 1.1 - Location Map - the roughly rectangular-shaped study area extends from approximately the Los Angeles– Ventura County line on the west, to the community of Lang on the east, and from the southern end of Castaic Lake on the north, to the intersection of the Golden State and Antelope Valley freeways on the south. The study area includes the valley of the Santa Clara River and its major tributary canyons, as well as a large area of rugged hills on the north and south sides of the river.

Elevations along the river valley range approximately from 1800 ft above mean sea level (asl) at Lang at the easterly limit of the region, to 800 ft asl at County line at the western boundary. The overall river gradient across this reach is on the order of 0.009 ft/ft (about 50 feet per mile). Maximum elevations in the hills north of the river are on the order of 2500 to 3000 ft asl, whereas maximum elevations to the south are typically 4000 ft asl in the San Gabriel Mountains and 3000 ft in the Santa Susana Mountains. The highest elevations in the region include Mt. McDill (5180 ft asl) in the headwaters of Mint Canyon north of the Santa Clara River, and Mt. Gleason (6532 ft asl) in the Condor Peak quadrangle south of the Santa Clara River and several miles southeast of the study area.

The largest community in the study area is the City of Santa Clarita, which was formed in 1987 through the amalgamation of the communities of Newhall, Valencia, Saugus, and Canyon Country. Other, smaller, unincorporated communities in the study area include Stevenson Ranch and Val Verde in the west, Castaic in the northwest, and Lang in the east.

The US 2000 Census revealed the population of the City of Santa Clarita to be approximately 151,260; see the approximate City limits on Figure 1.1. The Southern California Association of Governments (SCAG) estimates the population of the surrounding unincorporated Santa Clarita Valley at 48,237 (M. Modugno, City of Santa Clarita Planning Dept., personal communication, 2001); hence, the total current population of the Valley is approximately

200,000. This represents a significant increase over the 1980 Valley population of 79,000 reported in the Slade 1986 Report.

Accompanying this rapid population increase has been a gradual change in valley land use patterns, from largely agricultural use to urban and suburban developments. Nevertheless, a considerable portion of the hills and low mountains bordering the main river valley remain in a natural, undeveloped condition.

**Climate**

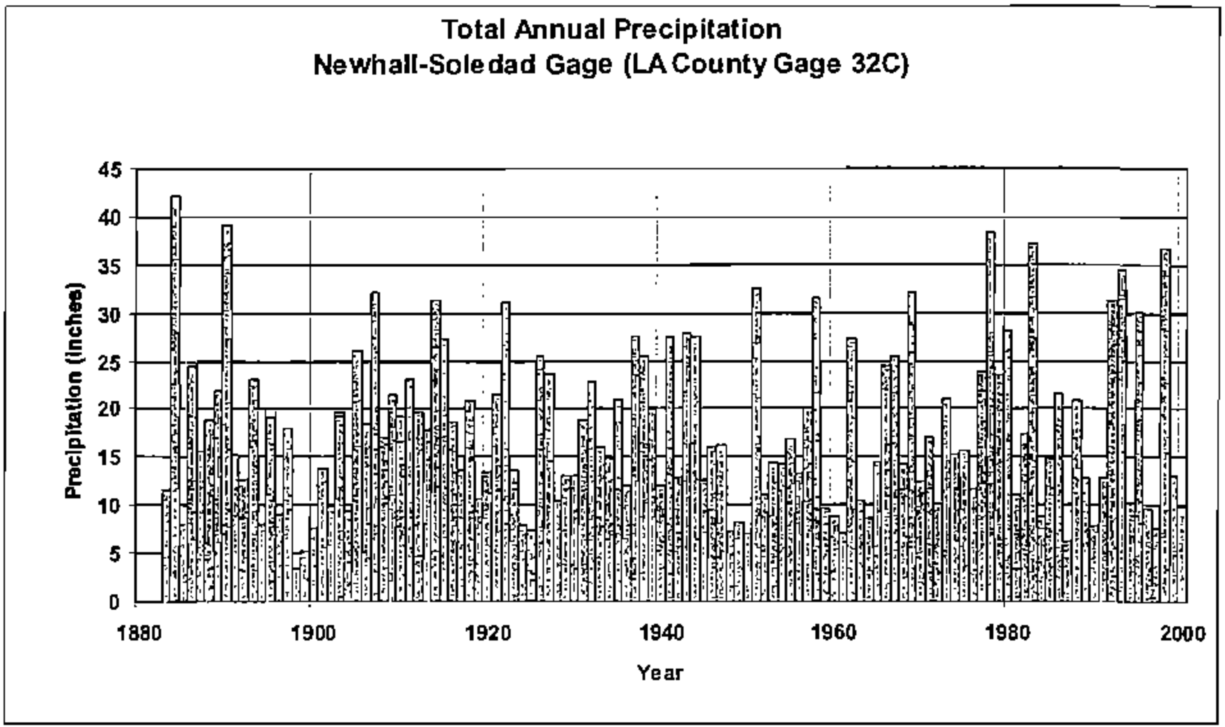
The study area has a semi-arid, Mediterranean-type climate characterized by long, dry summers and relatively short, wet winters. Temperatures in the Valley range from a maximum of approximately 100°F during the summer, to a minimum of 30°F in the winter. Mean monthly temperatures range between approximately 77°F in the summer, to 48°F in the winter.

Rainfall data have been obtained from LACFCD for the Newhall-Soledad gage (Station No. 32C), located near San Fernando Road in the community of Newhall. This gage has a period of record of 1883 to 2000. Unfortunately, the two rainfall gages (Stations Nos. 200 and 1009) discussed in the Slade 1986 Report have been discontinued. Figure 2.1 - Rainfall Totals and Cumulative Departure Curve – presents graphs of both the annual precipitation by water year (October to September), and the cumulative departure from the mean precipitation for the Newhall-Soledad gage.

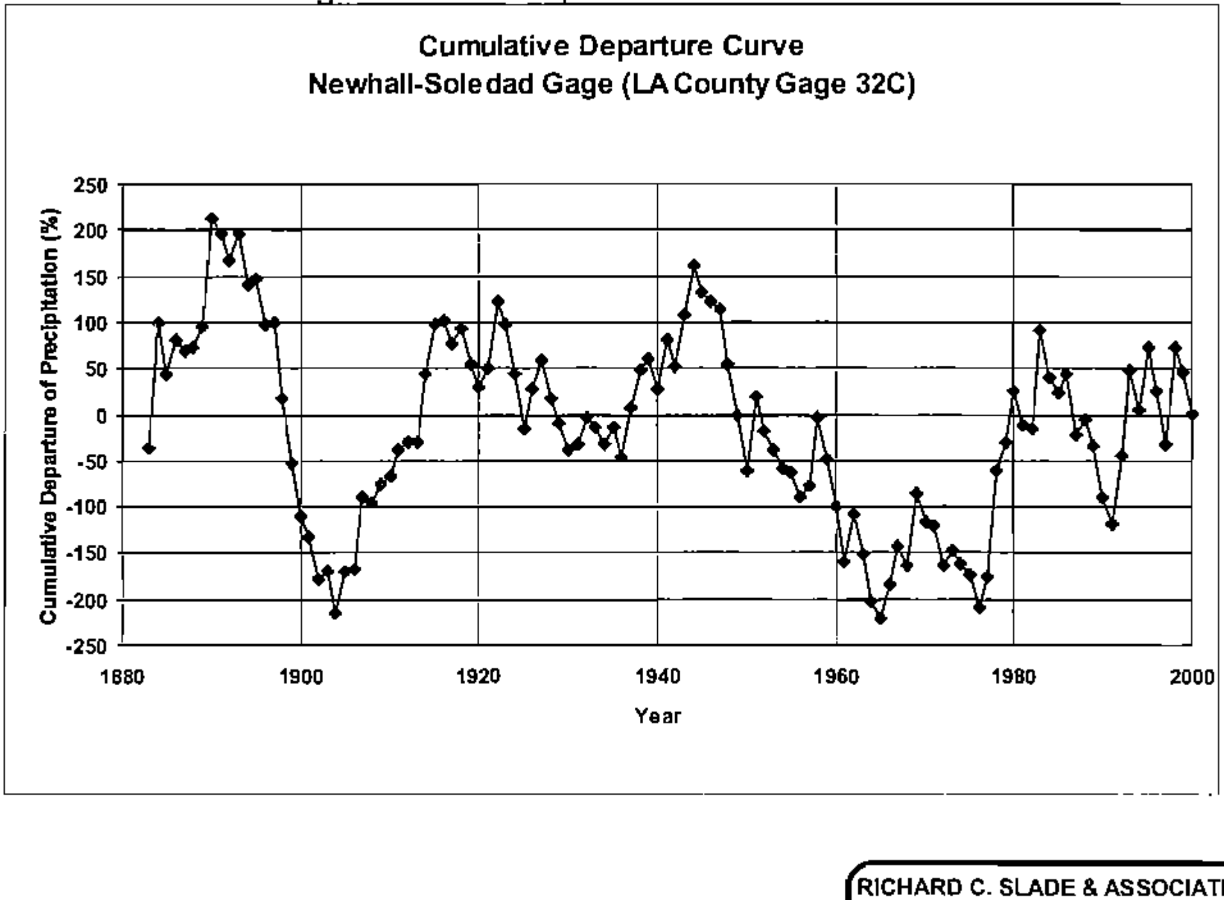
Review of the rainfall data from the Newhall-Soledad gage reveals the following:

- the average rainfall for the 1883 to 2000 period of record (118 years) is 17.95 inches.
- the highest amount of annual rainfall for the period of record is 42.11 inches in 1884, whereas the lowest historic annual total is 3.32 inches in 1898.
- annual rainfall totals show high variability from year to year.

Approximately 80 percent of the annual precipitation in the Valley falls between November and March. Most of these winter storms last only a few days, and are separated by relatively long periods of clear weather.



Average rainfall for period of record = 17.95 inches



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CONSULTING GROUNDWATER GEOLOGISTS

**FIGURE 2.1**
**Rainfall Totals & Cumulative Departure Curve**

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The cumulative departure curve for rainfall (see Figure 2.1) illustrates trends in the amount of rainfall over time, such that when the curve is descending towards the right (such as from 1890 to 1904, or from 1944 to 1965), an extended period of generally deficient precipitation (drought) has been occurring. In contrast, whenever the curve ascends to the right (such as from 1976 to 1983), an extended period of generally excess or increasing precipitation (wet period) has been occurring. As seen on the cumulative departure curve, the Valley has experienced episodic cycles of dry years followed by periods of wet years. However, these cycles show no discernable periodicity that might be used for predictive purposes.

### Drainage

The Santa Clara River provides regional drainage in an east to west direction across this portion of Los Angeles County, and continues westerly across Ventura County to the Pacific Ocean. This river has its headwaters in Soledad Canyon in north-central Los Angeles County and includes a watershed area of several hundred square miles.

Principal tributaries draining the northern side of the study area include, from east to west, Mint Canyon, Bouquet Canyon, San Francisquito Canyon, and Castaic Creek Canyon. Principal tributaries draining the southern side of the Valley include, from east to west, Oak Spring Canyon, Sand Canyon, and Potrero Canyon.

The South Fork of the Santa Clara River, which drains in a northerly direction toward its confluence with the main reach of the Santa Clara River (located just west of Bouquet Junction), has Placerita Creek Canyon, Newhall Creek Canyon, and Pico Canyon as its main tributaries.

Because the headwater areas of these drainages do not extend into high mountainous areas, and because the local climate precludes the buildup of a large snow pack in the watersheds, surface water runnoff in all of the canyons is ephemeral and diminishes rapidly after most rainfall events. Local springs and areas of rising water, together with outflows from the local WRPs, tend to maintain flows even in the summer months within the main reach of the Santa Clara River west of Bouquet Canyon. Following severe storms, river discharge has been reported to increase from nearly zero flow to as high as thousands of cubic feet per second within a few hours.

The annual volumes of runoff in the river vary directly with annual rainfall, but, in general, are considered to have increased over time due to two man-made activities: the increased importation and use of water in the area from the SWP; and the increased releases, over time, from the two local WRPs. Surface water runoff from the river drains westerly into Ventura County at County line at the western edge of the study area for this project (see Figure 1.1). This represents the only direct connection of surface water flow between the Valley and Ventura County.

### Local Water Purveyors

Domestic water purveyors located within the study area include LACWWD No. 36, NCWD, SCWC (a Division of CLWA), and VWC. These four domestic water purveyors and the CLWA make up the management committee for whom this report was prepared. LACWWD No. 36, SCWC and NCWD represent public agencies, whereas VWC is privately owned. Of the four domestic water purveyors, only LACWWD No. 36 has no active wells in either the alluvial or Saugus Formation aquifer systems within the study area.

In addition to the groundwater extractions by the local purveyors, supplemental water is provided to these purveyors for use in the Valley by CLWA via the SWP. SWP water, which is transported from the California Aqueduct, first became available to the Valley area in 1980. CLWA also delivers highly treated recycled water from one of the two WRPs in the Valley, owned by the Sanitation Districts of Los Angeles County, in order to help meet non-potable water demands (golf courses, landscape irrigation, etc.).

### Groundwater Basins

The DWR establishes the official names and locations of groundwater basins throughout California (Bulletin 118). At the time of the original Slade 1986 Report and the Slade 1988 Report on the Valley, the alluvial and Saugus Formation aquifer systems were included within an area known as the Eastern Hydrogeologic Subunit of the Santa Clara River Valley Unit. In addition, these two aquifer systems were considered to represent the only two water-bearing formations within the Valley. For the purposes of this report, the water-bearing sediments comprising the alluvial and Saugus Formation aquifer systems are considered to be those earth materials that are capable of providing groundwater in useable quantities and of acceptable quality for beneficial use by the municipal-supply water purveyors. Underlying these water-bearing sediments beneath the Valley and also forming the lateral (surface) margins of the local groundwater reservoir is a very thick accumulation of older sedimentary rocks that are considered to be essentially nonwater-bearing in terms of their general ability to provide groundwater for municipal-supply purposes.

In recent years, DWR has begun a process of updating its Bulletin 118 and has provided new GIS-format maps of its updated basin boundaries and names. Figure 2.2 – Groundwater Basins and Sub-basins – depicts the location and current nomenclature for the official groundwater basins along the Santa Clara River between the City of Santa Clarita on the east and the Pacific Ocean on the west, as adapted from recent DWR work. The alluvial and Saugus Formation aquifer systems are now together considered to lie within the Santa Clara River Valley East Groundwater Sub-basin of the Santa Clara River Valley Groundwater Basin.

DWR basin boundaries were selected on the basis of such features as faults, groundwater divides, exposures of bedrock in the hills, or areas of rising water caused by the presence of bedrock shallowly underlying river alluvium. Where none of these types of conditions exist, arbitrary or even political divides were selected as boundaries between the aforementioned groundwater basins and subbasins.

The western boundary of the Santa Clara River Valley East Groundwater Sub-basin is currently taken at County line where it meets the adjoining (downstream) Piru Sub-basin of Ventura County. The eastern boundary of the local groundwater sub-basin occurs at a narrows along the Santa Clara River near Lang. Upstream (east) of the Santa Clara River Valley East Sub-basin, and separated by a gap of approximately three miles, is the Acton Valley Groundwater Basin.

The only outflow from the Santa Clara River Valley East Groundwater Sub-basin to Ventura County occurs via direct subsurface outflow from the saturated portions of the alluvial aquifer

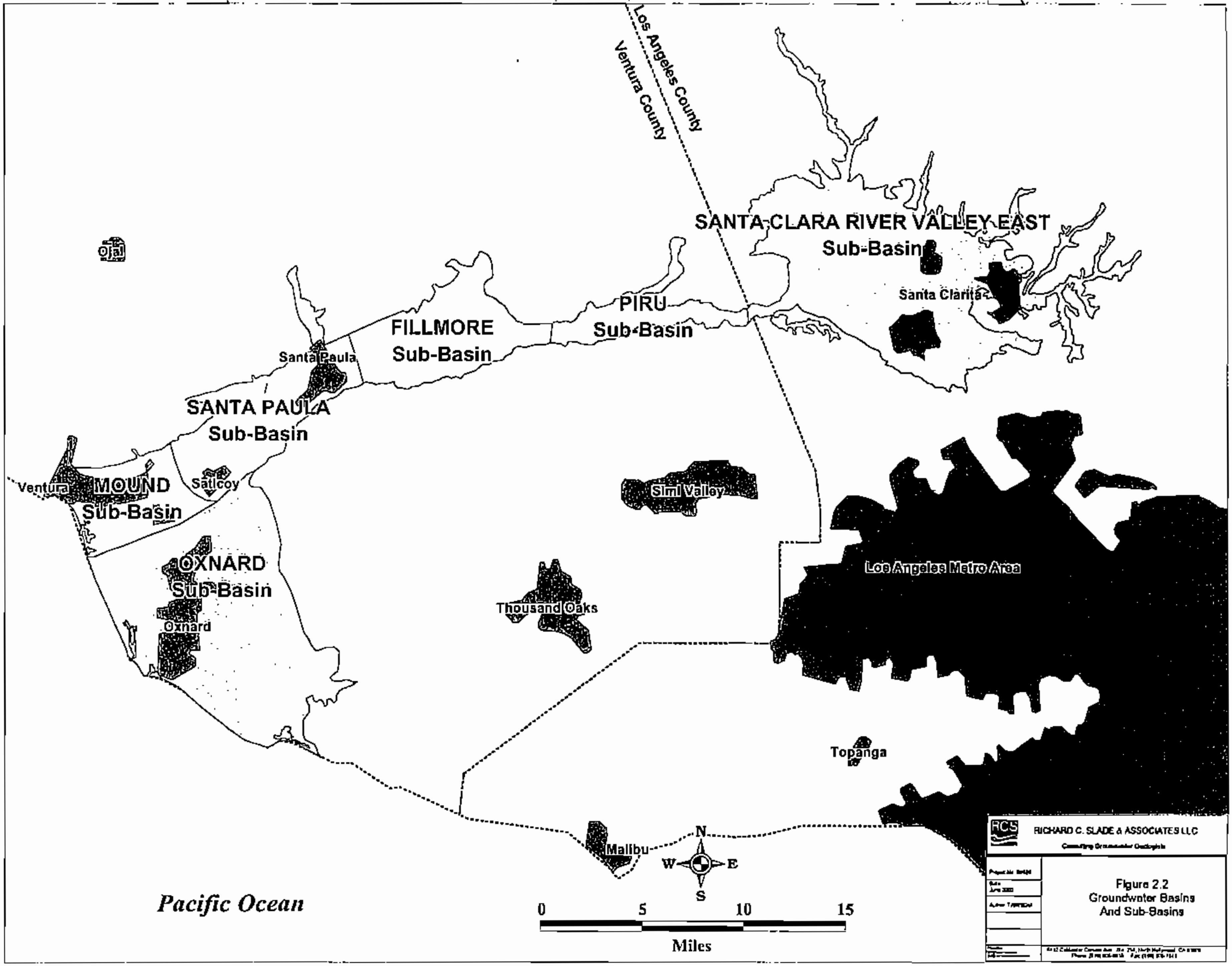

Figure 2.2
Groundwater Basins
And Sub-Basins

system of the Santa Clara River at County line; surface water outflow to Ventura County occurs only via direct surface runoff in the Santa Clara River at County line (see Figure 2.2).

## SECTION 3

## SUMMARY OF GEOLOGIC CONDITIONS

### General Statement

Geologic materials illustrated on Plate 3.1 – Geologic Map of the Santa Clarita Valley - have been divided according to their relative water-bearing characteristics, that is, by their relative ability to contain, transmit, and yield groundwater to wells. As such, two divisions are recognized in the Valley: a water-bearing sediment group and a non-water-bearing bedrock group.

The water-bearing sediments consist of a blanket of unconsolidated alluvium of Quaternary geologic age (map symbol, Qal) that covers the floor of the main river valley and its tributary canyons, and the consolidated sediments of the slightly geologically older Saugus Formation (Pliocene to Pleistocene geologic age; map symbol, QTs) which underlie the alluvium. Scattered outcrops of Quaternary-age Terrace deposits (map symbol, Qt) likely have the capacity to contain limited amounts of groundwater on a seasonal basis, but these deposits crop out in only limited areas that are typically situated at elevations above the regional water table.

The alluvium and the Saugus Formation have been penetrated to various depths by numerous water wells and have historically provided all the groundwater extracted in the Valley for municipal-supply purposes. Underlying the water-bearing sediments and exposed on the hillsides beyond the limits of the Saugus Formation exposures are the various older geologic formations that comprise the relatively impermeable, non water-bearing bedrock.

### Water-Bearing Sediments

#### Alluvial Deposits

Sediments shown on Plate 3.1 as Quaternary alluvium range in geologic age from Quaternary to Holocene (Recent), and consist primarily of stream channel and floodplain deposits of the Santa Clara River and its tributaries. Geologic logging performed by RCS geologists during recent water well drilling activities, and an analysis of drillers' logs of older water wells, reveals that the alluvial sediments are composed of complexly interlayered and interfingered beds of gravel, sand, silt, and clay, with variable amounts of cobbles and boulders. In general, alluvium along the main reach of the Santa Clara River ranges from cobbly- or gravelly-sand in the east, to medium-grained sand in the west. Due to its unconsolidated to poorly consolidated nature and its lack of cementation, the alluvium is considered to have relatively high permeability and porosity.

The maximum thickness of alluvium varies along the Santa Clara River, but generally is considered to be about 200 feet along the main reach of the river. Typically, the alluvium tends to be thickest near the central portion of the main river channel, but then thins or pinches out near the base of the adjoining hills.

Geologic logging of the pilot boreholes for municipal-supply water wells constructed in recent years within the alluvium along the main reach of the Santa Clara River reveals that the alluvium has maximum depths of approximately: 114 ft at SCWC Mitchell Well No. 5B (drilled in 2001); 155 ft in SCWC Lost Canyon Well No. 2A (drilled in 1989); 160 ft in VWC Well W-10 (drilled in 2001); and from 180 ft to 200 ft in VWC Wells S-6, S-7 and S-8 (drilled in 1999 to 2000). Locations of these alluvial wells are shown on Plate 4.1 in Section 4 of this report.

Alluvium in the tributary canyons is generally thinner than that along the main river valley. Larger tributary canyons such as Castaic Creek, San Francisquito Canyon and Bouquet Canyon are typically underlain by more laterally extensive and thicker accumulations of alluvium than which exist within the smaller canyons like Oak Spring or Pico canyons. In these latter canyons, the maximum alluvial thickness occurs near the confluence with the main river valley and is considered to be on the order of 100 feet.

Only two active municipal-supply alluvial wells (VWC W-9 and W-10) have been constructed in recent years in any of the major tributaries of the Santa Clara River. Well W-9 was drilled in 1990 in San Francisquito Canyon, approximately 7000 ft north of its confluence with the main reach of the Santa Clara River (see Plate 4.1). Geologic logging of the pilot hole for this well revealed that the alluvium has a maximum thickness of approximately 140 ft at this location. VWC Well W-10 was drilled in 2001 near the confluence of San Francisquito

Canyon and the Santa Clara River (see Plate 4.1). At this location, the alluvium was geologically logged to a depth of 160 ft.

Another well (now destroyed) was drilled in 1990 along San Francisquito Canyon (VWC No. 202, a Saugus Formation well), approximately 9500 ft north of its confluence with the Santa Clara River (see well location on Plate 5.1 in Section 5 of this report). Geologic logging of the pilot hole for this well revealed the alluvium to be approximately 50 ft thick at this location.

The approximate thickness of alluvium logged in the borehole for a new alluvial groundwater monitoring well in the South Fork area is 190 ft. This monitoring well was constructed in 2000, approximately 40 ft south of VWC 201, as part of the assessment of the feasibility for an aquifer storage and recovery (ASR) program in the Saugus Formation (Slade and Associates LLC, February 2001).

Geologic logging of the pilot boreholes for Saugus Formation water wells drilled since the Slade 1988 Report, and/or correlation of electric logs for existing Saugus Formation wells, reveal the following information on the approximate maximum thickness of the alluvial deposits at these sites (see well locations on Plate 5.1):

a. South Fork area: approximately 80 ft in NCWD-13; 120 ft in NCWD-12; 170 ft in Saugus Well No. 1; and in the range of 150 ft to 180 ft in SCWC Saugus Well No. 2.

b. Main Reach Santa Clara River: less than 50 ft at V-205; 120 ft at V-158; 190 ft at V-157 and V-201; 220 ft at V-203; and approximately 240 ft at V-160.

### Terrace Deposits

Terrace deposits are isolated remnants of what was, during the late Pleistocene, a continuous blanket of alluvial material covering the entire floor of the Santa Clara River Valley (Winterer and Durham, 1962). Tectonic uplift of the valley floor led to downcutting and incision of this geologically older alluvial material by the Santa Clara River, leaving the terrace deposits restricted to platforms or benches that are now topographically higher than the Santa Clara River, and hence above the regional water table. Sediments comprising the terrace deposits include crudely stratified, poorly consolidated reddish-brown gravel, sand and silt (Winterer and Durham, 1962). Terrace deposits may be weakly cemented by iron oxides, clay minerals, or calcium carbonate. Plate 3.1 illustrates the locations of the surface exposures of terrace deposits in the Valley as mapped by others.

Terrace deposits reportedly may be up to 200 ft thick in some areas, but because they are of limited areal extent and because they are generally above the regional water table, they are not considered a viable source for the development of groundwater resources. However, limited zones of perched groundwater may be locally present in portions of these terrace deposits on a seasonal basis. No wells in the Valley have ever been known to extract groundwater from these terrace deposits.

### Saugus Formation

The Saugus Formation has traditionally been divided into two stratigraphic units: the lowermost, geologically older Sunshine Ranch Member which is of mixed marine to terrestrial origin; and the remaining, overlying or upper portion of the formation which is entirely terrestrial (non-marine) in origin (Winterer & Durham, 1962); refer to Figure 3.1 – Saugus Formation Stratigraphy – for details of the stratigraphy. The Saugus Formation has been assigned a Pliocene to Pleistocene geologic age based on rare fossil occurrences (Winterer and Durham, 1962).

South of the San Gabriel fault, the gradational contact between the Sunshine Ranch Member and the underlying, geologically older Pico Formation represents a gradual transition from a marine to a continental (terrestrial) environment of deposition throughout the entire study area. Because of its gradational nature, the location of this contact is sometimes difficult to accurately identify, either visually in the field or from e-log correlations.

The Sunshine Ranch Member of the Saugus Formation comprises interfingering shallow marine, brackish-water, and nonmarine deposits of interbedded gray to greenish-gray sandstone and siltstone. Fossils found within the Sunshine Ranch Member indicate an upper Pliocene geologic age for this part of the Saugus Formation. The Sunshine Ranch Member obtains a maximum thickness of approximately 3,500 ft in the central part of the Valley.

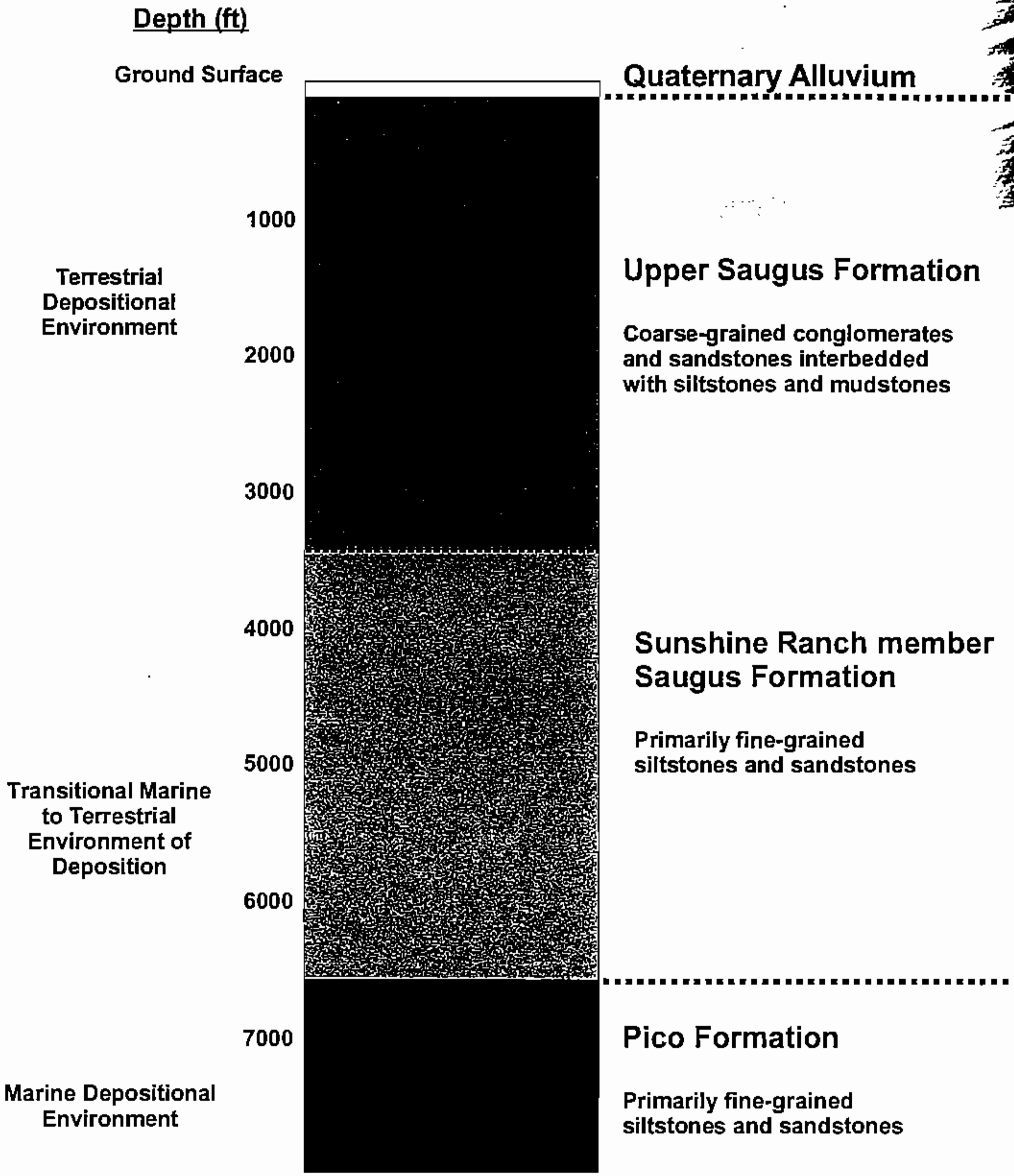

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FIGURE 3.1
Saugus Formation Stratigraphy

JOB NO. S9920 June 2002

Because of the marine origin and the fine-grained nature of the Suns[illegible]anch Member, it is not considered to be a viable target for groundwater exploration or production for municipal-supply purposes. Wells drilled near the periphery of the surface exposures of the Saugus Formation, that is, where the Sunshine Ranch Member is at or very close to ground surface, have typically produced groundwater at rates too low for municipal-supply purposes. Evidence from e-logs also suggests that the groundwater in much of the Sunshine Ranch Member may be somewhat brackish in quality and, hence, not useful for municipal-supply purposes.

Stratigraphically above the Sunshine Ranch Member, the Saugus Formation becomes coarser-grained, consisting mainly of lenticular beds of light-gray and brown sandstone and conglomerate that are interbedded with lesser amounts of reddish-brown sandy mudstone. These terrestrial sediments were deposited in stream channels, floodplains and alluvial fans by one or more ancestral drainage systems in the Valley area. The coarser-grained sand and gravel beds of the Saugus Formation were deposited in the main channels of the ancient drainage systems, and these more permeable beds constitute the potential aquifers within the present-day Saugus Formation that will be discussed in this report. As the locations of the ancestral drainage channels changed during the approximately 3 million-year period of deposition of the Saugus strata, the distribution of the coarse-grained channel deposits also changed, both laterally and vertically (in space and time).

The coarse-grained potential sand and gravel aquifers of the Saugus Formation can be distinguished from the finer grained silt and clay layers (i.e., the aquicludes or aquitards) on the basis of their respective electric log signatures. From our analysis of these e-logs, it is evident that the coarse-grained channel deposits (the potential water-bearing strata) are thicker and more numerous in some areas of the Valley than in others. The general distribution of sand and gravel units in the upper portion of the Saugus Formation (between the depths of 300 ft and 2500 ft below ground surface or bgs) can be seen on Plate 3.2 – Thickness of Potential Sand and Gravel Aquifer Units. Details on how that map was constructed are provided in Section 5 of this report.

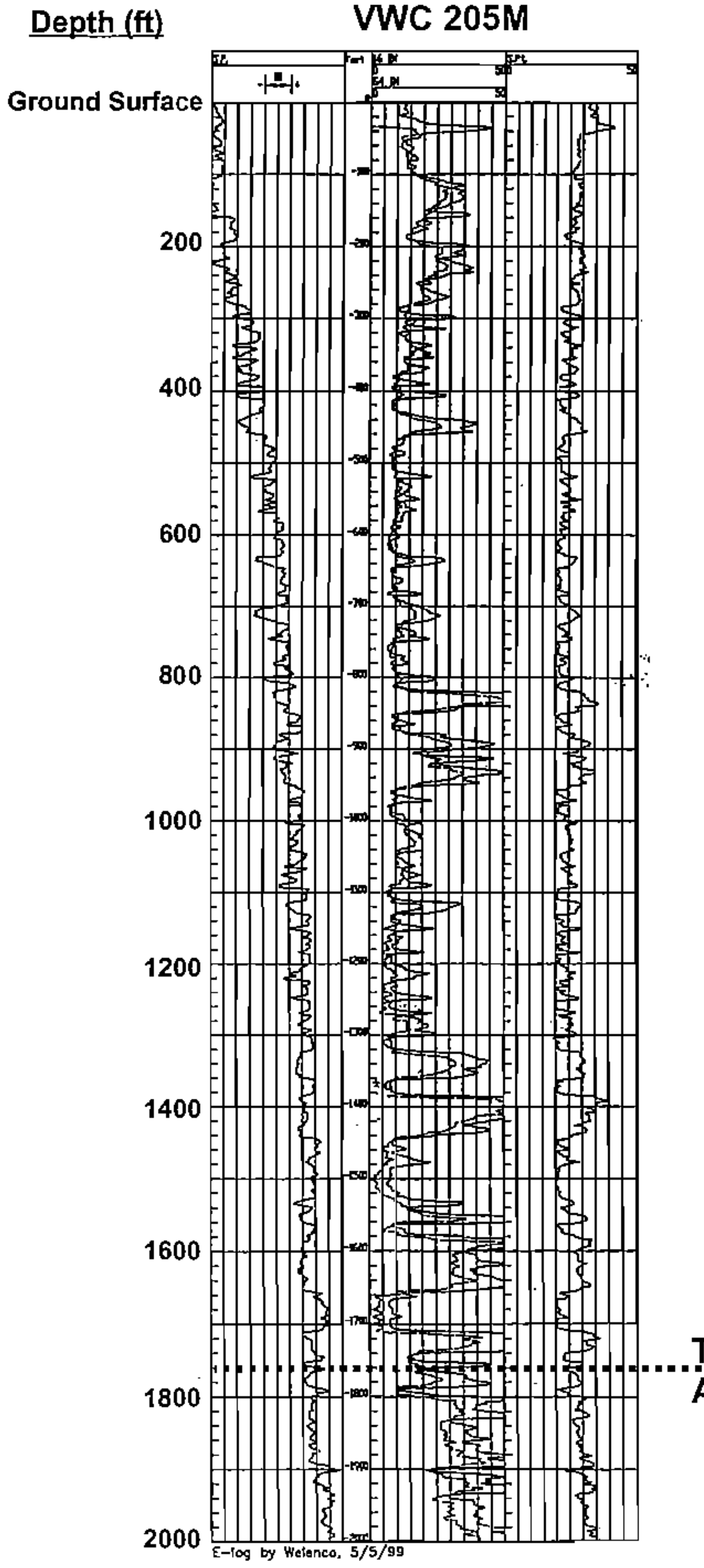
Although the Saugus Formation displays a considerable amount of lateral variability in lithology and grain size, some thicker stratigraphic packages can be correlated throughout large parts of the local groundwater sub-basin, as can be seen on Plate 3.3 – Geologic Cross-Section Z-Z'. These correlations were produced by identifying distinctive marker horizons during a detailed evaluation of e-logs from approximately 170 oil wells and water wells across the groundwater sub-basin. The locations of this new cross-section that is presented herein and of those presented in the Slade 1988 Report (not reproduced herein), are shown on Plate 5.1 in Section 5 of this report.

