SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
WATER RESOURCES ENGINEERING - CARPINTERIA

From Science to Solutions

TECHNICAL MEMORANDUM

TO: Mike Nunely

FROM: Brad Newton, Alex Pappas

RE: Questions 12-17: Yield of Aquifer Storage and Recovery, SAIC Project Number: 01-0236-00-9785

DATE: June 1, 2007

INTRODUCTION

Programmatic development of an aquifer storage and recovery system requires an overall understanding of the local and regional hydrogeology. The District is currently investigating the opportunities to develop recharge basins on the Nipomo Mesa to augment the native supply of water to the principle production aquifer, typically the unconsolidated alluvial deposits of the Paso Robles Formation. Cause for concern over the lack of geologic understanding of the Nipomo Mesa is warranted, specifically in that recent sentinel monitoring well observations for sea water intrusion at the coast documented artesian conditions for all three well depths. These observations strongly suggest that a confining layer exists, however its depth, location and areal extent is not currently understood. Additionally, the presence of the Santa Maria River Fault has been interpreted to impede the lateral flow of groundwater, however the data reviewed during this investigation does not support nor deny this hypothesis.

On February 13, 2007, SAIC entered a contractual agreement with Boyle Engineering Corporation (Boyle) to provide hydrogeology services related to evaluating alternative water supplies to Nipomo Community Services District (the District). The District's Board requested an assessment of the yield of aquifer storage and recovery for the main production aquifer contained within the Nipomo Mesa Management Area (NMMA). Subsequently, Boyle requested SAIC address specific questions contained in a memorandum dated May 9, 2007. This technical memorandum constitutes a partial deliverable (Questions 12 – 17) to be included in Boyle's TM #1 Constraints Analysis to the District. Provided below and in the attachments herewith is a preliminary assessment of the plausibility of aquifer storage and recovery.

Several independent lines of evidence reviewed and interpreted herein support a proposed conceptual model of the hydrogeology within the NMMA. Groundwater surface elevations above ground surface at the sentinel monitoring well location on the beach support the geologic interpretation of a confining layer west of NMMA. Twitchell Reservoir water releases operational strategy to enhance groundwater recharge of the principal production aquifer supports the geologic interpretation of a confining layer that extends westward from the Bonita School Road crossing within the Santa Maria River corridor. The presence of Black Lake

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Canyon supports the interpretation that a confining layer exists from the coastal dunes to the east of the canyon head. Drilling logs and well casing records also support the presence of confining layer from the western area of municipal production to Omiya well where the confining layer abruptly thins. Additional drilling logs and casing records would be needed to strengthen the confidence of the presence and extent of a regional confining layer in the western half of the NMMA.

The proposed conceptual model of the hydrogeology within the NMMA is preliminary and may be changed upon reviewing additional data. For the purposes of this constraints analysis, and foregoing any additional data review, the proposed conceptual model provides the context for evaluating the following questions presented in the Boyle memorandum dated May 9, 2007.

RESULTS

12. How will the use of aquifer storage and recovery change the answers to the previous questions 1-5?

The available space of groundwater storage in the aquifer (approximately 400,000 acre-feet [AF]) is sufficient to accommodate the volume of water obtainable from the SWP to meet the District's target additional maximum supply of 6,300 acre-feet per year (AFY). Therefore, the answers to question 1-5 would not change.

13. How much water can be stored in the aquifer underlying the NMMA?

The aquifer underlying the NMMA has an estimated available storage of 400,000 AF above sea level. However, the proposed conceptual model of the hydrogeology constrains the available area for storage capacity to approximately one-quarter of the total 20,000 acres on NMMA as the target recharge area. This target area is bound by the confining layer to the west, the Black Lake Canyon to the north, the topographic boundary to the south, and the Santa Maria River Fault trace to the east, although little is known regarding lateral flow across the fault. The storage of 6,300 AF of water within 5,000 acres area would likely cause an increase in the groundwater surface elevation by approximately 10 feet over the 5,000 acres.

14. Where are the best places to locate percolation/aquifer storage facilities?

The proposed preliminary target area is east of Omiya well, southwest of Santa Maria River Fault, and north of the mesa topographic boundary. The ideal location of recharge ponds will be places with high percolation rates and no confining layer or low hydraulic conductivity zones at depth. The proposed preliminary target area is bound by the confining layer to the west, the Black Lake Canyon to the north, the topographic boundary to the south, and the Santa Maria River Fault trace to the east.

