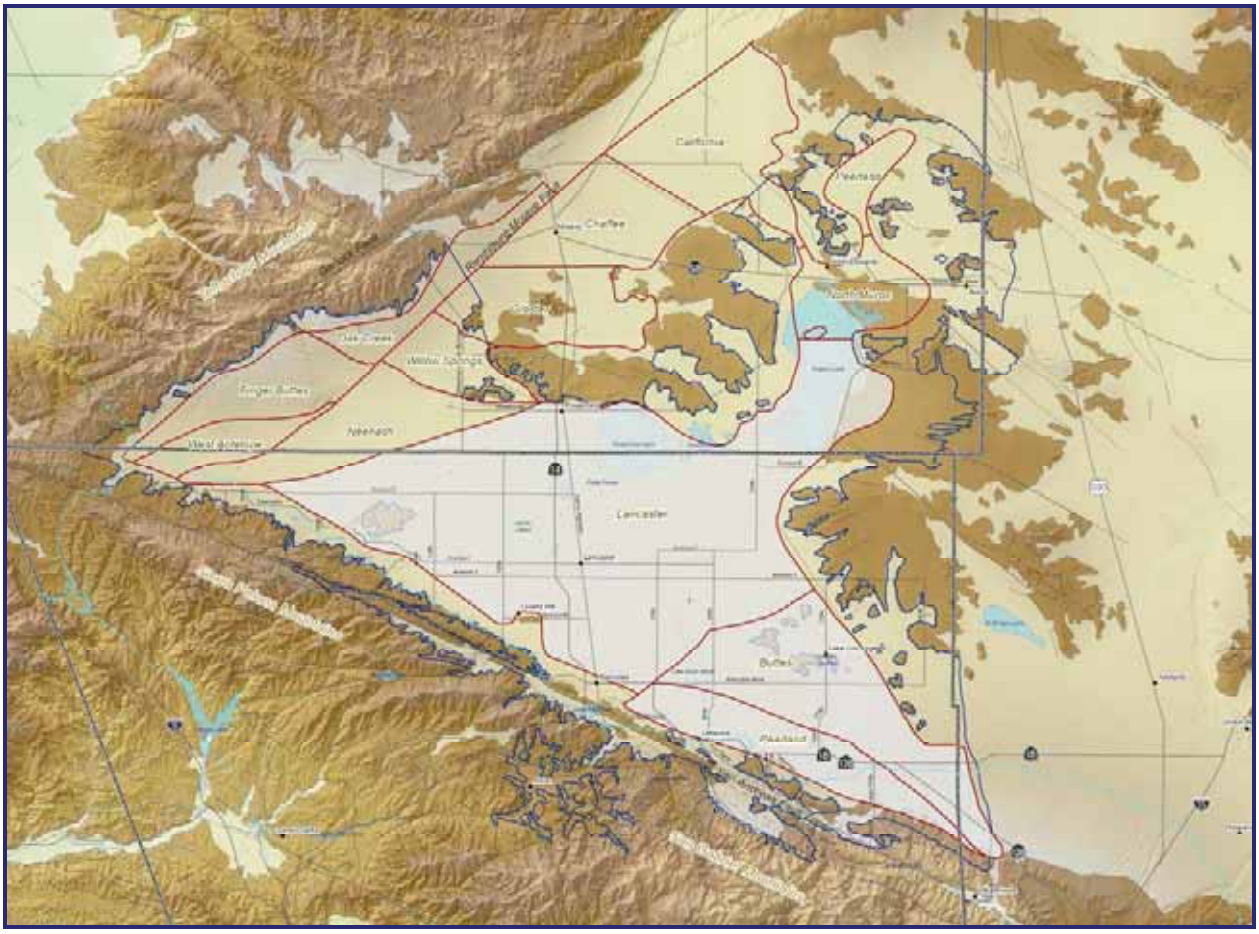
Recycled Water Groundwater Recharge Feasibility Study
Antelope Valley, California



Prepared for:

Prepared by:

WILDERMUTH ENVIRONMENTAL INC.

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ACRONYM AND ABBREVIATIONS LIST	
afy	acre-feet per year
bgs	below ground surface
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CWC	California Water Code
DHS	California Department of Health Services
DWR	California Department of Water Resources
GIS	geographic information system
LAWA	Los Angeles World Airports
LACSD	Los Angeles County Sanitation District
LCID	Littlerock Creek Irrigation District
maf	million acre-feet
MCL	maximum contaminant level
mg/L	milligrams per liter
MOU	memorandum of understanding
msl	mean sea level
NO_3	nitrate
NO_3-N	nitrate as nitrogen
NWIS	National Water Information System
O&M	operations and maintenance
RWQCB	Regional Water Quality Control Board, Lahonton Region
RWC	recycled water contribution
SAT	soil aquifer treatment
SWP	State Water Project
SWQIS	State Water Quality Information System



ACRONYM AND ABBREVIATIONS LIST	
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
TOC	total organic carbon
USGS	US Geological Survey
WDR	waste discharge requirement
WEI	Wildermuth Environmental, Inc.
WRR	water recycling requirement
WWD No. 40	Los Angeles County Waterworks District No. 40

1 INTRODUCTION

This recycled water groundwater recharge study (Study) was prepared by Wildermuth Environmental, Inc. (WEI) for the Palmdale Water District (PWD). Shortly after the start of this Study, a regional recycled water groundwater recharge study was initiated by the City of Lancaster. Much of the work proposed for this Study overlapped the work performed on the regional study. As is such, to reduce the duplication of information, references to the regional study are made throughout this document. This Study focuses on the feasibility of recycled water recharge in the vicinity of the PWD and the Palmdale Water Reclamation Plant (WRP).



2 SETTING

The primary driver for this Study is the need to secure a safe and reliable supply of water for the rapidly growing region that the PWD serves. This section focuses on the physical and regulatory environment within the region relative to recycled water groundwater recharge.

The Antelope Valley encompasses approximately 1,000 square miles of northeast Los Angeles County and southeast Kern County within the western portion of the Mojave Desert (Figure 2-1). This large westerly pointing wedge shaped basin is at the intersection of the San Andreas and Garlock Fault Zones and is bounded on the north and northwest by the Tehachapi Mountains, Rosamond Hills, and Bissell Hills; on the east by the San Bernardino County line; and on the south and southwest by the San Andreas Fault Zone. The valley floor slopes gently downward towards the north and ranges in elevation from 2,300 to 3,500 feet above mean sea level (msl).

2.1 Water Supplies and Demands

Currently, the PWD obtains water from three sources: Littlerock Creek Dam and Reservoir, the State Water Project (SWP), and groundwater. Approximately 60 percent of the PWD's water supply is surface water, and the remaining 40 percent is groundwater. The Littlerock Creek Dam and Reservoir receives runoff from rainfall and snowmelt and impounds the water until it is to be delivered through an open canal to Lake Palmdale. The Littlerock Creek Dam and Reservoir is estimated to provide the PWD with a reliable supply of approximately 3,405 acre-feet per year (afy) (Carollo, 2005).

In addition to receiving water from the Littlerock Creek Dam and Reservoir, Lake Palmdale serves as the PWD's impoundment for SWP deliveries. Under normal conditions, the PWD receives approximately 15,000 afy of SWP water. All of the surface water that the PWD serves is treated at the Palmdale Water Treatment Plant. In addition, the PWD operates 27 groundwater wells with a production of approximately 10,000 afy.

The PWD is expecting significant increases in water demand due to increases in population, throughout its service area. As shown in Table 2-1, the population within the City of Palmdale is expected to increase from 145,995 in 2005 to 337,314 by 2030 (Carollo, 2005): within the PWD service area, the population is expected to more than double by 2030.



TABLE 2-1: PROJECTED POPULATION IN STUDY AREA

Agency	Projected Population					
	2005	2010	2015	2020	2025	2030
City of Palmdale	145,995	176,506	218,387	259,712	299,324	337,314
Palmdale Water District	109,845	132,801	164,312	195,404	225,208	253,791

Source: Palmdale Water District, 2005 UWMP

As population increases, so does the demand for water. In 2000, the water demand in the PWD's service area was 25,901 afy. By 2030, that demand is expected to increase to 59,837 afy. Currently, the demand is met by existing surface water, SWP water, and groundwater supplies. As shown in Table 2-2, the projected water supplies from current sources will be inadequate by 2010, and a deficit of approximately 30,000 afy is expected by the year 2030.

The development of additional water supplies is therefore necessary for the continued growth of the region. The existing sources of surface water, SWP water, and groundwater are not expected to significantly increase and will not be able to meet the expected demand. As shown in the adjacent chart and Table 2-2, the implementation of a recycled water reuse plan will become necessary to meet the region's water needs. The indirect potable reuse of recycled water should be a primary component of the region's water supply plans. This method can replace the new and imported water supplies that would otherwise be required to meet demand.

At build-out, the City of Palmdale's and the PWD's expected recycled water demands for direct reuse are 6,978 afy and 3,873 afy, respectively. In 2030, the recycled water supply produced at the Palmdale WRP is expected to be 28,559 afy. Therefore, 17,708 afy is potentially available for supplying the indirect potable reuse of recycled water. An existing contract with the Los Angeles World Airports (LAWA) gives the first right of refusal to LAWA for recycled water produced at the Palmdale WRP.