One of these key correlated stratigraphic units identified on Plate 3.3 is informally designated herein as the Santa Clarita Aquifer Zone. This unit is not present everywhere in the local groundwater sub-basin, and where it is present, it occurs at different depths below ground surface. Plate 3.4 – Map of Top of Santa Clarita Aquifer Zone – illustrates these variations in the depth to this key stratigraphic unit based on e-log correlations.

It is noteworthy that existing Saugus Formation wells, depending on location, produce groundwater from Saugus Formation strata that lie both above and below the Santa Clarita Aquifer Zone. However, there is a general trend for wells that are screened within or stratigraphically above the Santa Clarita Aquifer Zone to have higher groundwater production rates. Figure 3.2 – Type Electric Log and Santa Clarita Aquifer Zone, VWC 205M – shows a typical e-log (i.e. the "type e-log") for the Saugus Formation from VWC 205M, the 1956-foot deep Saugus Formation groundwater monitoring well that lies approximately 35 ft from VWC 205. Shown on this type e-log is the top of the Santa Clarita Aquifer Zone. Geologically, this Santa Clarita Aquifer Zone lies stratigraphically within the younger (upper) portion of the Saugus Formation in the region.

### Non Water-Bearing Bedrock

The Saugus Formation, and in places the overlying Quaternary alluvium, overlie several older, non-water bearing formations in the region. Along the southern and western part of the study area, the Saugus Formation conformably and gradationally overlies the Pico Formation, an older unit of marine origin consisting of gray siltstone and fine-grained sandstone, and light-colored sandstone and conglomerate. The finer-grained portions of the



Top of Santa Clarita
Aquifer Zone at 1765 ft bgs

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FIGURE 3.2
Type Electric Log and Top of
Santa Clarita Aquifer Zone
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Pico Formation predominate in the western part of the Valley, whereas in the eastern part, the formation consists mainly of sandstone and conglomerate (Winterer & Durham, 1962). Quaternary alluvium lies directly on Pico Formation rocks in the area west of the Saugus Formation boundary (refer to Plate 3.1).

In the extreme southeastern portion of its outcrop area, the Saugus Formation lies directly and unconformably on much older (pre-Tertiary geologic age) igneous and metamorphic rocks of the San Gabriel Mountains (refer to Plate 3.1). North of the San Gabriel fault, the Saugus Formation unconformably overlies Miocene-age terrestrial sediments of the Tick Canyon and Mint Canyon formations (refer to Plate 3.1). Quaternary alluvium also lies directly on Mint Canyon Formation rocks in the area east of the Saugus Formation boundary.

These older formations that underlie the water-bearing alluvium and Saugus Formation tend to be well-consolidated and cemented, with relatively low porosity and permeability. Wells and test holes drilled in these rocks have typically encountered low groundwater production rates and sometimes groundwater of relatively poor water quality. These older rocks, which essentially form the bedrock to the alluvium and Saugus Formation within the Valley, are not considered water-bearing in terms of their ability to supply groundwater in useable quantities and of acceptable quality for municipal-supply purposes.

### Geologic Structure

The Quaternary alluvium is essentially undeformed by recent tectonic activity such as folding or faulting. To some extent, this is also true for the terrace deposits, although they have been tectonically uplifted and in some areas are slightly folded. One such fold has been mapped where the terrace deposits crop out in the hills east of San Fernando Road and the South Fork of the Santa Clara River.

The general structure of the underlying Saugus Formation is one of an isolated "bowl" that has been cut (at least in part) by two major faults and that has also folded along a number of east-west trending folds. The sedimentary layering in the Saugus Formation is inclined (dips) generally toward the center of the "bowl" from all locations along the outer (basal) contact of the Saugus Formation with the underlying formations.

The San Gabriel and Holser faults divide the outcrop area of the Saugus Formation into three structural blocks (refer to Plate 3.1). The San Gabriel fault is primarily a northeast-dipping reverse fault, with a small (less than 500 ft) component of right-lateral, post-Saugus Formation offset (Weber, 1982). The structural block north of the San Gabriel fault has been uplifted relative to the rest of the Valley, and consequently the Saugus Formation in this area is considerably thinner than elsewhere in the Valley. In addition, the Saugus Formation that remains north of the San Gabriel fault consists entirely of the lowermost Sunshine Ranch Member (see Figure 3.1). All overlying, younger and coarser-grained portions of the Saugus Formation have been removed by erosion in this area north of the San Gabriel fault.

The Holser fault is also primarily a reverse fault and the structural block south of this fault has also been uplifted relative to the rest of the Valley; this fault is considered to dip towards the southwest. However, the amount of uplift is considerably less than in the area north of the San Gabriel fault, and a substantial thickness of upper Saugus Formation sediments remains in the southern structural block (south of the Holser fault).

Work by Stitt and Yeats (1983) has cast some doubt on whether a portion of the Holser fault actually extends east of I-5 underneath the blanket of Quaternary alluvium, and whether or not the short fault strand which splays off of the San Gabriel fault in the hills just east of San Fernando Road is part of the Holser fault. Although our in-house e-log correlations do show some apparent offset of strata across the presumed subsurface trace of this fault, the offset could also be explained by dipping beds. In any case, the Holser fault does not appear to have a significant effect on groundwater availability or movement within the Saugus Formation.

The thickest part of the Saugus Formation occurs in the central structural block, bounded by the San Gabriel fault on its north side, and the Holser fault on its south side. This central block has not been uplifted and hence the upper, coarser-grained portions of the Saugus Formation rocks have been largely protected from erosion in this central block area.

SECTION 4

# HYDROGEOLOGIC CONDITIONS IN THE ALLUVIAL AQUIFER SYSTEM

## Water Wells

Available records reveal that several hundred water wells have been historically drilled in the Valley for domestic, agricultural, industrial, or municipal usage. Nearly all of these wells have been drilled within the areas of alluvial deposits along the Santa Clarita River and its tributaries. Most of these wells are less than 200 ft in depth and likely extract groundwater primarily from the alluvial sediments (Slade 1988 Report).

This section focuses on the relatively high-production municipal- and agricultural- supply alluvial wells in the Valley (refer to Plate 4.1 – Map of Alluvial Well Locations; and Table 4.1 – Construction Data for Existing Alluvial Wells). Municipal-supply wells extracting groundwater from the alluvial sediments in the Valley are owned and operated by: VWC (16 active wells); NCWD (7 active wells); and SCWC (12 active wells). In addition, the Los Angeles County Sheriffs Department has a number of alluvial wells in the Castaic Creek area that supply groundwater to the detention facilities within the WHR complex. However, only three of these wells are reportedly in active use. Further, NLF reportedly has approximately 24 currently active irrigation-supply alluvial wells, most of which are located in the western end of the Valley (west of I-5). Finally, CLWA owns an alluvial well (known as the Park well) near its headquarter facilities and operates it for irrigation-supply purposes (see Plate 4.1); construction data are not available for this well.

### New Wells

Between the publication of the Slade 1986 Report and 2000, more recent information reveals that 13 additional municipal- and agricultural-supply alluvial water wells have been constructed in the Valley by the water purveyors and by the WHR (refer to Plate 4.1 for locations). These new wells include: 2 wells constructed for SCWC (Lost Canyon 2A in 1989 and the Mitchell 5B in 2001); 5 wells constructed for VWC in 1990 (W9) and in 1999-2001 (S6, S7, S8, W10); and 6 wells constructed for WHR in the late-1980s (Nos. 1, 2, 3 and 4)

## Table 4.1

## Construction Data for Existing Alluvial Wells

| Agency | Owner Well No | State Well No | Year Drilled | Drilling Method | Status 2001 | Aquifer | Elevation (ft asl) | Total Depth (ft) | Perforated Intervals (ft bgs) | Perforation Type | Sanitary Seal (ft bgs) | Pump Setting (ft bgs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Newhall County Water District | Castaic 1 | 05N/17W-25G06 | 1966 | Unknown | Active | Alluvial | 1133 | 310 | 110-297 | Unknown | 20 | 110 |
| | Castaic 2 | 05N/17W-25B02 | 1951 | Unknown | Active | Alluvial | 1139 | 120 | 80- | Unknown | Unknown | 100 |
| | Castaic 3 | 05N/17W-25B04 | 1961 | Unknown | Active | Alluvial | 1140 | 135 | 55-136 | Unknown | Unknown | 100 |
| | Castaic 4 | 05N/17W-25G07 | 1988 | Unknown | Active | Alluvial | 1132 | 203 | 59.5- | Unknown | 50 | 160 |
| | Pinetree 1 | 04N/15W-13Q03 | 1966 | Unknown | Active | Alluvial | 1604 | 235 | 50-210 | Unknown | 20 | 160 |
| | Pinetree 2 | 04N/15W-24E03 | 1952 | Unknown | Inactive | Alluvial | 1580 | 132 | 50-130 | Unknown | 8 | Unknown |
| | Pinetree 3 | 04N/15W-23H01 | 1969 | Unknown | Active | Alluvial | 1576 | 146 | 50-135 | Unknown | 50 | 135 |
| | Pinetree 4 | 04N/15W-23G01 | 1975 | Unknown | Active | Alluvial | 1568 | 185 | 110-185 | Unknown | 50 | 165 |
| Santa Clarita Water Company | Clark | 04N/16W-12N02 | 1946 | Unknown | Active | Alluvial | 1264 | 160 | 20-120 | Knife Cut | Unknown | 110 |
| | Guida | 04N/15W-06P01 | 1960 | Rotary | Active | Alluvial | 1353 | 116 | 56-150 | factory | Unknown | 110 |
| | Honby | 04N/15W-18N03 | 1959 | Rotary | Active | Alluvial | 1286 | 226 | 50-202 | factory | 30 | 130 |
| | Lost Canyon 2 | 04N/15W-23F06 | 1965 | Rotary | Active | Alluvial | 1539 | 310 | 95-125 | factory | 30 | 295 |
| | Lost Canyon 2A | 04N/15W-23F07 | 1989 | Rotary | Active | Alluvial | 1533 | 155 | 95-125 | Wire wrap | 60 | 125 |
| | Methodist | 04N/16W-14E03 | 1973 | Unknown | Inactive | Alluvial | 1180 | 160 | 60-160 | 125 mesh | 60 | 110 |
| | Mitchell 5A | 04N/15W-22J01 | 1976 | Rotary | Active | Alluvial | 1502 | 262 | 76-246 | 125 mesh | 76 | 162 |
| | N.Oaks Central | 04N/15W-21N01 | 1965 | Unknown | Active | Alluvial | 1409 | 244 | 50-244 | Knife Cut | Unknown | 140 |
| | N.Oaks East | 04N/15W-21N03 | 1940 | Unknown | Active | Alluvial | 1407 | 132 | 81-150 | Knife Cut | Unknown | 130 |
| | N.Oaks West | 04N/15W-21N02 | 1940 | Unknown | Active | Alluvial | 1398 | 136 | 80-118 | Knife Cut | Unknown | 110 |
| | Sand Canyon | 04N/15W-23C05 | 1973 | Rotary | Active | Alluvial | 1525 | 127 | 60-140 | factory | 60 | 112 |
| | Sierra | 04N/15W-21K01 | 1973 | Rotary | Active | Alluvial | 1432 | 175 | 60-175 | factory | 60 | 128 |
| | Stadium | 04N/16W-23F01 | 1946 | Unknown | Active | Alluvial | 1207 | 130 | 33-130 | Knife Cut | Unknown | 130 |
| Valencia Water Company | D | 04N/17W-12C01S | 1950 | Unknown | Active | Alluvial | 1027 | 142 | 60-136 | Knife Cut | 50 | 100 |
| | I | 04N/16W-17A05S | 1945 | Unknown | Inactive | Alluvial | 1090 | 172 | 55-172 | Unknown | 55 | 120 |
| | K2 | 04N/16W-22C01S | 1945 | Unknown | Active | Alluvial | 1128 | 242 | 60-220 | Knife Cut | 50 | 63 |
| | L2 | 04N/16W-22C07S | 1941 | Unknown | Active | Alluvial | 1130 | 182 | 60-149 | Knife Cut | 50 | 120 |
| | N | 04N/16W-22D02S | 1936 | Unknown | Active | Alluvial | 1128 | 247 | 80-237 | Knife Cut | 50 | 140 |
| | N3 | 04N/16W-22C03S | 1941 | Unknown | Active | Alluvial | 1137 | 173 | 60-170 | Unknown | 50 | 110 |
| | N4 | 04N/16W-22C04S | 1941 | Unknown | Active | Alluvial | 1132 | 186 | 60-172 | Unknown | 50 | 120 |
| | Q2 | 04N/16W-15R02S | 1954 | Unknown | Active | Alluvial | 1170 | 170 | 86-136 | Unknown | Unknown | 100 |
| | S6 | 04N/16W-16Q04S | 1999 | Mud Rotary | Active | Alluvial | 1124 | 220 | 130-150, 160-195 | Louvers | 60 | |
| | S7 | 04N/16W-15N01S | 1999 | Mud Rotary | Active | Alluvial | 1120 | 210 | 130-150, 160-190 | Louvers | 60 | |
| | S8 | 04N/16W-15P01S | 1999 | Mud Rotary | Active | Alluvial | 1131 | 220 | 130-150, 160-195 | Louvers | 60 | |
| | T2 | 04N/16W-23A01S | 1952 | Unknown | Active | Alluvial | 1205 | 150 | 50-138 | Knife Cut | Unknown | 100 |
| | T4 | 04N/16W-23A02S | 1953 | Unknown | Active | Alluvial | 1199 | 138 | 60-132 | Knife Cut | 50 | 100 |
| | U3 | 04N/16W-24A06S | 1950 | Unknown | Active | Alluvial | 1260 | 142 | 46-140 | Unknown | Unknown | 100 |
| | U4 | 04N/16W-24B02S | 1944 | Unknown | Active | Alluvial | 1264 | 135 | 60-130 | Knife Cut | 53 | 100 |
| | W10 | 04N/16W-16B01S | 1999 | Rotary | Inactive | Alluvial | 1118 | 190 | 120-160 | Louvers | 99 | |
| | W6 | 04N/16W-09H02S | 1953 | Unknown | Active | Alluvial | 1155 | 158 | 60-129 | Knife Cut | 50 | 100 |
| | W9 | 04N/16W-09Q03S | 1990 | Rotary | Active | Alluvial | 1170 | 160 | 70-130 | Wire Wrap | 42 | 140 |
| Wayside Honor Ranch | 1 | 05N/17W-36G01 | 1936 | Unknown | Inactive | Alluvial | 1126 | 165 | 30-116 | Knife Cut | Unknown | Unknown |
| | 1A | Unknown | Unknown | Unknown | Abandoned | Alluvial | 1101 | Unknown | Unknown | Unknown | Unknown | Unknown |
| | 2 | 05N/17W-36K03 | Unknown | Unknown | Inactive | Alluvial | 1125 | 38 | Unknown | Unknown | Unknown | Unknown |
| | 3 | 05N/17W-36H01 | 1924 | Unknown | Inactive | Alluvial | 1120 | 114 | 40-114 | Open Hole | Unknown | Unknown |
| | 4 | 05N/17W-36H02 | 1928 | Unknown | Inactive | Alluvial | 1114 | 98 | Unknown | Unknown | Unknown | Unknown |
| | 5 | 05N/17W-36H04 | 1944 | Cable Tool | Inactive | Alluvial | 1094 | 110 | 30-104 | Knife Cut | Unknown | Unknown |
| | 8 | 04N/17W-12B04 | 1964 | Cable Tool | Inactive | Alluvial | 1035 | 151 | 50-113 | Knife Cut | Unknown | Unknown |
| | 10 | 05N/17W-36J01 | 1948 | Unknown | Active | Alluvial | 1092 | 110 | 27-39 | Knife Cut | Unknown | Unknown |
| | 11 | Unknown | 1999 | Unknown | Inactive | Alluvial | 1055 | Unknown | Unknown | Unknown | Unknown | Unknown |
| | 15 | 04N/17W-36H05 | 1953 | Unknown | Active | Alluvial | 1040 | 126 | 42-124 | Knife Cut | Unknown | Unknown |
| | 16 | 04N/17W-12B02 | 1954 | Unknown | Inactive | Alluvial | 1040 | 144 | 45-120 | Knife Cut | Unknown | Unknown |
| | 17 | 05N/17W-36H | 1955 | Cable Tool | Active | Alluvial | 1088 | 110 | 35-110 | Knife Cut | Unknown | Unknown |
| | 18 | Unknown | 1999 | Unknown | Inactive | Alluvial | 1068 | Unknown | Unknown | Unknown | Unknown | Unknown |
| Valencia Water Company | Alluvial Monitoring Well | Unknown | 2000 | Dual-Tube Rotary | Active | Alluvial | 1149 | 190 | 90-180 | Factory PVC | none | N/A |

and in 1999 (New No. 11 and New No. 18). Construction data are available for the new SCWC and VWC wells; similar information for the WHR wells was not available for this study.

Destroyed Wells

A number of older municipal- and agricultural-supply alluvial water wells have been destroyed between 1987 and 2000 (refer to Table 4.2 – Destroyed Alluvial Wells). These include NLF Wells E3, E7, Q, R, R2, S, S2, S3, and T. Each of these wells was reportedly destroyed in accordance with the regulations of the Los Angeles County Department of Health Services to minimize the possibility of surface contaminants migrating into the alluvial aquifer via the well bore. Two WHR Wells (Old Nos. 11 and 18) were also destroyed relatively recently, but no details on these well destructions were available for this study.

Private Wells

With a few exceptions, discussion of privately-owned water wells that are used for local domestic supply lies outside the scope of this study; the locations for these wells are not shown on any plates for this report. Although such private wells may be numerous, most of them are considered to be small, low-capacity wells, and the total annual groundwater extraction by these domestic-supply wells is considered to account for only about 1% of the alluvial groundwater production in the Valley.

The Robinson Ranch well is a new privately-owned alluvial-supply well reportedly constructed along the Santa Clara River to provide irrigation water to two new golf course developments in the hillsides south of the general area of NCWD's Pinetree wells in the easternmost part of the alluvium. No details on its construction were available for this study. Plate 4.1 illustrates the approximate location of this well.

**Groundwater Occurrence, Recharge and Discharge**

Within the saturated zone of the unconsolidated alluvial sediments, groundwater is present in the pore spaces between individual sedimentary grains. These alluvial sediments were deposited primarily by flowing streams and rivers that precluded the formation of areally extensive beds or layers of fine-grained silts and clays. Because of this, groundwater in the

**Table 4.2**
Destroyed Alluvial Water Wells

| Agency | Owner Well No. | Year Destroyed |
|---|---|---|
| **Wayside Honor Rancho** | 11-Old | Unknown |
|  | 18-Old | Unknown |
| **Valencia Water Company** | E3 | 1997 |
|  | E7 | 1997 |
|  | Q | 1990-1991 |
|  | R | 1987-1989 |
|  | R2 | 1991-1992 |
|  | S | 1999 |
|  | S2 | 2000 |
|  | S3 | 1999 |
|  | T | 2000 |

alluvium is considered to occur under unconfined (water table), conditions, although some localized zones of perched water may locally exist in certain tributary canyons or along the main reach of the Santa Clara River.

Recharge

Groundwater in the alluvial aquifer system is recharged from both natural and artificial (man-made) sources. Sources of natural recharge include deep percolation of precipitation that falls directly on the alluvial deposits, subsurface groundwater inflow from upstream areas along the Santa Clara River or its tributaries, upward groundwater flow from certain portions of the Saugus Formation where it is overlain by alluvium, and direct infiltration from surface water runoff along the Santa Clara River and its tributaries.

CH2M Hill recently examined recharge and discharge to the alluvial aquifer system as part of an ASR study (Newhall Ranch ASR Impact Evaluation, 2001). That study found that recharge to and discharge from the alluvium does not occur evenly across the area, but is focused in particular areas. Specifically, their work shows that the largest source of recharge to the alluvium is likely upward flow of groundwater from the underlying Saugus Formation, with this recharge occurring primarily in the downstream portion of the alluvium located generally west of I-5. The CH2M Hill work also indicates that deep percolation of groundwater from the alluvium occurs downward into the Saugus Formation in the upstream portions of the alluvium located in the central and eastern portions of the Valley.

Recharge to the alluvial aquifer system via infiltration of surface water runoff from the Santa Clara River will occur whenever and wherever groundwater levels in the aquifer are below the surface elevation of the river runoff. Using historic data on alluvial water levels, as well as data from several stream flow gages along the Santa Clara River and its tributaries, CH2M Hill determined that the alluvial aquifer system is being recharged from the Santa Clara River in the area upstream from the confluence with the South Fork of the Santa Clara River (CH2M Hill, 2001). In this area, the Santa Clara River is ephemeral, that is, it flows only in the hours or days immediately following significant winter rainfall events. Recharge will occur only while the river is actually flowing, and the amount of recharge will depend largely on the duration of each surface flow event, and, in some parts of the aquifer, on water levels within the alluvial aquifer.

The amount of recharge obtained by the alluvial aquifer from the direct percolation of precipitation will vary each year depending on such conditions as the amount and timing of rainfall, local soil type, and land use characteristics. Finally, natural recharge by inflow from upstream areas will depend on the cross-sectional area of the saturated alluvium at the upstream end of the study area, on the hydraulic conductivity of the alluvial materials, and on the gradient of the alluvial water table.

Recharge from deep percolation of irrigation water is obtained primarily from urban irrigation (landscape irrigation) in the developed areas of the Valley. Agricultural irrigation was previously more widespread in the Valley, but is now confined mainly to approximately 700 acres of cultivated land in the area west of I-5. Recharge also occurs indirectly as a result of the infiltration of reclaimed water that is actively being released to the Santa Clara River from the two WRPs in the area.

While artificial recharge of the alluvium via spreading basins or other means was discussed in the Slade 1986 Report, there are currently no artificial recharge facilities operating within the study area.

### Discharge

Except for groundwater outflow directly from the alluvium down into the underlying Saugus Formation or upward to the Santa Clara River, discharge from the alluvial aquifer system occurs primarily through pumping extraction for municipal-supply use by the water purveyors, and for agricultural-supply use by NLF. Historic annual extractions by these organizations have varied between 20,000 and 43,000 AF/yr during the period for which data are available (1947 to the present).

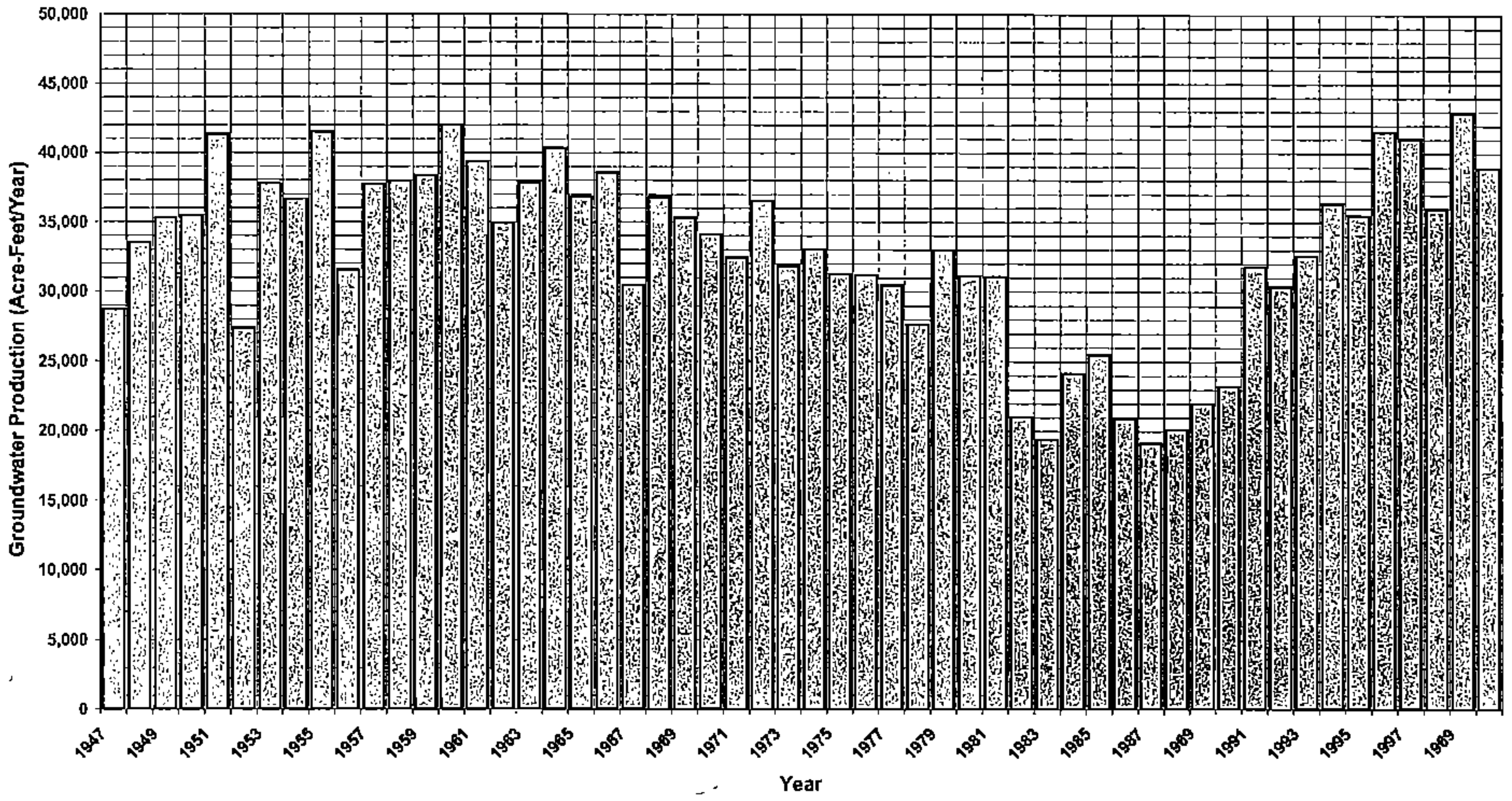
Evapotranspiration by phreatophyte vegetation is also an important component of the discharge of groundwater from the alluvium. Phreatophytes are plants such as willows and cottonwoods that root directly into the water table in areas of shallow groundwater. CH2M Hill (2001) estimated that as much as 8 to 12% of the total groundwater discharge from the alluvium occurs in this way, primarily in those alluvial areas west of I-5 where depths to groundwater are relatively shallow.

This westernmost part of the local groundwater sub-basin is also an area of groundwater discharge from the alluvium to the Santa Clara River. The amount of upward flow into the river will depend largely on water levels within the alluvium. Groundwater also flows out of the Valley into Ventura County, but this occurs solely as subsurface flow within the alluvium at the downstream end of the study area (the Los Angeles/Ventura County Line). The only other water to flow from the Valley into Ventura County is via direct surface water runoff in the Santa Clara River at County line.

**Groundwater Extractions**

Groundwater production from the alluvial aquifer system is used primarily for municipal-supply and agricultural-supply purposes. Because of the large number of alluvial wells that have existed since the 1950s, and the difficulty in obtaining groundwater production data for these wells, the groundwater production values discussed in this section can only be viewed as reasonable estimates, particularly for the period prior to 1985.

Figure 4.1 - Historic Alluvial Groundwater Production – illustrates, as a bar chart, the historic trends in alluvial groundwater production since the mid-1940s, the earliest date for which any production records are available. Since that time, total alluvial groundwater production has ranged from a low of approximately 20,000 AF/yr in 1983, to a high of at least 44,000 AF/yr in 1955. For the ten-year period from 1991 to 2000, the average annual alluvial groundwater production by the major producers was approximately 35,000 AF/yr. The historically largest groundwater periods of production from the alluvium occurred between 1951 and 1960, and between 1991 and 2000 (both 10-year periods), during which time the average extractions were approximately 37,000 AF/yr and 35,000 AF/yr respectively. Between those two periods, the region has experienced a dramatic land use change from mainly agricultural to mainly urban and suburban land use. Table 4.3 – Alluvial Groundwater Production 1986 – 2000 – provides a tabulation of groundwater production by each major producer for the period 1986 through 2000.



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CONSULTING GROUNDWATER GEOLOGISTS

**FIGURE 4.1**
**Annual Groundwater Production**
**Alluvial Aquifer**

JOB NO. S9920 June 2002

## Table 4.3
Alluvial Groundwater Production 1986-2000

| Agency | Owner Well No | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Newhall County Water District | Pinetree 1 | 9 | 0 | 3 | 153 | 0 | 47 | 15 | 248 | 154 | 88 | 89 | 89 | 227 | 404 | 245 |
| | Pinetree 2 | 229 | 320 | 356 | 350 | 31 | 0 | 252 | 327 | 218 | 182 | 97 | 0 | 0 | 0 | 0 |
| | Pinetree 3 | 801 | 782 | 768 | 676 | 790 | 723 | 607 | 451 | 608 | 656 | 866 | 812 | 716 | 505 | 494 |
| | Pinetree 4 | 261 | 80 | 5 | 1 | 0 | 0 | 9 | 19 | 231 | 60 | 460 | 510 | 337 | 5 | 355 |
| | Castaic 1 | 328 | 465 | 527 | 481 | 437 | 561 | 458 | 459 | 496 | 442 | 534 | 535 | 166 | 427 | 118 |
| | Castaic 2 | 423 | 553 | 328 | 682 | 0 | 0 | 0 | 478 | 518 | 419 | 453 | 268 | 257 | 332 | 289 |
| | Castaic 3 | 0 | 0 | 328 | 0 | 651 | 531 | 435 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Castaic 4 | 0 | 0 | 0 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 95 | 57 | 6 | 7 |
| | *NCWD Total* | *2051* | *2200* | *2315* | *2382* | *1909* | *1862* | *1776* | *1982* | *2225* | *1847* | *2499* | *2309* | *1760* | *1679* | *1508* |

| Agency | Owner Well No | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1989 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Newhall Land & Farming Company | *NLF Total* | *8071* | *6364* | *5804* | *6490* | *8387* | *8045* | *8939* | *8022* | *10641* | *11182* | *12133* | *12855* | *10272* | *13824* | *11858* |

| Agency | Owner Well No | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Santa Clarita Water Company | Clark | 205 | 337 | 248 | 301 | 407 | 542 | 662 | 635 | 572 | 662 | 1027 | 873 | 697 | 878 | 747 |
| | Guida | 217 | 561 | 158 | 530 | 676 | 801 | 978 | 895 | 942 | 744 | 1252 | 1479 | 1274 | 1556 | 853 |
| | Honby | 190 | 386 | 462 | 216 | 930 | 893 | 731 | 1393 | 476 | 553 | 352 | 814 | 532 | 1162 | 815 |
| | Lost Canyon 2 | 753 | 910 | 787 | 588 | 601 | 404 | 465 | 692 | 669 | 773 | 678 | 792 | 757 | 946 | 708 |
| | Lost Canyon 2A | 0 | 0 | 0 | 0 | 293 | 832 | 1284 | 1080 | 1383 | 1230 | 1370 | 1055 | 973 | 890 | 998 |
| | Methodist | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Mitchell | 437 | 573 | 485 | 435 | 264 | 3 | 474 | 663 | 564 | 610 | 598 | 633 | 482 | 913 | 439 |
| | N.Oaks Central | 299 | 356 | 153 | 329 | 525 | 704 | 701 | 1403 | 1313 | 965 | 851 | 870 | 1490 | 1682 | 1145 |
| | N.Oaks East | 849 | 959 | 774 | 914 | 454 | 194 | 588 | 1233 | 1473 | 1295 | 900 | 1033 | 1407 | 695 | 1483 |
| | N.Oaks West | 860 | 459 | 842 | 413 | 275 | 78 | 634 | 866 | 972 | 795 | 663 | 952 | 934 | 1894 | 1663 |
| | Sand Canyon | 507 | 460 | 498 | 1115 | 458 | 49 | 661 | 918 | 781 | 842 | 1211 | 1533 | 1622 | 1629 | 1317 |
| | Sierra | 842 | 217 | 459 | 730 | 772 | 719 | 1050 | 1413 | 1433 | 1092 | 1034 | 597 | 814 | 1158 | 640 |
| | Stadium | 164 | 287 | 211 | 214 | 328 | 374 | 60 | 825 | 418 | 656 | 509 | 637 | 444 | 338 | 721 |
| | *SCWC Total* | *5323* | *5505* | *5077* | *5785* | *5983* | *5593* | *8288* | *12016* | *10996* | *10217* | *10445* | *11268* | *11426* | *13741* | *11529* |

| Agency | Owner Well No | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Valencia Water Company | D | 0 | 316 | 606 | 581 | 494 | 661 | 239 | 173 | 491 | 403 | 454 | 1134 | 1209 | 921 | 880 |
| | I | 100 | 0 | 94 | 125 | 71 | 105 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | K2 | 0 | 0 | 0 | 0 | 0 | 953 | 1134 | 1708 | 2078 | 1154 | 1305 | 1076 | 1489 | 1420 | 861 |
| | L2 | 0 | 0 | 0 | 0 | 0 | 814 | 524 | 996 | 1231 | 818 | 961 | 307 | 187 | 531 | 493 |
| | N | 1551 | 1463 | 1519 | 1114 | 768 | 948 | 697 | 66 | 0 | 24 | 263 | 808 | 768 | 1036 | 935 |
| | N3 | 0 | 0 | 0 | 0 | 0 | 10 | 999 | 1536 | 29 | 942 | 1325 | 1034 | 1093 | 1057 | 778 |
| | N4 | 0 | 0 | 0 | 0 | 0 | 823 | 248 | 133 | 906 | 1328 | 1328 | 1185 | 772 | 894 | 710 |
| | Q2 | 882 | 920 | 528 | 1404 | 1355 | 1732 | 335 | 548 | 1341 | 1125 | 1385 | 1462 | 1655 | 1288 | 1387 |
| | T2 | 942 | 941 | 1039 | 975 | 623 | 643 | 379 | | 3 | 280 | 733 | 837 | 941 | 726 | 984 |
| | T4 | 176 | 0 | 0 | 0 | 0 | 158 | 687 | 3 | 1 | 974 | 1258 | 804 | 523 | 892 | 625 |
| | U3 | 1088 | 657 | 333 | 779 | 1215 | 1165 | 369 | 1 | 2 | 764 | 987 | 851 | 560 | 702 | 1126 |
| | U4 | 704 | 624 | 718 | 537 | 534 | 567 | 42 | 3 | 2 | 7 | 742 | 789 | 529 | 828 | 1073 |
| | W6 | 0 | 150 | 150 | 0 | 0 | 211 | 260 | 204 | 223 | 365 | 615 | 493 | 355 | 416 | 445 |
| | W9 | 0 | 0 | 0 | 0 | 11 | 876 | 699 | 444 | 504 | 508 | 1077 | 915 | 627 | 1111 | 1176 |
| | S6 | | | | | | | | | | | | | | | 515 |
| | S7 | | | | | | | | | | | | | | | 111 |
| | S8 | | | | | | | | | | | | | | | 79 |
| | W10 | | | | | | | | | | | | | | 0 | 0 |
| | *VWC Total* | *5443* | *5071* | *4987* | *5515* | *5071* | *9666* | *6613* | *5815* | *6812* | *8692* | *12433* | *11695* | *10708* | *11822* | *12178* |

| Agency | Owner Well No | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wayside Honor Rancho | 1 | | | | | | | | | | | | | | | |
| | 1A | | | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | | | |
| | 3 | | | | | | | | | | | | | | | |
| | 4 | | | | | | | | | | | | | | | |
| | 5 | | | | | | | | | | | | | | | |
| | 8 | | | | | | | | | | | | | | | |
| | 10 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 | 1130 |
| | 11 | | | | | | | | | | | | | | | |
| | 11 - Old | | | | | | | | | | | | | | | |
| | 15 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 |
| | 16 | | | | | | | | | | | | | | | |
| | 17 | 626 | 626 | 626 | 626 | 626 | 626 | 626 | 626 | 626 | 626 | 626 | 626 | 626 | 626 | 626 |
| | 18 | | | | | | | | | | | | | | | |
| | 18 - Old | | | | | | | | | | | | | | | |
| | *WHR Total* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* | *1840* |

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual Total for Major Producers Listed | 22,728 | 20,980 | 20,023 | 22,012 | 23,190 | 27,006 | 27,456 | 29,675 | 32,514 | 33,778 | 39,350 | 39,967 | 36,006 | 42,906 | 38,913 |

Note: Production figures from Wayside Honor Ranch are estimates based on total prison estimate populations.
All of the data is supplied by purveyors. Figures do not include domestic or other small-scale extractions.