15. If percolation ponds are used, what area would be required?

Based on a typical percolation rate of 6 inches per day, approximately 50 acres of ponds would be required to recharge 6,300 AFY.

16. How many new wells would be needed to recapture the stored water?

Based on wells currently operated by the Nipomo Community Services District (NCSD) five extraction wells with a production rate of 800 gallons per minute (gpm) would be required to capture 6,300 AFY of water.

17. Where should these wells be installed (location and depth)?

We recommend locating the wells east of Highway 1, south of the Black Lake Canyon, west of Santa Maria River Fault, and north of the Woodlands development. This general area will distribute pumping across the NMMA providing for a more even access to the water resource. These wells should be screened in zones that produce large volumes of high quality water, likely within the Paso Robles Formation.

DISCUSSION

The Paso Robles Formation is overlain by dune sands and younger alluvium, and overlies the Careaga Formation, an accumulation of unconsolidated to well-consolidated, shallow-water marine sands. The Paso Robles Formation is highly variable in color and texture, ranging from gavel and clay, sand and clay, gravel and sand, silt and clay. Most of it is fluvial in origin and in most places correlation between individual beds is not possible. The Careaga Formation is the lower most fresh water bearing formation and water quality is typically poor.

Identifying potential recharge sites on the Nipomo Mesa is contingent upon understanding the geology, the available land for recharge facilities construction, and the existing conveyance facilities or the need for new facility construction. The geologic conditions specific to recharge site identification on the Nipomo Mesa is poorly documented; however, anecdotal information, a few well logs, and existing reports have been reviewed and summarized herein to provide the basis for our current understanding. In general, recharge facilities are constructed over sediments where no confining layer exists in an effort to maximize percolation and therefore recharge to the groundwater aquifer. Set forth below is the summary of document reviews, geologic and topographic map evaluations, site visits, and well logs which indicates the likelihood of a confining layer and location of its inland margin.

Black Lake Canyon is an east-west trending topographic feature resulting from the erosion and transport of unconsolidated sand dune sediments westward to the active dune complex at the ocean. No river exists upstream of the canyon head, and the local surface drainage area at the canyon head is small. Surface water exists along much of the length in the canyon bottom and a terminal lake exists at the canyon mouth in the margin of the active beach dune complex.

No existing reports reviewed during this investigation explained the occurrence or physical processes that created the Black Lake Canyon. However, fine-grained layers in the upper portion of the Paso Robles Formation beneath dune sands are reported to function as a perching layer, and that some of the shallow groundwater that percolates downward within the permeable Nipomo Mesa dune sands is diverted laterally along these low-permeability layers and discharges into Black Lake Canyon and supports Black Lake and other systems of coastal drainages and lakes west of Nipomo Mesa (Papadapolas & Associates, 2004). While not specifically inferred in these reports, the laterally diverted perched shallow groundwater emerging at the ground surface can cause seepage erosion and over time develop a channel head which is likely to migrate up stream. This mechanism may explain the existence of Black Lake Canyon, and substantiate the occurrence of a confining layer above the principle production aquifer.

Santa Maria Valley Water Conservation District releases water stored in Twitchell Reservoir to enhance groundwater recharge by optimizing percolation to the principle production aquifer under the Santa Maria River. Reservoir water is released when there is no water flowing in the Sisquoc River as reported at the gage near Garey. Reservoir water is released at a steady flow rate, typically 300 cubic feet per second (cfs), to maximize groundwater recharge. This flow rate maintains a wetted reach up to but not beyond the Bonita School Road crossing. Anecdotal information suggests that a wetted reach beyond the crossing does not promote groundwater recharge to the principle aquifer because of the occurrence of confining layers at depth.

Drilling logs and well casing documentation may improve the understanding of the subsurface geology. The District provided this information for seven District production wells (Figure 1). Drilling logs were evaluated and correlations were made between well locations in order to identify the existence of a confining layer or sequence of layers. Well completion data documents the depth of the screened interval which is presumably located within the Paso Robles Formation (Table 1). General trends in the lithologies of each drilling log and the position of the screened interval were noted. The occurrence of a sequence of layers with a greater proportion of clay was identified and is interpreted as a confining sequence (Figure 2). The east-west transect of production well log data describes the presence of a confining layer directly above the screened interval in each well, however, the thickness of the confining sequence abruptly thins between the Omiya and Olympic wells. The occurrence of a thin clay layer at the Olympic well may indicate the eastern margin location of the regional confining layer that extends westerly to the ocean.