PROJECTED WATER SUPPLY AND DEMAND IN STUDY AREA

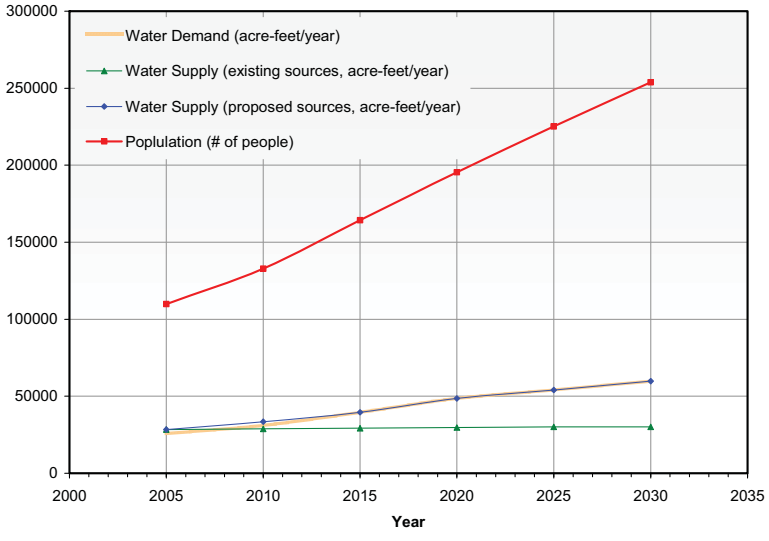


TABLE 2-2: HISTORICAL AND FUTURE WATER SUPPLY AND DEMAND

Supply	Historical						Projected[3]				
	2000	2001	2002	2003	2004	2005	2010	2015	2020	2025	2030
State Water Project[1,2]	8,974	10,365	18,480	11,421	12,076	14,697	15,123	15,549	15,975	16,401	16,401
Surface Water[1,2]	7,162	3,553	0	2,882	3,557	3,405	3,405	3,405	3,405	3,405	3,405
Groundwater[1,2]	9,765	11,302	8,298	10,606	11,038	10,310	10,310	10,310	10,310	10,310	10,310
Recycled Water[1]	0	0	0	0	0	0	14,784	18,368	21,840	25,087	28,559
Total (w/ RW)	**25,901**	**25,220**	**25,670**	**24,909**	**26,671**	**28,412**	**43,622**	**47,632**	**51,530**	**55,203**	**58,675**
Total (w/o RW)	**25,901**	**25,220**	**25,670**	**24,909**	**26,671**	**28,412**	**28,838**	**29,264**	**29,690**	**30,116**	**30,116**

Demand	Historical						Projected				
	2000	2001	2002	2003	2004	2005	2010	2015	2020	2025	2030
Total[2]	25,901	25,220	25,670	24,909	26,671	25,774	31,034	39,562	48,570	54,101	59,837
RW Demand at Build-out[1]											10851
RW Available for Recharge											17,708

[1] Final Facilities Planning Report, Antelope Valley Recycled Water Project, Kennedy/Jenks, 2006

[2] 2005 Urban Water Management Plan, Palmdale Water District, Carollo Engineers, 2005

[3] Normal year projections

2.2 Hydrogeology

The Antelope Valley Groundwater Basin is generally characterized as a topographically closed groundwater basin formed by an alluvial-filled structural depression with alluvial deposits locally as much as 8,000 feet thick (Durbin, 1978). The groundwater basin boundary defined by the California Department of Water Resources (DWR) in Bulletin 118, is shown in Figure 2-1, but is currently being redefined as part of the ongoing Antelope Valley adjudication proceedings. The west, northwest, and southern basin boundaries generally follow the contact between the Quaternary younger and older alluvial deposits of the basin floor and the broadly defined pre-Tertiary basement complex of the Tehachapi Mountains and San Gabriel Mountains. The north basin boundary roughly follows the pre-Tertiary basement complex outcrops of the Rosamond Hills, Bissell Hills, and north to the Fremont Valley. The east basin boundary is approximately defined by the pre-Tertiary basement complex outcrops along the western boundary of the San Bernardino County line. Based on apparent groundwater barriers caused by faults and other structural features, the groundwater basin is divided into thirteen subbasins (Bloyd, 1967). The Study area of this project consists of the Lancaster, Buttes, and Pearland subbasins. Figure 2-2 presents the general geologic conditions within the Study area.

The alluvium, which comprises the primary water bearing material, is composed of unconsolidated to moderately indurated, poorly sorted gravel, sand, silt, and clay. The alluvium is divided into seven lithographic units (Dutcher and Worts, 1963), including older fan deposits, older alluvium, younger fan deposits, younger alluvium, lakeshore deposits, old wind-blown sand, and dune sand. Of these deposits, only the older alluvium, younger fan deposits, and younger alluvium yield significant quantities of groundwater.

In addition to the alluvial deposits, a significant lacustrine deposit that helps define the aquifer system exists. The lacustrine deposit extends laterally from the Rosamond, Rogers, and Buckhorn Dry Lakes in the north to the San Gabriel Mountains in the south, the Little Buttes to the west, and the east edge of Rogers Lake to the east. The lacustrine deposits are characterized by massive, often blue, clay deposits up to 100 feet thick with interbedded lenses of coarse grained material up to 20 feet thick. The entire sequence of these deposits can be as many as 300 feet thick. At the southern end of the Lancaster subbasin, the lacustrine deposit is overlain by up to 800 feet of alluvium. The lacustrine deposit shallows in a northerly direction until it becomes exposed at the land surface around the Rosamond, Buckhorn, and Rogers Dry Lakes.

The historical conceptual model identified two primary aquifers within the basin: the principal (upper) aquifer and the deep aquifer. These aquifers are separated by the above-mentioned lacustrine deposit, which underlies a significant portion of the Lancaster subbasin. The principal aquifer is the alluvial deposit overlying the lacustrine deposit and is characterized as regionally unconfined with locally confined conditions that result from local aquitards. The deep aquifer is



the portion of the alluvial deposit beneath the lacustrine deposit and is characterized as confined.

Leighton and Phillips (2003) refined the conceptual model of the aquifer into a three aquifer system: an upper, a middle, and a deep aquifer. The new conceptual model incorporates a chronostratigraphic approach to delineate aquifers, based upon the premise that as the alluvial deposits increase in age they decrease in their ability to store and transmit water. As such, the upper aquifer is the saturated alluvium above 1,950 feet above msl, the middle aquifer occurs between 1,950 and 1,550 feet above msl, and the deep aquifer is that portion of the alluvial material between 1,550 feet above msl and the basement complex or bedrock.

The upper aquifer is of primary concern in this Study as this is where recharged water will have the most impact on the groundwater system. Within the southern portion of the Lancaster subbasin and in the Buttes and Pearland subbasins, the areas proposed for groundwater recharge, the upper aquifer is characterized as unconfined (Leighton and Phillips, 2003).

2.2.1 Groundwater Levels

Groundwater elevation data was collected from numerous sources, including previous reports, Los Angeles County Waterworks District No. 40 (WWD No. 40), the PWD, and the United States Geological Survey (USGS). The data for select time periods was analyzed to produce groundwater elevation maps that represent the extreme, intermediate, and current groundwater elevations within the Study area. These time periods were selected through the analysis of the following available information:

- Groundwater elevation contour maps for 1915 (Durbin, 1978), 1961 (Durbin, 1978), 1979 (Duell, 1987), and 1988 (Law, 1991)
- Piezometric time histories for 42 WWD No. 40 wells (January 2001 through April 2006)
- Piezometric time histories for 24 PWD wells (January 1992 through April 2006)
- Piezometric time histories for approximately 160 wells within the USGS database (1920s through April 2006)

The groundwater level mapping periods selected—1915, 1961, 1979, 1988, and 2006—were those with sufficient available data and that best represent the extremes in groundwater elevation that have been measured within the Study area. Each period was designated as follows:

- **High Water Level** - This Study assumes the period during which the highest water level elevations occurred within the Study area was prior to 1915—the period before significant groundwater production occurred. Previously published 1915 groundwater elevation contours (Durbin, 1978) were digitized to create the 1915 groundwater elevation contour map used in this Study (Figure 2-3).



- **Low Water Level** - The period during which the groundwater in storage was declining the fastest was the period of the heaviest groundwater production in the basin (approximately 300,000 afy in 1950, [Durbin, 1978]) and before the SWP began making surface water deliveries to Antelope Valley in 1972. Based on storage volume changes within the Study area (Section 2.3), groundwater levels continued to decline until approximately 1979. Previously published 1979 groundwater elevation contours (Duell, 1987) were digitized to create the 1979 groundwater elevation contour map used in this Study (Figure 2-4).
- **Intermediate Water Level 1 and 2** – Previously published groundwater elevation contours for 1961 (Durbin, 1978) and 1988 (Law, 1991) were digitized to create the groundwater elevation contour maps that represent the intermediate water levels used in this Study. The basin-wide groundwater elevations during these years were between the highest and lowest elevation years. The maps are presented in Figures 2-5 and 2-6, respectively.
- **Current Water Level** - The current water level map is for spring 2006 (Figure 2-7). Spring 2006 water level data was obtained from the PWD, WWD No. 40, and the USGS National Water Information System (NWIS) web service.[1] The groundwater elevations were calculated by subtracting the depth to water at each well location from the ground surface elevation. Ground surface elevations were obtained from a 30 meter digital elevation model[2] to standardize the reference point elevations for various data sources and well owners.

The onset of groundwater pumping in excess of natural recharge in the early 1900s initiated the lowering of groundwater levels within the Study area. However, the groundwater declines are not spatially or temporally uniform across the Study area. Within the eastern portion of the Buttes and Pearland subbasins, groundwater levels have remained relatively unchanged with groundwater level declines of approximately 20 feet. Within the western portion of these subbasins, groundwater levels have declined up to 100 feet, which is likely due to more concentrated pumping in urban areas and for agricultural use.

Within the Lancaster subbasin the groundwater level declines are more dramatic and varied with land use. In 1961, the groundwater levels reflect the occurrence of concentrated agricultural pumping in the eastern and western portions of the Lancaster subbasin, which resulted in water table declines of up to 200 feet below the 1915 levels. As the valley became more urbanized and SWP water became available, the water table depressions stabilized in the

1 http://nwis.waterdata.usgs.gov/usa/nwis/gwlevels

2 http://seamless.usgs.gov/



east and west and increased towards the central portion of the basin near the Cities of Lancaster and Palmdale.