Groundwater production from the alluvial aquifer system is distributed along the main reach of the Santa Clara River, in the Castaic Creek drainage, and in several of the tributary canyons. Thirteen municipal-supply water wells in the alluvial aquifer system each produced in excess of 1000 AF in 2000 as shown on Table 4.3.

Between 1986 and 2000, NCWD accounted for between 4% and 12% of the total annual alluvial groundwater production; VWC produced between 18% and 31% of the total annual production; SCWC extracted between 26% and 46% of the total annual production; NLF pumped between 25% and 35% of the total annual production; and WHR reportedly accounted for between 8% and 9% of the annual production in this period from the alluvium.

Annual production from the privately-owned, domestic-supply alluvial wells is not known, but is unlikely to have exceeded a total of 100 to 200 AF/yr for all privately-owned, domestic-supply alluvial wells in the region. This represents only about 1% of the average annual groundwater production since 1986 from the alluvium. Beginning in 2000, a new privately-owned golf course irrigation well along the Santa Clara River east of Sand Canyon became active. Although metered pumpage figures are not available for this new well, it is estimated that this well might extract on the order of 350 AF/yr for each of the two onsite 18-hole golf courses that it irrigates.

To illustrate the spatial variability in recent alluvial groundwater extractions within the Valley, we have prepared Plate 4.2 – Map of Alluvial Groundwater Extractions for 2000. Data for Plate 4.2 were derived from the information tabulated for the year 2000 on Table 4.3 for each active municipal-supply well. Annual groundwater extractions for each well on Plate 4.2 are illustrated via a circle centered on the respective well. The larger the diameter of the circle, the greater is the extraction for the particular well in 2000. The map scale used to illustrate the diameter of the circle which represents the year 2000 annual production is: 1 inch equals approximately 667 AF (or, ¾" = 500 AF). It must be noted that the circles (specifically, the diameter of the circles) graphed on Plate 4.2 are drawn to solely represent the relative annual production volume (in AF) for each respective well. The diameter of the circle surrounding each well does not represent and should not be construed or interpreted to signify the area of pumping influence (the extent of the drawdown cone) of the particular well.

For 2000, the largest municipal-supply alluvial extractions occurred along the main reach of the Santa Clara River, by SCWC (in areas east of Bouquet Junction) and by VWC (near and just west of Bouquet Junction); WHR extractions were the largest in Castaic Creek, north of its confluence with the Santa Clara River. There are no municipal-supply wells within the alluvium in the South Fork area of the Santa Clara River or along the main reach of the river valley west of I-5.

**Current Groundwater Levels and Flow Directions**

Groundwater levels and flow directions within the alluvial aquifer system were determined by creating contour lines of equal groundwater elevation (in ft above sea level, asl) for the available data from wells within the alluvial sediments in the study area. The data used to create these contour lines consisted of measurements, in numerous individual alluvial wells, of the depth to the static (non-pumping) water level. These depths were converted to elevations by subtracting the depth from the reported ground surface elevation at each wellhead. Groundwater flow directions were then determined by recognizing that groundwater flows from high head to low head; hence, the general direction of groundwater flow within the alluvial sediments is interpreted to be perpendicular to the equal elevation contour lines for the date depicted.

Plate 4.3 – Map of Alluvial Groundwater Elevation Contours, Spring 2000 – illustrates the groundwater elevations and interpreted flow directions for the spring (March to May) of 2000, a recent period for which widespread water level data are available. Water level data from approximately 100 different wells throughout the Valley were used to create the elevation contours, with data being obtained from the municipal water purveyors, agricultural well owners, the LACFCD database, and reports on water levels in piezometer wells provided by Seward Engineering Ltd (SE).

As illustrated by the broad arrows on Plate 4.3, groundwater flow directions within the alluvial aquifer system generally mimic surface water flow directions and the land surface gradient, with groundwater moving from east to west along the main reach of the Santa Clara River, and from highland areas towards the main river valley within the alluvium in the tributary canyons along each side of the valley floor. In the main river valley, groundwater elevations decline from a high of approximately 1700 ft above sea level (asl) in the eastern end of the study area, to a low of about 820 ft near the Los Angeles-Ventura County Line in the west (see Plate 4.3). This equates to a decline of approximately 880 ft over a distance (paralleling the Santa Clara River) of 22 miles, and calculates to an overall down-valley gradient of approximately 40 feet per mile (ft/mi).

The gradient is steeper in the eastern portion of the main Valley east of Bouquet Canyon, where the water level drops 325 ft in 5.6 miles; this represents a gradient of roughly 58 ft/mile. This compares with a gradient of 50 ft/mi for the same area calculated from 1985 water levels (Slade 1986 Report).

In the western part of the alluvium between Bouquet Canyon and the County Line, the groundwater elevation drops 555 ft over 16.3 miles, representing a gradient of roughly 34 ft/mi. This compares with a gradient of 31 ft/mi calculated from 1985 water levels (Slade 1986 Report).

Groundwater gradients are much steeper in the major tributary canyons for which sufficient data exist, with measured spring 2000 gradients of approximately 90 ft/mi in Mint Canyon, 56 ft/mi in Bouquet Canyon, 42 ft/mi in San Francisquito Canyon, and 31 ft/mi along Castaic Creek. The well monitored by LACFCD in the baseball park along Bouquet Canyon appears to be the Park well owned by CLWA; its LACFCD well number is likely 7086B (see Plate 4.2).

An interesting feature on Plate 4.3 is the very low groundwater gradient within the alluvium along the South Fork of the Santa Clara River, a feature that was also seen on previously prepared groundwater elevation maps of the alluvium (Slade 1986 Report). The average gradient along the South Fork for Spring 2000 data is only on the order of 13 ft/mi, although a detailed delineation of gradients in this area is made difficult by the virtual absence of requisite data from alluvial wells in this area. However, it does not appear that any "up-valley" or reversed groundwater flow is occurring southward into this South Fork area.

There is no evidence from the available data that either the San Gabriel or the Holser faults acts as a barrier to groundwater flow within the alluvial deposits of the Santa Clara River or its tributaries.

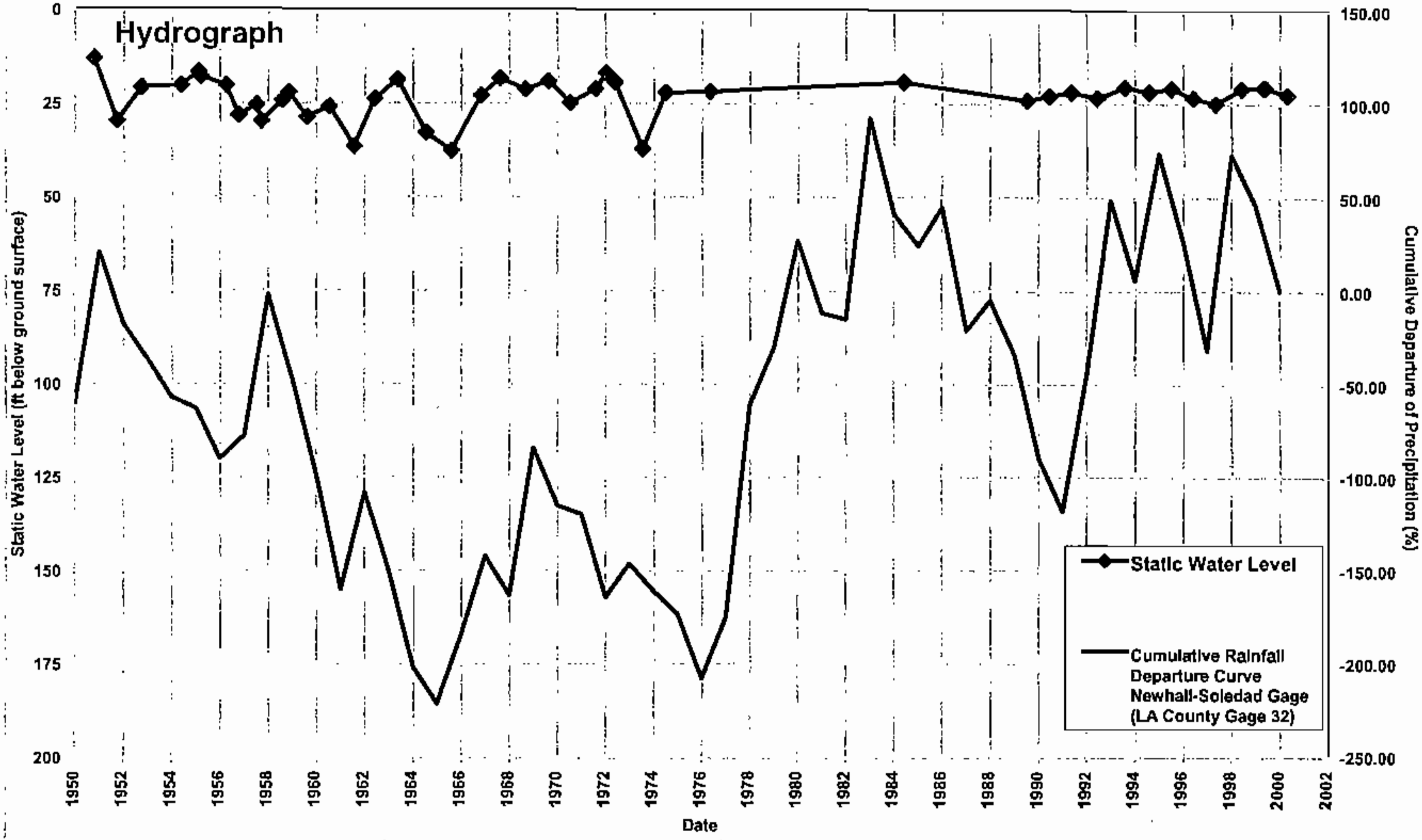
### Hydrographs

For the purpose of examining long-term water level trends within the alluvial aquifer, the Valley can be divided up into three areas: the western area, between the Los Angeles/Ventura County line and I-5; the central area, between I-5 and the mouth of Bouquet Canyon; and the eastern area, from Bouquet Canyon east to NCWD Pinetree Well No. 1, which is the easternmost municipal-supply well in the alluvial aquifer system. Long-term water level trends in selected alluvial wells are presented in the form of hydrographs which are graphs of the static water levels (i.e., the non-pumping water levels) in the well versus time; also provided on each hydrograph is a portion of the cumulative departure curve for rainfall (for the period 1950 to 2000) as adapted from Figure 2.1.

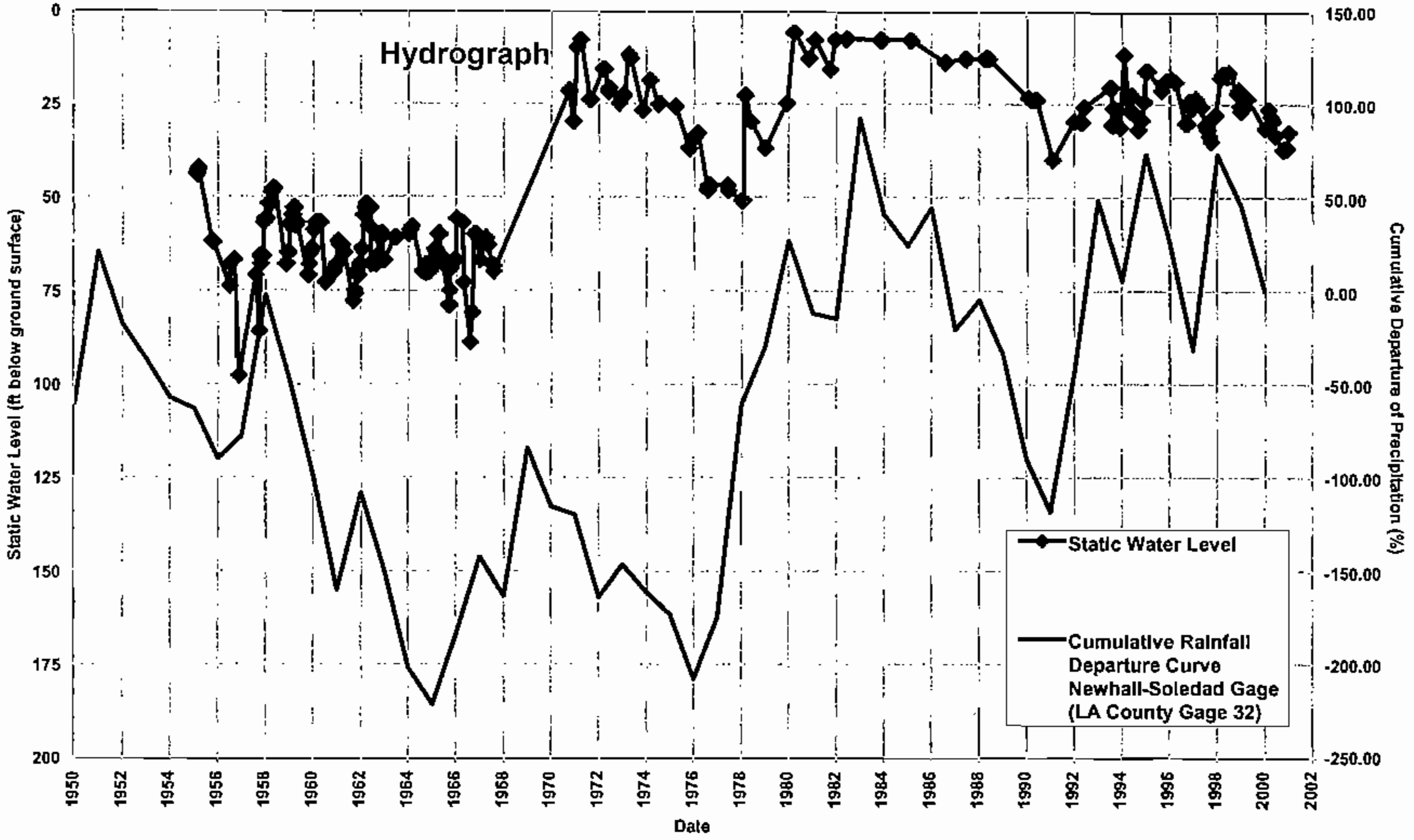
The hydrograph for NLF Well C8 (Figure 4.2 – Hydrograph of NLF Well C8: see well location on Plate 4.3 – Map of Alluvial Well Hydrographs) provides a useful, long-term record of water levels in this western part of the alluvial aquifer system (i.e., in the alluvium west of I-5). Water levels in this area have remained remarkably constant over time as evidenced by data for this well, ranging from a high of approximately 13 ft bgs, to a low of 37 ft bgs over a period of data record of approximately 50 years. This lack of marked water level fluctuation in this well is likely due to the well being located in an area where groundwater from the Saugus Formation is considered to be flowing upward into the overlying alluvium, thereby providing a fairly consistent source of recharge that is relatively independent of annual rainfall trends. There has also been somewhat less year-to-year variability in water levels in this well over the past twenty years, when compared to the variability seen in the same record from the 1950s through the 1970s. This may in part be due to the increased additional recharge to the alluvium provided by increasing outflows from the two WRPs located upgradient from this well. Total WRP discharges were approximately 19,000 AF in 2000.

In the central portion of the alluvium, in the area near the confluence of the South Fork with the main reach of the Santa Clara River, the hydrograph for VWC Well Q2 (Figure 4.3 – Hydrograph of VWC Well Q2: see also Plate 4.3 for well location) shows the typical water level response in this area over time. During the 1950s and 1960s, a time of high alluvial

## Figure 4.2
## NLF Well C8
## Water Level Hydrograph



# Figure 4.3
# VWC Well Q2
# Water Level Hydrograph



groundwater production and low rainfall, water levels in this well averaged approximately 70 to 75 ft bgs, within an historic range of 42 to 98 ft bgs. Reduced pumping in the alluvium, and a return to more normal rainfall patterns in the 1970s and 1980s, resulted in a rapid recovery of water levels to depths of between 6 and 27 ft bgs; water level declines were to depths as much as 51 ft bgs during the dry years of the mid-1970s. A return to the higher rates of annual alluvial groundwater extractions in the 1990s did not result in a return to the low water levels typical of the 1950s and 1960s. This in part is due to the generally normal rainfall patterns over the last ten years, and the increased recharge provided to the alluvium from the two local WRPs.

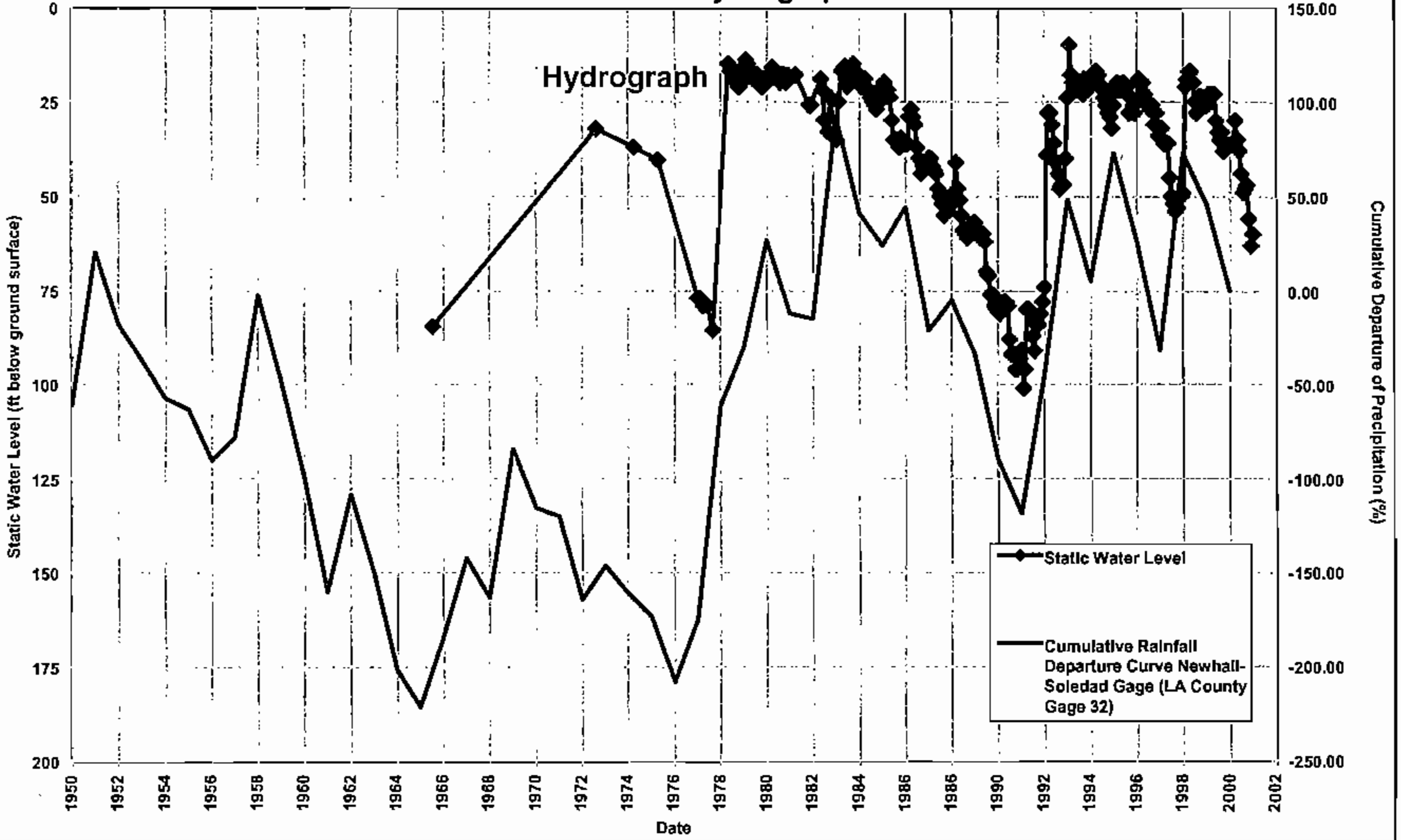
Finally, in the eastern portion of the alluvial aquifer, the representative hydrograph for the SCWC Mitchell Well 5A (Figure 4.4 – Hydrograph of SCWC Mitchell Well 5A and also Plate 4.4) shows a much stronger correlation with annual rainfall totals than is shown by the hydrographs for wells in either the central or western parts of the Valley. Water levels in these easterly-area wells during wet periods such as from 1978 to 1983 tend be in the range of 10 to 20 ft bgs, falling to as low as 101 ft bgs during periods of extended drought such as that from 1984 to 1991. However, by 1993, after a return to wetter climatic conditions, water levels recovered rapidly to their pre-drought range. Water levels also show a declining response during the dry years of 1996 to 1997, and 1999 to 2000. From past trends, it can be seen that these lower water levels are a temporary condition, which then (regardless of the total alluvial production) rapidly return to higher water level conditions as soon as wetter conditions prevail.

Differences in the response of water levels over time in wells located in different parts of the alluvial aquifer system in the Valley are readily seen on Plate 4.4. Hydrographs shown thereon are for various municipal-supply wells, an irrigation-supply well, and for a few LACFCD-monitored wells that are privately-owned (see for example LACFCD Well No. 7132 in the northern portion of Bouquet Canyon).

### Aquifer Parameters

The Slade 1986 Report presented a map of estimated aquifer parameters calculated from efficiency tests conducted in a number of alluvial water wells in the Valley by the Edison

# Figure 4.4
# SCWC Mitchell Well 5A
# Water Level Hydrograph



Company. Plate 7 from that report (not presented herein) showed the locations of these wells, annotated with values for transmissivity (T) and hydraulic conductivity (or permeability, herein denoted by symbol P). That report noted that T and P varied considerably over quite short lateral distances within the alluvial aquifer, and suggested that this was because T and P values were calculated from water level drawdowns in the pumping wells rather than from aquifer test data from nearby observation wells. Use of water level drawdown data from pumping wells to calculate T values may provide results that are strongly influenced not only by the properties of the aquifer, but also by the condition of the well casing and gravel pack, particularly with older wells.

Since 1985, a number of new alluvial water wells have been constructed and tested, and generally more accurate T and P values are now available for some of these new wells. In the eastern part of the alluvium, the SCWC Lost Canyon 2A and Mitchell 5B wells were constructed and tested in 1990 and 2001, respectively; these wells had calculated T values ranging from approximately 270,000 to 500,000 gallons per day per foot of aquifer (gpd/ft). This is consistent with the earlier T value of approximately 350,000 gpd/ft calculated for the SCWC Sand Canyon well, (located near Lost Canyon 2A), but is considerably higher than the T values of 96,000 gpd/ft and 81,000 gpd/ft previously calculated for the nearby, older Mitchell 5A and Lost Canyon 2 wells, respectively. This suggests that the higher value (on the order of 350,000 gpd/ft) is more representative of the transmissivity of the alluvial aquifer system in this area.

In the central area of the alluvium, near the Newhall Ranch Road bridge over the Santa Clara River, the Slade 1986 Report indicated NLF Well S2 displayed a T value of 61,200 gpd/ft and a P value of only 380 gallons per day per square foot (gpd/ft$^2$). More recent testing of VWC Wells S6, S7 and S8, constructed in 1999-2000 in this same central area, revealed T values of between 400,000 and 500,000 gpd/ft and hydraulic conductivities of approximately 3000 gpd/ft$^2$. Again, these higher values are likely more representative of the alluvial aquifer system in this area.

Finally, two alluvial wells (VWC W-9 and W-10) were constructed in San Francisquito Canyon in 1991 and 1999. Testing revealed T values of 118,000 gpd/ft for W-10 and an extremely high value of 750,000 gpd/ft for W-9. Whereas the W-9 value may be anomalously high, even the lower T value for VWC W-10 is approximately twice the T values that were previously calculated from Edison efficiency test data for older wells in that area.

## Geohydrology

### General Statement

Within an aquifer, the amount of groundwater in storage is the total volume of water that exists in underground storage at a particular time, and that could become readily available for extraction by wells. Groundwater within the alluvial aquifer system in the study area occurs under unconfined (water table) conditions, and the amount of groundwater in storage in this aquifer depends on: a) the total volume of the alluvial sediments; b) the specific yield of those sediments, and; c) the proportion of those sediments that is saturated with groundwater.

Because the volume and specific yield of an aquifer do not generally change over time, the amount of groundwater in storage in the alluvial aquifer is directly related to the saturated thickness, which is in turn indicated by measured groundwater levels in water wells within the alluvial sediments. A rising water table increases the thickness of the saturated water-bearing section, and results in an increasing volume of groundwater in storage, whereas the reverse is true for a declining water table.

Because groundwater levels in the alluvial aquifer system are strongly influenced by local rainfall and recharge (a highly variable factor in southern California), the amount of groundwater in storage in the alluvium has varied considerably over the past 50 to 60 years as the local climate has experienced periods of both higher than average rainfall (wet years) and lower than average rainfall (dry years). For example, in November 1965, at the end of a severe 21-year long dry period (see Figure 2.1), groundwater levels in the alluvial aquifer system were at their lowest recorded levels and the amount of groundwater in storage in the alluvium was calculated at 107,000 AF (Slade 1986 Report). Conversely, in April 1945, at the end of a 10- to 11-year period of above average rainfall, groundwater elevations were at their highest recorded levels and the amount of groundwater in storage was calculated to be approximately 201,000 AF (Slade 1986 Report).

In order to update the Slade 1986 Report, we have re-calculated the amount of groundwater in storage within the alluvial aquifer system based on water level data for the spring of 2000, a recent period for which widespread water level data are available.

### Groundwater Storage Capacity

The procedure for re-calculating the amount of groundwater in storage in the alluvial aquifer system is the same as was performed for the Slade 1986 Report, and is summarized as follows:

1. Subdivision of the alluvial aquifer into individual groundwater storage units.
2. Assessment of the total thickness of potentially saturated sediments in each storage unit.
3. Calculation of the thickness of saturated sediments in each storage unit, based on groundwater elevations for the period of interest in other nearby wells (Spring 2000, as seen on Plate 4.2).
4. Grouping of earth materials described on drillers' logs into categories based on grain size, and assignment of specific yield values to each category of earth materials.
5. Computation of groundwater in storage ($GW_{st}$) using the equation:

   $$GW_{St} = AmS_y$$

   Where A = the surface area of the storage unit, m = the saturated thickness of the aquifer, and $S_y$ = the assigned specific yield.

### Storage Units and Saturated Thicknesses

Because the alluvial sediments vary in character, thickness, and hydrogeologic properties, we have again subdivided the alluvium into the same smaller, more manageable groundwater storage units, as was done for the Slade 1986 Report. The boundaries of these units were again taken to coincide with surface or subsurface hydrogeologic boundaries, or topographic features such as canyon "narrows", obvious surface water divides, or similar features. Plate 4.5 – Map of Alluvial Groundwater Storage Units – illustrates the locations of the groundwater storage units and subunits for the alluvial aquifer system as used herein and as originally delineated in the Slade 1986 Report.

The storage units, and the methods used to determine their volume and saturated thickness are essentially unchanged from those presented in the Slade 1986 Report; a detailed description of these methods can be found in that report. However, the following are the salient points:

1. The water table surface was determined by contouring water level elevations for Spring 2000 and assigning an average water level elevation to each groundwater storage subunit within the alluvial aquifer area. The saturated thickness of each storage subunit was then defined as the distance between the average water table surface in that subunit and the bottom (base) of the alluvium in that subunit.
2. Within storage subunits where no water level elevation data were available for Spring 2000 (also see Plate 4.3), water level elevations for that subunit were estimated using 1985 water level elevations that were adjusted (generally downwards) to match Spring 2000 conditions.
3. The saturated volume of each subunit was calculated by multiplying the surface area of each subunit by the saturated thickness, and then reducing each volume by 25% to account for the fact that the sides and bottom of each alluvial subunit have the form of a generally U-shaped channel rather than a perfect rectangle.

The actual area and volume calculations for each storage subunit (see locations on Plate 4.5) were carried out using in-house GIS software.

### Specific Yield Values

The specific yield of an aquifer is that percentage of the total volume of contained groundwater that will drain from the aquifer under the influence of gravity. The remaining portion of the groundwater within the aquifer materials is held in-place during gravity drainage by such actions as molecular forces and capillary attraction.

Specific yield values for the alluvial aquifer materials were determined previously through an assessment of sediment types recorded on approximately 300 drillers' logs for alluvial water wells located throughout the study area (Slade 1986 Report). These same specific yield values, which ranged from 9 to 16 percent, were also used for each of the storage subunits in the updated storage calculations presented in this report.

Estimated Quantity of Groundwater in Storage

The estimated quantity of groundwater in storage within the alluvial aquifer system in the spring of 2000 is calculated by GIS methods to be approximately 161,000 AF (see Table 4.4 – Alluvial Groundwater in Storage Calculations). Because this volume was calculated using a GIS system and digitized versions of the original mylar maps used for the Slade 1986 Report, we have also re-calculated the previous groundwater in storage volumes for 1945, 1965, and 1985 as presented in the Slade 1986 Report. This was done to assess the consistency of the new computer calculations, and to allow comparison between the original calculations of groundwater in storage and the current ones presented at this time. The assessment shows that the variation between the GIS and manual calculations of the original storage volumes (presented in the Slade 1986 Report) is less than 1% in each case. When referring to these historic groundwater in storage volumes, this update report uses the new GIS calculated numbers, which differ only slightly from those presented in the original Slade 1986 Report.

Over time, groundwater levels and associated groundwater in storage in the alluvial aquifer have fluctuated, typically in response to wet and dry conditions as they affect water levels and storage in the eastern portion of the alluvial aquifer. However, there has been no long-term, progressive decline in the amount of groundwater in storage in the alluvium that could be considered indicative of overdraft conditions.

**Assessment of Operational Yield**

The perennial yield of a groundwater basin was considered in the Slade 1986 Report to be the average annual amount of groundwater that may be extracted over the long-term from the basin by pumping without causing undesirable effects; in essence, it was considered to be a practical rate of annual groundwater withdrawal. The range of undesirable effects can include such things as ground subsidence, a decrease in water quality, or continuous and long-term water level declines in the aquifer. The primary undesirable effect in the alluvial aquifer in the Valley would be a continued and progressive decline in groundwater levels, leading to a permanent loss of groundwater in storage and to excessive pumping lifts. Were this situation to occur, the aquifer would be considered to be in overdraft.

# Table 4.4
# Alluvial Groundwater in Storage Calculations

| Storage Unit | Storage Subunit | Formation | Planimeter Area (acres) | Effective Planimeter Area (75%) (acres) | GIS Area (acres) | Specific Yield (%) | Base of Storage Unit (ft asl) | Saturated Thickness 1945 (ft) | Saturated Thickness 1965 (ft) | Saturated Thickness 1985 (ft) | Saturated Thickness 2000 (ft) | GIS Storage Volume 1945 (AF) | Manual Storage Volume 1945 (AF) | GIS Storage Volume 1965 (AF) | Manual Storage Volume 1965 (AF) | GIS Storage Volume 1985 (AF) | Manual Storage Volume 1985 (AF) | GIS Storage Volume 2000 (AF) | Manual Storage Volume 2000 (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 1a | Undifferentiated Alluvium | 477 | 358 | 470 | 19% | 1550 | 95 | 20 | 87 | 82.5 | 6,363 | 6,457 | 1,340 | 1,359 | 5,827 | 5,914 | 5,525 | 5,608 |
| A | 1b | Undifferentiated Alluvium | 301 | 226 | 303 | 17% | 1443 | 111 | 32 | 90 | 74.5 | 4,288 | 4,260 | 1,236 | 1,228 | 3,477 | 3,454 | 2,878 | 2,859 |
| A | 1c | Undifferentiated Alluvium | 792 | 594 | 793 | 15% | 1346 | 118 | 35 | 92 | 84 | 10,527 | 10,514 | 3,122 | 3,119 | 8,208 | 8,197 | 7,494 | 7,484 |
| A | 1d | Undifferentiated Alluvium | 1324 | 993 | 1312 | 14% | 1202 | 128 | 39 | 107 | 105.5 | 17,633 | 17,795 | 5,373 | 5,422 | 14,740 | 14,875 | 14,534 | 14,667 |
| A | 1e | Undifferentiated Alluvium | 559 | 419 | 550 | 16% | 1072 | 128 | 53 | 119 | 115.5 | 8,448 | 8,586 | 3,498 | 3,555 | 7,854 | 7,983 | 7,623 | 7,748 |
| A | 2 | Undifferentiated Alluvium | 263 | 197 | 264 | 9% | 1505 | 85 | 5 | 55 | 39 | 1,515 | 1,509 | 89 | 89 | 980 | 976 | 695 | 692 |
| A | 3a | Undifferentiated Alluvium | 325 | 244 | 313 | 9% | 1680 | 50 | 7 | 42 | 50 | 1,056 | 1,097 | 148 | 154 | 887 | 921 | 1,056 | 1,097 |
| A | 3b | Undifferentiated Alluvium | 305 | 229 | 291 | 13% | 1525 | 105 | 10 | 50 | 45 | 2,979 | 3,122 | 284 | 297 | 1,419 | 1,487 | 1,277 | 1,338 |
| A | 4a | Undifferentiated Alluvium | 158 | 119 | 153 | 9% | 1570 | 60 | 10 | 55 | 47.5 | 620 | 640 | 103 | 107 | 568 | 587 | 491 | 507 |
| A | 4b | Undifferentiated Alluvium | 151 | 113 | 145 | 13% | 1400 | 75 | 10 | 75 | 57.5 | 1,060 | 1,104 | 141 | 147 | 1,060 | 1,104 | 813 | 847 |
| | | Subtotals | 4,655 | 3,492 | 4,594 | | | | | | | 54,489 | 55,084 | 15,334 | 15,477 | 45,020 | 45,498 | 42,386 | 42,847 |
| | | Actual Change from Previous Period: | | | | | | | | | | | | -39,155 | | 29,686 | | -2,634 | |
| B | 1a | Undifferentiated Alluvium | 1515 | 1136 | 1472 | 16% | 925 | 174 | 112 | 172 | 170 | 30,735 | 31,633 | 19,784 | 20,362 | 30,382 | 31,270 | 30,029 | 30,906 |
| B | 1b | Undifferentiated Alluvium | 963 | 722 | 958 | 15% | 900 | 131 | 100 | 133 | 115 | 14,119 | 14,192 | 10,778 | 10,834 | 14,334 | 14,409 | 12,394 | 12,459 |
| B | 2a | Undifferentiated Alluvium | 523 | 392 | 526 | 9% | 1412 | 73 | 30 | 58 | 33 | 2,592 | 2,577 | 1,065 | 1,059 | 2,059 | 2,048 | 1,172 | 1,165 |
| B | 2b | Undifferentiated Alluvium | 352 | 264 | 359 | 11% | 1225 | 90 | 42 | 95 | 85 | 2,666 | 2,614 | 1,244 | 1,220 | 2,814 | 2,759 | 2,517 | 2,468 |
| B | 2c | Undifferentiated Alluvium | 472 | 354 | 460 | 14% | 1115 | 105 | 22 | 95 | 83 | 5,072 | 5,204 | 1,063 | 1,090 | 4,589 | 4,708 | 4,009 | 4,113 |
| B | 3 | Undifferentiated Alluvium | 186 | 140 | 187 | 9% | 1150 | 80 | 36 | 60 | 48 | 1,010 | 1,004 | 454 | 452 | 757 | 753 | 606 | 603 |
| B | 4a | Undifferentiated Alluvium | 236 | 177 | 229 | 9% | 1245 | 57 | 17 | 55 | 41 | 881 | 908 | 263 | 271 | 850 | 876 | 634 | 653 |
| B | 4b | Undifferentiated Alluvium | 338 | 254 | 331 | 12% | 1140 | 80 | 37 | 78 | 65 | 2,383 | 2,434 | 1,102 | 1,126 | 2,324 | 2,373 | 1,936 | 1,977 |
| B | 4c | Undifferentiated Alluvium | 365 | 274 | 363 | 14% | 1025 | 130 | 76 | 126 | 105 | 4,955 | 4,982 | 2,897 | 2,913 | 4,802 | 4,829 | 4,002 | 4,024 |
| | | Subtotals | 4,950 | 3,713 | 4,885 | | | | | | | 64,412 | 65,548 | 38,649 | 39,327 | 62,911 | 64,025 | 57,299 | 58,368 |
| | | Actual Change from Previous Period: | | | | | | | | | | | | -25,763 | | 24,262 | | -5,612 | |
| C | 1a | Undifferentiated Alluvium | 565 | 424 | 557 | 15% | 836 | 144 | 121 | 134 | 124 | 9,023 | 9,153 | 7,582 | 7,691 | 8,397 | 8,517 | 7,770 | 7,882 |
| C | 1b | Undifferentiated Alluvium | 445 | 334 | 439 | 14% | 804 | 123 | 102 | 117 | 116 | 5,670 | 5,747 | 4,702 | 4,766 | 5,393 | 5,467 | 5,347 | 5,420 |
| C | 1c | Undifferentiated Alluvium | 718 | 539 | 842 | 13% | 750 | 115 | 102 | 97 | 110 | 9,441 | 8,051 | 8,374 | 7,141 | 7,963 | 6,790 | 9,030 | 7,701 |
| C | 2a | Undifferentiated Alluvium | 1056 | 792 | 987 | 16% | 1035 | 115 | 63 | 75 | 65 | 13,621 | 14,573 | 7,462 | 7,983 | 8,883 | 9,504 | 7,699 | 8,237 |
| C | 2b | Undifferentiated Alluvium | 1101 | 826 | 1107 | 16% | 940 | 114 | 82 | 104 | 90 | 15,144 | 15,062 | 10,893 | 10,834 | 13,815 | 13,740 | 11,956 | 11,891 |
| C | 3 | Undifferentiated Alluvium | 320 | 240 | 312 | 9% | 1050 | 35 | 15 | 30 | 19 | 737 | 756 | 316 | 324 | 632 | 648 | 400 | 410 |
| | | Subtotals | 4,205 | 3,155 | 4,244 | | | | | | | 53,635 | 53,342 | 39,328 | 38,739 | 45,083 | 44,666 | 42,202 | 41,541 |
| | | Actual Change from Previous Period: | | | | | | | | | | | | -14,307 | | 5,755 | | -2,681 | |
| D | 1a | Undifferentiated Alluvium | 1610 | 1209 | 1593 | 12% | 1100 | 71 | 38 | 51 | 40 | 10,179 | 10,288 | 5,448 | 5,506 | 7,312 | 7,390 | 5,735 | 5,796 |
| D | 1b | Undifferentiated Alluvium | 990 | 743 | 975 | 14% | 970 | 162 | 77 | 143 | 130 | 16,585 | 16,840 | 7,883 | 8,004 | 14,640 | 14,865 | 13,309 | 13,514 |
| | | Subtotals | 2,600 | 1,951 | 2,568 | | | | | | | 26,764 | 27,128 | 13,331 | 13,510 | 21,951 | 22,255 | 19,044 | 19,310 |
| | | Actual Change from Previous Period: | | | | | | | | | | | | -13,433 | | 8,621 | | -2,908 | |
| | | Total Groundwater in Storage | 16,410 | 12,311 | 16,291 | | | | | | | 199,301 | 201,102 | 106,642 | 107,053 | 174,966 | 176,444 | 160,930 | 162,066 |
| | | Difference in GIS vs Manual Methods: | | | | | | | | | | | 0.9% | | 0.4% | | 0.8% | | 0.7% |
| | | Actual Change in Storage from Previous Period: | | | | | | | | | | | | -92,658 | | 68,324 | | -14,036 | |
| | | Percent Change in Storage from Previous Period: | | | | | | | | | | | | 53.5% | | 164.1% | | 92.0% | |
| | | Percentage of All Time Maximum Storage: | | | | | | | | | | | | 53.5% | | 87.8% | | 80.7% | |

Groundwater production from the alluvial aquifer system is distributed along the main reach of the Santa Clara River, in the Castaic Creek drainage, and in several of the tributary canyons. Thirteen municipal-supply water wells in the alluvial aquifer system each produced in excess of 1000 AF in 2000 as shown on Table 4.3.

