Luhdorff & Scalmanini Consulting Engineers, "Evaluation of Groundwater Recharge Methods for the Saugus Formation in the Newhall Ranch Specific Plan Area" (March 2006)

TECHNICAL MEMORANDUM

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Evaluation of Groundwater Recharge Methods for the Saugus Formation in the Newhall Ranch Specific Plan Area

Prepared for: Tom Worthington, Impact Sciences

Prepared by: Joseph C. Scalmanini

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Introduction

Included with the approval of the Newhall Ranch Specific Plan was a condition that "prior to approval of the first subdivision map which permits construction, a report will be provided by the applicant which evaluates methods to recharge the Saugus Aquifer within the Specific Plan, including the identification of appropriate candidate land areas for recharge". In response to that condition, this technical memorandum has been prepared to address recharge of the Saugus Formation in general, as well as within the Specific Plan area. It also addresses groundwater recharge methods as might be applicable to the Saugus Formation, and it provides a summary of artificial recharge feasibility that was previously assessed for the Saugus Formation. Finally, this technical memorandum includes a summary of the recently completed analysis of groundwater basin yield, where that yield is comprised of both the Alluvial and Saugus aquifers, as a basis for concluding about the need for identifying land areas for recharge of the Saugus Formation within the Specific Plan area.

The Saugus Formation

The Saugus Formation is one of two significant aquifers in the Santa Clara River Valley Groundwater Basin, East Subbasin, the other being the less extensive Alluvium that overlies part of the Saugus Formation, generally near the main Santa Clara River and several of its tributaries. The Alluvium extends to a maximum depth of about 200 feet and has been estimated to have a maximum storage capacity of about 240,000 acre-feet. The geologically older Saugus Formation extends several thousand feet in total depth but, for groundwater supply purposes, contains sand and gravel units that represent aquifer materials generally between depths of about 300 and 2,500 feet. The fresh water storage capacity of the Saugus in that depth interval has been estimated to be about 1.65 million acre-feet.

In general, natural groundwater recharge in the Santa Clarita Valley occurs in the eastern portion of the basin, and at the northern and southern limits of the basin. Natural groundwater discharge occurs from the Saugus Formation and the Alluvium in the west-central portion of the basin, in the alluvial valley occupied by the Santa Clara River. Of course, groundwater pumping is also a groundwater discharge mechanism that occurs at distinct locations throughout the basin. Ultimately, however, in the general context of the Specific Plan condition regarding recharge of the Saugus Formation, the occurrence of natural groundwater discharge in the west-central portion of the basin is suggestive of prevailing groundwater conditions that support such a discharge; in other words, the basin has sufficient natural recharge and groundwater flow toward the west that additional efforts to identify and potentially utilize new recharge areas in the Newhall Ranch Specific Plan area, which is where groundwater is already discharging from the basin, would be counter-productive. To place that in some context, however, artificial recharge methods and their potential applicability in the basin are discussed in some detail below, as is the operating plan for groundwater use in the basin and its associated effects on the prevailing groundwater flow direction and associated groundwater storage and discharge.

Groundwater Recharge Methods

The implied intent of the Specific Plan condition addressed in this technical memorandum is an evaluation of purposeful supplemental groundwater recharge, commonly called artificial recharge, to augment natural recharge processes, presumably to benefit the yield of the basin. By specifically noting that the evaluation of recharge methods should also identify appropriate land areas for recharge, the condition further implies that potential artificial recharge would most likely involve the spreading of surface water for infiltration and deep percolation to the water table. Despite the latter implication, however, rather than limit this overall discussion to potential surface spreading of water for artificial recharge, and recognizing the nature of the aquifer systems in the basin, and particularly in the Specific Plan area, the following discussion of artificial recharge methods is included to provide a context for considering the applicability of artificial recharge in that local setting, and also to provide a context for the recent investigation of the feasibility of injection as a potential recharge mechanism, the results of which are summarized in the next section of this technical memorandum.