2.2.2 Groundwater Movement

Groundwater movement within the Buttes and Pearland subbasins is primarily to the northwest and parallel to the San Andreas Fault Zone. This has not changed significantly since pumping began in 1915. Local groundwater flow direction changes occur within the Buttes and Pearland subbasins near pumping wells, but the overall flow direction remains to the northwest.

Groundwater movement within the Lancaster subbasin has dramatically changed with the development of the groundwater basin. Under natural conditions, groundwater movement was from the high alluvial deposits along the San Gabriel Mountains (the primary source of groundwater recharge) towards the lower elevations of Rosamond and Rogers Dry Lakes. With the onset of significant agricultural pumping in the east-central and west-central portions of the Lancaster subbasin, pumping depressions developed and groundwater movement changed towards those depressions (Figure 2-4). Subsequently, as urbanization increased within the central and southern portions of the Lancaster subbasin, an additional pumping depression developed (Figure 2-5 and 2-6), resulting in a general reversal in the natural groundwater flow direction towards the south-central portion of the basin near the Cities of Lancaster and Palmdale.

The spring 2006 groundwater level contour map (Figure 2-7) shows the current groundwater elevations of the Study area. Two significant features are evident in the Lancaster subbasin during this period: (1) a ridge of relatively high groundwater in the west-central portion of the subbasin and (2) a pumping depression in the southeast portion of the subbasin.

This ridge of relatively high groundwater exists within the west-central portion of the Lancaster subbasin, extending from Rosamond Lake southwest towards Quartz Hill. The ridge is also evident in Figure 2-4, meaning that it was present as early 1961 and quite possibly even earlier. Specifically, the ridge occurs beneath the Lancaster WRP spreading ponds, which were developed around 1961 (LACSD, 2004). As of spring 2006, this groundwater elevation high extends southwest towards Apollo Lake, which is also used as an effluent spreading area for the Lancaster WRP. West of the ridge, groundwater flows toward the northwest, and groundwater east of the ridge flows southeast towards the Cities of Lancaster and Palmdale. The USGS has suggested that water spread at the Piute Ponds does not reach the regional groundwater table, owing to the high clay content of the subsurface soils (Leighton, 2003). Bloyd (1967) and Duell (1987) have suggested a regional perched water layer exists beneath this area, which may contribute to the relatively high groundwater elevations.

As previously stated, a significant pumping depression has developed within the southern portion of the Lancaster subbasin, between the cities of Palmdale and Lancaster. This



depression extends radially several miles from the lowest water level reading in the basin and is the result of concentrated groundwater pumping for municipal supplies.

2.2.3 Hydraulic Conductivity

Hydraulic conductivity estimates were made by the USGS in its development of the MODFLOW groundwater model for the Antelope Valley (Leighton, 2003). Hydraulic conductivity values for Layer 1 range from 2 to 30 feet per day and their distribution is shown in Figure 2-8.

2.2.4 Specific Yield

Specific yield estimates were made by the USGS in its development of the MODFLOW groundwater model for the Antelope Valley (Leighton, 2003). The specific yield estimates for the unconfined (upper) layer (Layer 1) range from 10 to 14 percent and their distribution is shown on Figure 2-9.

2.3 Changes in Groundwater Storage

Changes in groundwater storage were calculated to determine groundwater conditions within the Study area and to assess the effects that recharging water may have on groundwater quality beneath a recharge site. Storage volume changes within the Study area are directly related to the volume of groundwater extracted for consumptive use. Significant groundwater production in the Antelope Valley began in 1915 and continues through today. Groundwater production decreased from a high of over 300,000 afy in the 1950's (Durbin, 1978) to approximately 75,000 afy in 1995 (Leighton, 2003).

The USGS groundwater model divides the Antelope Valley into three layers, each defined in terms of elevation. As previously stated, Layer 1, the uppermost layer, is the primary layer of concern for this Study and is defined as the zone from 1,950 feet above msl to the water table. This layer is the primary concern of this Study because this is where water that is recharged through surface spreading will have the greatest impact.

The top and bottom elevations for Layers 2 and 3 are uniform at 1,950 ft, 1,550 ft, and 1,000 ft (unless bedrock is at an elevation greater than 1,000 ft), respectively. Aquifer information was extracted from the USGS MODFLOW model for Antelope Valley (Leighton, 2003). Water level elevation surface grid systems were overlain on the USGS model grids and the water level information was transferred to the USGS model grids. A spreadsheet model was developed to calculate the storage volume for each model grid cell and then to summarize the storage volume for each subbasin.

The storage volume of Layer 1 for each subbasin of the Study area was calculated by multiplying the area of the basin (acres) by the thickness of the saturated zone (feet) and by the



specific yield (Sy, %) of the saturated material. The extracted data included active model grid cells; top and bottom elevations of USGS model Layer 1 and specific yield.

Water level maps were digitized and projected to real world coordinates. Areas with missing information were interpolated from adjacent areas or from earlier maps. For example, the 1988 and 2006 water level maps do not contain water level information for the north-east portion of the Lancaster subbasin in the vicinity of Edwards Air Force Base. This missing data was supplemented with 1979 water level data. The digitized water level contour maps were converted to digital data and geo-statistical software was used to create water level surfaces.

Table 2-3 shows the Layer 1 storage volumes from 1915 to spring 2006 for each subbasin of the Study area, and Table 2-4 shows the changes in storage volume over time.

TABLE 2-3: STORAGE VOLUMES - LAYER 1

Subbasin	1915	1961	1979	1988	2006
Lancaster	14,571,500	10,806,600	9,698,000	10,176,500	9,902,900
Buttes	3,370,700	2,937,700	2,858,00	3,056,400	2,881,900
Pearland	2,342,600	2,150,300	2,084,900	1,691,500	1,741,900
Total	**20,284,800**	**15,894,700**	**14,640,900**	**14,924,400**	**14,526,700**

Note: All values in acre-feet.

TABLE 2-4: CHANGE IN STORAGE VOLUMES - LAYER 1

Subbasin	Total Change (1915 – 2006)		Period of Maximum Decline (1915-1979)		Recovery Since Low (1979 – 2006)	
Lancaster	-4.7 maf	-32.0%	-4.9 maf	-33.4%	0.20 maf	2.1%
Buttes	-0.50 maf	-14.5%	-0.50 maf	-15.2%	0.02 maf	0.8%
Pearland	-0.60 maf	-25.6%	-0.65 maf[1]	-27.8%[1]	0.05 maf[2]	3%[2]
Total	**-5.8 maf**	**-28.4%**	**-5.6 maf**	**-27.8%**	**0.28 maf**	**2.0%**

Note:

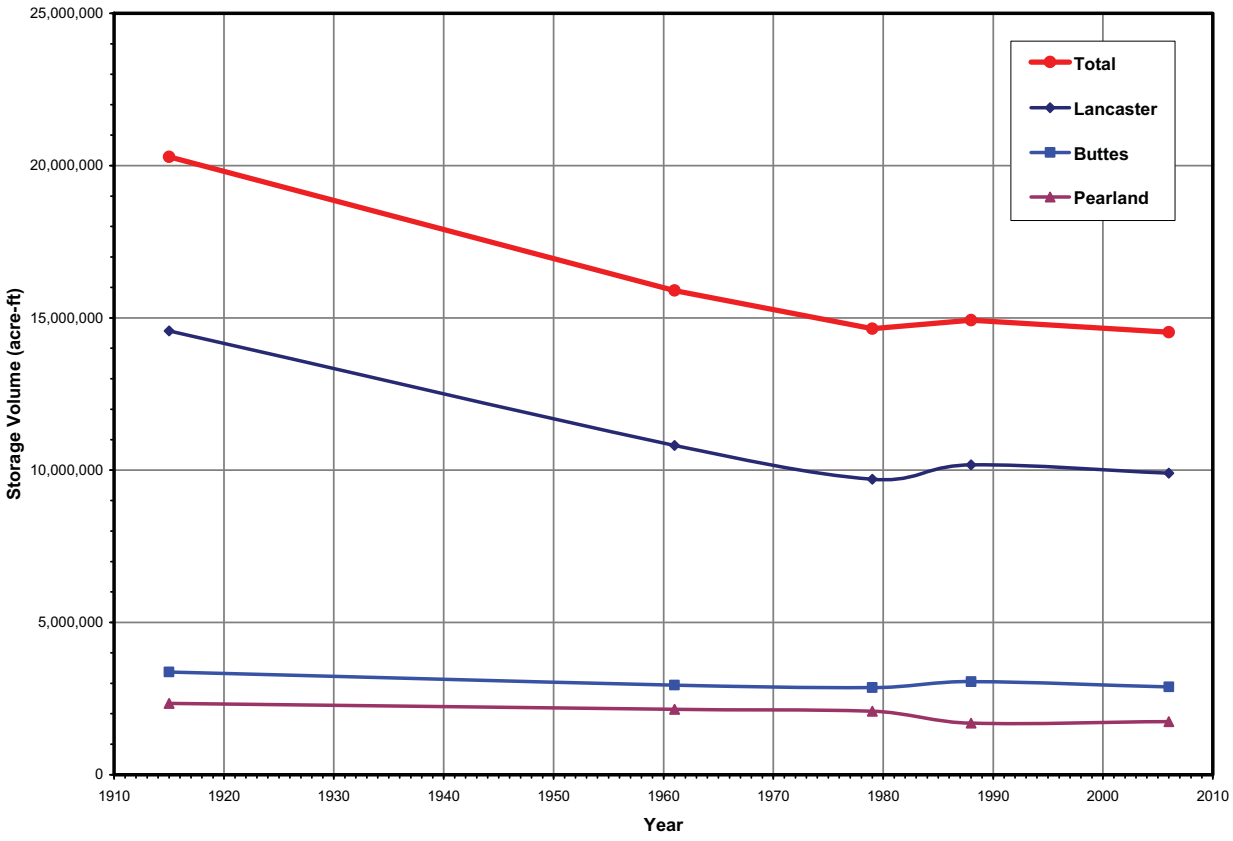
[1] = 1915 – 1988
[2] = 1988 – 2006
maf = million acre-feet

The volume of groundwater in storage within the Study area declined by approximately 5.8 million acre-feet (maf) between 1915 and spring 2006. The most significant decrease occurred



between 1915 and 1979 with a decline of 5.6 maf. Since 1979, groundwater in storage has increased or recovered by approximately 0.28 maf. Multiple factors may contribute to the storage volume trend seen since 1979, including the reduction of groundwater pumping, the increase in SWP deliveries, and the latent effects of agricultural, municipal, and industrial return flows reaching the water table.