Between 1986 and 2000, NCWD accounted for between 4% and 12% of the total annual alluvial groundwater production; VWC produced between 18% and 31% of the total annual production; SCWC extracted between 26% and 46% of the total annual production; NLF pumped between 25% and 35% of the total annual production; and WHR reportedly accounted for between 8% and 9% of the annual production in this period from the alluvium.

Annual production from the privately-owned, domestic-supply alluvial wells is not known, but is unlikely to have exceeded a total of 100 to 200 AF/yr for all privately-owned, domestic-supply alluvial wells in the region. This represents only about 1% of the average annual groundwater production since 1986 from the alluvium. Beginning in 2000, a new privately-owned golf course irrigation well along the Santa Clara River east of Sand Canyon became active. Although metered pumpage figures are not available for this new well, it is estimated that this well might extract on the order of 350 AF/yr for each of the two onsite 18-hole golf courses that it irrigates.

To illustrate the spatial variability in recent alluvial groundwater extractions within the Valley, we have prepared Plate 4.2 – Map of Alluvial Groundwater Extractions for 2000. Data for Plate 4.2 were derived from the information tabulated for the year 2000 on Table 4.3 for each active municipal-supply well. Annual groundwater extractions for each well on Plate 4.2 are illustrated via a circle centered on the respective well. The larger the diameter of the circle, the greater is the extraction for the particular well in 2000. The map scale used to illustrate the diameter of the circle which represents the year 2000 annual production is: 1 inch equals approximately 667 AF (or, ¾" = 500 AF). It must be noted that the circles (specifically, the diameter of the circles) graphed on Plate 4.2 are drawn to solely represent the relative annual production volume (in AF) for each respective well. The diameter of the circle surrounding each well does not represent and should not be construed or interpreted to signify the area of pumping influence (the extent of the drawdown cone) of the particular well.

For 2000, the largest municipal-supply alluvial extractions occurred along the main reach of the Santa Clara River, by SCWC (in areas east of Bouquet Junction) and by VWC (near and just west of Bouquet Junction); WHR extractions were the largest in Castaic Creek, north of its confluence with the Santa Clara River. There are no municipal-supply wells within the alluvium in the South Fork area of the Santa Clara River or along the main reach of the river valley west of I-5.

**Current Groundwater Levels and Flow Directions**

Groundwater levels and flow directions within the alluvial aquifer system were determined by creating contour lines of equal groundwater elevation (in ft above sea level, asl) for the available data from wells within the alluvial sediments in the study area. The data used to create these contour lines consisted of measurements, in numerous individual alluvial wells, of the depth to the static (non-pumping) water level. These depths were converted to elevations by subtracting the depth from the reported ground surface elevation at each wellhead. Groundwater flow directions were then determined by recognizing that groundwater flows from high head to low head; hence, the general direction of groundwater flow within the alluvial sediments is interpreted to be perpendicular to the equal elevation contour lines for the date depicted.

Plate 4.3 – Map of Alluvial Groundwater Elevation Contours, Spring 2000 – illustrates the groundwater elevations and interpreted flow directions for the spring (March to May) of 2000, a recent period for which widespread water level data are available. Water level data from approximately 100 different wells throughout the Valley were used to create the elevation contours, with data being obtained from the municipal water purveyors, agricultural well owners, the LACFCD database, and reports on water levels in piezometer wells provided by Seward Engineering Ltd (SE).

As illustrated by the broad arrows on Plate 4.3, groundwater flow directions within the alluvial aquifer system generally mimic surface water flow directions and the land surface gradient, with groundwater moving from east to west along the main reach of the Santa Clara River, and from highland areas towards the main river valley within the alluvium in the tributary canyons along each side of the valley floor. In the main river valley, groundwater elevations decline from a high of approximately 1700 ft above sea level (asl) in the eastern end of the study area, to a low of about 820 ft near the Los Angeles-Ventura County Line in the west (see Plate 4.3). This equates to a decline of approximately 880 ft over a distance (paralleling the Santa Clara River) of 22 miles, and calculates to an overall down-valley gradient of approximately 40 feet per mile (ft/mi).

The gradient is steeper in the eastern portion of the main Valley east of Bouquet Canyon, where the water level drops 325 ft in 5.6 miles; this represents a gradient of roughly 58 ft/mile. This compares with a gradient of 50 ft/mi for the same area calculated from 1985 water levels (Slade 1986 Report).

In the western part of the alluvium between Bouquet Canyon and the County Line, the groundwater elevation drops 555 ft over 16.3 miles, representing a gradient of roughly 34 ft/mi. This compares with a gradient of 31 ft/mi calculated from 1985 water levels (Slade 1986 Report).

Groundwater gradients are much steeper in the major tributary canyons for which sufficient data exist, with measured spring 2000 gradients of approximately 90 ft/mi in Mint Canyon, 56 ft/mi in Bouquet Canyon, 42 ft/mi in San Francisquito Canyon, and 31 ft/mi along Castaic Creek. The well monitored by LACFCD in the baseball park along Bouquet Canyon appears to be the Park well owned by CLWA; its LACFCD well number is likely 7086B (see Plate 4.2).

An interesting feature on Plate 4.3 is the very low groundwater gradient within the alluvium along the South Fork of the Santa Clara River, a feature that was also seen on previously prepared groundwater elevation maps of the alluvium (Slade 1986 Report). The average gradient along the South Fork for Spring 2000 data is only on the order of 13 ft/mi, although a detailed delineation of gradients in this area is made difficult by the virtual absence of requisite data from alluvial wells in this area. However, it does not appear that any "up-valley" or reversed groundwater flow is occurring southward into this South Fork area.

There is no evidence from the available data that either the San Gabriel or the Holser faults acts as a barrier to groundwater flow within the alluvial deposits of the Santa Clara River or its tributaries.

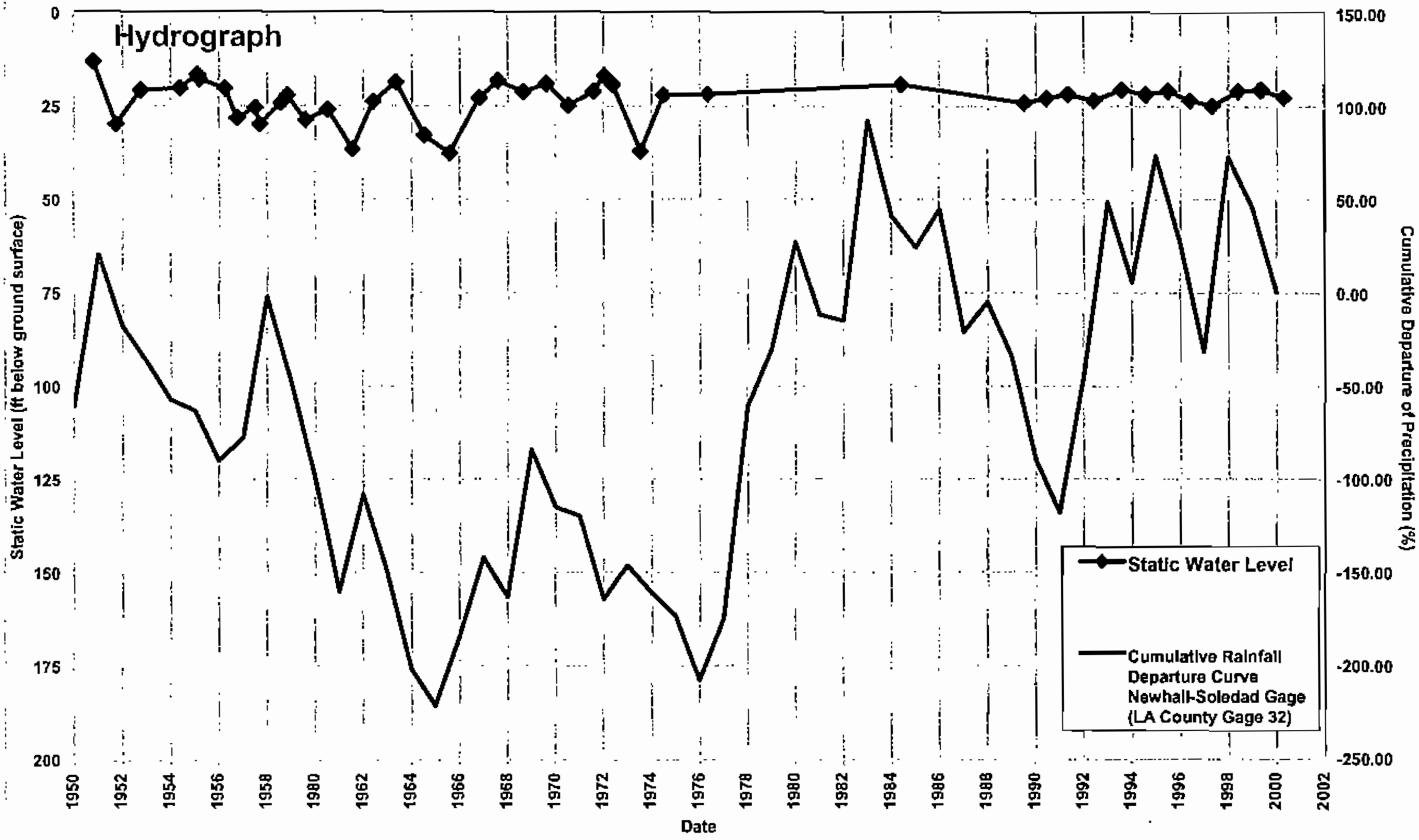
**Hydrographs**

For the purpose of examining long-term water level trends within the alluvial aquifer, the Valley can be divided up into three areas: the western area, between the Los Angeles/Ventura County line and I-5; the central area, between I-5 and the mouth of Bouquet Canyon; and the eastern area, from Bouquet Canyon east to NCWD Pinetree Well No. 1, which is the easternmost municipal-supply well in the alluvial aquifer system. Long-term water level trends in selected alluvial wells are presented in the form of hydrographs which are graphs of the static water levels (i.e., the non-pumping water levels) in the well versus time; also provided on each hydrograph is a portion of the cumulative departure curve for rainfall (for the period 1950 to 2000) as adapted from Figure 2.1.

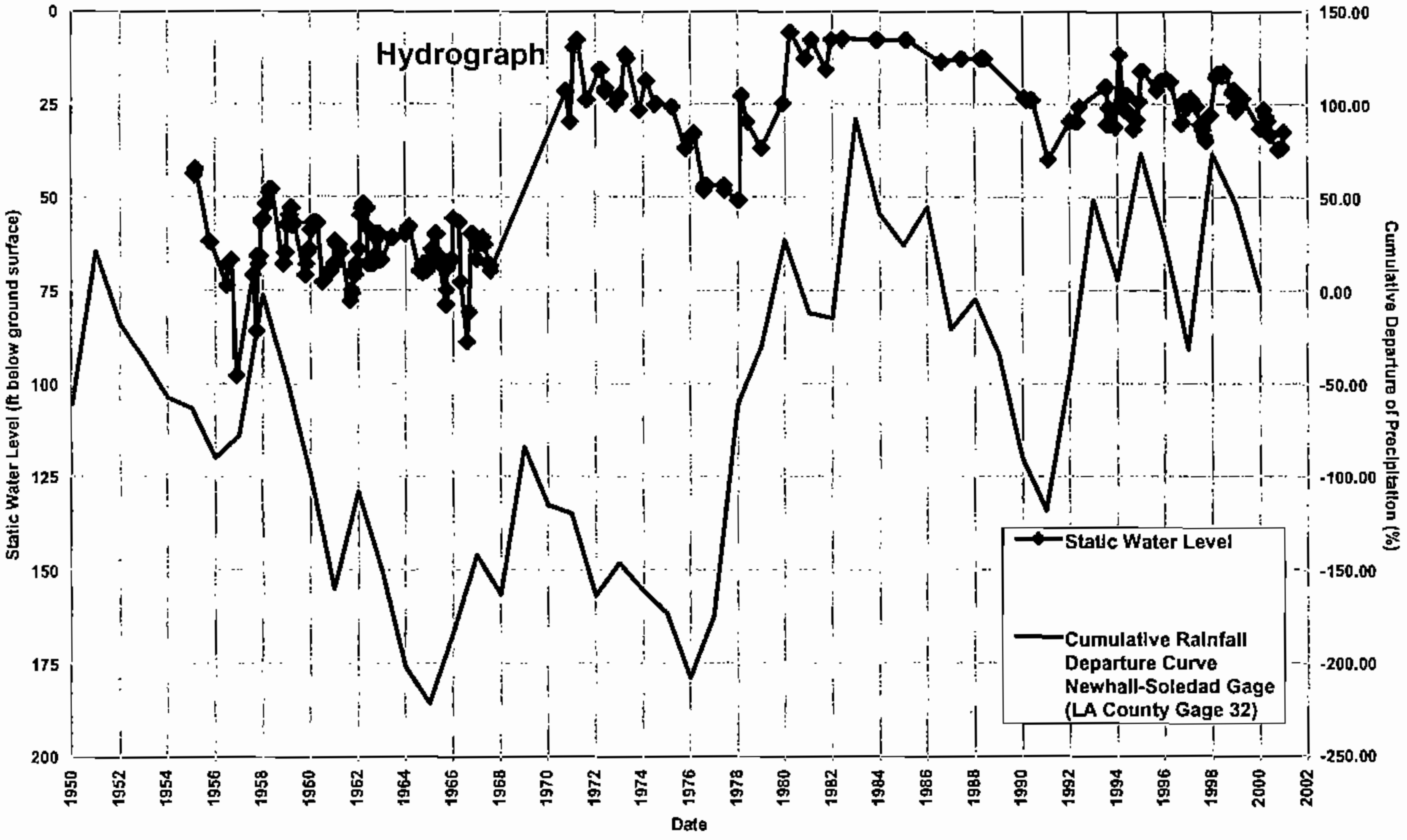
The hydrograph for NLF Well C8 (Figure 4.2 – Hydrograph of NLF Well C8: see well location on Plate 4.3 – Map of Alluvial Well Hydrographs) provides a useful, long-term record of water levels in this western part of the alluvial aquifer system (i.e., in the alluvium west of I-5). Water levels in this area have remained remarkably constant over time as evidenced by data for this well, ranging from a high of approximately 13 ft bgs, to a low of 37 ft bgs over a period of data record of approximately 50 years. This lack of marked water level fluctuation in this well is likely due to the well being located in an area where groundwater from the Saugus Formation is considered to be flowing upward into the overlying alluvium, thereby providing a fairly consistent source of recharge that is relatively independent of annual rainfall trends. There has also been somewhat less year-to-year variability in water levels in this well over the past twenty years, when compared to the variability seen in the same record from the 1950s through the 1970s. This may in part be due to the increased additional recharge to the alluvium provided by increasing outflows from the two WRPs located upgradient from this well. Total WRP discharges were approximately 19,000 AF in 2000.

In the central portion of the alluvium, in the area near the confluence of the South Fork with the main reach of the Santa Clara River, the hydrograph for VWC Well Q2 (Figure 4.3 – Hydrograph of VWC Well Q2: see also Plate 4.3 for well location) shows the typical water level response in this area over time. During the 1950s and 1960s, a time of high alluvial

## Figure 4.2
## NLF Well C8
## Water Level Hydrograph



# Figure 4.3
# VWC Well Q2
# Water Level Hydrograph



groundwater production and low rainfall, water levels in this well averaged approximately 70 to 75 ft bgs, within an historic range of 42 to 98 ft bgs. Reduced pumping in the alluvium, and a return to more normal rainfall patterns in the 1970s and 1980s, resulted in a rapid recovery of water levels to depths of between 6 and 27 ft bgs; water level declines were to depths as much as 51 ft bgs during the dry years of the mid-1970s. A return to the higher rates of annual alluvial groundwater extractions in the 1990s did not result in a return to the low water levels typical of the 1950s and 1960s. This in part is due to the generally normal rainfall patterns over the last ten years, and the increased recharge provided to the alluvium from the two local WRPs.

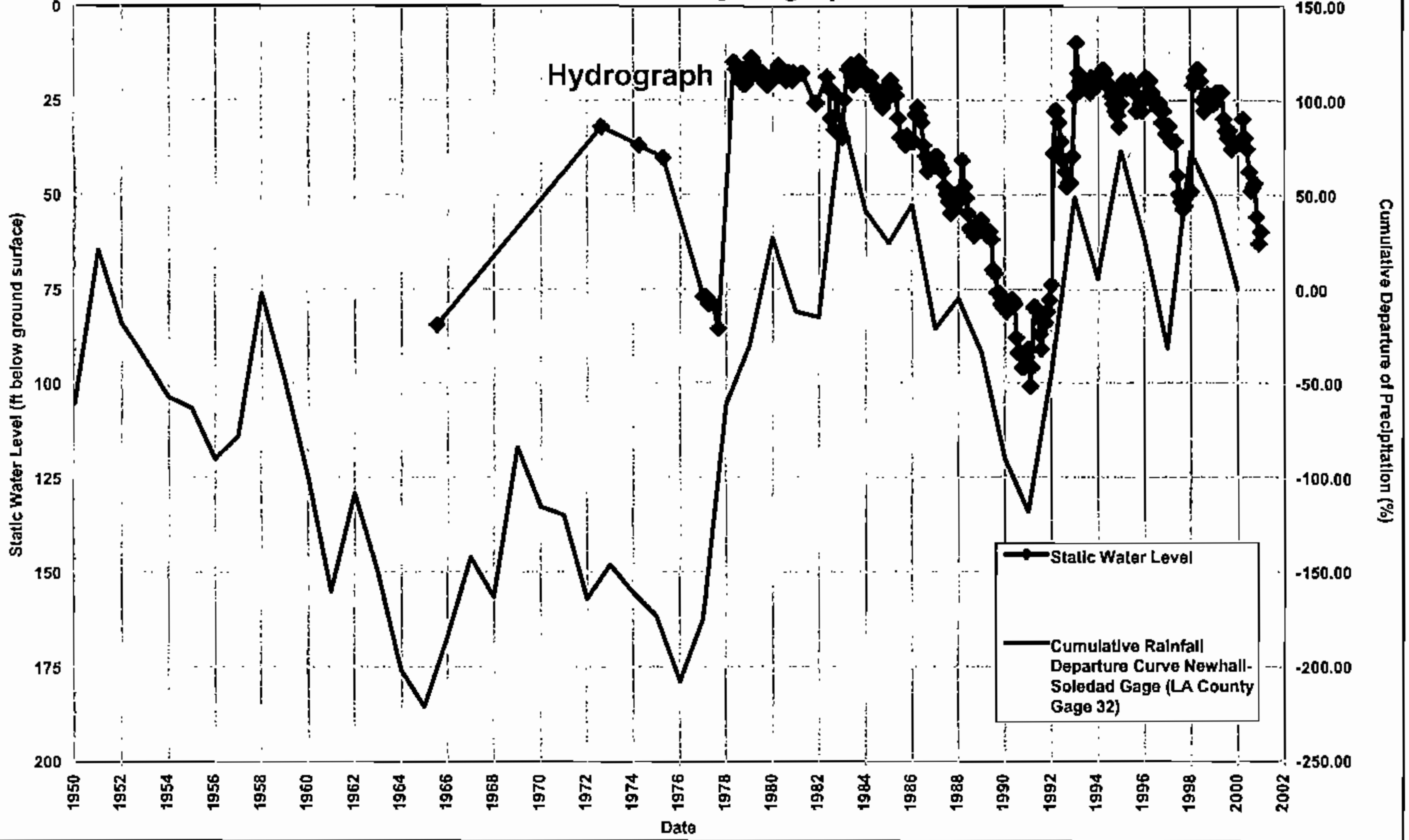
Finally, in the eastern portion of the alluvial aquifer, the representative hydrograph for the SCWC Mitchell Well 5A (Figure 4.4 – Hydrograph of SCWC Mitchell Well 5A and also Plate 4.4) shows a much stronger correlation with annual rainfall totals than is shown by the hydrographs for wells in either the central or western parts of the Valley. Water levels in these easterly-area wells during wet periods such as from 1978 to 1983 tend be in the range of 10 to 20 ft bgs, falling to as low as 101 ft bgs during periods of extended drought such as that from 1984 to 1991. However, by 1993, after a return to wetter climatic conditions, water levels recovered rapidly to their pre-drought range. Water levels also show a declining response during the dry years of 1996 to 1997, and 1999 to 2000. From past trends, it can be seen that these lower water levels are a temporary condition, which then (regardless of the total alluvial production) rapidly return to higher water level conditions as soon as wetter conditions prevail.

Differences in the response of water levels over time in wells located in different parts of the alluvial aquifer system in the Valley are readily seen on Plate 4.4. Hydrographs shown thereon are for various municipal-supply wells, an irrigation-supply well, and for a few LACFCD-monitored wells that are privately-owned (see for example LACFCD Well No. 7132 in the northern portion of Bouquet Canyon).

### Aquifer Parameters

The Slade 1986 Report presented a map of estimated aquifer parameters calculated from efficiency tests conducted in a number of alluvial water wells in the Valley by the Edison

# Figure 4.4
# SCWC Mitchell Well 5A
# Water Level Hydrograph



Company. Plate 7 from that report (not presented herein) showed the locations of these wells, annotated with values for transmissivity (T) and hydraulic conductivity (or permeability, herein denoted by symbol P). That report noted that T and P varied considerably over quite short lateral distances within the alluvial aquifer, and suggested that this was because T and P values were calculated from water level drawdowns in the pumping wells rather than from aquifer test data from nearby observation wells. Use of water level drawdown data from pumping wells to calculate T values may provide results that are strongly influenced not only by the properties of the aquifer, but also by the condition of the well casing and gravel pack, particularly with older wells.

Since 1985, a number of new alluvial water wells have been constructed and tested, and generally more accurate T and P values are now available for some of these new wells. In the eastern part of the alluvium, the SCWC Lost Canyon 2A and Mitchell 5B wells were constructed and tested in 1990 and 2001, respectively; these wells had calculated T values ranging from approximately 270,000 to 500,000 gallons per day per foot of aquifer (gpd/ft). This is consistent with the earlier T value of approximately 350,000 gpd/ft calculated for the SCWC Sand Canyon well, (located near Lost Canyon 2A), but is considerably higher than the T values of 96,000 gpd/ft and 81,000 gpd/ft previously calculated for the nearby, older Mitchell 5A and Lost Canyon 2 wells, respectively. This suggests that the higher value (on the order of 350,000 gpd/ft) is more representative of the transmissivity of the alluvial aquifer system in this area.

In the central area of the alluvium, near the Newhall Ranch Road bridge over the Santa Clara River, the Slade 1986 Report indicated NLF Well S2 displayed a T value of 61,200 gpd/ft and a P value of only 380 gallons per day per square foot (gpd/ft$^2$). More recent testing of VWC Wells S6, S7 and S8, constructed in 1999-2000 in this same central area, revealed T values of between 400,000 and 500,000 gpd/ft and hydraulic conductivities of approximately 3000 gpd/ft$^2$. Again, these higher values are likely more representative of the alluvial aquifer system in this area.

Finally, two alluvial wells (VWC W-9 and W-10) were constructed in San Francisquito Canyon in 1991 and 1999. Testing revealed T values of 118,000 gpd/ft for W-10 and an extremely high value of 750,000 gpd/ft for W-9. Whereas the W-9 value may be anomalously high, even the lower T value for VWC W-10 is approximately twice the T values that were previously calculated from Edison efficiency test data for older wells in that area.

## Geohydrology

### General Statement

Within an aquifer, the amount of groundwater in storage is the total volume of water that exists in underground storage at a particular time, and that could become readily available for extraction by wells. Groundwater within the alluvial aquifer system in the study area occurs under unconfined (water table) conditions, and the amount of groundwater in storage in this aquifer depends on: a) the total volume of the alluvial sediments; b) the specific yield of those sediments, and; c) the proportion of those sediments that is saturated with groundwater.

Because the volume and specific yield of an aquifer do not generally change over time, the amount of groundwater in storage in the alluvial aquifer is directly related to the saturated thickness, which is in turn indicated by measured groundwater levels in water wells within the alluvial sediments. A rising water table increases the thickness of the saturated water-bearing section, and results in an increasing volume of groundwater in storage, whereas the reverse is true for a declining water table.

Because groundwater levels in the alluvial aquifer system are strongly influenced by local rainfall and recharge (a highly variable factor in southern California), the amount of groundwater in storage in the alluvium has varied considerably over the past 50 to 60 years as the local climate has experienced periods of both higher than average rainfall (wet years) and lower than average rainfall (dry years). For example, in November 1965, at the end of a severe 21-year long dry period (see Figure 2.1), groundwater levels in the alluvial aquifer system were at their lowest recorded levels and the amount of groundwater in storage in the alluvium was calculated at 107,000 AF (Slade 1986 Report). Conversely, in April 1945, at the end of a 10- to 11-year period of above average rainfall, groundwater elevations were at their highest recorded levels and the amount of groundwater in storage was calculated to be approximately 201,000 AF (Slade 1986 Report).

In order to update the Slade 1986 Report, we have re-calculated the amount of groundwater in storage within the alluvial aquifer system based on water level data for the spring of 2000, a recent period for which widespread water level data are available.

Groundwater Storage Capacity

The procedure for re-calculating the amount of groundwater in storage in the alluvial aquifer system is the same as was performed for the Slade 1986 Report, and is summarized as follows:

1. Subdivision of the alluvial aquifer into individual groundwater storage units.
2. Assessment of the total thickness of potentially saturated sediments in each storage unit.
3. Calculation of the thickness of saturated sediments in each storage unit, based on groundwater elevations for the period of interest in other nearby wells (Spring 2000, as seen on Plate 4.2).
4. Grouping of earth materials described on drillers' logs into categories based on grain size, and assignment of specific yield values to each category of earth materials.
5. Computation of groundwater in storage ($GW_{st}$) using the equation:

   $$GW_{St} = AmS_y$$

   Where A = the surface area of the storage unit, m = the saturated thickness of the aquifer, and $S_y$ = the assigned specific yield.

Storage Units and Saturated Thicknesses

Because the alluvial sediments vary in character, thickness, and hydrogeologic properties, we have again subdivided the alluvium into the same smaller, more manageable groundwater storage units, as was done for the Slade 1986 Report. The boundaries of these units were again taken to coincide with surface or subsurface hydrogeologic boundaries, or topographic features such as canyon "narrows", obvious surface water divides, or similar features. Plate 4.5 – Map of Alluvial Groundwater Storage Units – illustrates the locations of the groundwater storage units and subunits for the alluvial aquifer system as used herein and as originally delineated in the Slade 1986 Report.

The storage units, and the methods used to determine their volume and saturated thickness are essentially unchanged from those presented in the Slade 1986 Report; a detailed description of these methods can be found in that report. However, the following are the salient points:

1. The water table surface was determined by contouring water level elevations for Spring 2000 and assigning an average water level elevation to each groundwater storage subunit within the alluvial aquifer area. The saturated thickness of each storage subunit was then defined as the distance between the average water table surface in that subunit and the bottom (base) of the alluvium in that subunit.
2. Within storage subunits where no water level elevation data were available for Spring 2000 (also see Plate 4.3), water level elevations for that subunit were estimated using 1985 water level elevations that were adjusted (generally downwards) to match Spring 2000 conditions.
3. The saturated volume of each subunit was calculated by multiplying the surface area of each subunit by the saturated thickness, and then reducing each volume by 25% to account for the fact that the sides and bottom of each alluvial subunit have the form of a generally U-shaped channel rather than a perfect rectangle.

The actual area and volume calculations for each storage subunit (see locations on Plate 4.5) were carried out using in-house GIS software.

Specific Yield Values

The specific yield of an aquifer is that percentage of the total volume of contained groundwater that will drain from the aquifer under the influence of gravity. The remaining portion of the groundwater within the aquifer materials is held in-place during gravity drainage by such actions as molecular forces and capillary attraction.

Specific yield values for the alluvial aquifer materials were determined previously through an assessment of sediment types recorded on approximately 300 drillers' logs for alluvial water wells located throughout the study area (Slade 1986 Report). These same specific yield values, which ranged from 9 to 16 percent, were also used for each of the storage subunits in the updated storage calculations presented in this report.

Estimated Quantity of Groundwater in Storage

The estimated quantity of groundwater in storage within the alluvial aquifer system in the spring of 2000 is calculated by GIS methods to be approximately 161,000 AF (see Table 4.4 – Alluvial Groundwater in Storage Calculations). Because this volume was calculated using a GIS system and digitized versions of the original mylar maps used for the Slade 1986 Report, we have also re-calculated the previous groundwater in storage volumes for 1945, 1965, and 1985 as presented in the Slade 1986 Report. This was done to assess the consistency of the new computer calculations, and to allow comparison between the original calculations of groundwater in storage and the current ones presented at this time. The assessment shows that the variation between the GIS and manual calculations of the original storage volumes (presented in the Slade 1986 Report) is less than 1% in each case. When referring to these historic groundwater in storage volumes, this update report uses the new GIS calculated numbers, which differ only slightly from those presented in the original Slade 1986 Report.

Over time, groundwater levels and associated groundwater in storage in the alluvial aquifer have fluctuated, typically in response to wet and dry conditions as they affect water levels and storage in the eastern portion of the alluvial aquifer. However, there has been no long-term, progressive decline in the amount of groundwater in storage in the alluvium that could be considered indicative of overdraft conditions.

## Assessment of Operational Yield

The perennial yield of a groundwater basin was considered in the Slade 1986 Report to be the average annual amount of groundwater that may be extracted over the long-term from the basin by pumping without causing undesirable effects; in essence, it was considered to be a practical rate of annual groundwater withdrawal. The range of undesirable effects can include such things as ground subsidence, a decrease in water quality, or continuous and long-term water level declines in the aquifer. The primary undesirable effect in the alluvial aquifer in the Valley would be a continued and progressive decline in groundwater levels, leading to a permanent loss of groundwater in storage and to excessive pumping lifts. Were this situation to occur, the aquifer would be considered to be in overdraft.

The phrase "continued and progressive decline" is the key to understanding the concept of overdraft. Groundwater levels within the alluvial aquifer system experience temporary fluctuations in response to natural variations in recharge (such as from precipitation or upward flow of groundwater from the Saugus Formation aquifer system), and to changes in groundwater discharge such as pumping extractions. However, these temporary fluctuations in the storage of groundwater in the alluvial aquifer system are not continued or progressive; hence, they are not indicative of overdraft. Examples of this type of temporary fluctuation can be seen in the hydrographs for the SCWC Mitchell Well 5A on Figure 4.4 and SCWC North Oaks East Well on Plate 4.4. During periods of reduced rainfall, as in the periods 1969-1976 and 1983-1991, water levels in these wells declined by 75 ft or more, but these temporarily depressed water levels were clearly seen to recover quickly to their pre-drought levels once rainfall (and recharge) returned to more typical long-term average values. The recent decline in water levels in these wells is in response to the reduced rainfall conditions that began in 1999; the trends in rainfall over time are illustrated by the rainfall accumulated departure curve that is also provided with the hydrograph.

<u>Background</u>

The Slade 1986 Report calculated a "practical or perennial yield" for the alluvial aquifer in the range of 31,600 to 32,600 AF/yr. In deriving this perennial yield value, that study relied on the information available at that time, using the so-called Pumpage and Change-in-Storage method and a base period from 1958 to 1985. That method calculates the changes in storage within an aquifer over a period of time (the base period) that is sufficiently long enough to average out the influence of these temporary water level fluctuations. Groundwater extractions by pumping are then compared to the changes of groundwater in storage. The average annual level of pumping that would maintain the amount of groundwater in storage at a relatively constant figure on a long-term basis (i.e. no overdraft) is considered a reasonable estimate of the perennial yield.

Although that method is used because difficult-to-quantify terms such as recharge and subsurface outflow are not required, the method does have its drawbacks as described in a review of several perennial yield studies of the Yucaipa Valley of southern California (David

Keith Todd Consulting Engineers, 1987). Firstly, because the method works best in aquifers that are fully developed or possibly in overdraft, and where recharge does not play an important role in determining the amount of groundwater in storage, the method may be less reliable in aquifers where these assumptions are not met. As discussed previously, water level hydrographs of alluvial water wells illustrate clearly that: a) the alluvial aquifer is not in overdraft; and b) rainfall recharge will rapidly increase the amount of groundwater in storage, particularly in the alluvium east of the mouth of Bouquet Canyon.

Secondly, because the calculation method relies on average pumping rates and net changes in storage over time, it does not consider cumulative or progressive changes in the hydrology of a basin such as changing land use patterns, or an increase in imported water. The Slade 1986 Report (pg. 87) states specifically that "no recharge of imported water was assumed."