In most general terms, artificial recharge can be defined as augmenting the natural movement of surface water into underground formations by some method of construction, by spreading of water, or by artificially changing natural conditions. While a variety of artificial recharge methods have been developed and applied in various areas, they can generally be grouped into three categories: water spreading on the ground surface to increase infiltration, recharging through wells to directly introduce water into the aquifer system, and pumping in proximity to surface water bodies to induce recharge from them.

Of the three general categories of artificial recharge methods, the most widely practiced are water spreading operations, where surface waters are purposely introduced to a spreading basin,

or onto selected lands, or into a stream channel such that the water can infiltrate from the surface and then deep percolate to the water table, thus adding to other waters that "naturally" recharge the aquifer, e.g. precipitation, water applied for irrigation, etc. In contrast to surface spreading, artificial recharge of groundwater through wells is much less widely practiced and is typically much smaller in rate of recharge. Individual wells might be capable of recharge rates of a few acre-feet per day, where surface spreading, depending on the nature and physical extent of the spreading ponds or in-channel watercourse, can infiltrate tens to hundreds of acre-feet per day. Despite such limitations, two key factors that lead toward the potential applicability of recharge wells, rather than spreading basins, in some settings are the physical presence of confining layers in the aquifer system that could impede the deep percolation of infiltration from the surface, and the lack of available surface area for surface spreading. In this setting, the nature and depth of the Saugus Formation, which contains alternating layers of fine (confining) and coarse aquifer materials, would likely warrant consideration of recharge wells for those reasons, if artificial recharge of the Saugus were being considered. However, as discussed below, neither recharge method (surface spreading or recharge wells) is warranted in the basin, and particularly in the westerly portion of the Saugus Formation in the vicinity of the Newhall Ranch Specific Plan.

Feasibility of Injection for Saugus Formation Recharge

Early considerations of potential water supply for the Newhall Ranch Specific Plan included so-called Aquifer Storage and Recovery, or "ASR", whereby water from outside the local basin would be imported and injected into the Saugus Formation, where it would be stored for subsequent recovery by pumping for the municipal water requirements of the project. While ASR is not part of the integrated groundwater/imported surface water/reclaimed water supply that is the current and planned future water supply in the valley, the consideration of ASR as a water supply concept for Newhall Ranch resulted in field testing and analysis to assess the hydrogeologic feasibility of injecting and recovering water in the Saugus Formation. That work, briefly summarized as follows, provides some useful insight to potential artificial recharge of the Saugus Formation since it specifically tested both injection (recharge) into, and recovery of water from that aquifer.

A detailed description of the assessment of the hydrogeologic feasibility of injection and recovery in the Saugus Formation, which was conducted in the summer-fall of 2000, is documented in **Assessment of the Hydrogeologic Feasibility of Injection and Recovery of Water in the Saugus Formation, Santa Clarita Valley** (Richard C. Slade & Associates, 2001). That feasibility assessment included the injection of water from Valencia Water Company's municipal distribution system into Valencia's Saugus Well No. 205 for seven day periods at each of 500, 800, and 1,100 gallons per minute (gpm). That injection was followed by a brief (9 days) observation of groundwater storage, followed in turn by pumping (recovery) of water from the same well at its normal operating capacity of about 2,300 gpm over a period of 10 days. During injection, groundwater quality sampling at a nearby production well was conducted to assess any discernable impacts of injection on groundwater quality during injection. During subsequent

pumping of the tested injection well, daily water quality sampling was conducted to assess the "recovery" of injected water, followed by extraction of typical formation water quality after recovery of the injected water. Other related work at the time of injection feasibility testing included the separate pumping of another Saugus Formation well, and concurrent observation of groundwater response in a number of wells completed in either the Saugus Formation or the overlying Alluvium. The purpose of the latter testing was to examine the extent of direct effects, if any, of Saugus pumping on the Alluvium.