STORAGE VOLUME VS. TIME FOR LAYER 1



2.4 Water Quality

Groundwater quality within the Study area exhibits a calcium bicarbonate characteristic and is suitable for domestic, irrigation, and most industrial uses (Duell, 1987).

Groundwater quality data for total dissolved solids (TDS), nitrate (as N), and Trihalomethanes (THMs) was obtained from the USGS, the PWD, WWD No. 40, and Air Force Plant 42 investigations (Geomatrix, 2005). Table 2-5 presents a summary of available data for TDS, nitrate, and THM concentrations within the Study area, and Figures 2-10 and 2-11 present the

average TDS and nitrate concentrations collected from PWD and WWD No. 40 wells during 2004.

TABLE 2-5: GROUNDWATER QUALITY IN STUDY AREA

Constituent	Units	Range of Concentrations	Average / Median Concentrations
TDS	mg/L	110 to 1,480	290 / 221
Nitrate (as N)	mg/L	Non-Detect to 15	1.0 / 0.71
THMs	ug/L	Non-Detect	-

Note: Limited THM data was available. PWD collected THM samples from the majority of wells during 2004 and all of the results were non-detect.

TDS concentrations within the Study area range from 110 to 1,480 milligrams per liter (mg/L) with an average concentration of 290 mg/L. Of the 75 wells with data available in 2004, four were above the secondary maximum contaminant level (MCL) of 500 mg/L. Figure 2-10 presents the average 2004 TDS concentrations in PWD and WWD No. 40 wells.

Nitrate (as N) concentrations within the Study area range from non-detect to 15 mg/L with an average concentration of 1 mg/L. All of the wells with nitrate (as N) data available in 2004 were below the MCL of 10 mg/L. Figure 2-10 presents the average 2004 nitrate (as N) concentrations in PWD and WWD No. 40 wells.

THMs were not detected in any of the PWD and WWD No. 40 wells sampled in 2004.

2.5 Regulatory Environment

This recycled water groundwater recharge project is subject to a combination of public health and environmental objectives and regulations set by the California Department of Health Services (DHS) and the Lahontan Regional Water Quality Control Board (RWQCB). This section identifies the current regulatory setting and potential regulatory pathways for this recycled water groundwater recharge project.

The reuse of recycled water is regulated under several state laws and regulations:

- The California Water Code (CWC) contains requirements for the production, discharge, and use of recycled water. In particular, CWC, Sections 13000 through 13999.19 include provisions that require the DHS to establish water recycling criteria and give the RWQCBs responsibility for prescribing Water Recycling Requirements (WRR) or Waste Discharge Requirements (WDR) for water that is used or proposed to be used as recycled water.



- The CWC also requires the RWQCBs to adopt water quality control plans and establish water quality objectives in those plans to protect surface waters and groundwaters.
- Regulations for recycled water are contained in the California Code of Regulations (CCR), Titles 17 and 22.
- Recycled water groundwater recharge projects are also subject to policies developed by the state for the protection of groundwater and drinking water.

Regulatory oversight of recycled water groundwater recharge projects is carried out by the DHS and individual RWQCBs. The responsibilities[3] and associated regulatory requirements managed by each agency are discussed in the following sections.

2.5.1 Department of Health Services Requirements

The two major elements of DHS requirements are the Water Recycling Criteria (Title 22 CCR, Division 4, Chapter 3) and the draft groundwater recharge reuse regulations[4], which, once finalized, will be incorporated in the Water Recycling Criteria. The DHS uses the draft regulations as de facto regulations.

2.5.1.1 Water Recycling Criteria

The Water Recycling Criteria include general requirements for the recharge of domestic water supply aquifers. Surface spreading project regulations state that reclaimed water "shall be at all times of a quality that fully protects public health" and that DHS recommendations "will be based on all relevant aspects of each project, including treatment, effluent quality and quantity, spreading area operations, soil characteristics, hydrogeology, underground residence time, distance to extraction."

All recycled water projects must submit engineering reports for DHS review.[5] The RWQCBs must consult with and review recommendations from DHS on proposed projects, and permits issued by RWQCBs must be in conformance with the Water Recycling Criteria.

2.5.1.2 Draft Groundwater Recharge Regulations

The draft regulations have gone through several iterations and, when finalized and subsequently adopted, will be included in the Water Recycling Criteria.

The January 4, 2007 draft regulations specify recycled water dilution requirements that are related to the level of recycled water treatment. The recycled water contribution (RWC) is the

3 These responsibilities are also specified in a memorandum of agreement between the SWRCB and DHS.

4 California Department of Health Services, 2007; DRAFT Title 22, CCR, Division 4, Chapter 3. §60320 *et seq.*

5 Title 22 CCR, Division 4, Chapter 3, section 60323.



quantity of recycled water applied at a recharge facility divided by the sum of the recycled water and diluent water applied at a recharge facility.

The RWC can be 100 percent with the advanced treatment of the recycled water, but for tertiary treated water, the RWC is limited to a maximum of 50 percent. The RWC, which is tied to the total organic carbon (TOC) concentration, is a critical factor in determining how much recycled water can be used for a recharge project and/or what additional control measures are required. TOC measured within the vadose zone or groundwater mound is used in the following equation to determine the RWC.

$$RWC_{proposed} = \frac{0.5 mg/L}{TOC_{max}}$$

2.5.2 Regional Board Requirements

The primary responsibility for the protection of water quality in California rests with the State Water Resources Control Board (SWRCB) and the nine RWQCBs. The Lahontan RWQCB has jurisdiction over Antelope Valley. The SWRCB sets statewide policy for the implementation of state and federal laws and regulations. The RWQCBs adopt and implement Water Quality Control Plans (Basin Plans), which establish beneficial uses and water quality objectives for waters within their regions.

The CWC requires any person who proposes to recycle or use recycled water to file an engineering report on the proposed use with their respective RWQCB.[6] After receiving such a report, consulting with and receiving recommendations from the DHS, and any necessary evidentiary hearing, the RWQCB must prescribe WRRs or WDRs for the use.[7] The requirements may be placed on the person recycling the water, the user, or both.[8]

The key regulatory challenges in obtaining WRRs or WDRs for a groundwater recharge project are meeting the Basin Plan requirements, including the state's Anti-degradation Policy.

2.5.2.1 Basin Plan Considerations

In evaluating a proposed project (long-term or pilot), it is necessary to assess how it complies with both the numeric and narrative water quality standards in the Basin Plan. Water quality standards consist of the beneficial uses of water bodies and the applicable water quality objectives to protect these uses. Water quality objectives can be numeric or narrative. How a

6 CWC section 13522.5

7 CWC section 13523

8 CWC section 13523



RWQCB interprets narrative objectives for toxic substances can often result in challenging issues for recycled water projects, depending on what level of protection a RWQCB considers to be acceptable. In addition, the Basin Plan has generic prohibitions related to pollution and the creation of nuisance.

Water Quality Objectives

In the Lahontan Basin Plan, water quality objectives for groundwater are divided into the two categories:

- Objectives that apply to all groundwater
- Objectives that apply to specific groundwater basins

There are no specific objectives that currently apply to the Antelope Valley Groundwater Basin.

The water quality objectives that apply to groundwater are narrative, combined with a limited number of numeric objectives. These objectives define the upper concentration or another limit that the RWQCB considers protective of beneficial uses. The objectives apply to all groundwater rather than only at a wellhead, at a point of consumption, or at point of application of discharge.

Non-Degradation Objective

The Basin Plan also incorporates the state's Anti-degradation Policy[9] as part of the water quality objectives section. The application of this policy has recently become one of the significant challenges encountered when trying to implement water recycling projects. Anti-degradation, as defined in state policy, is the lowering of water quality in rivers, streams, or groundwater, which is allowed if the change is consistent with providing a maximum benefit to the people of the state and does not unreasonably affect present and anticipated beneficial uses of the state's waters.