### Current Conditions

Current hydrologic conditions in the Valley have in fact changed dramatically over the past twenty years, by such factors as the increased importation of water, the increase in the annual volumes of reclaimed water released to the alluvium, and the rapid conversion of agricultural and ranch lands to urban and suburban uses. In particular, the importation of SWP water has risen from approximately 1,100 AF/yr in 1980 to over 32,000 AF/yr in 2000. Much of this imported water is eventually discharged by the two local WRPs directly into the alluvium of the Santa Clara River. Combined discharges from these two WRPs totaled 19,000 AF in 2000, and this water is directly available for recharging the alluvial aquifer system along the Santa Clara River. Additional recharge comes from the proportion of deep percolation of SWP water that has been used for outdoor irrigation throughout the region.

The effects of this additional available recharge can be seen in the hydrograph for VWC Well Q2 (see Figure 4.3), located downstream of the discharge point for the Saugus WRP. From 1956 to 1970, a period during which groundwater production from the alluvial aquifer system averaged approximately 37,000 AF/yr, water levels in this well were typically at depths of 70 to 75 ft bgs. These water levels recovered rapidly to typical levels of approximately 25 to 30 ft bgs when alluvial groundwater production declined significantly in the early 1970s, eventually reaching an average of just 23,000 AF/yr between 1980 and 1990. However, when alluvial groundwater production again increased to approximately 35,000 AF/yr (between 1990 and 2000), water levels in Well Q2 (and other nearby wells) did not show a corresponding decline. In fact, water levels in Well Q2 are currently at or near their historic highs in spite of the higher alluvial annual groundwater extractions in the past 10 years.

Because of the progressive changes in the local hydrology over time, and the significance of imported SWP water in recharging the alluvial aquifer, simply re-calculating the perennial yield of the aquifer by updating the prior Pumping and Change-in-Storage calculations would not provide an accurate or useful value.

Operational Yield

One of the disadvantages of utilizing perennial yield as a basis for managing pumpage from an aquifer system is that it represents a long-term average value for annual yield. There is a potential for the perennial yield value to be interpreted as a not-to-exceed volume, with a related potential for pumpage above the perennial yield value in any given year to be interpreted as "overdraft". A recently advanced concept intended to deal with such misinterpretations is that of operational yield. Operational yield can be defined as a fluctuating value of pumpage that may be above or below the perennial yield in any given year, and that varies as a function of the availability of other water supplies. The basic intent of the operational yield value is that it should not exceed the perennial (or average) yield of the groundwater basin over multi-year wet and dry cycles.

The operational yield concept includes flexibility of groundwater use by allowing increased pumping during dry periods and increased recharge (direct or in-lieu) with supplemental water when it is available in wet/normal rainfall periods. The operational yield protects the aquifer by helping to assure that groundwater supplies are adequately replenished on a long-term basis from one wet/dry cycle to the next. In the Valley, historical groundwater data demonstrate that the alluvium has been, and continues to be developed within its long-term sustainability (i.e. no continuous lowering of water levels, no notable trend toward degradation of groundwater quality, etc.). Limited historical data for the Saugus Formation show no lowering of water levels or degradation of water quality where it has been developed at known well locations.

It is evident from observation of alluvial aquifer response to average pumping over the last several decades, and its response to pumping in individual years, that this aquifer system can be operated at a higher average pumping rate over a wide range of yearly pumping rates without inducing undesirable conditions that would be indicative of "overdraft," i.e., long-term continuous and progressive decline in water levels and in groundwater in storage. This observation is particularly evident since the initiation of supplemental SWP water deliveries in 1980. As a result, operational yield of the alluvial aquifer system or the yearly yield for operating purposes, could range from an individual annual pumping volume as low as about 20,000 AF, to an individual annual pumping volume as high as about 45,000 AF. The ultimate goals, of course, would be to avoid both short-term adverse impacts as a result of year-to-year fluctuations in pumping, and to avoid long-term adverse impacts such as continuously lowered water levels and storage in this aquifer system.

Recognition of historical alluvial aquifer response to the wide range of annual pumping and the higher average rate of pumping in recent years has led to the following two plans regarding operation of this aquifer system: 1) development of an UWMP that includes water supply from the alluvium within both the long-term yearly operational range and the recent (last ten years) average pumping capacity; and 2) commitment via an MOU process between the Santa Clarita Valley Water Purveyors and the downstream United Water Conservation District to develop a numerical groundwater flow model in order to analyze in greater detail how this aquifer system can be operated in the future to optimize its yield without adverse impact either to the aquifer (avoidance of depressed water levels and depleted storage) or to the environment associated with the aquifer (avoidance of decreased stream flows, avoidance of depleting riparian vegetation, etc.).

In summary, the combination of historical observations and current planning has led to the current conclusion that the alluvial aquifer system can be operated over a wide range of pumping volumes in any given year, on the order of 20,000 to 45,000 AF, and on a long-term average basis can be operated at an average pumping volume on the order of 10 percent higher than was reported as a "practical or perennial yield" in 1986. As summarized in the UWMP, the operation of the alluvium will typically be in the 30,000 to 40,000 AF per year range for most types of normal or wet years, with an expected reduction into the 30,000 to

35,000 AF per year in dry years.

**Water Quality**

Groundwater quality is affected by the relative concentrations of dissolved inorganic constituents, organic chemicals, and entrained organisms such as bacteria. This report discusses only the inorganic constituents and organic chemicals in the local groundwater.

The quality of surface water percolating into an aquifer is affected by such factors as the type of earth materials over which the surface water flowed, and the type and location of possible surface contaminants the water might encounter prior to infiltration. After percolation, the water quality is further influenced by such factors as: the lithology and age of the earth materials through which it flows; the rate of groundwater flow; the amounts, rates and locations of recharge; fluctuations in basin-wide water levels; potential contamination due to improperly constructed or destroyed wells; the location and quality of artificially recharged water; and the proximity of irrigated lands or industrial facilities from which degraded water might percolate into the aquifer system.

Groundwater Character

Groundwater character, as illustrated on a Stiff water quality pattern diagram, is defined by the relative proportions of the major dissolved anions and cations within a water sample. In most groundwater, these major ions include the cations calcium, magnesium and sodium, and the anions bicarbonate, sulfate and chloride. As illustrated on Plate 4.6 – Map of Alluvial Wells, Stiff Pattern Diagrams – the groundwater within the alluvial aquifer system changes in character as it moves from east to west across the valley floor. In the easternmost part of the Valley, near NCWD's Pinetree wells, the groundwater has a distinctive calcium bicarbonate (Ca-$HCO_3$) character, with only minor proportions of the other cations and anions. Moving westward down the Valley, the relative proportion of sulfate ($SO_4$) anions begins to increase such that groundwater in the area between the SCWC Honby and Stadium wells displays both a Ca-$HC0_3$ and a calcium sulfate (Ca-$SO_4$) character, depending on the particular well. Wells in the central part of the alluvium, between the mouth of Bouquet Canyon and I-5, show a mixed calcium-bicarbonate-sulfate (Ca-$HC0_3$-$S0_4$)

character. West of I-5, the groundwater within the alluvium has a Ca-$SO_4$ character (see Plate 4.6).

Within the tributary canyons for which requisite water quality data are available, alluvial groundwater within Bouquet Canyon displays a consistent Ca-$HC0_3$ character, whereas in San Francisquito Canyon a Ca-$SO_4$ water predominates. In Castaic Creek, groundwater appears to change from a Ca-$SO_4$ character in the upstream reaches near Castaic Dam, to a Ca-$HC0_3$-$S0_4$ character in the middle reaches near the I-5 bridge, and then back to Ca-$SO_4$ character in the lower reaches of the creek. This sulfate-rich groundwater within the alluvium of Castaic Creek may be one of the main sources for the higher sulfate groundwater conditions known within the alluvium west of I-5.

Inorganic Constituents

Two important inorganic components in groundwater from the alluvial aquifer system include nitrate (as $NO_3$), which has a State Primary Maximum Contaminant Level (MCL) of 45 milligrams per liter (mg/l) for domestic use, and the TDS concentration; the State Secondary MCL for TDS is expressed as a range with the lower level set at 500 mg/l and the upper level set at 1000 mg/l. No fixed consumer acceptance contaminant level has been established for TDS.

As with water character, the concentrations of nitrate and TDS within the alluvium show measurable changes as one moves from the eastern to the western sides of the Valley. In the eastern portion of the area (near the NCWD Pinetree wells), nitrate concentrations average approximately 14 mg/l, and TDS concentrations average approximately 550 mg/l.

In this easterly area near SCWC's North Oaks wells, average nitrate concentrations are approximately 27 mg/l and TDS is approximately 608 mg/l. Nitrate concentrations in this area are among the highest within any portion of the alluvial aquifer, although still well below the MCL for nitrate as $NO_3$ of 45 mg/l. Elevated nitrate concentrations in this area may originate from subsurface septic systems located in the unsewered tributary canyons north and south of the main Santa Clara River, or from the former Canyon Park Hog Ranch, located some distance south of the Santa Clara River; water samples from alluvial monitoring wells on the hog ranch property have reportedly recorded nitrate concentrations as high as 1816 mg/l (Mr. Steve Cole, SCWC, personal communication, 2001). This former hog ranch is reportedly being remediated under the direction of the Regional Water Quality Control Board – Los Angeles Region.

In the area between SCWC's Stadium and Honby wells, just upstream from the mouth of Bouquet Canyon, nitrate concentrations average 22 mg/l and TDS averages 664 mg/l. Just west of Bouquet Canyon, wells in VWC's Pardee wellfield have average nitrate concentrations of 27 mg/l and average TDS values of 706 mg/l. The relatively elevated nitrate concentrations in these wells (although still well below its MCL of 45 mg/l) may be influenced a number of possible factors, including former agricultural activities in this area that used nitrate-bearing fertilizers, or by the lack of deep cement sanitary seals in these former agricultural production wells.

Groundwater from five NLF agricultural-supply wells in the area west of I-5 has an average nitrate concentration of just 6.6 mg/l, despite the ongoing agricultural operations in this part of the Valley. These low nitrate values are likely due to dilution of the higher nitrate concentrations found in upstream groundwater by relatively low nitrate water from three possible sources. The first possible source is water from the Saugus and Valencia WRPs, where nitrate concentrations in the discharge water average approximately 5 and 23 mg/l, respectively. These two plants discharged a total of approximately 19,000 AF of water in 2000. The second possible source of low nitrate water is underflow of groundwater from Castaic Creek Canyon, where groundwater has average nitrate concentrations of approximately 6 mg/l. Finally, the third possible source of low nitrate water is the area west of I-5 where groundwater from the Saugus Formation is considered to be discharging into the alluvium. Saugus Formation groundwater has nitrate values that are typically lower than those in the alluvial groundwater.

TDS concentrations, on the other hand, are highest in the alluvial groundwater west of I-5, averaging approximately 1000 mg/l in the five NLF agricultural-supply wells mentioned above. The Slade 1986 Report discusses some possible sources of the high TDS values in this area, including irrigation return, WRP effluent, oilfield activities, and runoff from surface drainages where sedimentary rocks are cemented with gypsum or anhydrite ($CaSO_4$ minerals). Another possible cause of the high TDS values in this portion of the alluvium may be groundwater movement from the Saugus Formation into the alluvium.

Other Constituents

A search of the California Department of Health Services (DHS) water quality database reveals that between 1985 and 2000, no VOCs were detected in alluvial municipal-supply wells in the Valley at concentrations exceeding their respective MCLs. Some VOCs were detected in lower concentrations sufficient to require reporting to DHS, but many of these were disinfection byproducts such as chloroform, that result from chlorination of water at the wellhead for disinfection purposes prior to delivering the water into the distribution system.

Perchlorate ($ClO_4$), a component of rocket fuel, and related chemicals, have been detected in groundwater monitoring wells and in one now-abandoned industrial water well on the north side of a former industrial facility located in the hills southeast of Bouquet Junction. The current DHS advisory action level for perchlorate is 4 micrograms per liter (µg/l). No perchlorate has ever been detected in any of the municipal-supply water wells located in the alluvial aquifer system along the Santa Clara River in this region (see Plate 4.1 for locations of these alluvial-supply water wells).

## SECTION 5

# HYDROGEOLOGIC CONDITIONS IN THE SAUGUS FORMATION AQUIFER SYSTEM

### Water Wells

According to available historic records, the first known water well specifically constructed to extract water from the Saugus Formation aquifer appears to have been NCWD Well No. 1, drilled in 1954 (Slade 1988 Report). At the time of that Slade 1988 Report, 22 Saugus Formation water wells were known to have been drilled in the region. As of 1988, 11 of the known Saugus Formation water wells were considered to be on active or inactive status, whereas the other 11 had been either abandoned or destroyed. NLF Well 155, which was listed as destroyed in the Slade 1988 Report, is now known to have only been abandoned (i.e., the pump has been removed from the well). The current condition of this well is not known. Plate 5.1 – Map of Saugus Formation Well Locations – illustrates the locations of known historically-drilled Saugus Formation wells in the Valley.

Between 1988 and 2001, eight additional Saugus Formation water wells were drilled and constructed in the Valley (refer to Plate 5.1). Of this group of 30 historically known water wells in the Saugus Formation, 17 either are in active operation, or are on some type of inactive or standby status. Table 5.1 – Construction Details for Existing Saugus Formation Wells – summarizes the relevant construction details for each of the existing wells, along with the operational status of each of those wells as of 2001. Also listed on Table 5.1 are the construction details for a groundwater monitoring well drilled in 1999 adjacent to new VWC 205; this groundwater monitoring well (205M) is used solely to monitor water levels and/or water quality in the Saugus Formation.

The remaining 13 wells of the 30 known historically-drilled wells in the Saugus Formation have been destroyed (data for the privately-owned Smiser well are unclear whether it is abandoned or destroyed at this time). Table 5.2 – Destroyed Saugus Formation Water Wells – summarizes the known construction details for those wells which have been reported to be destroyed as of 2001.

## Table 5.1
## Construction Data for Existing Saugus Formation Wells

| Agency | Owner Well No | State Well No | Year Drilled | Drilling Method | Status 2001 | Surface Elevation (ft msl) | Total Depth (ft) | Perforated Intervals (ft bgs) | Perforation Type | Sanitary Seal (ft bgs) | Pump Setting (ft bgs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Newhall County Water District | 7 | 04N/16W-35L01 | 1954 | Cable Tool | Inactive | 1253 | 994 | 520-578<br>622-664<br>720-726<br>874-974 | Knife Cut |  | 306 |
|  | 9 | 03N/16W-02R02 | 1958 | Rotary | Inactive | 1348 | 675 | 311-674 | Louvers | 75 | 230 |
|  | 10 | 04N/16W-34A03 | 1961 | Rotary | Inactive | 1207 | 1555 | 780-1544 | Louvers | 114 | 335 |
|  | 11 | 04N/16W-27J03 | 1973 | Reverse Rotary | Active | 1165 | 1136 | 200-1076 | Louvers | 150 | 340 |
|  | 12 | 04N/16W-35A01 | 1985 | Reverse Rotary | Active | 1209 | 1340 | 486-1280 | Louvers | 420 | 400 |
|  | 13 | 04N/16W-01 | 1990 |  | Active | 1105 | 1300 | 420-530<br>600-750<br>780-830<br>870-1280 | Unknown | 60 | 445 |
| Private | Lennar (D. Poe) | 04N/17W-24(?) | 1990 | Rotary | Active | 1240 | 2040 | No Data | Louvers | 500 | Unknown |
|  | Lombardi (Anden) | 04N/17W-047 | 1990 | Reverse Rotary | Inactive | 1280 | 1986 | No Data | Louvers | 450 | None |
| Santa Clarita Water Company | Saugus 1 | 04N/16W-22K06 | 1988 | Reverse | Inactive | 1182 | 1640 | 490-520<br>570-630<br>710-810<br>890-1000<br>1020-1080<br>1130-1190<br>1290-1330<br>1400-1620 | Wire wrap screen | 450 | 500 |
|  | Saugus 2 | 04N/16W-22K10 | 1988 | Reverse | Inactive | 1166 | 1612 | 490-495<br>515-555<br>665-725<br>824-883<br>923-983<br>1043-1103<br>1212-1251<br>1310-1581 | Wire wrap screen | 460 | 500 |
| Valencia Water Company | 157 | 04N/16W-22N01 | 1982 | Rotary | Active | 1150 | 2008 | 586-2006 | Vertical Slots | 15 | 340 |
|  | 159 (irrigation) | 04N/16W-33L01 | 1982 | Rotary | Active | 1297 | 1950 | 682-1900 | Louvers | No Data | 460 |
|  | 160 | 04N/16W-21D01 | 1984 | Rotary | Active | 1102 | 2000 | 950-2000 | Louvers | 65 | 260 |
|  | 201 | 04N/16W-21J01 | 1989 | Mud Rotary | Active | 1149 | 1690 | 540-570<br>612-690<br>720-750<br>780-840<br>960-1000<br>1060-1160<br>1220-1380<br>1350-1380<br>1420-1490<br>1540-1670 | Louvers | 460 | 380 |
|  | 205 | 04N/16W-21L01 | 1999 | Mud Rotary | Active | 1153 | 1950 | 820-1030 | Louvers | 680 | None |
|  | 205M | Monitoring Well Near VWC-205 | 1999 | Mud Rotary | Active | 1152 | 1958 | 820-1504<br>1524-1685<br>1705-1938 | Vertical Slots | 100 | None |
| Newhall Land & Farming Company | 155 | 04N/16W-27R2 | 1960 | Mud Rotary | Abandoned | 1190 | 1515 | 106-1468 interspersed | louvers | No Data | None |
| (Private; Irrigation only) | 150 | 04N/17W-13J1 | 1961 | Mud Rotary | Active | 1053 | 1605 | 320-1600 interspersed | louvers | 15 | 210 (?) |

## Table 5.2

Destroyed Saugus Formation Water Wells

| Owner | Owner Well No. | Year Destroyed |
|---|---|---|
| **Newhall County Water District** | 1 | pre- 1988 |
| | 2 | pre- 1988 |
| | 3 | pre- 1988 |
| | 4 | pre- 1988 |
| | 5 | pre- 1988 |
| | 6 | pre- 1988 |
| | 8 | 1987 |
| **Santa Clarita Water Company** | Lombardi | 1982 |
| **Valencia Water Company** | 202 | 1991 |
| | 203 (pilot hole only) | 1993 |
| **Smiser (Private)** | -- | Abandoned or destroyed post 1988 |
| **Newhall Land and Farming Company (Private; Irrigation only)** | P2 | 1967 |
| | 154 | 1982 |
| | 155 | Abandoned 1978 |
| | 158 | 1985 |

Note: NCWD - 9 to be destroyed in 2001

All but one of the existing Saugus Formation water wells are located in the southern structural block, that is, south of the Holser and San Gabriel faults (refer to Plates 3.1 and 5.1). Only the privately-owned Lombardi-Anden well is located within the central structural block (between the two faults), and there are no known existing Saugus Formation wells north of the San Gabriel fault. Historically, only one known attempt has been made to drill and construct a Saugus Formation water well in the area north of the San Gabriel fault where the lower and geologically older portion of the Saugus Formation (i.e., Sunshine Ranch member) is known to exist. That well (VWC 202) did not produce a sufficient quantity of groundwater of acceptable quality for municipal-supply purposes and was subsequently destroyed.

Maximum casing depths for existing Saugus Formation wells range from 675 ft for NCWD Well No. 9, to 2040 ft for the privately-owned Lombardi-Anden well. The depths to the top of the uppermost perforations in existing wells range between 200 and 950 ft bgs, whereas the depths to the base of the perforations range between 674 and 2000 ft bgs.

Pumping capacities in Saugus Formation wells for which data exist, have ranged from approximately 100 gallons per minute (gpm) in wells completed in the lowermost Sunshine Ranch Member near the outer margin of the formation, to rates in excess of 3000 gpm in wells located near the center of the Saugus Formation along the floor of the Valley.

<u>New Wells</u>

Between 1988 and May 2001, eight new Saugus Formation water wells were drilled and constructed in the Valley. The currently inactive SCWC Saugus No. 1 and No. 2 wells, and the currently active NCWD Well No. 13, were drilled and constructed along the South Fork of the Santa Clara River. New Saugus Formation wells along Valencia Blvd include the currently active VWC Well 201, and VWC Well 205. This latter water-supply well also has a 6-inch diameter monitoring well (VWC 205M) which is located approximately 30 ft from the main well, and which was completed with an almost identical perforated interval and casing depth. In the hills in the southwest part of the Saugus Formation outcrop area is the currently active, privately-owned Stevenson well (formerly known as the Poe well). The currently inactive Lennar-Anden well is located in Hasley Canyon. Finally VWC 202 was drilled and constructed in San Francisquito Canyon, but was subsequently destroyed for the reasons stated above; refer to Plate 5.1 for locations of these wells.

One additional attempt to drill and construct a new Saugus Formation water well in 1993 (VWC 203, located south of Magic Mountain Parkway) had to be terminated and the pilot borehole was destroyed after the contractor encountered technical problems during the drilling phase of the project: However, a detailed geologic log of the drill cuttings from the pilot hole and an electric log of the borehole were completed prior to permanent destruction of the borehole.

Destroyed Wells

As mentioned above, VWC Well No. 202, located in San Francisquito Canyon, was destroyed shortly after its construction in 1990.

In addition, recent discussions with the Ranch Manager at the Smiser Farm located near the I-5 Freeway and Lyons Avenue (personal communication, November 2000) suggest that the Saugus Formation water well on that property was abandoned and covered over sometime after 1988. RCS geologists were unable to locate this well during a brief visit to the property in the fall of 2000, and the date and method for destruction of this well are not known.

Finally, NCWD Well 8 is reported to have been destroyed in 1987, and NCWD Well 9 was reportedly slated for destruction in 2001.

Privately-Owned Domestic Wells

An unknown number of privately-owned, domestic-supply water wells within the Saugus Formation likely exist in some tributary canyons to the Santa Clara River (such as in the upper portion of Hasley Canyon). These wells are thought to provide water primarily for domestic-supply purposes to single-family dwellings and/or ranches that lie outside of the service areas of the local water purveyors. Because the Saugus Formation crops out at or very near ground surface in these areas, the wells are probably relatively shallow, on the order of 100 ft to perhaps 300 or 400 ft in total depth. Maximum pumping rates in such wells would typically be in the range of a few tens of gpm.

## Groundwater Occurrence, Recharge and Discharge

Depending on location, groundwater within the Saugus Formation may exist under confined, semi-confined or even unconfined (water table) conditions. In the center of the Valley (refer to Plate 3.1 and to Plate 5.1), the sedimentary layering of the formation is nearly horizontal, and confining layers of low permeability (fine-grained silts and clays) limit groundwater movement in an upward or downward direction. As a result, groundwater in these areas occurs under pressure within the intervening sand and gravel units, and water levels in Saugus Formation water wells are above the top of the perforated casing intervals that intersect coarse-grained aquifer units, indicating confined or semi-confined conditions.

In contrast, near the lateral margins of the Saugus Formation, the sedimentary layering is tilted downward toward the center of the "bowl," and the permeable sand and gravel beds of the formation are either exposed directly at ground surface, or they are in direct contact with overlying, highly permeable alluvial sediments or terrace deposits. In these areas, the Saugus Formation aquifer may be under unconfined, water table conditions.

### Recharge

Direct natural recharge to the Saugus Formation occurs via deep percolation of rainfall in the outer portions of the outcrop area where the permeable sand and gravel beds are either exposed at ground surface or lie directly beneath the relatively thin, permeable terrace deposits. Natural recharge to the Saugus Formation also takes place in the eastern end of the outcrop area due to leakage from overlying portions of the saturated alluvium, as originally discussed in the Slade 1988 Report and as corroborated by recent work by CH2M Hill (Newhall Ranch ASR Impact Evaluation, 2001).

Man-made sources of recharge to the Saugus Formation include deep percolation of agricultural and landscape irrigation water in areas where this formation is exposed at ground surface. Urban developments (residential, office, and recreational lands) occupy approximately 9600 acres (17%) of the Saugus Formation outcrop area, and are likely to provide significant amounts of irrigation recharge. On the other hand, direct recharge from infiltration of excess agricultural irrigation is likely to be a fairly minor source of recharge to the Saugus Formation because most agricultural land in the Valley is situated atop Quaternary alluvium.

To date, deliberate artificial recharge of the Saugus Formation via injection wells or highland spreading basins has never been undertaken in the region. Importantly, however, an injection and recovery study carried out in 2000 in the vicinity of VWC Well No. 205 has demonstrated the feasibility of operating at least a limited ASR program in the Saugus Formation within the Valley (Slade & Associates, LLC, February 2001; and Newhall Ranch ASR Impact Evaluation, 2001).

Discharge

Discharge from the Saugus Formation has historically occurred primarily via groundwater extractions for municipal- and agricultural-supply purposes, but also via natural discharge to the overlying Quaternary alluvium in the western portion of the Saugus Formation (CH2M Hill, 2001).

### Depth to Base of Fresh Water

The maximum depth to which fresh groundwater occurs within the Saugus Formation (the base of fresh water) can be determined with some accuracy by examining oil well e-logs, and this has been done for approximately 250 e-logs of oil wells and water wells located throughout the Valley. On some e-logs, the vertical transition from the overlying fresh water to the underlying brackish or saline water is very abrupt and unambiguous. On other e-logs, the transition from fresh water to saline water is gradual and may occur over a vertical distance of hundreds of feet. In such cases, and to be conservative, the base of fresh water was selected, insofar as possible, at the top of the zone of transition from fresh water to saline water.

Plate 3.3 – Geologic Cross Section Z-Z' - provides our interpretation of subsurface conditions within the Saugus Formation in a west to east direction along the main reach of the Santa Clara River (see Section 3 of this report); the basis for the subsurface interpretations was the analysis and correlation of e-logs of wildcat oil wells and water wells. Plate 5.1 illustrates the surface location of this new geologic cross section, together with the lines of geologic

sections A-A' through F-F' that were originally prepared for the Slade 1988 Report (those cross sections are not reproduced herein).

The interpretation of the depth below ground surface to the base of fresh water (i.e. the thickness of fresh water-bearing deposits) within the Valley was originally published as Plate 5 in the Slade 1988 Report. The items of principal interest include:

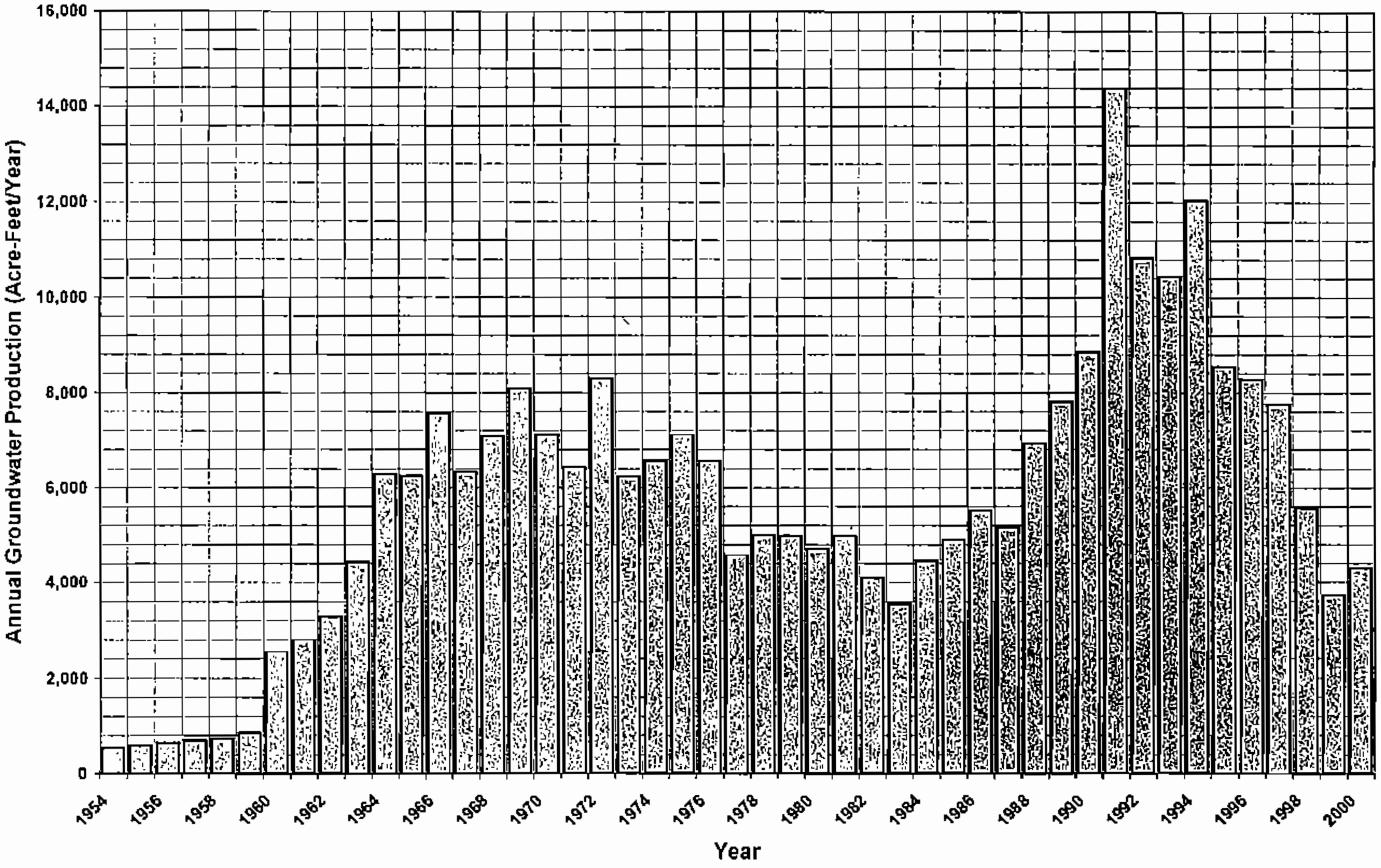
1. Northeast of the San Gabriel fault, the maximum depth to the base of fresh water within the Saugus Formation is approximately 1500 ft. By comparison, the maximum total thickness of the Saugus Formation, based on e-logs, is on the order of 2000 ft in this area.
2. In the wedge-shaped central fault block between the San Gabriel fault and the Holser fault, the maximum depth to the base of fresh water within the Saugus Formation is approximately 5500 ft. In this area, the maximum total thickness of the Saugus Formation is approximately 8500 ft.
3. Southwest of the Holser fault, the maximum depth to the base of fresh water within the Saugus Formation is approximately 5000 ft. The Saugus Formation obtains a maximum total thickness on the order of 7500 ft in this area.

## Groundwater Extractions

Groundwater production from the Saugus Formation has been primarily for municipal-supply purposes, particularly in recent years. Only NLF Well No. 156, the Lennar-Poe well, and possibly the Smiser well are currently or were recently used for agricultural and/or industrial purposes.

Figure 5.1 - Historic Saugus Formation Groundwater Production – illustrates, as a bar chart, the historic trends in Saugus Formation groundwater production since the mid-1950s, the earliest date for which production records are available (see also Table 5.3 – Saugus Formation Groundwater Production 1986-2000). Historically, total Saugus Formation groundwater production has ranged from a low of approximately 550 AF/yr in 1954, to a high of approximately 15,000 AF/yr in 1991. For the ten-year period from 1991 to 2000, the average annual Saugus Formation groundwater production was approximately 8600 AF/yr (see Table 5.1). The total combined groundwater production from the Saugus Formation from 1954 through 2000 has been approximately 268,000 AF. These figures do not include annual pumpage by the smaller domestic-supply water wells known to exist at the single-

## Figure 5.1
## Historic Saugus Formation Groundwater Production



## Table 5.3
## Saugus Groundwater Production 1986-2000

| Agency | Owner Well No | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Newhall County Water District | 4 | 225 | 0 | destroyed | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 7 | 275 | 230 | 332 | 244 | 241 | 245 | 176 | 259 | 320 | 363 | 337 | 288 | 281 | 172 | 0 |
| | 9 | 116 | 123 | 1 | 0 | 5 | 1 | 1 | 0 | 4 | 1 | 1 | 0 | 1 | 0 | 0 |
| | 10 | 740 | 789 | 613 | 457 | 642 | 307 | 345 | 59 | 0 | 1 | 0 | 0 | 2 | 0 | 0 |
| | 11 | 2237 | 2106 | 1264 | 1291 | 1248 | 926 | 420 | 706 | 614 | 520 | 360 | 81 | 14 | 0 | 0 |
| | 12 | 0 | 0 | 1829 | 2737 | 2595 | 2992 | 2756 | 1891 | 1917 | 2254 | 2181 | 1798 | 1915 | 1158 | 1767 |
| | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1368 | 1985 | 2246 | 1616 | 2084 | 3001 | 2361 | 1298 | 419 |
| | ***NCWD Total*** | ***3593*** | ***3248*** | ***4039*** | ***4729*** | ***4731*** | ***4471*** | ***5066*** | ***4900*** | ***5101*** | ***4755*** | ***4963*** | ***5168*** | ***4574*** | ***2628*** | ***2186*** |
| Newhall Land & Farming Company | 156 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 266 | 445 | 426 | 479 | 374 |
| ***(Private; Irrigation only)*** | ***NLF Total*** | ***20*** | ***20*** | ***20*** | ***20*** | ***20*** | ***20*** | ***20*** | ***20*** | ***20*** | ***20*** | ***266*** | ***445*** | ***426*** | ***479*** | ***374*** |
| Santa Clarita Water Company | Saugus 1 | 0 | 0 | 31 | 0 | 0 | 1690 | 437 | 1226 | 1333 | 0 | 410 | 451 | 0 | 0 | 0 |
| | Saugus 2 | 0 | 0 | 32 | 0 | 40 | 3091 | 2476 | 1675 | 2530 | 1726 | 1766 | 617 | 0 | 0 | 0 |
| | ***SCWC Total*** | ***0*** | ***0*** | ***63*** | ***0*** | ***40*** | ***4781*** | ***2913*** | ***2901*** | ***3863*** | ***1726*** | ***2176*** | ***1068*** | ***0*** | ***0*** | ***0*** |
| Valencia Water Company | 157 | 780 | 698 | 1491 | 1382 | 732 | 1109 | 677 | 524 | 730 | 518 | 123 | 166 | 0 | 0 | 0 |
| | 159 | 0 | 0 | 0 | 0 | 4 | 69 | 77 | 89 | 174 | 88 | 7 | 1 | 0 | 0 | 0 |
| | 160 | 1137 | 1186 | 1314 | 1599 | 968 | 1462 | 688 | 1105 | 1134 | 752 | 551 | 827 | 508 | 553 | 1332 |
| | 201 | 0 | 0 | 0 | 69 | 2351 | 2482 | 1389 | 904 | 1002 | 680 | 191 | 71 | 63 | 62 | 295 |
| | ***VWC Total*** | ***1917*** | ***1884*** | ***2805*** | ***3050*** | ***4055*** | ***5122*** | ***2831*** | ***2622*** | ***3040*** | ***2038*** | ***872*** | ***1065*** | ***571*** | ***615*** | ***1627*** |

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Annual Total for Major Producers Listed** | **5,530** | **5,152** | **6,927** | **7,799** | **8,846** | **14,394** | **10,830** | **10,443** | **12,024** | **8,539** | **8,277** | **7,746** | **5,571** | **3,722** | **4,187** |

Note: All of the above data is supplied by purveyors. Figures do not include domestic or other small-scale extractions.
VWC 205 became active in 2001
VWC 159 used for irrigation only

family homes and ranches in certain tributary canyons in the Valley that lie outside the service areas of the major water purveyors. Total annual production from all of these privately-owned, domestic-supply wells in the Saugus Formation may be on the order of 100 AF.

Groundwater production from the Saugus Formation is concentrated in the central and southern portions of the Valley where the majority of the currently producing Saugus Formation municipal-supply water wells are concentrated. These existing wells are located within the southern structural block, south of both the Holser and San Gabriel fault zones. The majority of the Saugus Formation groundwater production in 2000 was from two wells, namely, NCWD 12 (1767 AF) and VWC 160 (1332 AF); see Table 5.3 and Figure 5.1.

Between 1986 and 2000, NCWD accounted for between 33% to 82% of the total annual Saugus Formation municipal-supply groundwater production; in this same period, VWC production represented between 10% and 46% of the total annual production; SCWC production has been 0% to 32% of the total annual production in that time period; and NLF accounted for between 0% and 15% of the annual production from the formation. Annual production from such privately-owned, domestic-supply Saugus Formation wells is not known, but is unlikely to have exceeded a total of perhaps 100 AF/yr for all privately-owned wells in the region. This unmetered, privately-owned, domestic-type production represents roughly 1% of the average annual groundwater production from the Saugus Formation since 1986.