The results of the testing described above were interpreted by Slade to conclude that it is hydrogeologically feasible to inject (recharge) and recover water in the Saugus Formation. The aquifer readily accepted water from the injection well, and it subsequently yielded a comparable volume to the same well when it was pumped. The measured effects of injection and pumping were indistinguishable from normal seasonal fluctuations in groundwater levels in the Saugus Formation. The yield of the injection/production well, as measured by its specific capacity (injection or pumping rate divided by water level increase during injection, or drawdown during pumping) was determined to be as generally expected; specific capacity during injection was about 60 to 80 percent of specific capacity during pumping, a phenomenon typically attributed to clogging during injection by some combination of sediment and air. Finally, the injection into, and pumping from the Saugus wells were observed to have no measurable effect on water levels in the overlying Alluvial aquifer system.

In the context of this technical memorandum, the conclusions derived from the assessment of hydrogeologic feasibility of injection and extraction in the Saugus Formation can be extrapolated to project that the Saugus can be recharged via injection at capacities that correlate with fractions of the yields of equivalent Saugus production wells. Some amount of clogging of the injection wells can be expected, resulting in a probable need to regularly interrupt injection (recharge) for routine "purging" of the wells by pumping and, probably less frequently, for well rehabilitation of a more complex nature, e.g. using chemical and/or mechanical means to restore and maintain well injectivity. In the more focused context of the Specific Plan condition regarding land areas for potential recharge, the feasibility assessment and conclusions to date suggest that typical well sites, plumbed with provisions to deliver water from the municipal distribution system for injection and also to discharge water from routine and other well rehabilitation efforts, can be adequate to provide for the installation of injection (recharge) wells if artificial recharge of the Saugus were to be desired for some reason. In that light, however, the next section discusses the yield of the local groundwater basin, and the integration of supplemental water supplies with that yield to meet existing and projected water requirements in the basin, including those of the Specific Plan area.

Groundwater Basin Yield

Total water requirements in the Santa Clarita Valley were nearly 88,000 acre-feet in 2004. That total demand represents an average annual increase of about 3.5 percent per year since 1980,

when surface water from the State Water Project (SWP) was initially imported to supplement local groundwater for municipal and agricultural water supply. Current groundwater use is lower than peak historic, pre-SWP use, and it has remained within a generally constant range of about 38,000 to 44,000 acre-feet per year over the last 15 years. That historical groundwater use and resultant conditions, i.e. no long-term changes in groundwater levels and storage, have been such that there has been no need to initiate and operate artificial groundwater recharge projects. In effect, natural recharge processes have resulted in recharge that sustains, i.e. refills, the aquifer system sufficiently that there has been no long-term depletion of groundwater. Groundwater levels have remained basically unchanged for several decades throughout the western half of the basin; to varying degrees, groundwater levels in the eastern part of the basin have fluctuated through wet and dry hydrologic cycles, but fully recover through natural recharge processes in wet and normal periods of rainfall and stream flow. Thus, with particular focus on the western portion of the basin where the Specific Plan is located, the aquifer system has remained basically full, discharging to some degree to the Santa Clara River to sustain surface water flows out of the basin and downstream to Ventura County.

Based on empirical observation of groundwater basin conditions in response to historical pumping, and also in recognition of the increases in Santa Clara River flows and related groundwater recharge that indirectly derive in part from increased imported SWP water, the concept of a groundwater operating plan was developed to define the groundwater component of overall water supply in the basin. The groundwater operating plan is also a product of the formal Groundwater Management Plan adopted for the basin in 2003, which incorporates a number of elements aimed at developing groundwater in conjunction with other water supplies to meet existing and projected water requirements, and to do so without overdrafting the groundwater basin. The groundwater operating plan is based on the concept that pumping can vary from year to year to allow increased groundwater use in dry periods and increased recharge during wet periods, and to collectively assure that the groundwater basin is adequately replenished through various wet/dry cycles, thus maintaining the basin in a sustainable condition, i.e. no long-term depletion of groundwater or interrelated surface water. In summary, the operating yield concept has been quantified as ranges of annual pumping volumes as follows:

Alluvium – Pumping from the Alluvial Aquifer in a given year is governed by local hydrologic conditions in the eastern Santa Clara River watershed. Pumping ranges between 30,000 and 40,000 afy during normal and above-normal rainfall years. However, due to hydrogeologic constraints in the eastern part of the Basin, pumping is reduced to between 30,000 and 35,000 afy during locally dry years.