2.5.2.2 Water Code Considerations and the State's Anti-degradation Policy

The CWC contains provisions related to waste wells[10] that prohibit the use of any waste well that extends into a water bearing stratum that is or could be used as a water supply for domestic purposes. But, an exception can be provided if the RWQCB finds that water quality considerations do not preclude the direct injection and if the DHS, after a public hearing, finds that the recharge will not degrade the quality of the aquifer as a source of water supply for domestic purposes. In making its finding on degradation, the DHS must consider the state's Anti-degradation Policy.[11] While these provisions are typically interpreted to apply to recharge

9 Resolution 68-16: "Statement of Policy with Respect to Maintaining High Water Quality in California."

10 CWC section 13540.

11 Ibid.



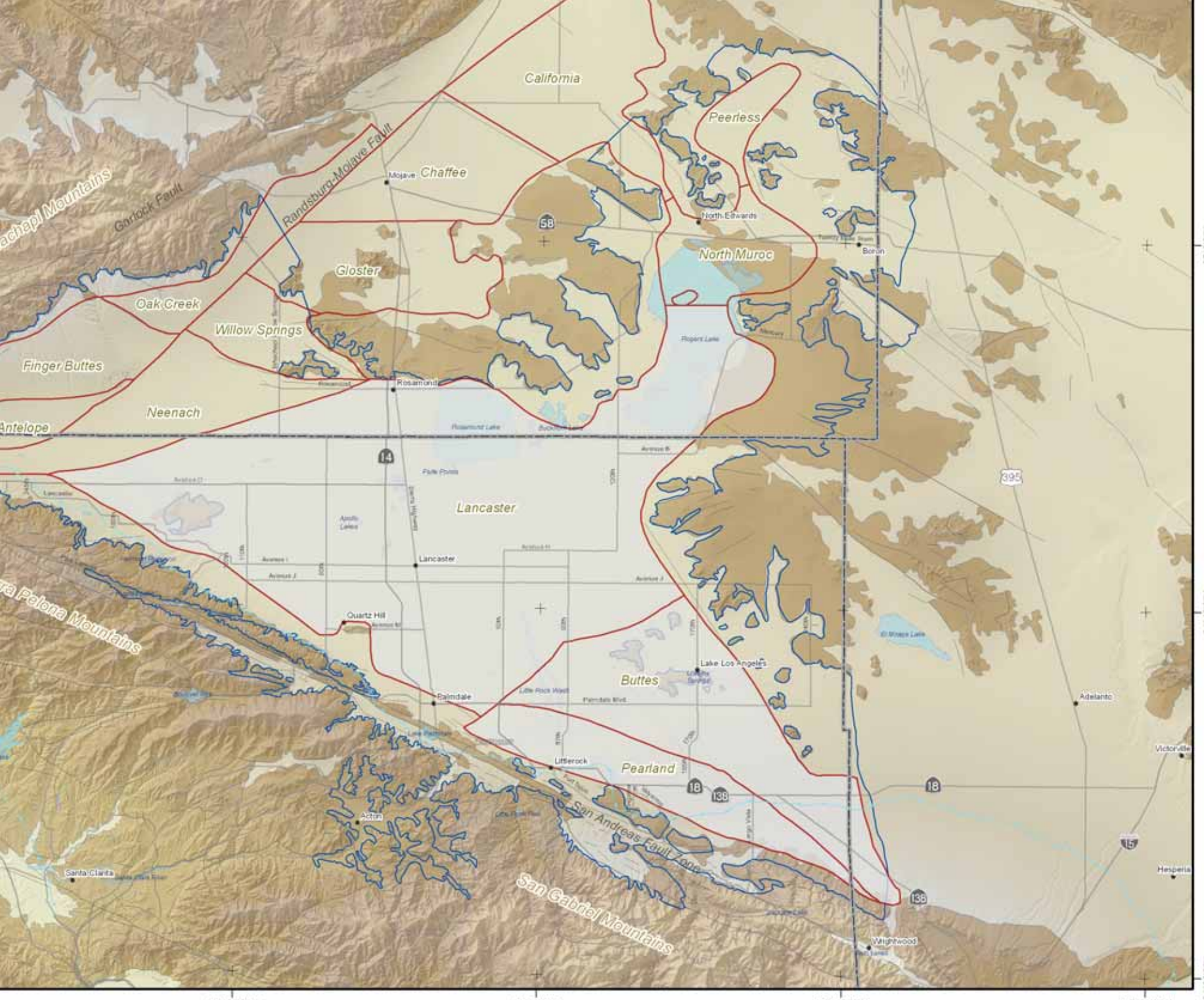
by injection, the DHS and some RWQCBs also apply this statute to surface spreading projects. Consequently, the assessment of a groundwater recharge project has to take these statutory requirements into consideration.

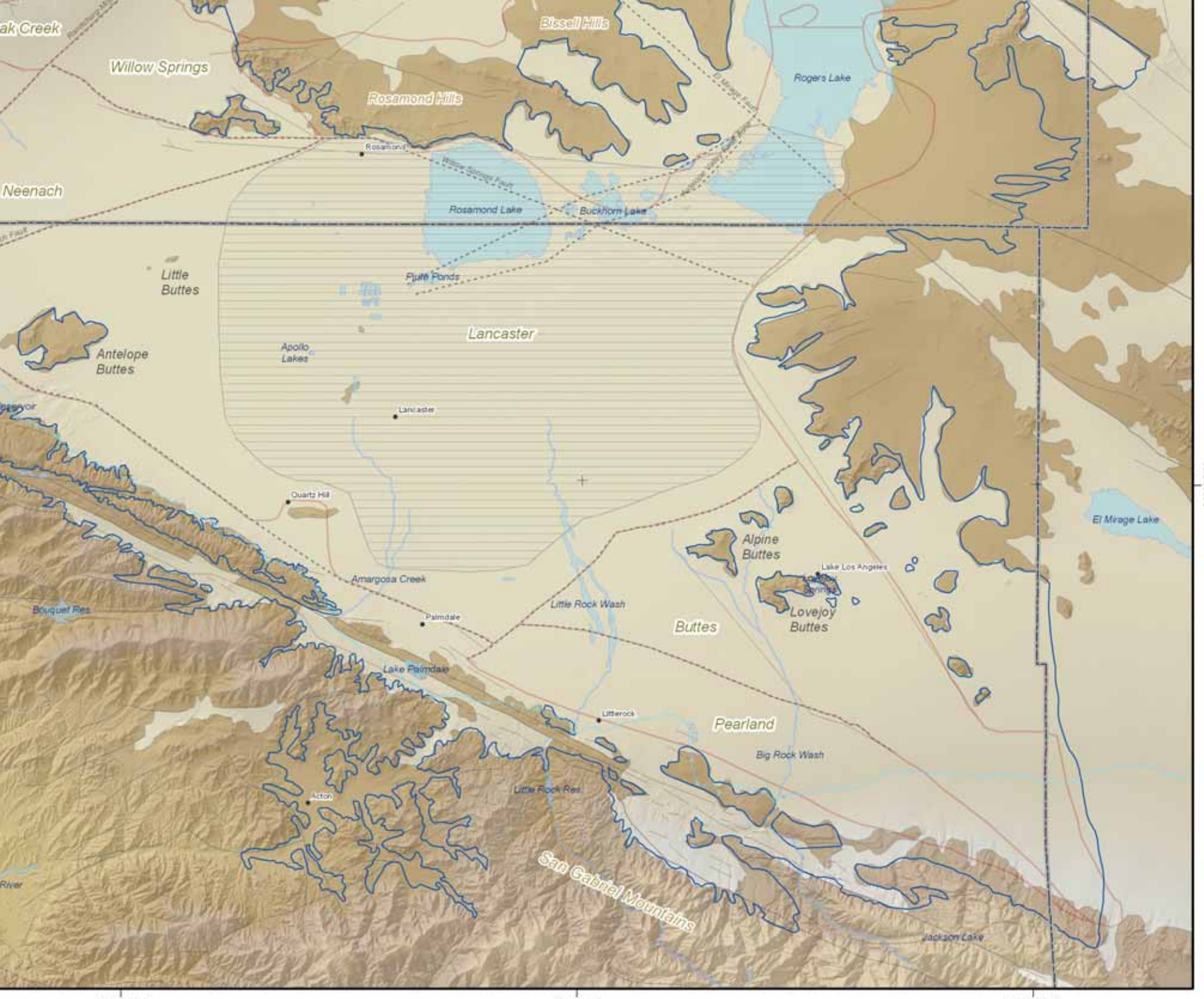
A section on water reclamation requirements in the CWC states that a RWQCB may not deny issuance of water reclamation requirements to a project that violates only a salinity standard in a basin plan.[12] In 1988, soon after this provision was added to the CWC, the SWRCB's Office of Chief Counsel issued a legal opinion, concluding that this requirement applied to WRRs, but not to WDRs. The Lahontan RWQCB, in practice, has elected to issue joint WRRs/WDRs for non-potable reuse projects and would probably take the same approach for a groundwater recharge project. Thus, the permit for a recharge project would contain limits on discharges of salts if necessary to meet water quality objectives or otherwise protect beneficial uses.

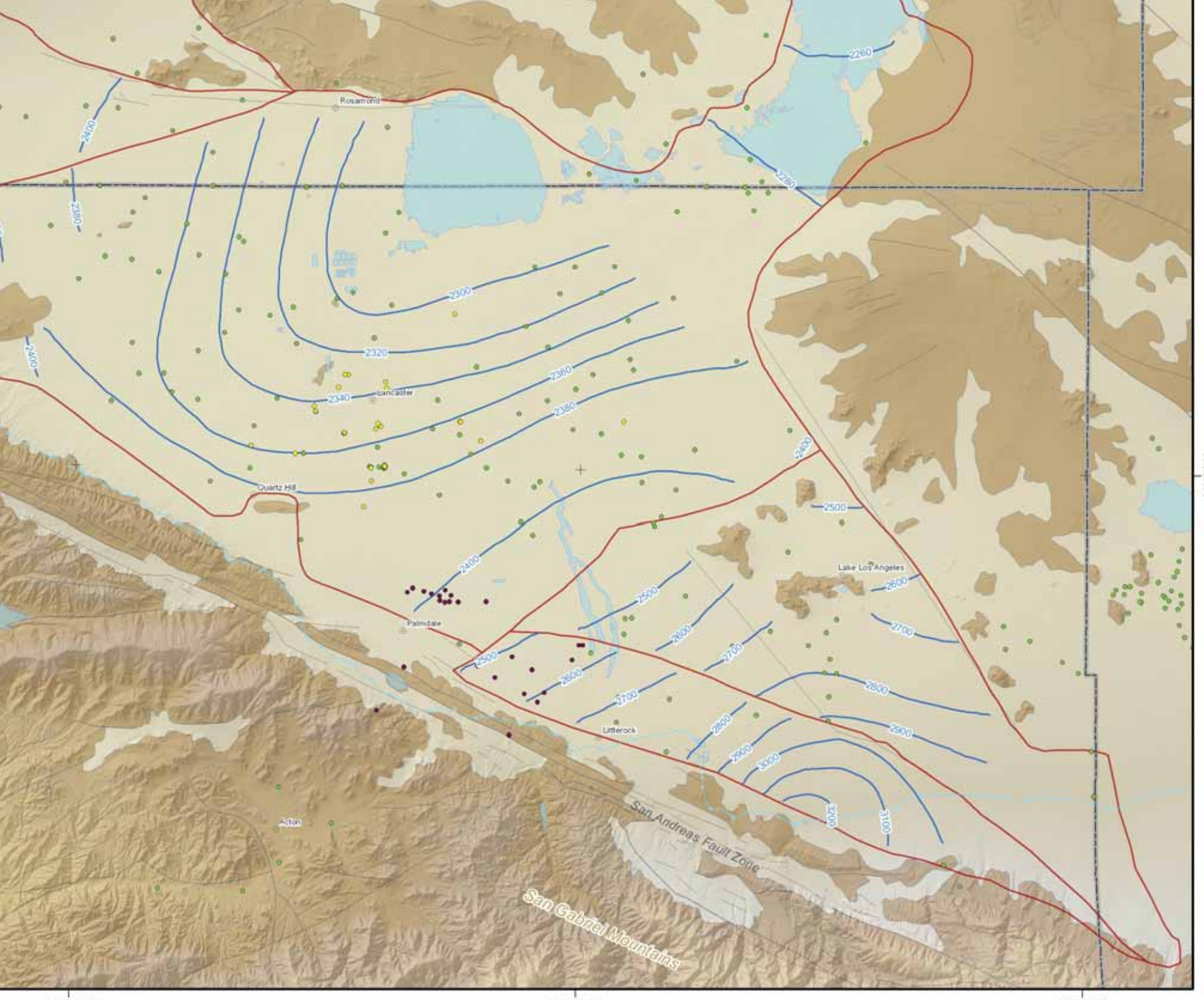
Our experience with the Santa Ana RWQCB demonstrates that it is possible to modify Basin Plan objectives to provide the maximum benefit to the basin users.