Plate 5.2 – Map of Saugus Formation Groundwater Extractions for 2000 – has been prepared to illustrate the spatial variability in recent groundwater extractions from the Saugus Formation. Data for Plate 5.2 were derived from information tabulated on Table 5.3 for the year 2000 for each active well. Annual groundwater extractions for each of the five active Saugus Formation water wells in 2000 are illustrated on Plate 5.2 via a circle centered on the respective well. The larger the diameter of the circle, the greater is the extraction for the particular well in 2000. The map scale used to illustrate the annual production for each well is: 1 inch equals approximately 667 AF or, ¾" = 500 AF. It must be noted that the circles (specifically, the diameter of the circles) graphed on Plate 5.2 are drawn to solely represent

the relative annual production volume (in AF) for each respective well. The diameter of the circle surrounding each well does not represent and should not be construed or interpreted to signify the area of pumping influence (the extent of the drawdown cone) of the particular well.

As seen on Plate 5.2, the greatest producer from the Saugus Formation in 2000 was NCWD-12, located in the South Fork area. The second highest production was from VWC-160 located along the main reach of the Santa Clara River. Privately-owned NLF-156, located near Castaic Junction, produced 374 AF of groundwater in 2000 for irrigation-supply purposes only.

### Current Groundwater Levels and Flow Directions

In order to assess groundwater levels and flow directions in the Saugus Formation, we have compiled a database of over 2500 historic and recent Saugus Formation water level measurements from purveyor records, Edison Company well efficiency tests, and RCS data files. In addition, a number of field visits were made in the fall of 2000 to measure water levels in as many Saugus Formation wells as possible (including a few privately-owned wells) within a relatively short time frame. After correcting these fall 2000 water level measurements to mean sea level for each well, maps depicting contours of equal groundwater elevation for these Saugus Formation water wells were prepared. Because the Saugus Formation in those areas where Saugus Formation wells exist is largely confined or semi-confined, these water level elevations are considered to represent the elevation of the piezometric (pressure) surface within the Saugus Formation for that time period.

Plate 5.3 – Map of Saugus Formation Groundwater Elevation Contours, Fall 2000 – illustrates the interpreted groundwater elevation contours for the Saugus Formation for the fall of 2000, a recent period for which requisite data are available. This plate also shows the locations of the Saugus Formation water wells for which water level elevation data were available, and these wells are annotated with the respective well ownership, well number and water level elevation for fall 2000.

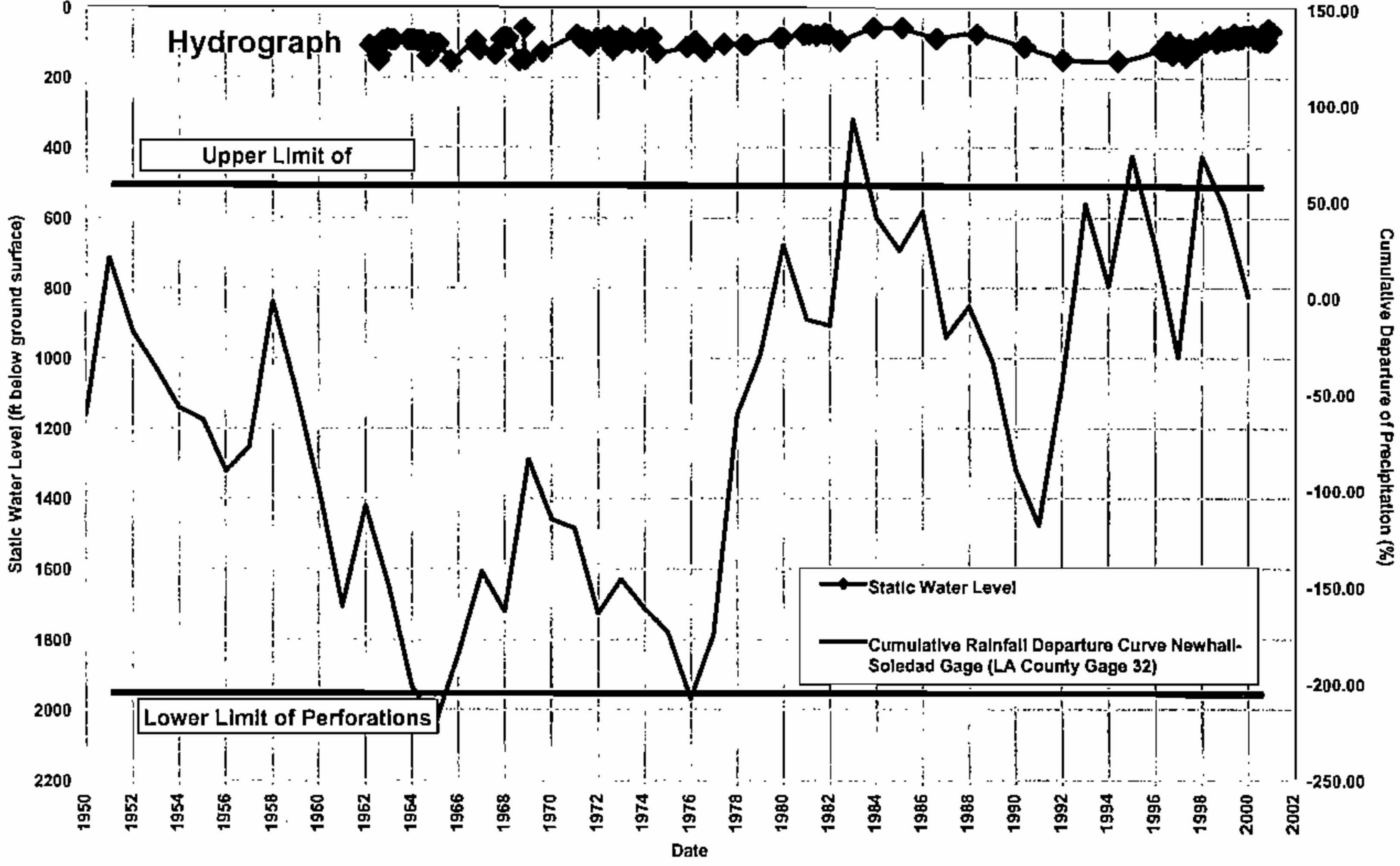
Key points from Plate 5.2 include:

1. Data points (i.e. Saugus Formation water wells) are not evenly or broadly distributed throughout the outcrop area of the Saugus Formation. Wells are generally concentrated along the South Fork of the Santa Clara River and in the community of Valencia, with only a few outlying agricultural or privately-owned wells in other areas. All but one of the known, existing Saugus Formation wells is situated within the southern structural block of the Saugus Formation, south of the Holser fault. No data are available for the region north of the San Gabriel fault because only one Saugus Formation well (now destroyed) has ever been drilled there. As such, the preparation of the Fall 2000 water level elevation contours has been restricted to areas near wells for which current data exist.
2. South of the Holser fault (*i.e.*, the Southern structural block), groundwater elevations range between approximately 1300 ft in NCWD Well No. 9, to approximately 976 ft in NLF Well No. 156. Groundwater in this southern structural block likely flows from the topographic highlands along the edge of the Saugus Formation northward towards the center of the Valley. Upon reaching the center of the Valley, which is delineated by the channel of the Santa Clara River, groundwater generally flows westward and then southwestward before discharging from the Saugus Formation into the alluvium in the area roughly between the I-5 Freeway and the western edge of the formation.
3. In the central structural block (between the Holser and San Gabriel faults), groundwater appears to also flow from the topographic highlands near the edge of the formation towards the Valley floor. In this central structural block, this regional flow appears to be towards the southeast. A confluence between the northerly and westerly flowing groundwater in the southern structural block, and the southeasterly flowing groundwater in the central structural block seems to occur in the vicinity of NLF Well No. 156.
4. Groundwater gradients within the Saugus Formation generally mimic topographic land surface gradients, in that they tend to be steeper in areas of steep topographic relief such as in the highlands south of the Valley, and considerably more gentle (flatter) along the Valley floor. Gradients range from roughly 150 ft/mile (0.028 ft/ft) between NCWD Well Nos. 9 and 7 near the edge of the Saugus Formation, to approximately 25 ft/mile (0.0047 ft/ft) between VWC Well No. 157 and NLF Well No. 156 along the Valley floor.

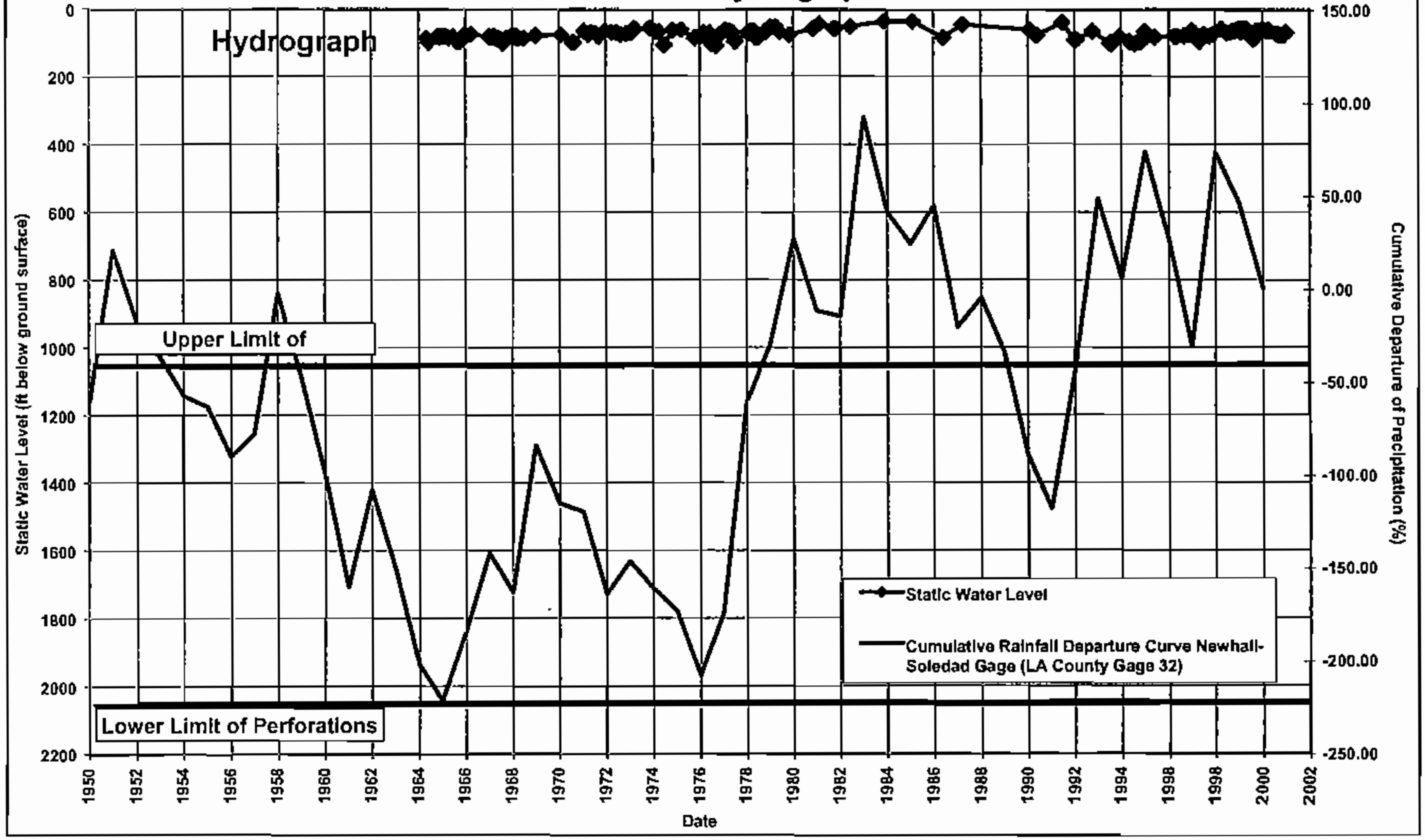
### Hydrographs

Figure 5.2A through 5.2F – Representative Saugus Formation Hydrographs – provides graphs of the available static (non-pumping) water level records versus time for six Saugus Formation wells. Plate 5.4 – Map of Saugus Formation Hydrographs – shows several of these hydrographs on a map of the Saugus Formation. These wells (VWC No. 157 and 160

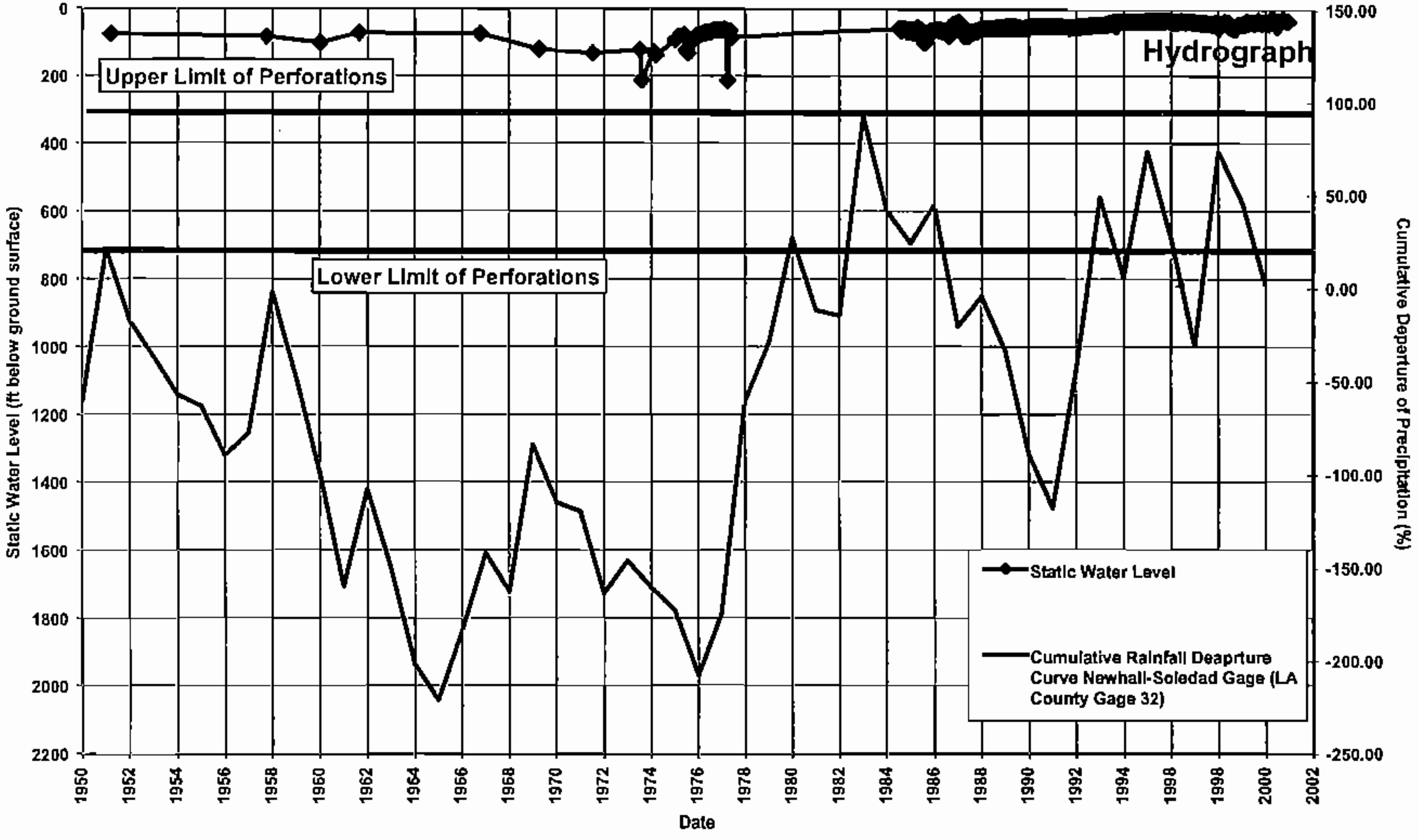
# Figure 5.2A
# VWC 157
# Water Level Hydrograph



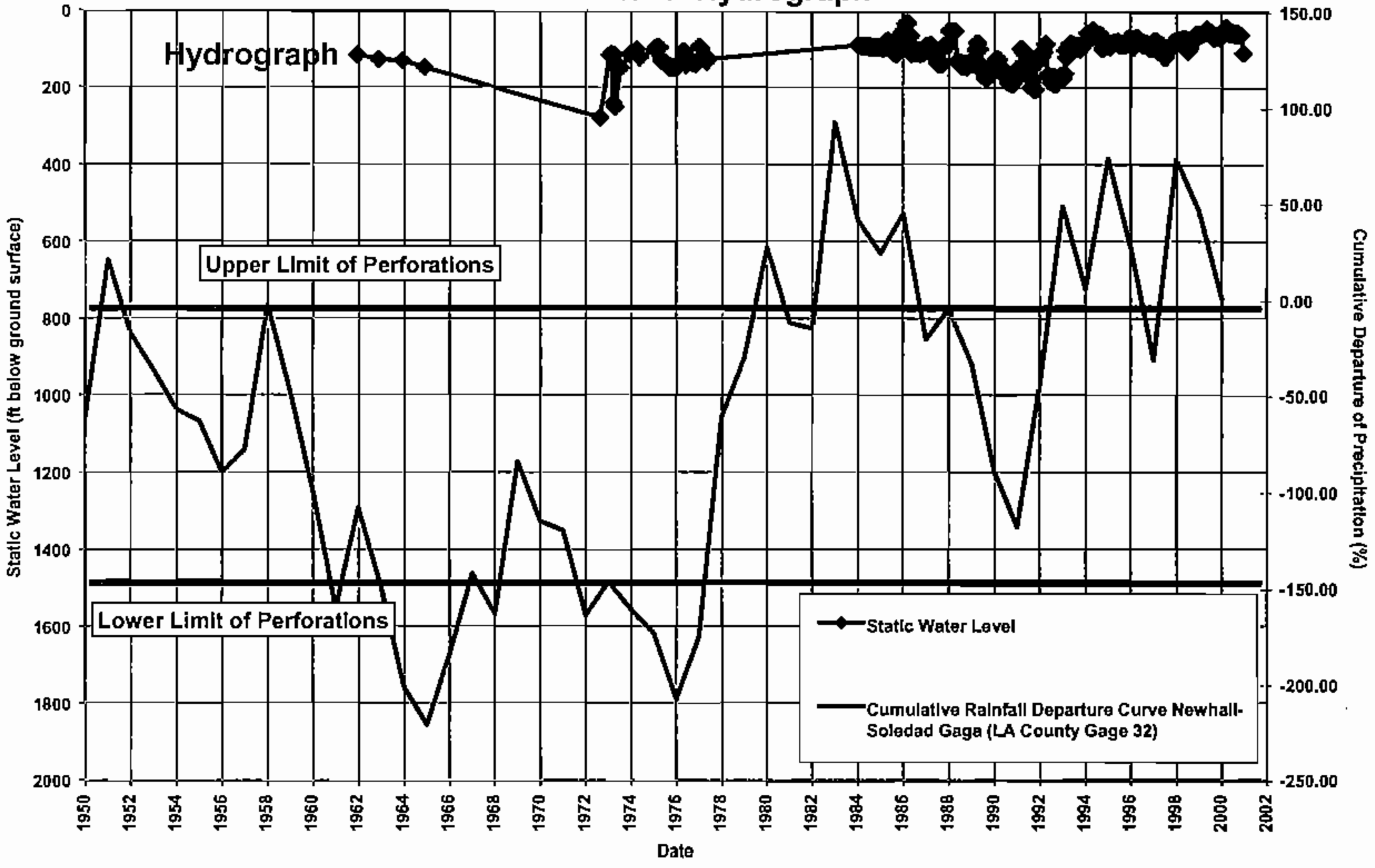
# Figure 5.2B
# VWC 160
# Water Level Hydrograph



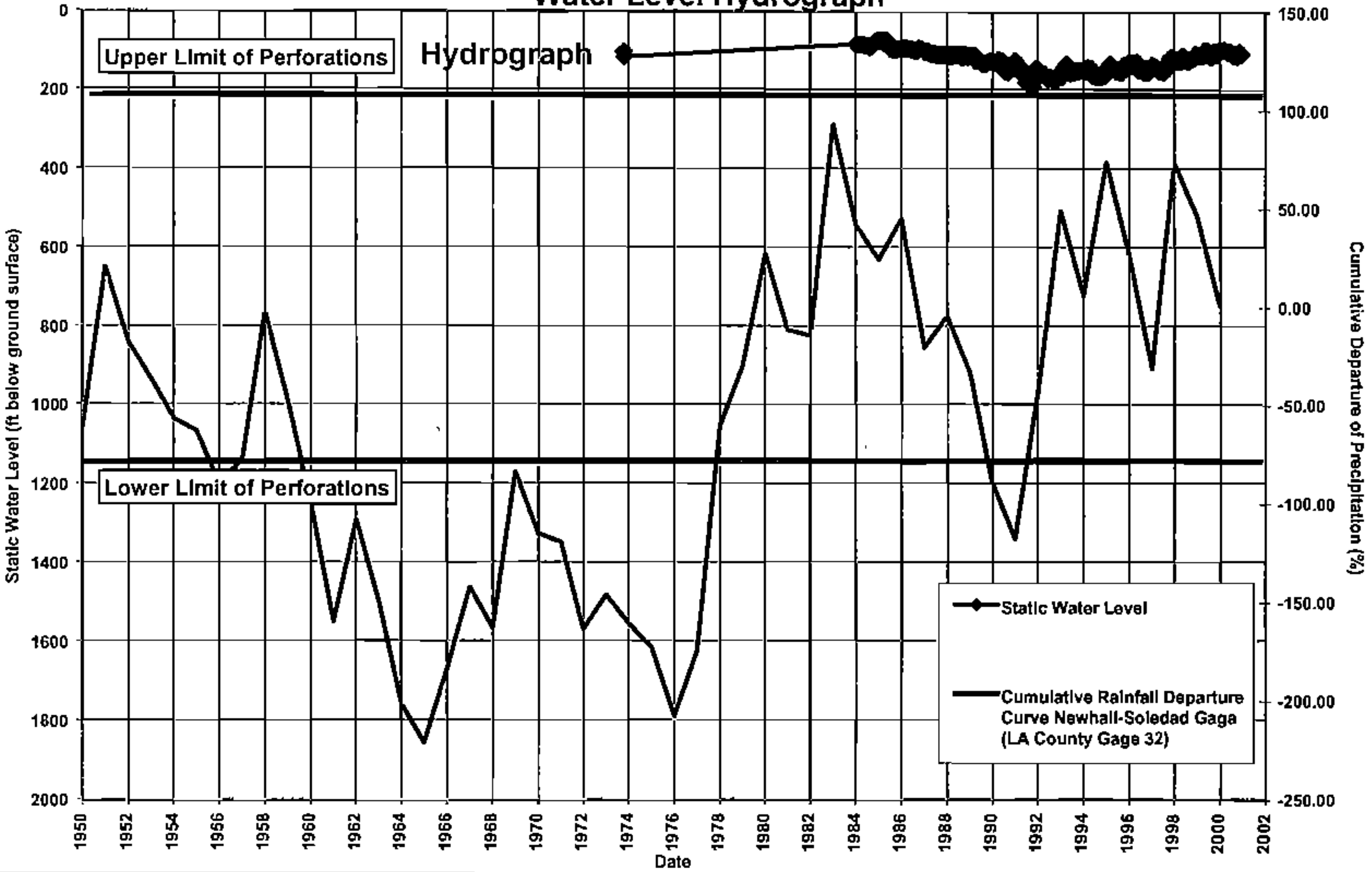
# Figure 5.2C
# NCWD 9
# Water Level Hydrograph



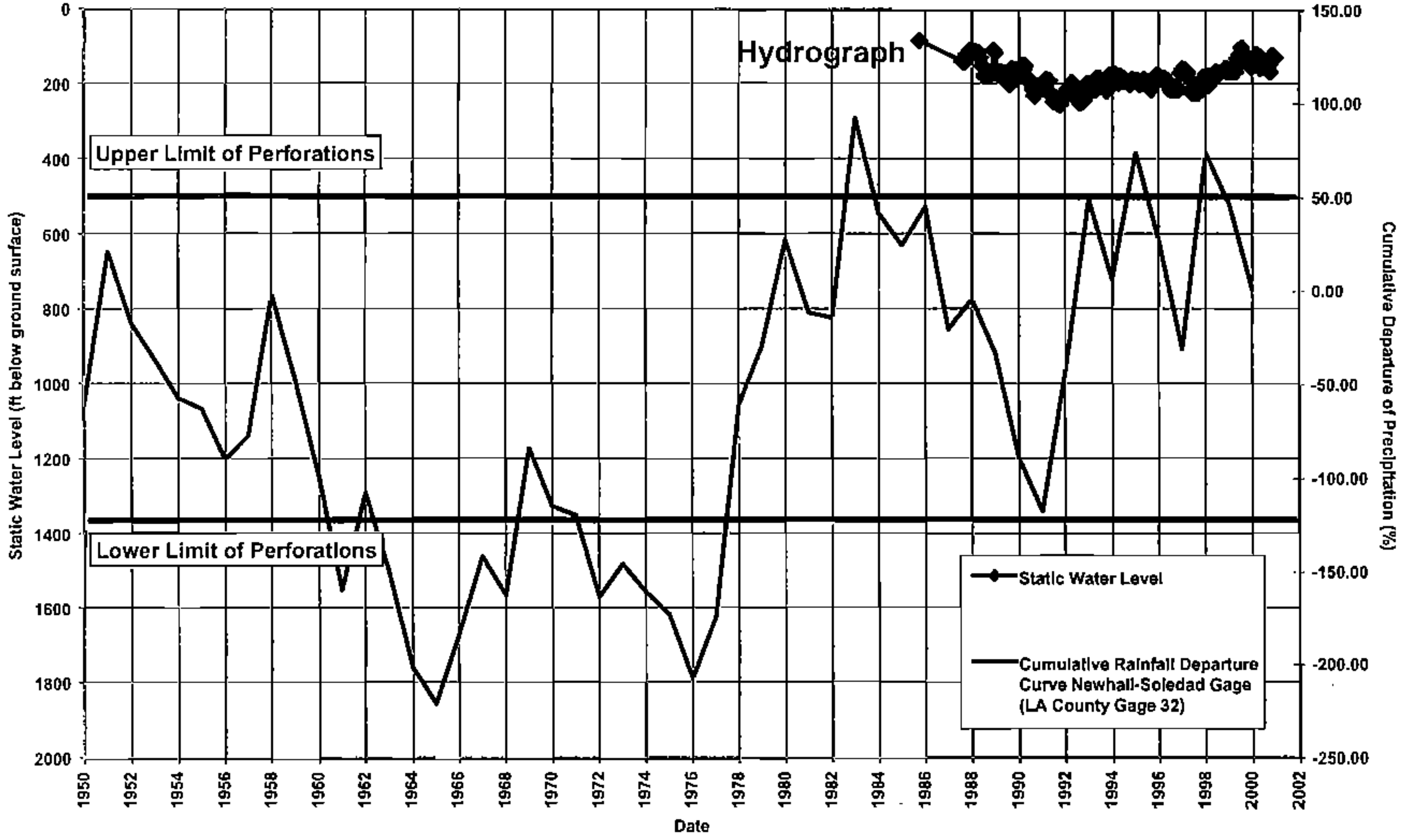
# Figure 5.2D
# NCWD 10
# Water Level Hydrograph



## Figure 5.2E
## NCWD 11
## Water Level Hydrograph



# Figure 5.2F
# NCWD 12
# Water Level Hydrograph



and NCWD Nos. 9, 10, 11 and 12) have been selected for evaluation because of their long, relatively continuous water level monitoring records. Examination of hydrographs for other Saugus Formation wells with shorter water level records (not presented herein) reveals similar patterns of water level fluctuation to those presented herein.

As illustrated on Figures 5.2A through 5.2F and Plate 5.4, historic static water levels (technically, the piezometric surfaces) in these active Saugus Formation water wells have typically fluctuated over time: the magnitude of these historic fluctuations varies with each well, but has generally ranged from a minimum of 50 ft to a maximum of 175 ft of water level change; these water level conditions are for wells that typically range in total casing depth between 750 to 2000 ft. Importantly, it is clearly evident from the hydrographs, that no long-term or continuous decline in water levels has occurred over time in any Saugus Formation water well. For comparison purposes, the depths to the upper limit and lower limit of perforated casing in each well are also shown on the six hydrographs on Plate 5.4.

Also shown on Figures 5.2A through 5.2F and Plate 5.4 are graphs of the cumulative departure from average annual precipitation for the period of 1950 to 2000; the trend of total Saugus Formation groundwater extractions over time are shown for comparative purposes on the figures also. The cumulative departure curve for rainfall illustrates trends in the amount of rainfall over time, such that when the curve is descending towards the right (such as from 1983 to 1991), an extended period of generally deficient precipitation (drought) is considered to have been occurring. In contrast, whenever the curve ascends to the right (such as from 1976 to 1983), an extended period of generally excess or increasing precipitation (wet period) has been occurring.

Water levels in Saugus Formation wells appear to fluctuate in response to patterns of increasing or decreasing rainfall, and to some extent to patterns of increasing or decreasing groundwater extraction from the Saugus Formation. It is somewhat difficult to differentiate the effects of rainfall vs. pumping on historic water levels because total Saugus Formation pumping has historically increased during dry periods, and decreased during wet periods.

**Aquifer Parameters**

The hydraulic properties (aquifer parameters) of Saugus Formation aquifers are used to help assess well yields, potential water level drawdown interference between pumping wells, and well spacing criteria, but are also useful for developing and calibrating numerical groundwater models. These key aquifer parameters (transmissivity and storativity) and the specific capacities of wells are typically calculated from water level drawdown and recovery data monitored during aquifer (pumping) tests. During the preparation of the original Slade 1988 Report, aquifer tests were performed in 1987 on five selected Saugus Formation water wells in order to provide data for the calculation of the aquifer parameters. Over time, additional aquifer tests have been conducted as part of the construction of each new Saugus Formation well and as part of the Saugus Formation ASR study carried out in 2000. Table 5.4 – Selected Saugus Formation Aquifer Parameters - presents the aquifer parameters calculated from the results of the original 1987 aquifer tests, as well those derived from the more recent tests. Locations of these Saugus Formation wells are shown on Plate 5.1.

Transmissivity and Storativity

Transmissivity, an important aquifer parameter, is a measure of the ability of an aquifer to transmit water to a pumping well, or to accept water from an injection well; it is expressed in units of gallons per day per foot of aquifer width (gpd/ft). Storativity, another important aquifer parameter, is a measure of the volume of water released to a pumping well, or accepted by an injection well, from a given volume of aquifer materials. Storativity is a dimensionless parameter and, thus, has no units. Both transmissivity and storativity values are calculated from water level drawdown and water level recovery data measured in non-pumping wells during an aquifer test.

Transmissivity values presented in the Slade 1988 Report ranged from lows of 3000 to 4000 gpd/ft in NCWD Well No. 9, to highs of 157,000 to 182,000 gpd/ft in VWC Well No. 160. A review of the spatial variability in transmissivity values for wells with such data indicates a general trend from lower transmissivity values near the southeastern edge of the Saugus Formation outcrop area near NCWD 9, to higher transmissivity values near the center of the Valley near VWC 160.

## Table 5.4
## Selected Saugus Formation Aquifer Parameters

| Well No. | Date | Type of Test | Pumping/Injection Rate (gpm) | Length of Test (mins) | Well Monitored | Specific Capacity (gpm/ft ddn) | Transmissivity (gpd/ft) | Storativity | Analytical Method |
|---|---|---|---|---|---|---|---|---|---|
| NCWD 7 | Mar-87 | Drawdown | 341 | 1440 | NCWD 7 | 3.1 | 28,400 | | "Theisfit" Software |
| NCWD 7 | Mar-87 | Recovery | | 1500 | NCWD 7 | | 23,300 | | "Theisfit" Software |
| NCWD 10 | Mar-87 | Drawdown | 364 | 1440 | NCWD 10 | 8.3 | 28,500 | | "Theisfit" Software |
| NCWD 10 | Mar-87 | Drawdown | 364 | 1440 | NCWD 12 (160 ft away) | | 57,700 | 9.10E-04 | "Theisfit" Software |
| NCWD 10 | Mar-87 | Recovery | | 1480 | NCWD 10 | | 38,400 | | "Theisfit" Software |
| NCWD 10 | Mar-87 | Recovery | | 1490 | NCWD 12 (160 ft away) | | 61,500 | 7.60E-04 | "Theisfit" Software |
| NCWD 9 | Mar-87 | Drawdown | 256 | 1460 | NCWD 9 | 1.9 | 3,700 | | "Theisfit" Software |
| NCWD 9 | Mar-87 | Recovery | | 1500 | NCWD 9 | | 3,000 | | "Theisfit" Software |
| VWC 160 | Mar-87 | Drawdown | 2562 | 720 | VWC 160 | 49.8 | 163,000 | | "Theisfit" Software |
| VWC 160 | Mar-87 | Recovery | | 850 | VWC 160 | | 182,000 | | "Theisfit" Software |
| VWC 205 | Jul-00 | Injection + Recovery | 500-800-1100 | 30,240 / 12,960 | 205M (40 ft) | 12.2 | 41,370 | 6.88E-04 | "Aqtesolv" Software - Theis Solution |
| VWC 205 | Jul-00 | Injection + Recovery | 500-800-1100 | 30,240 / 12,960 | 201 (2400 ft) | | 50,450 | 7.56E-04 | "Aqtesolv" Software - Theis Solution |
| VWC 205 | Jul-00 | Injection + Recovery | 500-800-1100 | 30,240 / 12,960 | 157 (4100 ft) | | 54,860 | 6.45E-04 | "Aqtesolv" Software - Theis Solution |
| VWC 205 | Aug-00 | Pumping | 2273 | 12,960 / 14,440 | 205 | 18.7 | | | |
| VWC 205 | Aug-00 | Pumping + Recovery | 2273 | 12,960 / 14,440 | 205M (40 ft) | 18.7 | 78,910 | 9.48E-04 | "Aqtesolv" Software - Hantush-Jacob Leaky-Aquitard Solution |
| VWC 205 | Aug-00 | Pumping + Recovery | 2273 | 12,960 / 14,440 | 201 (2400 ft) | | 76,410 | 1.37E-03 | "Aqtesolv" Software - Hantush-Jacob Leaky-Aquitard Solution |
| VWC 205 | Aug-00 | Pumping + Recovery | 2273 | 12,960 / 14,440 | 157 (4100 ft) | | 65,880 | 1.36E-03 | "Aqtesolv" Software - Hantush-Jacob Leaky-Aquitard Solution |
| VWC 201 | Oct-00 | Pumping | 2439 | 14,440 / 2,880 | 201 | 30 | 65,100 | 5.75E-04 | |
| VWC 201 | Oct-00 | Pumping + Recovery | 2439 | 14,440 / 2,880 | 157 (1900 ft) | | 44,230 | 1.17E-03 | "Aqtesolv" Software - Hantush-Jacob Leaky-Aquitard Solution |
| VWC 201 | Oct-00 | Pumping + Recovery | 2439 | 14,440 / 2,880 | 205M (2360 ft) | | 57,210 | 8.49E-04 | "Aqtesolv" Software - Hantush-Jacob Leaky-Aquitard Solution |
| VWC 201 | Oct-00 | Pumping + Recovery | 2439 | 14,440 / 2,880 | 205 (2400 ft) | | 47,690 | 6.75E-04 | "Aqtesolv" Software - Hantush-Jacob Leaky-Aquitard Solution |
| SCWC Saugus-1 | Jul-88 | Pumping | 2041 | 1440 | Saugus-1 | 30.2 | 60,300 | | "Theisfit" Software |
| SCWC Saugus-1 | Jul-88 | Recovery | 2041 | 480 | Saugus-1 | | 59,700 | | "Theisfit" Software |
| SCWC Saugus-2 | Sep-88 | Pumping | 2531 | 2880 | Saugus-2 | 24.1 | 53,500 | | Semi-log plot |
| SCWC Saugus-2 | Sep-88 | Recovery | 2531 | 1320 | Saugus-2 | | 55,700 | | Semi-log plot |
| SCWC Saugus-2 | Sep-88 | Pumping | 2531 | 2880 | Saugus-1 | | 71,500 | 3.60E-04 | Semi-log plot |
| SCWC Saugus-3 | Sep-88 | Recovery | 2531 | 1320 | Saugus-1 | | 60,200 | | Semi-log plot |

Storativity values from the 1987 aquifer tests were calculated from water level drawdown and recovery data measured in NCWD 12 during pumping of nearby NCWD 10. These storativity values were on the order of $10^{-4}$ (0.0001), with such values being considered typical of confined to semi-confined aquifer conditions.