Saugus Formation – Pumping from the Saugus Formation in a given year is tied directly to the availability of other water supplies, particularly from the SWP. During average-year conditions within the SWP system, Saugus pumping ranges between 7,500 and 15,000 afy. Planned dry-year pumping from the Saugus Formation ranges between 15,000 and 25,000 afy during a drought year and can increase to between 21,000 and

25,000 afy if SWP deliveries are reduced for two consecutive years and between 21,000 and 35,000 afy if SWP deliveries are reduced for three consecutive years. Such high pumping would be followed by periods of reduced (average-year) pumping, at rates between 7,500 and 15,000 afy, to further enhance the effectiveness of natural recharge processes that would recover water levels and groundwater storage volumes after the higher pumping during dry years.

To examine the sustainability of the groundwater basin under the operating plan, which already derived from observation of actual basin response to generally comparable historical operations, the municipal purveyors in the Santa Clarita Valley commissioned the development and calibration of a numerical groundwater flow model which could be used to project groundwater level and storage response to the variations in pumping planned through wet and dry hydrologic cycles as described in the operating plan. That model was developed and calibrated in 2004 (CH2M Hill, 2004) to simulate the basin's response to the various natural recharge processes (e.g. infiltration of precipitation, infiltration of applied water, infiltration of stream flow) and discharge processes (e.g. pumping, groundwater discharge to streams). The calibrated model was then used to analyze the yield of the basin, i.e. the groundwater operating plan, in 2005 (CH2M Hill and LSCE, 2005). Basin yield was examined by running the model over a 78-year hydrologic period, which was selected from actual historical precipitation to examine a number of hydrologic conditions which could be expected to affect both groundwater pumping and groundwater recharge. The selected 78-year simulation period was assembled from an assumed recurrence of 1980 to 2003 conditions, followed by an assumed recurrence of 1950 to 2003 conditions. The 78-year period was analyzed to define both local hydrologic conditions (normal and dry), which affect the rate of pumping from the Alluvium, and hydrologic conditions that affect SWP operations, which in turn affect the rate of pumping from the Saugus. The resultant simulated pumping cycles included the distribution of pumping among existing and planned Alluvial and Saugus Aquifer wells, for normal and dry years respectively, including the planned restoration of wells that have been impacted by perchlorate in the central part of the basin.

Simulated Alluvial Aquifer and Saugus Formation response to the ranges of pumping under assumed recurrent hydrologic conditions is essentially a long-term repeat of the historical conditions that have resulted from similar pumping over the last several decades in the Alluvium, and consistent with actual experience under smaller pumping rates in the Saugus Formation. The resultant response consists of: (1) generally constant groundwater levels in the middle to western portion of the Alluvium and fluctuating groundwater levels in the eastern portion as a function of wet and dry hydrologic conditions, (2) variations in natural recharge that directly correlate with wet and dry hydrologic conditions, and (3) no long-term decline in groundwater levels or storage. The combination of actual experience with Alluvial Aquifer pumping at capacities similar to those in the operating plan, and the resultant natural recharge of groundwater levels and storage, complemented by modeled projections of similar recharge to future pumping, result in a conclusion that the operating plan represents a sustainable yield of the Alluvium.

In the Saugus Formation, the simulated response consists of (1) short-term declines in groundwater levels and storage near pumped wells during dry-period pumping, (2) rapid recovery of groundwater levels and storage after cessation of dry-period pumping, and (3) no long-term decreases or depletion of groundwater levels or storage. The combination of actual experience with Saugus pumping and recharge up to about 15,000 afy, complemented by modeled projections of aquifer response that show long-term utility of the Saugus at 7,500 to 15,000 afy in normal years and rapid recovery from higher pumping rates during intermittent dry periods, all without any purposeful artificial recharge, shows that the Saugus Formation can be considered a sustainable water supply source to meet the Saugus portion of the operating plan for the groundwater Basin.