Drilling logs record the total drilling depth and a description of the lithology. All logs report that drilling ceased upon drilling into a blue clay lithology. This lithology is interpreted as the Franciscan Formation. Well casing is generally installed to total depth with the screened interval at bottom, directly above the Franciscan Formation. The elevation of the top of the Franciscan Formation is 100 feet lower on the west side of the Oceano Fault relative to the east side (Figure 2). The Sundale well is more consistent with the geology west of the Oceano Fault than the geology on the east side of the fault. Reviewing additional drilling logs and casing records may improve the understanding of the vertical offset along the Oceano Fault.

The principle production aquifer under the NMMA has an estimated total storage capacity 500,000 AF of groundwater above sea level (DRW, 2002). Currently, generally 90,000 AF (SAIC, 2007) of water is stored above sea level in the aquifer. Therefore, approximately 400,000 AF of groundwater storage is available in the Nipomo Mesa groundwater basin. The district currently is interested in obtaining at most 6,300 AFY of supplemental water from an alternative water supply. Based on these estimates, there is sufficient available storage to accommodate the 6,300 AFY of supplemental water supply.

The Southland Wastewater Treatment Facility (WWTF) operated 3 recharge basins covering 2.8 acres during the period of 1988 to 1992. The aggregate percolation during this 5 year period was 760 AFY (Lawrance, 1993). This is equivalent to 53.6 AFY per acre or 1.8 inches per day per acre. This includes rotation of the ponds between filling, percolating and drying. Typical long-term percolation rates are on the order of 6 inches per day. It is reasonable to expect effective percolation rates for a recharge facility to be less when considering pond rotations for drying and maintenance, typically 2 of 3 ponds are wet at any time. Approximately 50 acres of recharge ponds would be required in order to bank 6,300 AFY. However, this is programmatically less efficient than to firstly utilize the 6,300 AFY of water in direct deliveries, while reducing pumpage, then secondly, to recharge the un-deliverable water in percolation ponds.

The number of wells needed to capture this volume of water can be estimated from current production data. The three most productive wells operated by the NCSD are the Eureka Well, Sundale Well and the Via Choncha Well. The respective capacity of these wells is 850 gpm, 1000 gpm and 700 gpm (Boyle 2002). Assuming an average capacity per well of 850 gpm, it is expected that a properly install production well will produce 1370 AFY. This value takes into account normal well operations such as downtime and maintenance. It is assumed that similar pumping operations would be implemented. To capture 6,300 AFY of water would require approximately 5 wells.

Geologic features present in the basin will dictate the optimal locations for new extraction wells. The wells should be located seaward of the recharge areas with sufficient distance to allow for mixing and natural filtration of the recharged water. However, wells should be placed far enough away from the coast to avoid causing seawater intrusion. We recommend locating the wells in areas where little pumping currently exists, east of Highway 1, south of the Black Lake Canyon, west of Santa Maria River Fault, and north of the Woodlands development. This general area will distribute pumping across the NMMA providing for a more even access to the water resource. These wells should be screened in zones that produce large volumes of high quality water, likely within the Paso Robles Formation.

REFERENCES:

Boyle Engineering Corporation, (Boyle, 2002), Water and Sewer System Master Plan 2001, prepared for Nipomo Community Services District, update, March 2002.

Department of Water Resources, (DWR, 2002), Water Resources of the Arroyo Grande – Nipomo Mesa Area, 2002.