Additional transmissivity values were derived from more recent aquifer test data obtained during construction and testing of SCWC Saugus Wells 1 and 2 (Slade, 1989 and 1990) and VWC 201 (Slade, 1990). Transmissivity values ranged from 60,200 to 70,300 gpd/ft for the two SCWC Saugus wells, respectively, and from 99,000 to 150,000 gpd/ft for VWC 201. These values are within, and toward the upper end of the previously calculated transmissivity values for the Saugus Formation. Storativity values calculated from these test results were 0.0001 ($10^{-4}$) for the SCWC Saugus wells, and 0.001 ($10^{-3}$) for VWC 201.

Transmissivity values were also calculated from the data derived from aquifer tests carried out as part of the 2000 ASR study. Calculated transmissivity data ranged from 66,000 to 76,000 gpd/ft for the pumping test of VWC 205, and from 44,000 to 65,000 gpd/ft for the pumping test of VWC 201 (see well locations on Plate 5.1). These values are in good general agreement with data from prior testing of Saugus Formation water wells (see Table 5.4). Storativity values calculated from these aquifer test data ranged from $10^{-3}$ to $10^{-4}$, which is also in general agreement with previous data.

For the data generated from the ASR study, transmissivity and storativity calculations were carried out using the software program AQTESOLV, using the automatic curve fitting procedure. This permitted the rapid evaluation of several possible numerical solutions for each set of water level drawdown and recovery data. Using this software, it was found that the Hantush-Jacob solution for a leaky confined aquifer provided a good fit for the monitored water level data from VWC 205. This indicates that the individual aquifers within the Saugus Formation at this well site may exhibit some degree of vertical hydraulic connection.

Noteworthy during the pumping tests of the new Saugus Formation wells drilled since 1988 are the pumping rates utilized during the individual step drawdown tests. Step drawdown tests are the initial pumping tests conducted in a new well after its construction and are performed by pumping the well at 3 or 4 increasingly higher pumping rates (or steps), with each rate (step) lasting approximately three to four hours. After the step drawdown test is performed, a final constant rate discharge test (i.e., the aquifer test) is then conducted in each new well.

The ranges of pumping rates used during the step drawdown tests in each new municipal-supply Saugus Formation water well were as follows:

- NCWD-13 - 1100 gpm to 3350 gpm
- SCWC Saugus -1 - 2014 gpm to 3731 gpm
- SCWC Saugus 2 - 1721 gpm to 3740 gpm
- VWC-201 - 1767 gpm to 3788 gpm
- VWC-205 - 2440 gpm to 4000 gpm
- VWC-202 - 115 gpm (constant rate only)
  (now destroyed)

These data clearly reveal the relatively high pumping rates that have been achieved during the step drawdown testing of these Saugus Formation water wells. Each subsequent constant rate discharge test in these wells was conducted at rates in the range of 2500 to 3400 gpm, except for that in VWC-202. As noted previously, VWC-202 was destroyed shortly after its construction in 1991 due to its very limited pumping capacity and very low specific capacity; this well was constructed in San Francisquito Canyon within sediments of the Sunshine Ranch Member of the Saugus Formation, north of the San Gabriel fault.

### Specific Capacity

Although technically not an aquifer parameter, the specific capacity of a well is commonly used as a measure of the yield of a well. It is calculated by dividing the discharge rate of a well (in gpm) by the total water level drawdown created in that well while pumping at that rate; it is expressed as gallons per minute per foot of water level drawdown (gpm/ft ddn). Specific capacity is not strictly an aquifer property, because it is affected not only by aquifer characteristics but also by the design, construction and condition of the well.

As illustrated in Table 5.4, historically known specific capacity values for Saugus Formation wells are typically on the order of 10 to 70 gpm/ft ddn. Values calculated from the results of pumping tests during the 2000 ASR study for both VWC 205 (20.4 gpm/ft ddn) and VWC 201 (29.9 gpm/ft ddn) are toward the lower end of the range for Saugus Formation wells in the region.

As a particular well ages, groundwater quality can also impact specific capacity because the casing perforations and the surrounding gravel pack may become clogged with mineral precipitates and/or bacterial growths, leading to an increase in head loss (increase in water level drawdown) for groundwater trying to enter the perforations. This, in turn, leads to a reduction in specific capacity over time and the eventual need for rehabilitation of the well.

## Geohydrology

### General Statement

The amount of useable groundwater in storage in the Saugus Formation was calculated in the Slade 1988 Report to be approximately 1.41 million AF. In that report, useable groundwater was defined as the groundwater contained only within potential sand and gravel aquifer beds and only between the depths of 500 ft below ground surface (bgs) and the shallower of either: a) a depth of 2500 ft bgs; or b) the base of fresh water within the Saugus Formation; or c) the base of the Saugus Formation. At that time, an upper limit of approximately 500 ft bgs was utilized as the shallowest that a Saugus Formation water well might be perforated while still minimizing potential water level drawdown interference with nearby alluvial water wells. More recent information on the thickness of the alluvium, and the degree of potential drawdown interference between adjacent Saugus Formation and alluvial water wells (based on testing conducted during the ASR project of 2000), has led us to adjust this upper limit from 500 ft bgs to 300 ft bgs for use in the revised calculations of groundwater in storage for this update report.

In order to update the 1988 calculations of groundwater in storage within the Saugus Formation, it was necessary to do the following: identify potential sand and gravel aquifer units from e-logs for a large number of widely distributed oil wells and water wells; calculate the total thickness of these potential aquifer units at each well location; determine the volume of these potential aquifer units both laterally and vertically; and then assign a specific yield factor to the various areas of the Saugus Formation. The details of these steps are provided below.

Potential Saugus Formation Aquifers

The Saugus Formation is not a single homogeneous aquifer, but rather it consists of numerous potentially water-bearing sand and gravel beds (aquifer units) of varying thickness that are interlayered with finer-grained silt and clay beds. These potential aquifer units were identified by their distinctive signatures on approximately 150 e-logs from oil wells and water wells distributed throughout the Valley. A practical approach to evaluate the feasibility of using a potential aquifer unit to calculate the total potential aquifer unit thickness for any given e-log was utilized in the original Slade 1988 Report. The basic criterion used in that evaluation was whether or not perforated casing would be placed adjacent to a particular sand or gravel unit in a hypothetical water well constructed at that location. Using this criterion, thin sand and gravel units bounded above and below by relatively thick, impermeable silt or clay beds were considered hydrogeologically isolated units and, thus, were not included in the total thickness calculations. To be consistent with that 1988 methodology, this updated report utilizes that same practical approach.

For the Slade 1988 Report, it was assumed that the deeper potential aquifer units at a particular location would actually contribute groundwater to a well constructed at that location. Until recently, there were no data to verify that original assumption. However, two downhole flow meter (spinner) surveys have been conducted in VWC 205, one under pumping conditions and one under non-pumping conditions (see well location on Plate 5.1). These tests revealed that groundwater is produced by this well throughout its entire perforated length (*i.e.*, from 820 to 1930 ft bgs). Specifically, the 1999 spinner survey (performed at a pumping rate of approximately 3400 gpm at the time the well was initially constructed) showed that 2223 gpm, or 65% of the total flow, was from the perforated zone of 820 to 1045 ft bgs. Flow from the remaining perforated zones ranged from: 190 gpm (6% of the total flow) at 1045 to 1270 ft bgs; 401 gpm (12% of the total flow) at 1270 to 1495 ft bgs; 368 gpm (11% of the total flow) at 1495 to 1720 ft bgs; and 218 gpm (6% of the total flow) at 1720 to 1930 ft bgs.

A more recent spinner survey of VWC-205 was conducted for the 2000 ASR project and its results corroborated the initial 1999 testing. The greatest production in VWC 205 was derived from two specific zones: the first zone between 820 to 960 ft brp (34.3% of the total pumping test rate of 2253 gpm), and the second zone between 1570 to 1700 ft brp (22.6% of total flow). The remainder of the groundwater production was distributed fairly evenly over the rest of the perforated intervals in this well. Both of these spinner surveys demonstrate that the aquifer units within the entire perforated thickness of the Saugus Formation at this well (to a depth of at least 1930 ft) are capable of providing groundwater to wells.

In February 2002, NCWD conducted a spinner survey under non-pumping conditions in NCWD No. 10 which is located in the South Fork area (see Plate 5.1). Preliminary results of this spinner survey under non-pumping conditions revealed that groundwater from the deeper perforated sections of the casing was moving upward in the well and outward through the shallower sections of the perforated casing (from Table 5.1, casing perforations are from 780 ft to 1544 ft bgs in NCWD No. 10).

### Total Thickness of Potential Aquifers

Plate 3.2 in Section 3 presents a map of contours of equal thickness of potential sand and gravel aquifer units within the Saugus Formation, along with the individual data points (wells) used to create those contours. Potential aquifer units for this update report are now considered to be between the depths of 300 ft bgs and the shallower of either: a) depth of 2500 ft bgs; or b) the base of fresh water within the Saugus Formation; or c) the base of the Saugus Formation.

Key observations from this plate include:

1. The greatest thickness of potential aquifer units within the Saugus Formation occurs within the central structural block, adjacent to the Holser fault zone in the area where the fault alignment crosses the I-5 Freeway. In this area, the total thickness of potential aquifers is in excess of 1500 ft.
2. In the southern structural block, the area of greatest aquifer unit thickness (in excess of 1100 ft) occurs in part beneath the South Fork of the Santa Clara River. This suggests that historical drainage patterns during the original deposition of the Saugus Formation were, in part, similar to those of the present day.

3. North of the San Gabriel fault, the total thickness of potential aquifer units reaches a maximum interpreted thickness of between 500 and 600 ft. A large area north of the San Gabriel fault near the margin of the Saugus Formation outcrop area is interpreted as having no potential aquifer units at all due to the presence of the Sunshine Ranch Member of the formation; this member lies near the base of the formation and is comprised principally by fine-grained strata of relatively low permeability.

Storage Units and Thickness Zones

Because the storage calculations for the Slade 1988 Report relied on hand-drafted maps, the outcrop area of the formation originally had to be divided into smaller, more manageable storage units, before calculating the individual areas using a planimeter. The GIS database and software used in this current report simplified this process, and allowed a slightly different approach to be used.

On the contoured map of potential sand and gravel aquifer units (Plate 3.2), the regions between successive contours were assigned a thickness intermediate between the lower and upper contour values. For example, the region bounded by the 800 ft and 1000 ft contour lines was assigned a thickness of 900 ft. For regions bounded by only a single contour on one side and by one of the fault zones on the other side, a value 100 ft greater than the lower bounding contour was assigned; for example, a region bounded by the 1500 ft contour on one side and the Holser fault on the other would be assigned a thickness value of 1600 ft. The planar surface area, and the total volume of the potential aquifer units for each contour-bounded region, were then calculated using the GIS software.

Specific Yield Values

Specific yield is the volume of water that may drain by gravity from a given volume of aquifer materials, relative to the total volume of aquifer materials; it is typically expressed as a percentage. Specific yield is dependent primarily on the permeability and grain size distribution of the aquifer materials. Because the Saugus Formation aquifer units vary horizontally and vertically in both grain size characteristics and permeability, it was necessary to assign different specific yield factors to different areas of the formation.

The original Slade 1988 Report assigned conservative specific yield values that ranged only between 5 and 8 percent to the Saugus Formation in calculating the approximate volume of groundwater in storage. Because there is no available evidence to suggest that these values should be adjusted, we have retained the conservative 1988 values for specific yield for the updated calculations presented below.

### Estimated Quantity of Groundwater in Storage

The estimated volume of groundwater in storage in the Saugus Formation is calculated by multiplying the total volume of potential aquifer units in each contour-bounded region by their assigned specific yield factors, and then summing the results for each region. This is rapidly accomplished using the GIS database.

Table 5.5 - Summary of Groundwater in Storage in the Saugus Formation – summarizes the results of these calculations. As shown, the updated estimate of groundwater in storage is approximately 1.65 million AF, an increase of roughly 18% over the 1.41 million AF calculated in the original Slade 1988 Report. This increase is due almost entirely to raising the upper limit of our depth zone of interest from 500 ft to 300 ft bgs as discussed previously.

The calculated volume of 1.65 million AF is still far less than the approximately 6 million AF estimated by Robson (1972) for the USGS. The difference between the two calculated volumes appears to be due to three main differences in the methods used. The first is that our calculations extend only to a maximum depth of 2500 ft bgs or to the base of fresh water, or to the base of the Saugus Formation (whichever is shallower), whereas Robson's calculations extended to depths as great as 3500 ft bgs. Second, Robson (his Plate 2, 1972) shows considerably thicker aquifer units (up to 2000 ft thick) compared to those determined for this present study, which measured a maximum total aquifer thickness of approximately 1600 ft. Third, the single specific yield value used by Robson (10%) for the entire Saugus Formation is considerably greater than those used in our calculations (5 to 8%).

### Operational Yield

As discussed in the preceding Section 4 regarding the alluvial aquifer system, one of the disadvantages of utilizing perennial yield as a basis for managing the pumpage from an

# Table 5.5

## Summary of Groundwater In Storage in the Saugus Formation

| Storage Unit | Lower Thickness Contour (ft) | Upper Thickness Contour (ft) | Average Thickness (ft) | Area (acres) | Sand and Gravel Volume (AF) | Specific Yield (%) | Groundwater In Storage (AF) |
|---|---|---|---|---|---|---|---|
| **Storage Unit 1 - North of San Gabriel Fault** | | | | | | | |
| 1A | 0 | 200 | 100 | 5,153 | 515,286 | 7% | 36,070 |
| 1B | 200 | 400 | 300 | 4,086 | 1,225,773 | 7% | 85,804 |
| 1C | 400 | Fault | 500 | 1,786 | 892,930 | 7% | 62,505 |
| 1D | 400 | 600 | 500 | 149 | 74,510 | 7% | 5,216 |
| **Subtotal** | | | | | | | **189,595** |
| Slade (1988) Subtotal | | | | | | | 130,540 |
| **Storage Unit 2 - Between San Gabriel and Holser Faults** | | | | | | | |
| 2A | 400 | 600 | 500 | 122 | 61,170 | 7% | 4,282 |
| 2B | 600 | 800 | 700 | 673 | 470,806 | 7% | 32,956 |
| 2C | 800 | 1,000 | 900 | 4,506 | 4,055,265 | 6% | 243,316 |
| 2D | 1,000 | 1,000 | 1,000 | 563 | 562,860 | 6% | 33,772 |
| 2E | 800 | 1,000 | 900 | 181 | 163,035 | 6% | 9,782 |
| 2F | 1,200 | 1,400 | 1,300 | 1,203 | 1,563,575 | 6% | 93,815 |
| 2G | 1,400 | Fault | 1,500 | 689 | 1,034,085 | 6% | 62,045 |
| 2H | 600 | 800 | 700 | 89 | 62,643 | 7% | 4,385 |
| 2I | 600 | 400 | 500 | 82 | 41,005 | 7% | 2,870 |
| 2J | 600 | 800 | 700 | 1,168 | 817,719 | 7% | 57,240 |
| 2K | 400 | 600 | 500 | 1,025 | 512,325 | 7% | 35,863 |
| 2L | 200 | 400 | 300 | 950 | 285,096 | 8% | 22,808 |
| 2M | 0 | 200 | 100 | 1,241 | 124,085 | 8% | 9,927 |
| 2N | 1,000 | 1,200 | 1,100 | 1,678 | 1,846,031 | 6% | 110,762 |
| **Subtotal** | | | | | | | **723,622** |
| Slade (1988) Subtotal | | | | | | | 641,330 |
| **Storage Unit 3 - South of Holser Fault** | | | | | | | |
| 3A | 1,000 | Fault | 1,100 | 3,314 | 3,645,037 | 6% | 218,702 |
| 3B | 800 | 1,000 | 900 | 4,214 | 3,793,032 | 6% | 227,582 |
| 3C | 1,000 | 1,000 | 1,000 | 174 | 174,310 | 6% | 10,459 |
| 3D | 600 | 800 | 700 | 2,355 | 1,648,164 | 7% | 115,371 |
| 3E | 400 | 600 | 500 | 2,448 | 1,223,830 | 7% | 85,668 |
| 3F | 200 | 400 | 300 | 2,618 | 785,493 | 8% | 62,839 |
| 3G | 0 | 200 | 100 | 2,538 | 253,837 | 8% | 20,307 |
| **Subtotal** | | | | | | | **740,929** |
| Slade (1988) Subtotal | | | | | | | 641,240 |
| **Total Groundwater in Storage** | | | | | | | **1,654,346** |
| Slade (1988) Total | | | | | | | 1,413,110 |

aquifer system is that it represents a long-term average value for yield. There is a potential for the perennial yield value to be interpreted as a not-to-exceed volume, with a related potential for pumpage above the perennial yield value in any given year to be interpreted as "overdraft". A recently advanced concept intended to deal with such potential misinterpretations is that of operational yield. This is defined as a fluctuating value of pumpage that may be above or below the perennial (average) yield in any given year and that varies as a function of the availability of other water supplies. The basic intent of the operational yield value is that it should not exceed the perennial (or average) yield of the groundwater basin over multi-year wet and dry cycles.

The operational yield concept includes flexibility of groundwater use by allowing increased pumping during dry periods and increased recharge (direct or in-lieu) with supplemental water when it is available in wet/normal rainfall periods. The operational yield protects the aquifer by helping to assure that groundwater supplies are adequately replenished on a long-term basis from one wet/dry cycle to the next. In the Valley, historical groundwater data demonstrate that the alluvium has been, and continues to be developed within its long-term sustainability (i.e. no continuous lowering of water levels, no notable trend toward degradation of groundwater quality, etc.). Limited historical data for the Saugus Formation show no lowering of water levels or degradation of water quality where it has been developed at known well locations.

It is evident from observation of the response of water levels in the Saugus Formation to historical pumping that this aquifer system can be operated (pumped) over a range of capacities to at least 15,000 AF/yr per year without causing undesirable conditions that would be indicative of "overdraft," i.e. long-term continuous and progressive decline in water levels and in groundwater in storage. As a result, the operational yield of the Saugus Formation, or its yearly yield for operating purposes, could range up to an individual annual pumping volume on the order of 15,000 AF based on historical pumpage values available at this time. The ultimate goals, of course, would be to avoid both short-term adverse impacts as a result of year-to-year fluctuations in pumping, and to avoid longer-term adverse impacts such as continuously lowered water levels and storage in this aquifer system.

It is also evident from the analysis of aquifer extent, both spatial and vertical, and from the analysis of groundwater in storage, that historical Saugus Formation pumpage has been very small in comparison to aquifer thickness, groundwater in storage, and potential recharge (the latter as reported in the Slade 1988 Report). Recognition of the lack of any adverse impacts associated with historical Saugus Formation pumpage, and the latter observations of aquifer extent, groundwater in storage, and potential recharge has led to the following two plans regarding operation of the Saugus Formation aquifer system: 1) development of an UWMP that includes water supply from the Saugus Formation within the long-term yearly operational range on average (average/normal rainfall years), with short-term increases in single to multiple dry years into the range of 15,000 to 35,000 AF/yr; and 2) commitment via an MOU process between the Santa Clarita Valley Water Purveyors and the downstream United Water Conservation District to develop a numerical groundwater flow model in order to analyze in greater detail how the Saugus Formation aquifer system can be operated in the future to optimize its yield without adverse impact either to the Saugus Formation (avoidance of depressed water levels and depleted storage) or to the overlying alluvial aquifer system (avoidance of decreased flow into the alluvium) and associated environment effects.

In summary, the combination of historical observations and current planning has led to the current conclusion that the Saugus Formation can be operated at this time on a long-term average basis in the range of 7,500 to 15,000 AF/yr. Infrequently, during dry periods of one to three years, pumping operations can be ramped up from 15,000 to 25,000 AF/yr, and ultimately to 35,000 AF/yr if dry conditions continue. These latter increases would be temporary and would then return to or below the historical range of 7,500 to 15,000 AF/yr once rainfall patterns return to normal. As summarized in the UWMP, the operation of the Saugus Formation aquifer system will typically be in the 7,500 to 15,000 AF/yr range for most types of rainfall years, with possible short-term ramped increases in dry periods into the 15,000 to 35,000 AF/yr range. Such temporary and short-term increases above historic pumping volumes are unlikely to have an adverse impact on the Saugus Formation, and in particular, are unlikely to induce a permanent loss of groundwater in storage and/or a permanent decline in water levels. Any short-term water level decline or groundwater storage decline is expected to be restored upon return to the historical operating range on an average basis.

**Water Quality**

Groundwater Character

As illustrated on Plate 5.5 – Map of Saugus Formation Wells, Stiff Pattern Diagrams - groundwater in the Saugus Formation varies in character from: calcium-bicarbonate (Ca-$HCO_3$) in NCWD Well Nos. 7, 8, 10, and 12; to calcium-sulfate (Ca-$SO_4$) in NLF Well No. 156 and VWC Well Nos. 158 and 160; to sodium-bicarbonate (Na-$HCO_3$) in the privately-owned Lombardi/Anden well located further west within the central fault block.

Groundwater of Ca-$HCO_3$ character is generally considered to be representative of oxidizing conditions, indicative of meteoric (rain) water that has percolated and circulated in the aquifer system. The Ca-$SO_4$ character of groundwater obtained from wells in the central part of the Valley likely reflects a longer residence time of water in the aquifer system allowing the soluble, sulfate-bearing gypsum and/or anhydrite minerals within the Saugus Formation sediments to dissolve into the groundwater. The cause of the Na-$HCO_3$ character in the Lombardi-Anden well is unclear, but in any case is represented by the results of laboratory testing of only a single sample from this one well.

Aquifer Zone Isolation Testing

Aquifer zone isolation testing (zone testing) has been performed in at least three of the Saugus Formation municipal-supply water wells at the time of their construction. Zone testing is performed in the open borehole (pilot hole) for a new well, after the geologic log and the e-log have been completed, but prior to reaming the borehole and setting the well casing. The basic purpose of the zone testing is to obtain a groundwater sample for subsequent water quality laboratory analysis from the potential aquifer zone being tested.

Specifically, the procedure involves: selecting a potential aquifer zone to test using the geologic log and the e-log; setting an approximately 15- to 30-foot long perforated sampling tool to the desired depth beginning at the deepest aquifer zone to be tested (the tool is lowered into the open borehole at the bottom end of the drill string); placing a bentonite seal and a gravel pack above and below the perforated tool, and a gravel pack around the tool itself, in order to help isolate the perforated tool in the potential aquifer zone to be sampled; and lowering an air line inside the drill string and using an air compressor to inject high capacity/high pressure air into the air line. This injected air then essentially lifts the fluids from the isolated aquifer zone up within the drill string and to the ground surface. Airlifting continues until the fluids observed at ground surface are relatively clear, and then a water sample is collected for laboratory testing.

Zone tests were performed in SCWC-Saugus 1 at depths of 1510 to 1530 ft bgs and at 490 to 510 ft bgs. The analytical laboratory test results indicated the groundwater was Ca-Na-$HCO_3$ and Ca-$SO_4$-$HCO_3$ in character, with TDS concentrations of 410 mg/l and 530 mg/l, respectively.

Zone testing of VWC-202 (located along San Francisquito Canyon, north of the San Gabriel fault zone) was performed in four separate, 20-foot long zones between the depths of 280 ft and 810 ft bgs. Water quality in these zones ranged from Na-$SO_4$-$HCO_3$ to sodium chloride (Na-Cl). Both TDS and TH were relatively low, but iron, manganese and fluoride concentrations were relatively high.

Zone testing was also performed in NCWD-13, located in the South Fork area (see Plate 5.1), at depths of: 1365 to 1385 ft bgs; 970 to 990 ft bgs; 430 to 450 ft bgs; and 320 to 340 ft bgs. Laboratory test data show that the groundwater character was Ca-$HCO_3$ in the two shallower sampling zones, Ca-Na-$HCO_3$ in the 970 to 990 ft zone, and Na-Ca-$HCO_3$ in the deepest zone. TDS in the upper two zones were between 677 and 725 mg/l, whereas in the lower two sampled zones the TDS was 488 to 581 mg/l. Total hardness values showed that groundwater was very hard in the three upper zones (240 to 354 mg/l) but was only moderately hard in the deepest sampling zone (70 mg/l).

### Inorganic Constituents

The TDS concentration of Saugus Formation groundwater typically ranges from 500 to 900 mg/l. The State Secondary MCL for TDS is expressed as a range with 500 mg/l set as the lower level whereas the upper level is set at 1000 mg/l. No fixed consumer acceptance contaminant level has been established for TDS.

Our firm recently re-examined available TDS data from Saugus Formation water wells in the Valley. For that effort, the original laboratory data from each well were used to re-calculate TDS using a more standard, additive method as described in a USGS report by Hem (1985). These data were then compared to historic pumping and water level records to look for possible trends in TDS concentrations over time, and to examine if these trends were related to changes in groundwater production.

The results of that evaluation revealed that although there has been a slight increase in TDS concentrations in most Saugus Formation wells in the past 40 years, this increase could not be correlated with increased groundwater production. Results indicate that TDS concentrations have actually decreased during periods of increased Saugus Formation groundwater production.

Final well blend sample results (where available) for Saugus Formation wells generally show iron and manganese levels below their State Secondary MCLs of 0.3 mg/l and 0.05 mg/l, respectively. The DHS drinking water database lists several analyses for Saugus Formation groundwater with iron levels above 0.3 mg/l and included values up to 1.8 mg/l, but these are likely caused by small amounts of suspended material in the samples, rather than actual dissolved iron.

Well blend samples, and a review of the DHS drinking water quality database, reveals that nitrate (as $NO_3$) concentrations in Saugus Formation groundwater are also below the Primary MCL of 45 mg/l for this constituent.

Organic Constituents

Organic chemicals generally have not been detected in Saugus Formation groundwater, with the exception of four Saugus Formation water wells in the eastern portion of the Valley. These wells include SCWC Saugus 1 and Saugus 2, NCWD-11 and VWC 157 (see Plate 5.1 for well locations). Trichloroethylene (TCE), an industrial solvent, has been detected at concentrations ranging from 0.5 to 3.8 µg/l in VWC 157 between 1998 and 2001. TCE has also been detected in concentrations ranging from 0.07 to 3.9 µg/l in SCWC Saugus 1, and from 0.07 to 1.3 µg/l in SCWC Saugus 2, between 1991 and 1997 when the two wells were put on inactive status.

None of the detected TCE concentrations in these wells was above its MCL of 5 µg/l for domestic use, and none of the three affected wells has been used for municipal-supply purposes since 1997.

## Perchlorate

Perchlorate ($ClO_4$), and other related products, have also been detected in the same four wells, listed in the prior paragraph, that are located in the eastern part of the Saugus Formation. The current California DHS advisory action level for perchlorate is 4 µg/l. Testing of NCWD Well No. 11 showed perchlorate concentrations ranging between 9.9 and 23 µg/l between May 1997 and October 2000. This well is currently considered to be on inactive status, although NCWD has voluntarily refrained from using the well since 1998. Testing of VWC Well No. 157 between 1997 and 2000 showed perchlorate concentrations ranging from not detected (ND) to 14 µg/l. This well is also currently considered to be on inactive status, although VWC has voluntarily refrained from using the well since 1997. Finally, testing of SCWC Saugus No. 1 and Saugus No. 2 in 1997 and 1998 revealed perchlorate concentrations ranging from 16 to 42 µg/l in Well No. 1, and from 12 to 47 µg/l in Well No. 2. Neither of these two wells is currently being pumped, and both are on inactive status.

Results of ongoing laboratory testing of the remaining active Saugus Formation municipal-supply wells in the Valley have all shown non-detected concentrations of perchlorate. VWC Well Nos. 201 and 160 were sampled and analyzed for perchlorate in the third quarter of 2000, with the laboratory test data reporting not-detected results for both samples. Existing Saugus Formation water wells owned by NCWD were all tested for perchlorate in October 2000, with all samples returning not-detected results (with the exception of Well No. 11, discussed above).

Depth Discrete Aquifer Sampling

Until recently, little was known about the possible vertical variation in water quality in the Saugus Formation other than the presence of lower quality, higher salinity water in the stratigraphically lowermost portions of the formation (i.e., the Sunshine Ranch Member). However, depth specific water quality samples are now available for VWC Well 205 and NCWD Well 11.

As part of the 2000 ASR testing program, six discrete zones were sampled under pumping conditions within VWC 205, the details of which are summarized in Table 5.6 – Results of Depth-Discrete Sampling of VWC 205. The overall results generally agree with existing water chemistry data for the Saugus Formation. Specifically, the groundwater water has: a Ca-$SO_4$ to Na-$SO_4$ character; moderately high TDS (504 to 661 mg/l); low nitrate as $NO_3$ (4.78 to 8.6 mg/l); and moderately high iron (0.072 to 1.27 mg/l).

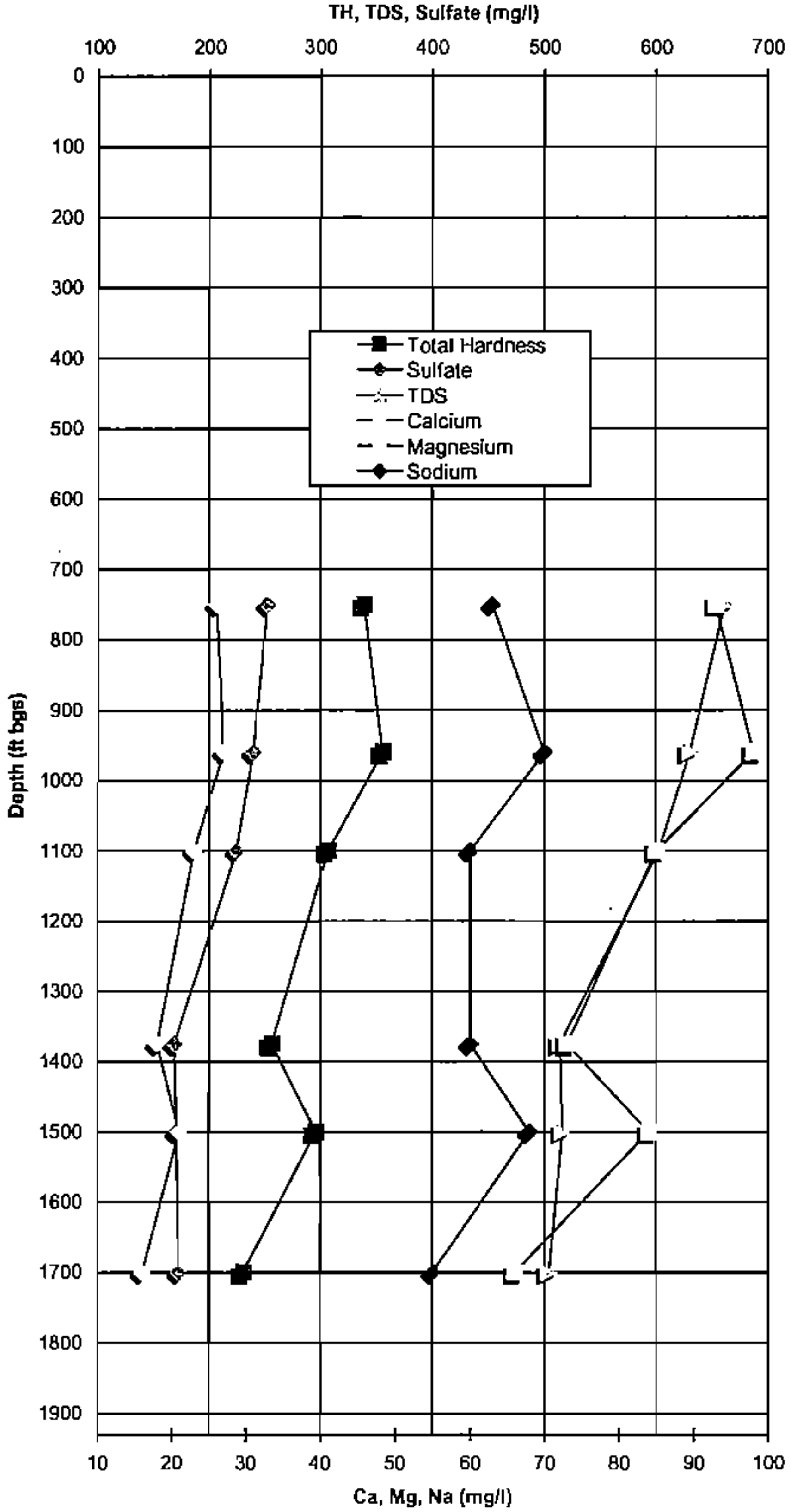
An interesting aspect of these VWC 205 laboratory results is the indication of a vertical chemical gradient within the upper 2000 ft of the Saugus Formation, with the concentration of virtually all dissolved constituents showing a generally consistent decrease with increasing depth of sampling (see Figure 5.3 – Plot of Water Quality vs. Depth, VWC 205). These new data appear to corroborate a similar improvement in water quality with depth that was observed in 1990 in a series of depth-discrete zone samples taken during construction of the Saugus Formation NCWD Well No. 13. It should be noted that VWC 205 penetrates only the upper one-third and geologically younger portion of the total Saugus Formation thickness at that site, and these results provide no information as to water quality in the older underlying beds near the base of the Saugus Formation.

**Recent Aquifer Storage and Recovery (ASR) Testing**

A preliminary program of aquifer storage (injection) and recovery testing by our firm, combined with groundwater modeling by CH2M Hill, were conducted in 2000-2001 as part of the Environmental Impact Report for the proposed Newhall Ranch development; the program was performed to examine the preliminary hydrogeologic feasibility of conducting an aquifer storage and recovery (ASR) program in the Saugus Formation. Details of the program are

## Table 5.6
## Results of Depth-Discrete Sampling of VWC 205

| | Sampling Depth (ft, bgs) | | | | | |
|---|---|---|---|---|---|---|
| **Chemical Constituent** | **1700** | **1500** | **1375** | **1100** | **960** | **750** |
| Total Hardness (mg/l) | 231 | 296 | 256 | 307 | 356 | 339 |
| Ca (mg/l) | 66 | 84 | 73 | 85 | 98 | 93 |
| Mg (mg/l) | 16 | 21 | 18 | 23 | 27 | 26 |
| Na (mg/l) | 55 | 68 | 60 | 60 | 70 | 63 |
| K (mg/l) | 2.6 | 3.4 | 2.8 | 2.7 | 3.1 | 2.9 |
| Alkalinity (mg/l) | 153 | 161 | 163 | 170 | 170 | 175 |
| Hydroxide (mg/l) | 0 | 0 | 0 | 0 | 0 | 0 |
| Carbonate (mg/l) | 0 | 0 | 0 | 0 | 0 | 0 |
| Bicarbonate (mg/l) | 187 | 196 | 199 | 207 | 207 | 214 |
| Sulfate (mg/l) | 173 | 171 | 169 | 225 | 240 | 252 |
| Chloride (mg/l) | 25 | 28 | 29 | 30 | 30 | 33 |
| Nitrite as NO2 (mg/l) | <1 | <1 | <1 | <1 | <1 | <1 |
| Nitrate as NO3 (mg/l) | 4.9 | 4.7 | 5.2 | 6.4 | 6.8 | 8.6 |
| Fluoride (mg/l) | 0.18 | 0.21 | 0.23 | 0.27 | 0.28 | 0.27 |
| Orthophosphate (mg/l) | <1 | <1 | <1 | <1 | <1 | <1 |
| Bromide (mg/l) | 0.11 | 0.12 | 0.12 | 0.15 | 0.15 | 0.15 |
| pH | 7.64 | 7.67 | 7.62 | 7.58 | 7.52 | 7.52 |
| Specific Conductance (µmhos/cm) | 744 | 784 | 755 | 858 | 908 | 920 |
| TDS (mg/l) | 504 | 516 | 514 | 602 | 630 | 661 |
| Color | 10 | 5 | 5 | <5 | <5 | 10 |
| Turbidity (NTU) | 9 | 7 | 5 | 4 | 2 | 12 |
| Al (µg/l) | 9 | 11 | 9 | 11 | <5 | <5 |
| As (µg/l) | <2 | <2 | <2 | <2 | <2 | <2 |
| B (µg/l) | | | | | | |
| Ba (µg/l) | 53 | 53 | 49 | 48 | 44 | 43 |
| Be (µg/l) | <1 | <1 | <1 | <1 | <1 | <1 |
| Cd (µg/l) | 2 | <1 | <1 | <1 | <1 | <1 |
| Co (µg/l) | <1 | <1 | <1 | <1 | <1 | <1 |
| Cr (µg/l) | 2 | 3 | <1 | 2 | 1 | 1 |
| Cu (µg/l) | 6 | <1 | <1 | <1 | <1 | <1 |
| Fe (µg/l) | 376 | 482 | 125 | 276 | 72 | 1273 |
| La (µg/l) | <1 | <1 | <1 | <1 | <1 | <1 |
| Mn (µg/l) | 5 | 5 | 1 | 3 | 2 | 13 |
| Mo (µg/l) | 1 | 0 | 1 | 2 | 1 | 2 |
| Ni (µg/l) | 78 | 20 | 13 | 5 | 10 | 6 |
| P (µg/l) | 58 | 40 | 25 | 71 | 40 | 114 |
| Pb (µg/l) | <20 | <20 | <20 | <20 | <20 | <20 |
| Sb (µg/l) | <100 | <100 | <100 | <100 | <100 | <100 |
| Se (µg/l) | <100 | <100 | <100 | <100 | <100 | <100 |
| Sr (µg/l) | <100 | <100 | <100 | <100 | <100 | <100 |
| V (µg/l) | 15 | 18 | 14 | 10 | 13 | 11 |
| Zn (µg/l) | 500 | 495 | 182 | 406 | 33 | 84 |



**RICHARD C. SLADE & ASSOCIATES LLC**
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**FIGURE 5.3**
**Plot of Water Quality vs Depth**
**VWC 205**

JOB NO. S9920
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contained in the report entitled Additional Analysis to the Newhall Ranch Specific Plan and Water Reclamation Plant Final Environmental Impact Report (2001), but the key points of that report are as follows:

1. It is hydrogeologically feasible to inject into and recover from the Saugus Formation significant volumes of water. The formation readily accepted water from the injection well, and subsequently yielded a comparable amount of water to the same well during pumping. Local mounding or depression of nearby static water levels (piezometric or pressure levels) due to injection or pumping, respectively, quickly returned to near pre-test levels once injection or pumping ceased.
2. An ASR program operated at annual injection rates of 4500 AF/yr during wet and normal years, and at annual extraction rates of 4100 AF/yr during dry years, was determined to have no significant negative effects on either the Valley, or on downstream users (i.e. Ventura County), as modeled by CH2M Hill (2001). The analysis predicted measurable benefits, including more rapid recovery of Saugus Formation water levels following drought periods.