As a result of the analysis described in the preceding, i.e. the combination of actual historical basin conditions and simulated future basin conditions, the groundwater operating plan and the natural recharge associated with it have become the existing and projected groundwater supply component of water supply to meet ongoing water requirements in the valley.

For purposes of this technical memorandum, the existence of historical and existing groundwater conditions, combined with the balance of the hydrogeologic setting in the Specific Plan area, indicates that there has been no need for artificial recharge of the aquifer system in that portion of the basin. Since natural recharge processes have maintained long-term stable groundwater conditions, including sufficiently high groundwater storage that there is groundwater discharge from the aquifer to the Santa Clara River, efforts to artificially augment natural recharge in that area could be expected to result in "rejected" recharge, i.e. recharged water would simply add to groundwater discharging from the aquifer system, resulting in no net benefit to the basin's yield or storage. Recent analysis of the groundwater basin's yield and the projected impact of the operating plan for groundwater pumping in the basin shows that future conditions are expected to generally repeat historical observations, resulting in no need for artificial recharge in the western (Specific Plan) portion of the basin.

Need for Saugus Formation Recharge Locations in Newhall Ranch Area

All the preceding description and discussion of the occurrence of groundwater, its recharge and discharge areas, and its sustainable yield maintained by natural recharge processes can be summarized to conclude that there is no definable need to identify land areas for artificial recharge of the Saugus Formation. More specifically, there is no need to identify land areas for artificial recharge of the Saugus Formation in the small part of that aquifer system that underlies the Newhall Ranch Specific Plan area. In summary form, that conclusion derives from the following points.

- The Upper Santa Clara River Groundwater Basin, East Subbasin is comprised of two aquifers, the Alluvium and the Saugus Formation, which are generally recharged in the east to central portion of the basin, well east of the Newhall Ranch Specific Plan

area. Groundwater flow in the basin is generally east to west, with resultant groundwater discharge at the western end of the basin.

- The Newhall Ranch Specific Plan area overlies a very small portion of the Saugus Formation at the far western end of the basin, as illustrated in Figure 1, where the basin is discharging water that flows downstream toward Ventura County.

- Historical observations for several decades have shown no long-term changes in groundwater storage or levels. Natural recharge processes have sustained groundwater levels, including long-term essentially constant, high groundwater levels. There has thus been no need for addition of artificial recharge operations to augment natural recharge to the basin.

- The presence of high, relatively constant groundwater levels in the Specific Plan area is indicative of no vacant aquifer storage space into which artificial recharge might be introduced. Thus, attempts to artificially recharge the basin in that area can be expected to result in rejected recharge, or the rapid discharge of any recharged water to the overall outflow from the basin.

- The future operating plan for the basin includes future pumping that is generally similar to historic pumping, with one notable change whereby short-term intermittent increases in Saugus pumping would occur during dry periods when supplemental imported State Water Project deliveries might be reduced. Simulation of basin response to such pumping projects conditions generally comparable to historic experience: future Alluvial aquifer levels and storage comparable to historical conditions; and future Saugus Formation levels and storage lowered during dry periods (in response to increased pumping) but fully replenished by natural recharge processes in subsequent wet/normal conditions.

- While there is no defined need for artificial recharge in the western part of the basin, the nature of the Saugus Formation is such that, physically, recharge to that formation would likely be more effective through injection wells. Thus, if artificial recharge of the Saugus Formation were to become desirable for some reason, feasibility testing of injection has been undertaken, with results showing such a mechanism to be hydrogeologically feasible.