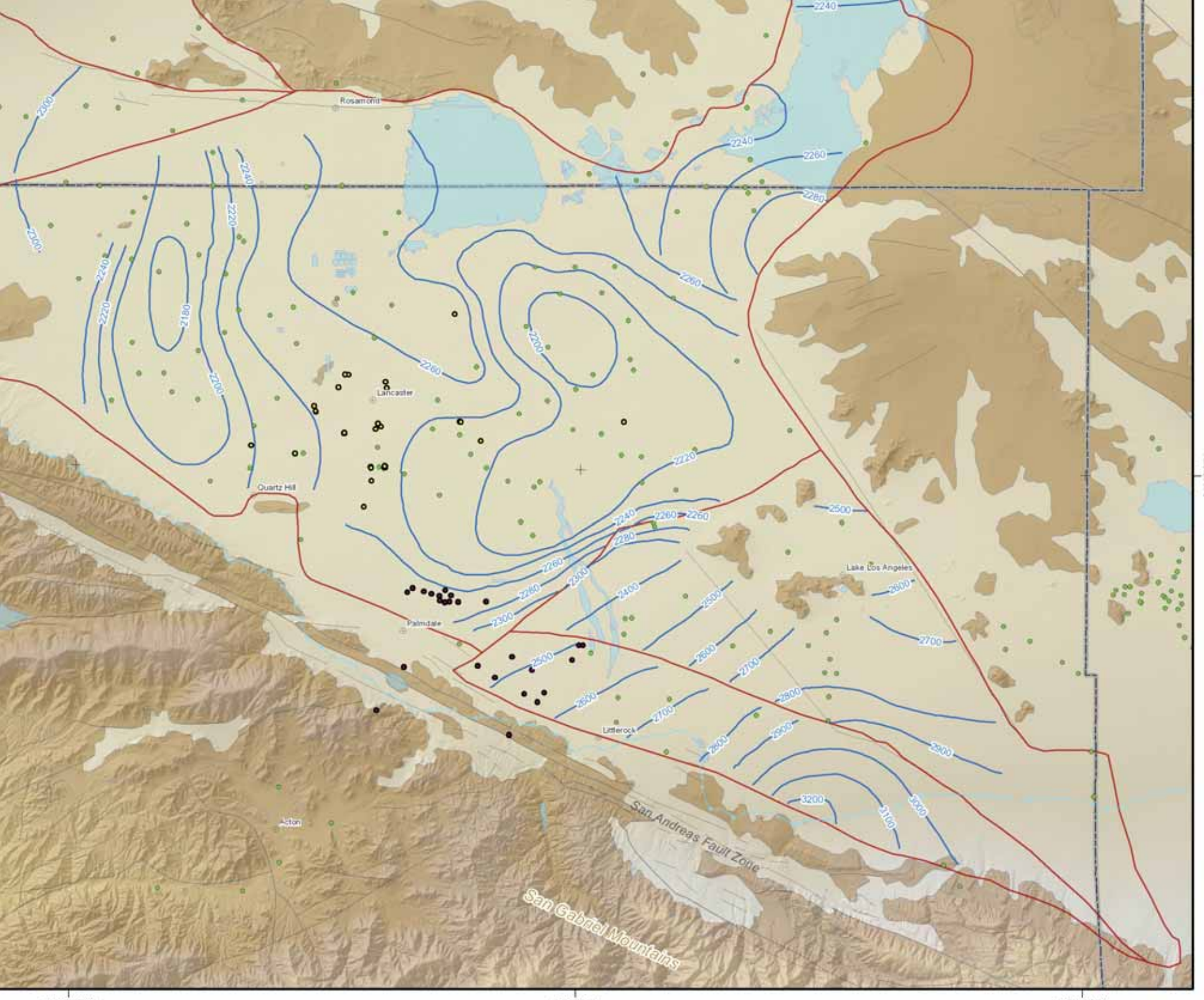
12 *See* Water Code section 13523.5.