An ASR project of a scope beyond that envisioned for the Newhall Ranch development may provide further benefits to the Saugus Formation aquifer system, particularly in light of the increased drought-year pumping levels outlined in the UWMP.

## SECTION 6

# CONCLUSIONS AND RECOMMENDATIONS

### General Statement

The Santa Clarita Valley is has two local aquifer systems, the alluvial aquifer and the Saugus Formation aquifer. These important aquifer systems have provided and should be able to continue to provide reliable sources of potable drinking water for the area. Since the publication of the first significant hydrogeologic reports on these aquifer systems in the Slade 1986 Report and the Slade 1988 Report, respectively, significant new hydrogeologic data have been acquired and have greatly enhanced the understanding of the local groundwater sub-basin. Based on recent state-wide updating of groundwater basins in California, DWR currently is defining the local groundwater reservoir in the Valley as the Santa Clara River Valley East Groundwater Sub-basin. The western boundary at this sub-basin is currently taken at County line where it meets the adjoining (downstream) Piru sub-basin of Ventura County. The eastern boundary of the local groundwater sub-basin occurs at a narrows in the alluvium near Lang.

Based on our review of these new hydrogeologic data, we present the following conclusions and recommendations.

### Hydrogeologic Conditions in the Alluvial Aquifer System

Extent and Thickness

The alluvial aquifer covers an area of approximately 16,000 acres on the floor of the main Santa Clara River Valley and its major tributary canyons. The aquifer is comprised by unconsolidated sand, gravel, silt and clay, and reaches a maximum thickness of 200 ft in local areas along the main reach of the Santa Clara River. In all canyons that are tributary to the main river, and as the lateral margins of the main river course and of the tributary canyons are reached, the thickness of the alluvium decreases. Groundwater occurs under unconfined (water table) conditions in the alluvial aquifer.

Water Levels

Water levels in the western portion of the alluvium (west of I-5) have historically been quite stable and insensitive to fluctuations in the amount of annual rainfall and surface water recharge. This is likely due, at least in part, to the upward flow of groundwater from the underlying Saugus Formation (particularly west of I-5), which provides a consistent source of recharge that is relatively independent of annual rainfall trends.

In addition, water levels in both the western portion and especially the central portion of the river valley (I-5 to Bouquet Canyon) have shown a progressive reduction in the amount of year-to-year variability, and a decreasing sensitivity to fluctuations in the amount of annual rainfall and recharge over the past ten years. This decreasing amount of annual water level fluctuation is due to the additional recharge provided to the alluvium from the annually increasing outflows (totaling 19,000 AF in 2000) from the two WRPs located between I-5 and Bouquet Canyon along the main river valley. The increase in WRP outflows and subsequent recharge of the alluvial aquifer system is directly related to the ongoing urbanization of the Valley and the concomitant and dramatic increase in the amounts of SWP water imported into the Valley since 1980. Imports of SWP water have risen from approximately 1,100 AF/yr in 1980 to over 32,000 AF/yr in 2000.

Water levels in wells along the main river valley east of Bouquet Canyon continue to display a much greater year-to-year variation, and a stronger correlation with changes in precipitation. In this reach of the river valley, water levels in alluvial wells decline temporarily during dry periods, but quickly recover to pre-drought levels once normal rainfall conditions return. This area is upstream from the two local WRPs, and is not influenced to the same degree by the increases in imported SWP water.

Overall, there is no evidence of a long-term, continuous or permanent decline in water levels in any alluvial aquifer well, and thus there is no evidence that the alluvial aquifer system is being pumped beyond its sustainable capacity. Whereas water levels in the alluvial aquifer do fluctuate over time, there is no continued and progressive decline in groundwater levels, leading to a permanent loss of groundwater in storage, which would be indicative of overdraft. There is clearly no overdraft in the alluvial aquifer system in the Valley.

### Groundwater in Storage

As water levels in the alluvial aquifer fluctuate over time, so does the total quantity of groundwater in storage within this aquifer system. The alluvial aquifer contained an estimated 200,000 acre-feet of water in storage at its historical high in 1945. In the spring of 2000, the total volume of groundwater in storage in the alluvial aquifer was approximately 161,000 AF. Over time, groundwater levels and associated groundwater in storage in this aquifer system have fluctuated in response to wet and dry conditions in the Valley; this is particularly evident in the eastern portion of the alluvial aquifer. However, there has been no long-term, progressive decline in the amount of alluvial groundwater storage that could be considered indicative of overdraft conditions.

### Groundwater Production and Operational Yield

Annual groundwater production from the alluvial aquifer by the major purveyors over the last ten years has averaged approximately 35,000 AF/yr, about 10 percent above the "practical or perennial yield" of 31,600 to 32,600 AF/yr calculated in the Slade 1986 Report. However, this recent increase in average annual production has occurred without any onset of undesirable conditions such as lowered water levels that might be indicative of excessive extractions or overdraft. The primary reason that the alluvial aquifer system has been able to supply groundwater for the past ten years in annual volumes that are well in excess of its previously estimated perennial yield is the greatly increased amount of water that has been imported into the Valley via the SWP since the early 1980s. Specifically, imports of SWP water into the Valley have risen from approximately 1,100 AF/yr in 1980 to over 32,000 AF/yr in 2000. Much of this additional water is returned to the alluvial aquifer system in the form of discharge from the two WRPs located along the Santa Clara River.

It is evident from observation of alluvial aquifer response to average pumping, and response to pumping in individual years, that the alluvial aquifer can be operated at a higher average pumping rate and over a wide range of yearly pumping rates without inducing undesirable conditions that would be indicative of overdraft, i.e., long-term continuous and progressive decline in water levels and storage. This observation is particularly evident since the initiation of supplemental SWP water deliveries in 1980. The ultimate goals of an increased operational yield for the alluvium would be to avoid both short-term adverse impacts as a result of year-to-year fluctuations in pumping, and to avoid long-term adverse impacts such as continuously lowered water levels and groundwater in storage in this aquifer system.

In summary, the combination of historical observations and current planning has led to the current conclusion that the alluvial aquifer system can be operated over a wide range of pumping rates, and on a long-term average basis it can be operated at an average pumping rate on the order of 10% higher than was reported as a "practical or perennial yield" in 1986. As summarized in the UWMP, the operational yield of the alluvial aquifer system will typically be in the 30,000 to 40,000 AF/yr range for most average and/or wet years, with expected reduction into the 30,000 to 35,000 AF/yr in dry year periods.

### Groundwater Quality

Groundwater pumped by the local water purveyors is routinely sampled and tested by State-certified laboratories. These laboratory data show that the water quality of groundwater pumped from the alluvial aquifer system meets all current Federal and State drinking water standards.

Two important constituents in the groundwater in this aquifer system are nitrate and TDS. Nitrate concentrations in alluvial wells ranged from 14 mg/l in the easternmost alluvial wells, to 27 mg/l in alluvial wells near the confluence between the South Fork and main reach of the Santa Clara River. Nitrate concentrations in the area west of I-5 are quite low, with the concentration in five agricultural-supply wells in this area averaging just 6.6 mg/l. Nitrate concentrations in municipal-supply water wells within the alluvium are below its MCL of 45 mg/l for domestic use.

TDS generally increases from approximately 500 mg/l in the easternmost alluvial wells, to approximately 1000 mg/l in agricultural-supply wells west of I-5. All of the existing municipal-supply alluvial wells are located east of I-5.

VOCs, specifically 1,1,1-TCA and PCE, have occasionally been detected in a few municipal-supply wells in the eastern part of the Valley, but the detected concentrations of these VOCs have been consistently below their respective MCLs. The source(s) of these VOCs is not known and has not been investigated for this update report. No other alluvial municipal-supply wells have shown repeatable detections of any VOCs. There has also been no detection of perchlorate in any municipal-supply well constructed in the alluvial aquifer system in the Valley.

Groundwater extracted from the alluvial aquifer system by the municipal-supply water purveyors in the Valley has been and continues to be of acceptable quality for beneficial use.

## Hydrogeologic Conditions in the Saugus Formation Aquifer System

### Extent and Thickness

The Saugus Formation aquifer system is comprised by a deep bowl-shaped group of layered sediments having a surface outcrop area of approximately 55,500 acres. The formation is comprised of semi-consolidated sand, gravel, silt and clay, and reaches a maximum thickness beneath the central part of the Valley of approximately 8,000 ft. However, useable groundwater at this time is considered only to occur in the uppermost 2,500 ft of these sediments. Groundwater occurs under semi-confined to confined conditions within most of the formation; unconfined (water table) conditions may occur within some of the coarser-grained Saugus Formation strata exposed at or near ground surface in the hillsides surrounding the river valley.

The results of recent spinner surveys in selected Saugus Formation wells demonstrate that groundwater is being produced over the entire screened intervals in these tested wells, down to their maximum cased depths of approximately 2000 ft. Pumping tests (both step drawdown tests and constant rate tests) performed in the newer municipal-supply wells in this formation have been conducted at rates in the range of 1720 to 4000 gpm, and 2500 to 4000 gpm, respectively. Such rates document the high pumping rate capacity of this formation south of the San Gabriel fault.

### Water Levels

Water levels (piezometric levels) in Saugus Formation water wells have typically fluctuated over time, with the magnitude of these historic fluctuations varying with each well; these annual fluctuations have generally ranged from a minimum of 50 ft to a maximum of 175 ft. It is important to note that these fluctuations are considered to be small because the Saugus Formation wells in which these fluctuations have occurred range in total cased depth from 750 ft to nearly 2000 ft. Furthermore, the depth to the top of the uppermost perforations in most existing Saugus Formation wells is typically 400 ft or more below ground surface.

Water levels in Saugus Formation wells appear to fluctuate in response to patterns of increasing or decreasing rainfall, and to some extent to patterns of increasing or decreasing groundwater extraction from the Saugus Formation. However, a significant observation from the hydrographs of wells constructed in the Saugus Formation is that no long-term or continuous decline in water levels has occurred in any Saugus Formation water well over time, thereby demonstrating that this aquifer system is not and has not been overdrafted.

### Groundwater in Storage

The Slade 1988 Report calculated the volume of groundwater in storage in the Saugus Formation aquifer to be approximately 1.41 million AF. Groundwater in storage at that time was defined as that groundwater contained solely within with potential sand and gravel aquifer beds identified on e-logs, and only between the depths of 500 ft bgs and the shallower of either: a) a depth of 2500 ft bgs; b) the base of fresh water within the Saugus Formation; or c) the base of the Saugus Formation.

For this updated report, the volume of groundwater in storage in the Saugus Formation has been re-calculated using the same criteria used in 1988 except that the uppermost portion of the zone of interest within the formation has been raised from a depth of 500 ft to 300 ft bgs. This change is based on our increased knowledge of the thickness of the alluvial sediments in the Valley and the minimal degree of pumping interaction that was monitored between a pumping Saugus Formation well and a nearby alluvial groundwater monitoring well during the injection test program in 2000.

The current calculated volume of groundwater in storage in the Saugus Formation is approximately 1.65 million AF, or about 18% more than the 1988 calculation value. This increase is entirely due to raising the upper limit of the zone of storage from 500 ft to 300 ft bgs.

The actual volume of groundwater in storage in an aquifer can be less important than the amount of annual recharge to the aquifer for the purposes of determining the amount of water that can be withdrawn by pumping over the long term. However, when the volume in storage is particularly large in comparison to the amount of annual pumping, considerable flexibility is added to the available strategies for aquifer management. For example, the aquifer may be pumped heavily during dry years and then allowed to recover during wet years, either via natural or artificial recharge.

Groundwater Production and Operational Yield

Groundwater production from the Saugus Formation has averaged approximately 8,600 AF/yr from 1991 to 2000, whereas the maximum historical production volume was approximately 15,000 AF occurring in 1991, towards the end of a multi-year drought. No long-term continuous or permanent decline in either water levels or the amount of groundwater in storage has occurred under this historical range of pumping.

The operational yield concept includes flexibility of groundwater use by allowing increased pumping during dry periods and increased recharge (direct or in-lieu) with supplemental water when it is available in wet/normal periods. The operational yield protects the aquifer by helping to assure that groundwater supplies are adequately replenished on a long-term basis from one wet/dry cycle to the next. Limited historical data for the Saugus Formation show that no lowering of water levels or degradation of water quality has occurred in the area.

It is evident from observation of response to historical pumping from the Saugus Formation that this aquifer system can be operated (pumped) over a range of capacities to at least 15,000 AF/yr without causing undesirable conditions that would be indicative of "overdraft," i.e., a long-term continuous and progressive decline in water levels and in groundwater in storage. As a result, the operational yield of the Saugus Formation, or the yearly yield for operating purposes, could range up to an individual annual pumping volume on the order of 15,000 AF based on data available to date. As with the alluvial aquifer system, the ultimate goals of an increased operational yield for the Saugus Formation would be to avoid both short-term adverse impacts as a result of year-to-year fluctuations in pumping, and to avoid long-term adverse impacts such as continuously lowered water levels and storage.

In summary, the combination of historical observations and current planning has led to the current conclusion that the Saugus Formation aquifer system can be operated on a long-term average basis in the range of 7,500 to 15,000 AF/yr. Infrequently, during dry periods of one to three years, pumping operations can be ramped up from 15,000 to 25,000 AF/yr, and ultimately to 35,000 AF/yr if dry conditions continue. These latter increases would be temporary and would return to or below the historical range of 7,500 to 15,000 AF/yr once rainfall patterns returned to normal. As summarized in the UWMP, the operational yield of the Saugus Formation will typically be in the 7,500 to 15,000 AF/yr range for most year types, with possible short-term ramped increases in dry periods into the 15,000 to 35,000 AF/yr range. Such temporary and short-term increases above historic pumping are unlikely to have an adverse impact on the Saugus Formation aquifer system, and, in particular, are unlikely to induce a permanent loss of groundwater in storage. Any short-term water level decline or groundwater in storage decline is expected to be restored upon return to the historical operating range on an average annual basis.

### Groundwater Quality

Groundwater pumped from the Saugus Formation aquifer system by the local water purveyors is routinely sampled and tested by State-certified laboratories. These laboratory data show that the water quality of pumped groundwater down to the existing known maximum depth of these wells (2000 ft) meets all current Federal and State drinking water standards. Aquifer zone isolation testing performed in individual aquifer units during the drilling of selected Saugus Formation wells further corroborates that water quality to depths of at least 1530 ft bgs is suitable for municipal-supply purposes.

Groundwater character within the Saugus Formation generally varies from calcium-bicarbonate in the area along the South Fork of the Santa Clara River, to calcium-sulfate towards the deeper central parts of the local groundwater sub-basin.

An important water quality parameter in Saugus Formation groundwater is its TDS concentration. TDS concentrations of Saugus Formation groundwater typically range from 500 to 900 mg/l. The State Secondary MCL for TDS for domestic use is expressed as a range, with the upper value for TDS being 1000 mg/l. No fixed consumer acceptance level has been established for TDS.

A detailed re-calculation and review of available historic TDS data from Saugus Formation water wells has been performed and revealed that although there has been a slight increase in TDS levels in most Saugus Formation wells in the past 40 years, this increase can not be correlated with increased groundwater production. In fact, there is evidence that TDS concentrations have actually decreased during periods of increased Saugus Formation groundwater production.

Recent depth specific sampling of several Saugus Formation wells under pumping conditions indicates that groundwater quality, as determined by the quantities of certain dissolved inorganic constituents, actually improves slightly with depth in the upper 2,000 ft of the formation.

### Perchlorate

Perchlorate ($ClO_4$), a component of rocket fuel, has been detected at concentrations ranging from approximately 10 to 47 µg/l in four wells (SCWC Saugus Nos. 1 and 2, NCWD-11 and VWC-157) in the eastern part of the outcrop area of the Saugus Formation. The current California DHS advisory action level for perchlorate is 4 µg/l. Each of these four wells was taken out of service following the initial detection of perchlorate in 1997.

Results of ongoing laboratory testing of the remaining active Saugus Formation municipal-supply wells have all shown perchlorate to be not detected. VWC Well Nos. 201 and 160 were sampled and analyzed for perchlorate in the third quarter of 2000, with the laboratory test data showing not-detected results for both samples. The other active Saugus Formation water wells owned by NCWD were all tested for perchlorate in October 2000, with all samples also revealing not-detected results.

Perchlorate in the Saugus Formation groundwater is currently known to affect only the eastern portion of the Saugus Formation aquifer system. The local water purveyors are currently investigating a treatment program using an existing and approved technology to restore the water supply capacity of the four impacted wells, and to assist in remediating and containing the groundwater contaminated by perchlorate. The California Department of Toxic Substances Control is overseeing the ongoing remediation and cleanup of a suspected source of this (and related) contaminants. All other existing Saugus Formation municipal-supply production wells are unaffected by perchlorate and this aquifer system remains a viable source of groundwater for the Valley.

### Future Well Construction

Alluvial Aquifer System

It is considered hydrogeologically feasible to site, drill and construct new municipal-supply water wells within the alluvial aquifer system in the Valley. These new wells, specifically designed and constructed for municipal-supply purposes, should gradually replace those older existing municipal-supply wells that were originally constructed for agricultural-supply purposes. Additional new well construction may also occur as urbanization of the Valley continues and the groundwater currently pumped by existing agricultural-supply wells is designated for municipal-supply purposes.

The site-specific siting and design of new individual alluvial aquifer wells is beyond the scope of this report, but the following points summarize some key siting and design considerations for those new municipal-supply wells:

- New wells should be properly designed, constructed, developed and tested, and then equipped with water level transducers, if appropriate, for ongoing water level monitoring.
- Lateral separation between future and existing municipal-supply wells, and between those wells and existing privately-owned domestic wells, should be carefully selected to minimize the potential for water level drawdown interference.
- New municipal-supply wells should be constructed with relatively deep perforated intervals, and sufficiently deep cement sanitary seals to reduce the potential for inflow of surface water and/or shallow, poor-quality groundwater.
- New wells should be drilled and completed only within the alluvial aquifer to avoid the unplanned cross-flow of water between the alluvial aquifer, and confined portions of the underlying Saugus Formation.
- Proposed well sites should be evaluated for possible sources of past or present groundwater contamination. This will be particularly important as the urbanization of the Valley continues.

- Siting studies for new municipal-supply alluvial wells should include a field reconnaissance and well canvass to determine whether or not there are any nearby wells owned by others that might lie within the cone of water level depression created by future pumping of each newly proposed municipal-supply water well.

Saugus Formation Aquifer System

It is considered to be hydrogeologically feasible to site, drill and construct new municipal supply water wells in the Saugus Formation aquifer system. New Saugus Formation water wells will be needed to provide the increased Saugus Formation groundwater production envisioned by the 2000 UWMP. In anticipation of this new well construction, we have reviewed the construction details and well performance characteristics of existing Saugus Formation water wells in light of recent advances in our understanding of the geology and hydrogeology of the Saugus Formation. This has led to the development of several criteria for identifying areas that are hydrogeologically favorable for the drilling and construction of new Saugus Formation water wells. These criteria include:

1. New wells should be located in areas where the total thickness of potential Saugus Formation sand and gravel units in the depth range of 300 ft to 2500 ft bgs is generally greater than 800 ft (refer to the locations of such areas on Plate 3.2). This criterion will help maximize the total thickness and number of potential coarse-grained aquifer units intersected during drilling of the pilot hole for the new well. Because of the "bowl-shaped" structure of the Saugus Formation in the Valley, areas of thickest potential sand and gravel aquifers are found nearer the center of the basin, especially in areas adjacent to the Holser fault, within the southern and central fault blocks.
2. New wells should be located in areas where the depth to the top of the Santa Clarita Aquifer Zone beneath the potential well site is at least 800 ft below ground surface. This is because the more productive of the existing Saugus Formation water wells tend to intersect the Santa Clarita Aquifer Zone at depths of 1000 ft or more.
3. Extrapolation of the results of recent aquifer testing carried out on VWC Well Nos. 205 and 201 has been used to provide a reasonable approximation of potential drawdown interference between new and nearby existing Saugus Formation municipal-supply water wells. New wells should be located in areas that will provide a minimum separation of 1000 ft from existing Saugus Formation municipal- or agricultural-supply water wells; this is important to help minimize the potential for mutual water level drawdown interference between pumping municipal-supply wells.

4. Siting studies for the new municipal-supply wells in this formation should include a field reconnaissance and well canvass to determine whether or not there are any nearby wells owned by others that might lie within the cone of water level depression created by future pumping of each newly proposed municipal-supply water well.

The depth to the base of fresh water as calculated from e-logs has also been used as a criterion in evaluating these recommended drilling areas. In the recommended areas presented herein, the depth to the base of fresh water was found to be greatly in excess of the anticipated depth range of 1500 to 2000 ft for new Saugus Formation water wells.

At the present time, it is not known if the San Gabriel and/or Holser faults act as barriers to groundwater flow within the Saugus Formation, particularly in the area west of Bouquet Junction. Recent groundwater modeling by CH2M Hill (Newhall Ranch ASR Impact Evaluation, 2001) suggests that the faults do not act as groundwater barriers, but there is currently no way to test this hypothesis due to a complete absence of deep, Saugus Formation water wells north of the faults. The issue is further complicated by the fact that there is not a consensus among geologists as to the position, or even the existence of the Holser fault where it is projected beneath alluvium in the main river valley.

Given the present lack of hydrogeologic information regarding the San Gabriel and Holser faults, we suggest that new Saugus Formation wells avoid being located near mapped traces of the two faults in order to minimize the potential for increased water level drawdown that might occur if the faults were barriers to groundwater flow.

Plate 6.1 – Recommended Areas for New Saugus Formation Water Wells - illustrates a large area in the central portion of the Saugus Formation outcrop area that meets the above hydrogeological and logistical criteria. The favorable areas identified at this time occur within the central and southern fault blocks. Circular buffer zones are shown around existing wells to identify minimum separation zones covered by criteria 3, 4 and 5 above.

The area shown in Plate 6.1 is intended only as a general guide to prospective drilling areas. Each specific future well site should still undergo a detailed evaluation of its unique subsurface geology, geologic structure, site logistics and position relative to existing or planned infrastructure.

When evaluating potential sites for new Saugus Formation water wells, the following site logistics criteria should also be considered:

- Sufficient room to maintain required setbacks from nearby sewers and storm drains.
- Sufficient room for drilling and testing equipment.
- Possible presence of overhead obstructions such as trees or aboveground utilities.
- Availability of water for drilling, from either a nearby hydrant or an existing water well, or from a nearby water transmission line.
- Proximity to nearby residences or other structures for which there could be the potential need for noise abatement procedures and equipment.
- Sufficient room for temporary water storage tanks and an available discharge point for releasing water produced during drilling, development and testing of a new well, to permit conformance with NPDES requirements.

## Artificial Recharge

### Alluvial Aquifer System

Artificial recharge is the process of augmenting the natural recharge to the aquifer, a process that normally occurs on an ongoing basis via the natural infiltration of precipitation and surface water runoff. Artificial recharge programs utilize a variety of man-made works that are designed to maintain infiltration rates, increase the surface area over which infiltration takes place, and increase the length of time during which infiltration can occur. Regardless of the exact method used, the goals of an artificial recharge program typically include:

- Replenishing or increasing the amount of groundwater in storage in the aquifer.
- Storing water in times of low demand for subsequent use in high demand periods.
- Increasing the infiltration of surface water runoff, particularly during flood flow periods.
- Increasing the flexibility of the operating and management plans of local water purveyors.

Of the numerous methods available for artificial recharge, the most appropriate to the water table conditions in the alluvial aquifer would be a system of surface spreading basins or off-stream basins, or similar structures. This would involve the construction of basins or impoundments to store water from one or more available sources, and permit the infiltration of the water into the underlying alluvial aquifer.

Plate 6.2 – Potential Areas for Artificial Recharge, Alluvial Aquifer – illustrates the areas within the main river valley upstream (east) of Bouquet Canyon where the Slade 1986 Report suggested artificial recharge could potentially be carried out by means of surface spreading basins. Those areas were chosen for their potentially relatively high rates of vertical infiltration of water through the local soils (generally greater than 6 inches per hour), and the possible absence of low-permeability clay layers in the uppermost 25 ft of alluvial sediments. In addition, local surface water quality constraints and the quality of the local alluvial groundwater at that time were also considered.

Even in areas that may be otherwise suitable for artificial recharge, high (shallow) water levels may limit the amount of available (extra) storage capacity in the aquifer. The limited amount of water level fluctuations seen on hydrographs for wells in the western and central portions of the alluvial aquifer suggests that the aquifer is essentially "full" or nearly "full" in these areas, and thus the aquifer system in those portions of the Valley would tend to have little or no available capacity to receive and store additional water from a nearby artificial recharge program. It is probable that only in those areas along or near the Santa Clara River east of Bouquet Canyon are groundwater levels sufficiently below their likely maximum levels to provide available storage capacity that could be filled by artificial recharge on a regular basis.

Detailed investigations of potential recharge sites have not been performed to date. The Slade 1986 Report discusses the general types of additional work required to evaluate individual sites in greater detail, as well as some potential problems associated with artificial recharge of the alluvium.

### Saugus Formation Aquifer System

Because the Saugus Formation is predominantly a semi-confined to confined aquifer with lower permeability and transmissivity than the alluvial aquifer, artificial recharge of the Saugus Formation via spreading basins would not be practical. However, recent field testing and groundwater modeling have demonstrated that ASR using deep injection wells is both feasible and potentially advantageous for the Saugus Formation.

An ASR project of a scope beyond that envisioned for the Newhall Ranch development may provide further benefits to the Saugus Formation aquifer, including:

- Increased volume of groundwater in storage in the aquifer.
- More rapid post-drought recovery of Saugus Formation water levels.
- Possible improvement in the groundwater quality in the Saugus Formation, depending on the source of the injection water.
- Greater flexibility in the operations and management being performed by the local water purveyors.

**Conjunctive Use and Management of the Alluvial and Saugus Formation Aquifers**

Conjunctive use refers to the coordinated management and operation of multiple water supplies to achieve improved reliability of the water supply. In this aspect, the Valley is fortunate to have two local aquifers that can be conjunctively used with imported SWP water in order to provide the Valley with a reliable supply of potable drinking water.

Since beginning to import a supplemental surface water supply in 1980, the Santa Clarita Valley Water Purveyors have been conjunctively utilizing that imported surface water with local groundwater from the alluvial and Saugus Formation aquifer systems. It has been conjunctive use that has allowed increasing water demands to be met while maintaining groundwater production within a range that precludes either aquifer system from being in overdraft. A similar, but expanded, conjunctive use program, as described in detail in the recently adopted UWMP, is expected to integrate additional supplemental sources of water supply in order to meet further projected increases in water demand while maintaining both aquifer systems within long-term sustainable yield, i.e. no overdraft.

As projected increases in water demand are experienced in the future, it is anticipated that pumpage from the alluvial and Saugus Formation aquifer systems will remain, on a long-term basis, in the same range as in recent years. Increasing water demands will be met by increased imported supplies, recycled water, demand-side management (conservation), and other sources to be developed.

Future conjunctive use operations are expected to entail some short-term increased pumping from the Saugus Formation during dry periods and reduced SWP water availability. While that pumping could increase into a range of 15,000 to 35,000 AF/yr for one to three consecutive dry years, surface water will be conjunctively used in greater amounts during wet and normal years to allow Saugus Formation pumpage to decrease such that, again on a long-term basis, pumpage is maintained within historic range; overdraft would be avoided. Such future conjunctive use may also include some purposeful injection of water into the Saugus Formation to enhance the recovery of water levels and also to increase the amount of groundwater in storage following periods of higher pumping during dry periods.

A conjunctive use strategy for the Valley could include:

- Utilizing a combination of imported SWP water and increased groundwater pumpage from the alluvial aquifer system during periods of average or above average rainfall (normal and wet years).
- Utilizing increased extraction from the Saugus Formation during periods of lower than average rainfall in the Valley (dry years), or during periods of decreased availability of water from the SWP.
- Enhancing the recovery of water levels and the volume of groundwater in storage in the Saugus Formation through a program of artificial recharge, via injection, whenever additional water supplies are available.
- Increasing the available storage capacity of the alluvial aquifer through increased pumping in the area east of Bouquet Canyon. This would serve to enhance both the natural recharge to the aquifer, and the effectiveness of an artificial recharge program using surface spreading basins in the same area.
- Augmenting the natural recharge to the alluvial aquifer system through the use of spreading basins or similar structures along the river in the area east of Bouquet Canyon.

## Groundwater Monitoring

### General Statement

During the preparation of this report, a significant effort was made to research, collect, and verify current and historic data on groundwater levels and water quality, on water well locations and construction details, and on aquifer parameters, for both the alluvial and Saugus Formation aquifer systems. A large component of this effort was the construction of a GIS database that not only serves as a repository and analytical tool for historic data, but which should be used as the basis for any future monitoring program. This data collection effort and database creation are now expected to evolve into a formal program of monitoring, data collection, and database maintenance, with standardized procedures for data collection and a central, single repository for the data.

In addition, an effort should be made to fill in existing data gaps by collecting data from existing private wells, agricultural-supply wells, or piezometers (where possible), or, where practical, by drilling and constructing a limited number of new monitoring wells in both aquifer systems in the Valley.

### Selection of Monitoring Sites

A specific site for the collection of water quality data is not necessarily a suitable site for the measurement of water level data in an aquifer, and therefore data collection efforts for these two types of data need not be conducted at the same monitoring sites. For example, an active, properly constructed production water well is an excellent location for the collection of water quality samples. However, water levels measured in this same active production well may be strongly affected by incomplete recovery or by pumping water level drawdown in the vicinity of the well, and hence the collected water level data may not be representative of conditions in that portion of the aquifer as a whole. This is particularly true for wells that are not currently equipped with pressure transducers, and that are pumped almost continuously during periods of heavy water demand (e.g. the NCWD Saugus Formation wells). For an existing well to be used in the monitoring program, it will also be necessary to verify that pertinent well construction data exist or can be obtained via a video survey in the well.

Each well selected for water level monitoring should have a permanent reference point marked on the wellhead, and the elevation of each reference point should be accurately determined using either traditional survey methods tied to a benchmark of known elevation, or a survey-grade differential GPS unit. All vertical elevations should be tied to a single, widely used vertical datum.

### Alluvial Aquifer System

Given that water levels are used to determine changes in the amount of groundwater in storage, a practical approach to selecting sites for water level monitoring in the alluvial aquifer may be to choose at least one monitoring site in each of the alluvial storage subunits described in Section 4. This would permit a more accurate and reliable determination of the year-to-year variation in groundwater in storage in the alluvium.

It may also be very useful to establish a series of monitoring wells near the downstream end of the alluvial aquifer between Castaic Junction and County Line. This could help to quantify the amount of subsurface outflow within the alluvium, and to assist in groundwater model calibration and groundwater basin management efforts.

### Terrace Deposits

Terrace deposits are not considered to be a viable water-bearing aquifer unit because they are generally situated above the regional water table. In addition, surface exposures of these terrace deposits are not considered to be either areally extensive or thick. Hence, establishment of a groundwater monitoring program for these deposits is not recommended.

### Saugus Formation Aquifer System

Monitoring of water levels and water quality within the Saugus Formation will likely be restricted to existing and/or newly constructed Saugus Formation water-supply wells for the foreseeable future, given the high cost of constructing deep monitoring wells in this aquifer system. However, a program of regular monitoring of both water levels and (where possible) water quality in existing wells, both active and inactive, would add to the ever-increasing database on the Saugus Formation.

If monitoring wells are to be constructed, careful consideration should be given to areas within the outcrop area of the Saugus Formation where data are lacking, or where the data would be particularly useful for groundwater model calibration purposes. Areas where data are particularly lacking include the area between the Holser and San Gabriel faults, and the area north of the San Gabriel fault. Both the siting and the design of new monitoring wells should be undertaken with these considerations in mind.

Another step that could be taken to enhance the current understanding of Saugus Formation water levels and water quality would be to include several of the existing privately-owned Saugus Formation wells (e.g. the Poe and Anden wells, and NLF-156) in the ongoing monitoring program. These wells are located in key areas in the Saugus Formation where no nearby municipal-supply wells exist.

### Network Operation and Monitoring

Data collected should include:

- Static and pumping water levels in both the alluvial and Saugus Formation aquifer systems.
- Water quality data for both aquifers and for the Santa Clara River and its major tributaries.
- Annual groundwater extraction volumes pumped by individual wells from all of the major water users, including private and agricultural users.
- Detailed well construction information for new and existing wells.
- Records of any well destruction activities, including the dates and methods used.
- Historic data on aquifer parameters, as well as newer data acquired during new well construction and testing.
- A well canvass to better define the locations and annual production from privately-owned, domestic-type water wells in both aquifer systems.
- Information on potential groundwater contamination sites obtained from available government and/or private databases and publications.
- Discharge volume and water quality data for existing and future WRPs.
- Rainfall records.
- The amounts, rates, locations, and water quality for any water that is recharged into the two local aquifer systems in the future.

- Other relevant data, such as major changes in land use, and annual variations in the volume of water imported to the Valley.

A series of standardized procedures for collecting, recording, verifying and reporting of the data should be established and implemented on a regular basis. All records collected by the coordinating entity should be stored in a relational database and integrated with a GIS system.

The measurement and recording of water level data should be done, where feasible, via recording pressure transducers, with periodic manual measurements to provide confirmation. This will provide a continuous record that is considerably more useful than infrequent manual measurements for monitoring water level conditions in the Valley. Transducers not only provide a much more complete and accurate water level record, but may also be more cost effective and reliable than a program relying strictly on manual measurements.

## SECTION 7

# REFERENCES REVIEWED

The following provides a listing of key references that were reviewed as part of the work for the preparation of this update report. The reader is referred to the substantial reference list provided in the Slade 1986 Report and the Slade 1988 Report for additional background information for the region.

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