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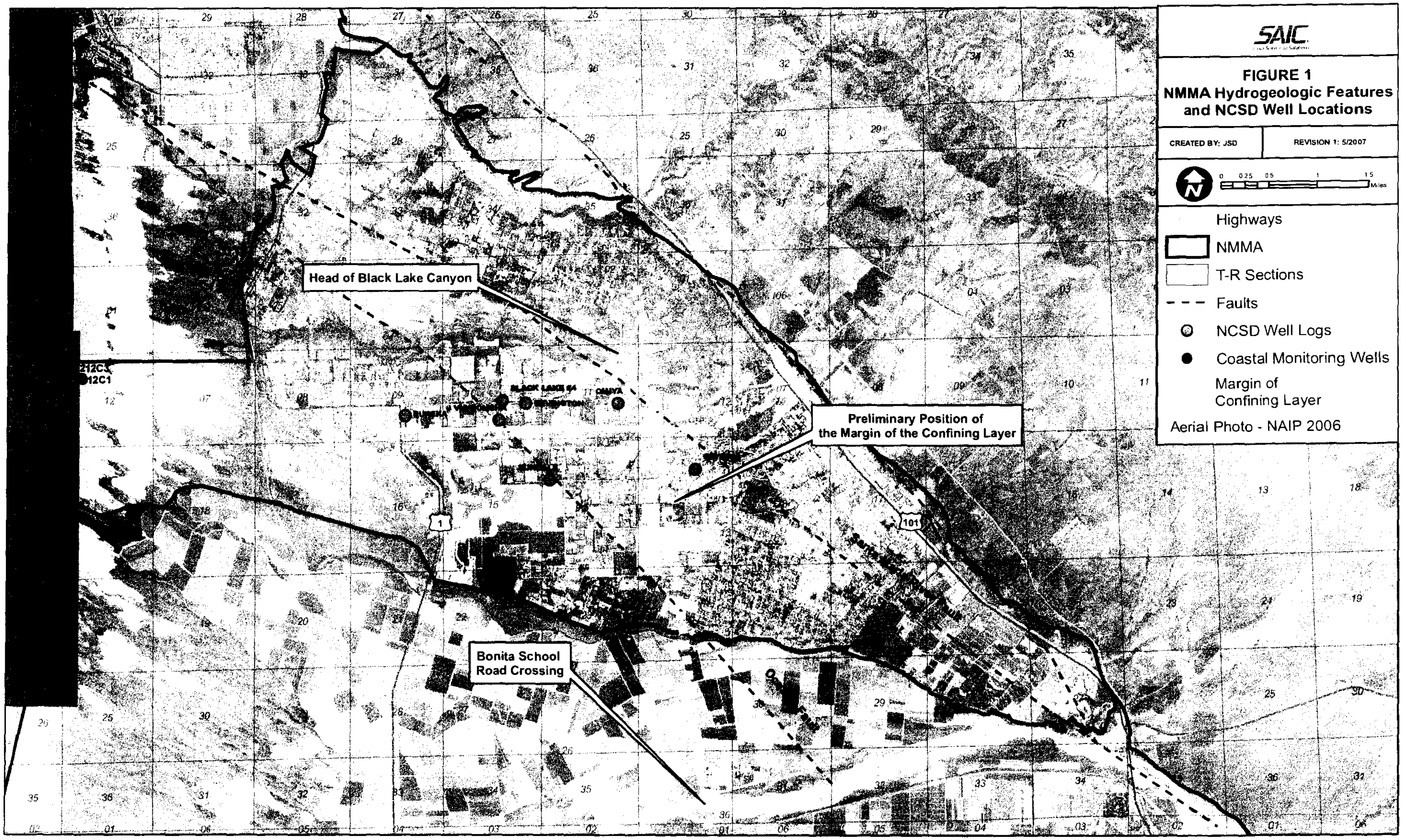
S.S. Papadapolas & Associates, INC., (Papadopulos et al. 2004), Nipomo Mesa Groundwater Resources Capacity Study, San Luis Obispo County, California, prepared for the County of San Luis Obispo, 2004.


SAIC
FIGURE 1
NMMA Hydrogeologic Features and NCSD Well Locations
CREATED BY: JSD
REVISION 1: 5/2007
Miles
Highways
NMMA
T-R Sections
Faults
NCSD Well Logs
Coastal Monitoring Wells
Margin of Confining Layer
Aerial Photo - NAIP 2006
Head of Black Lake Canyon
Preliminary Position of the Margin of the Confining Layer
Bonita School Road Crossing

Well Completion Table

Nipomo Mesa Management Area

Well ID	Latitude	Longitude	Ground Surface Elevation (ft msl)	Total Depth (ft msl)	Screen (ft msl)		Screen Interval (ft)	Comments		
								Confining Layer (ft msl)		Confining Layer Interval (ft)
					Top	Bottom		Top	Bottom	
Eureka 11N35W09K05	35° 02' 44.20"	120° 34' 04.93"	174	-546	-46	-401	355	31	-71	102
Via Concha 11N35W10L01S	35° 02' 40.61"	120° 33' 02.26"	264	-464	-126	-426	300	-4	-54	50
Sundale 11N35W15H01S	35° 02' 07.01"	120° 32' 29.11"	251	-459	-129 -379	-329 -419	200 40	-19	-119	100
Black Lake #4	35° 02' 51.19"	120° 32' 59.53"	301	-299	-59	-219	160	207	111	96
Bevington #2 11N35W10J02S	35° 02' 49.57"	120° 32' 43.93"	317	-329	-13	-253	240	47	-93	140
Omiya #2 11N35W11J02S	35° 02' 11.17"	120° 30' 52.05"	390	-260	0	-75	75	255	10	245
Olympic 11N35W13G01S	35° 02' 48.30"	120° 31' 42.57"	346	-129	-19	-109	90	46	28	18