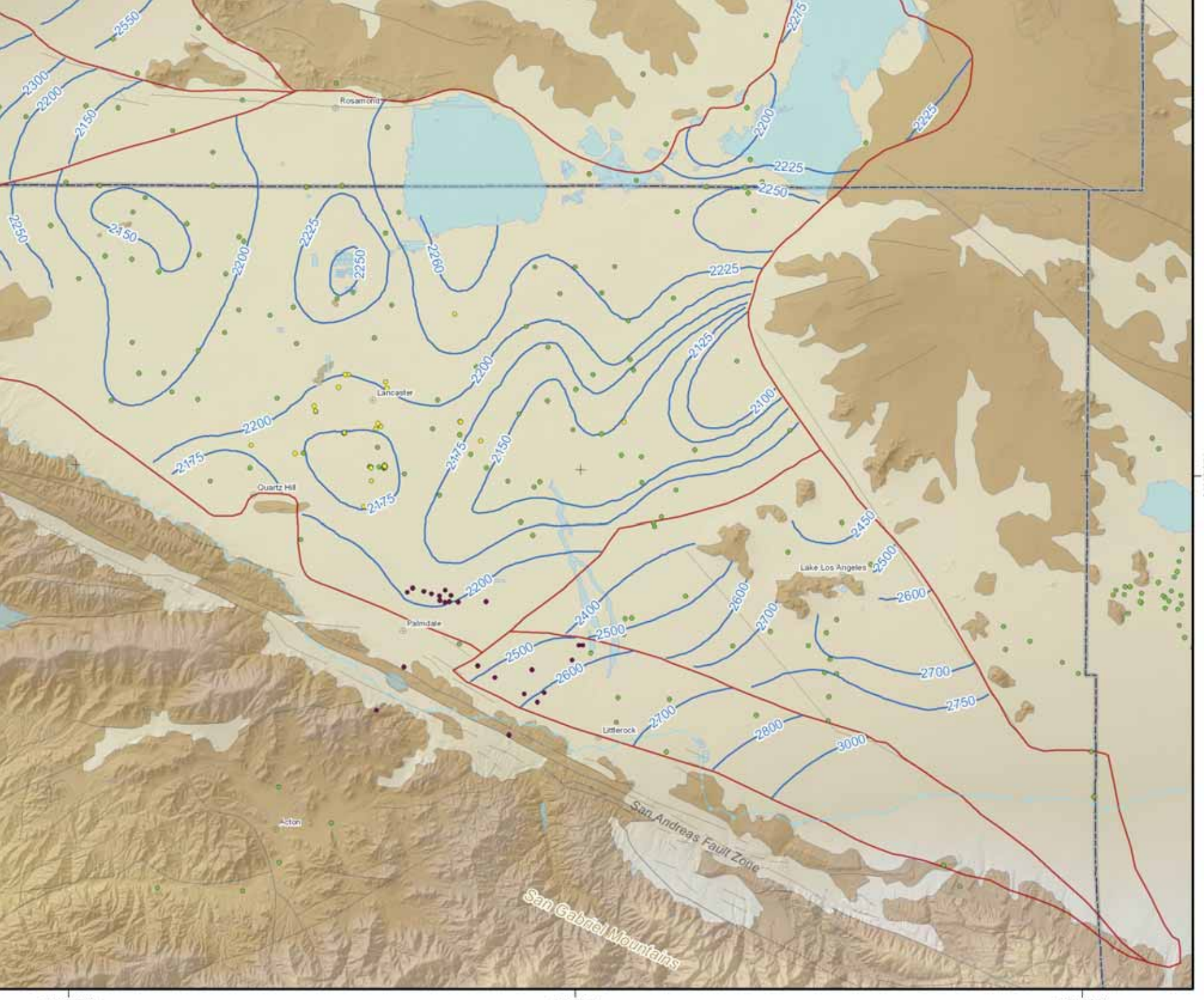

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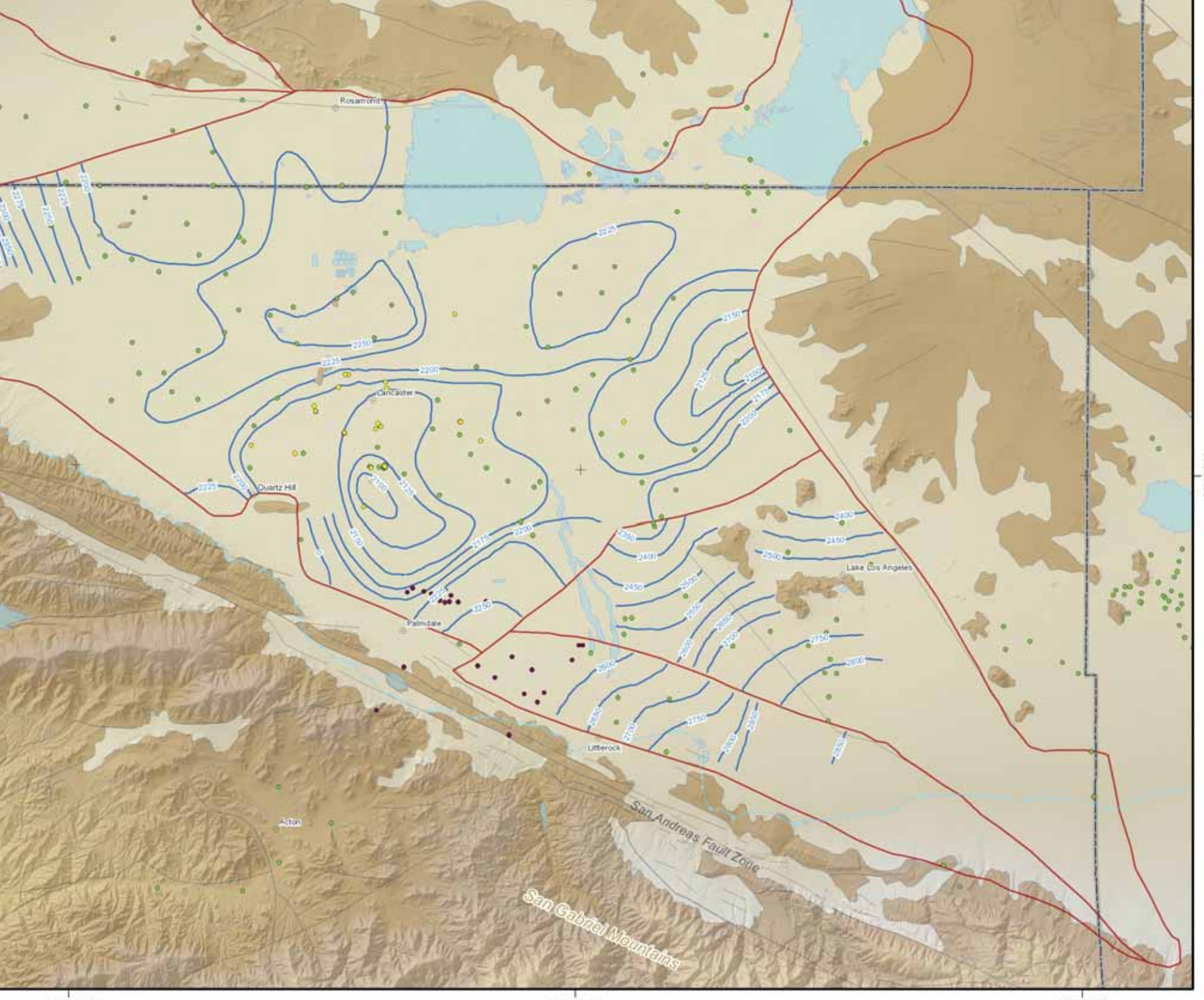