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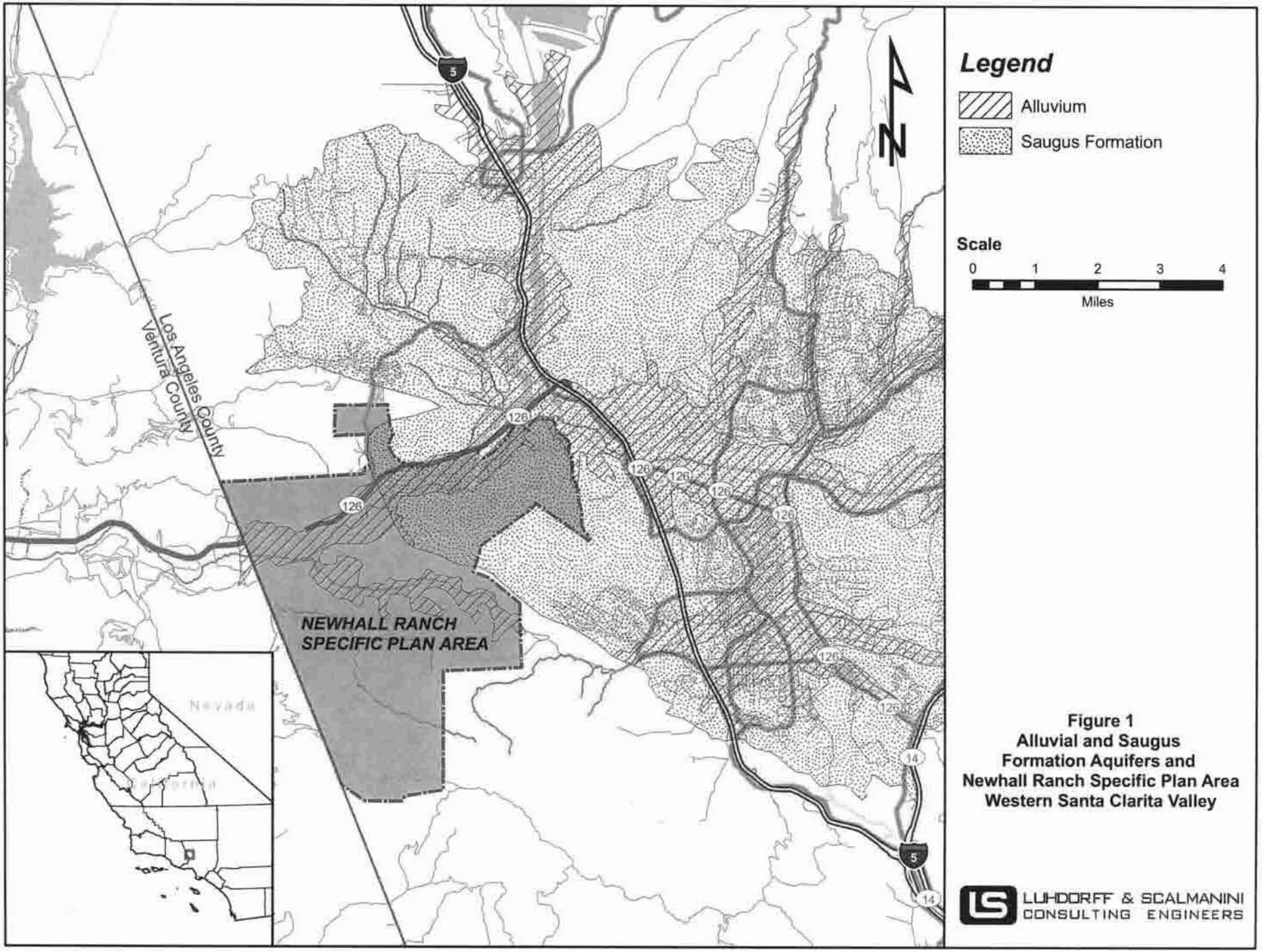

Figure 1
Alluvial and Saugus Formation Aquifers and Newhall Ranch Specific Plan Area Western Santa Clarita Valley

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TRANSMITTAL

Date *March 17, 2006*

TO: *Tom Worthington*
Steve Zimmer
Mark Dillon
Glenn Adamick

Phone

FROM: *Bob DiPrimio*
Valencia Water Company
24631 Avenue Rockefeller
Valencia, CA 91355

Phone *661-295-6501*
Fax Phone *661-294-3806*

CC:

REMARKS: ☐ *Urgent* ☒ *For your review* ☐ *Reply ASAP* ☐ *Please Comment*

Note: Here is Joe's signed Tech memo.

Bob