Notes:

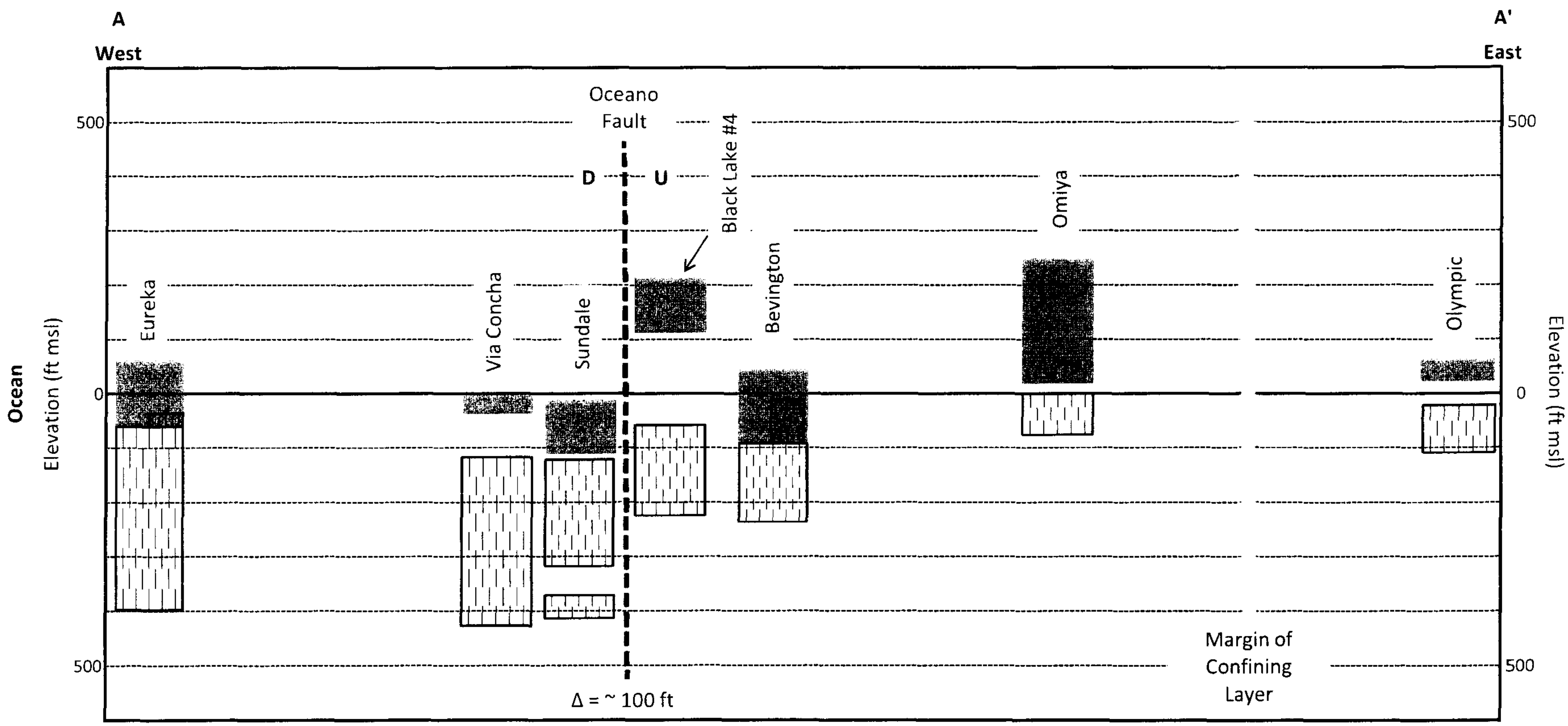
Information based on review of driller logs provided by NCSD

W:\Boyle - NCSD (9785)\Technical\Yield of Aquifer Storage and Recovery\
2007-05-31_Recharge techmemo table I.xlsx

Table 1
6/1/2007

DRAFT

Hydrogeology of Nipomo Mesa Mangement Area
Conceptual Model



Confining Layer Dominate Clay (ft msl)

Screened Interval (ft msl)

Note:

All well data is projected to line (Figure 1)

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FIGURE 2
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