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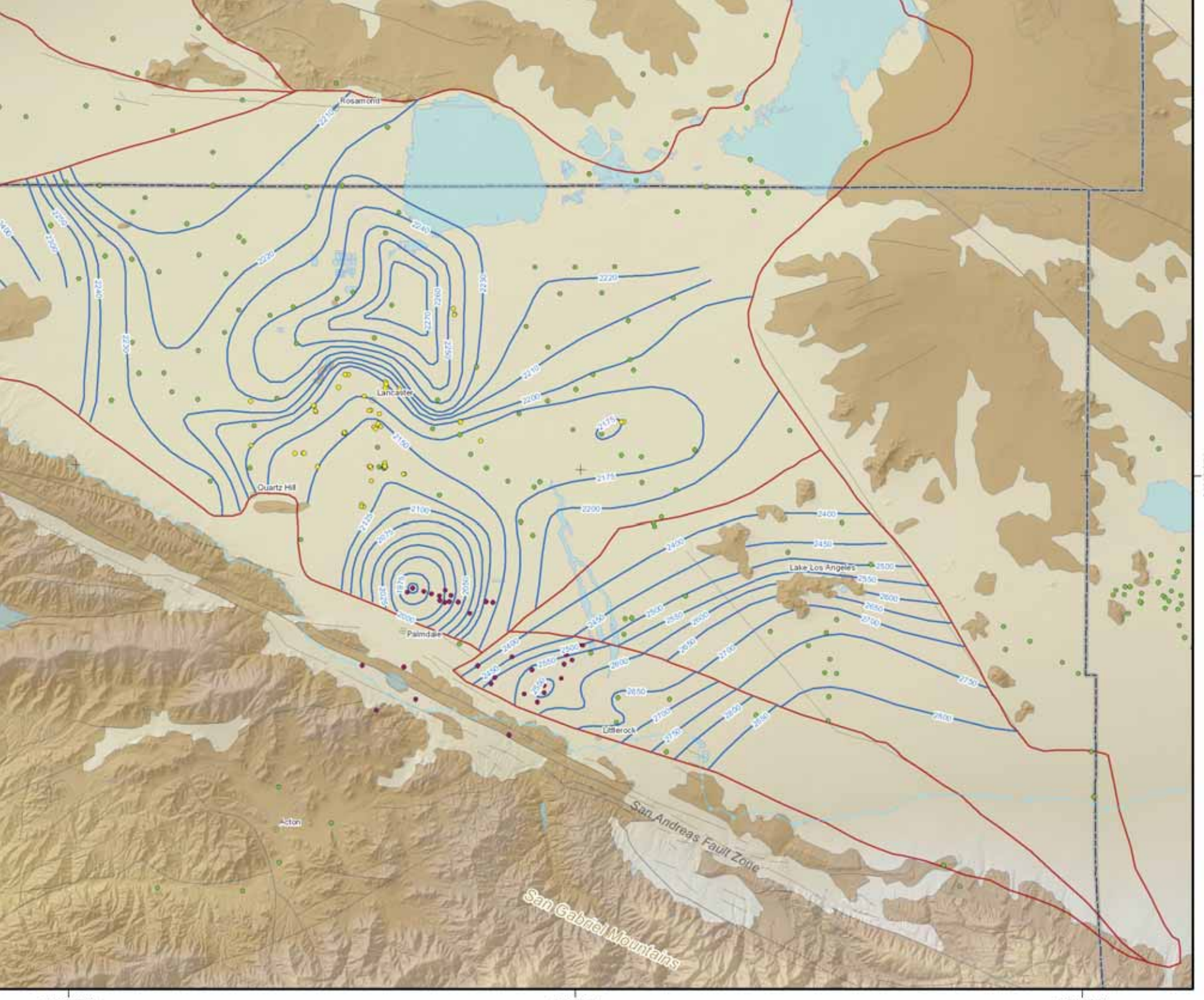
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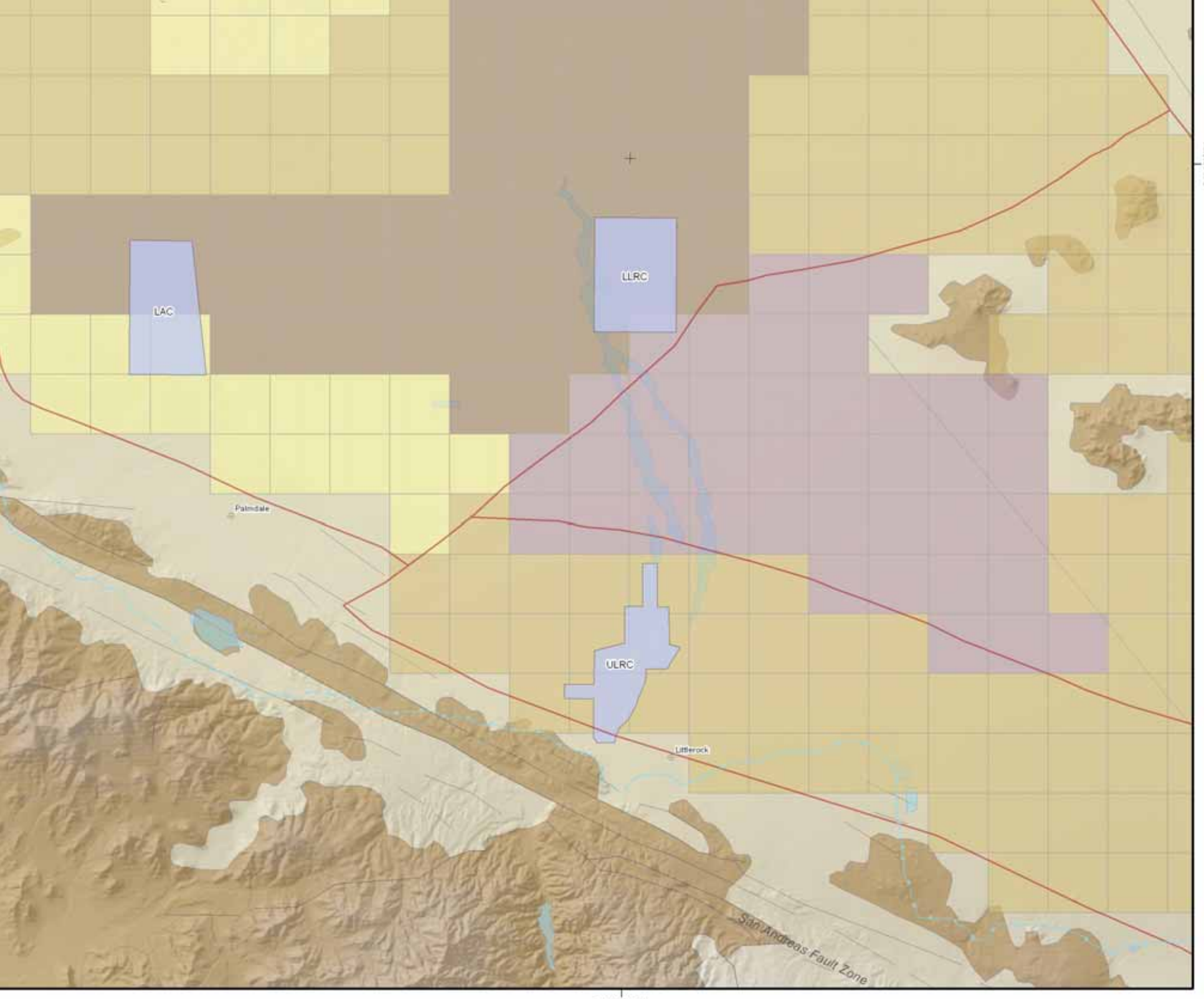
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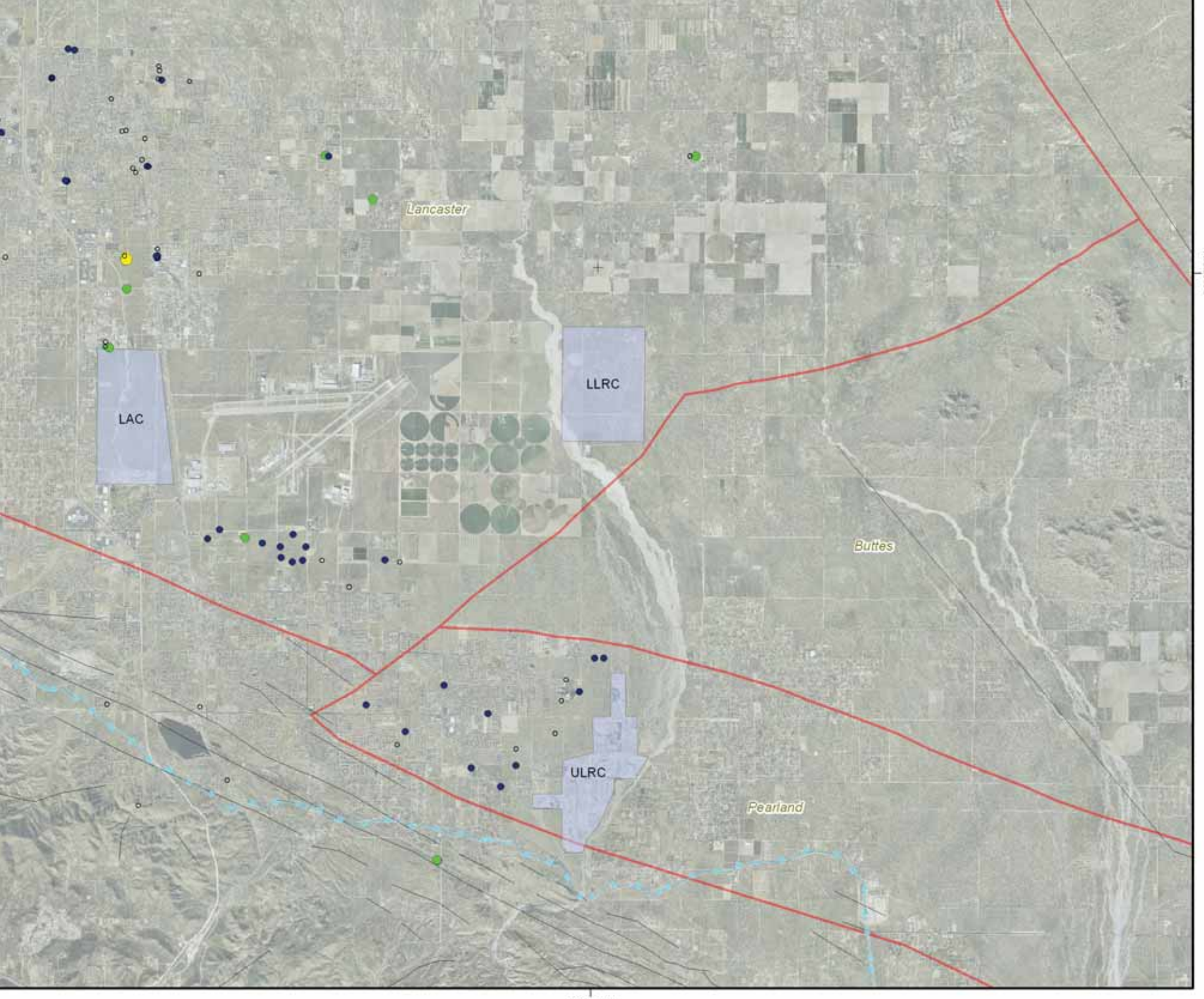
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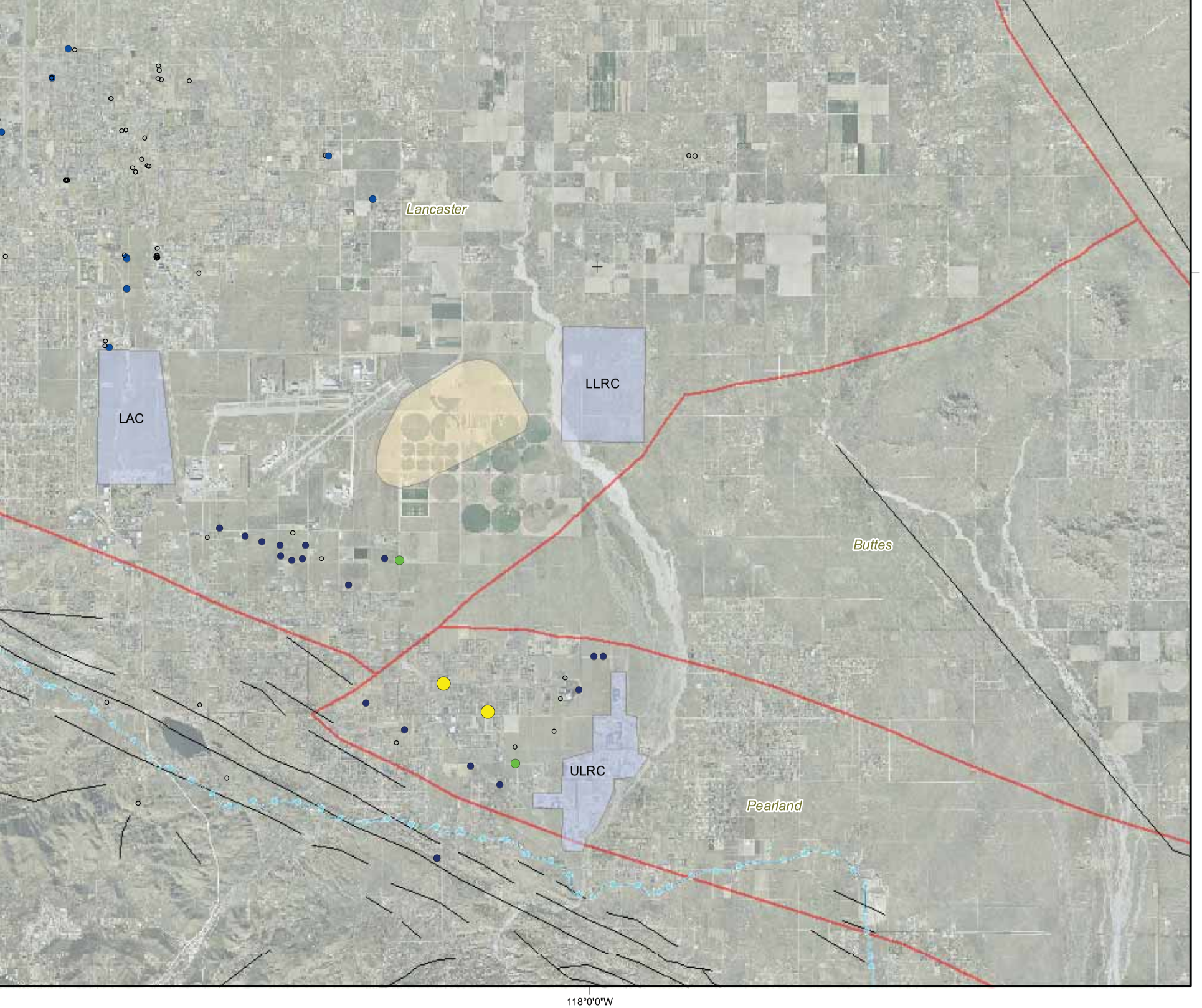
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3 IDENTIFICATION AND EVALUATION OF RECHARGE SITES

This section describes the development of the siting criteria, the application of the siting criteria to several potential recharge sites in the Study area, the modeling of several recharge scenarios at each potential site, and the selection of a preferred site for recycled water groundwater recharge.

3.1 Siting Criteria

Siting criteria were developed based on regulatory requirements for recycled water recharge, hydrogeologic characteristics within the Study area, land use constraints, and conceptual project needs. The following siting criteria were used to evaluate basin suitability for recycled water recharge:

- DHS Title 22 Groundwater Recharge Reuse Draft Regulations
- Local Hydrogeology
- Spreading Basin Size Requirements
- Proximity to Sources of Water
- Land Use Consistency

3.1.1 DHS Regulations

DHS Groundwater Recharge Reuse Draft Regulations specify, for a surface spreading project, that all the recycled water shall be retained underground for a minimum of six months prior to extraction for use as a drinking water supply and shall not be extracted within 500 feet of any surface spreading area.

These criteria will need to be satisfied prior to the implementation of a recycled water groundwater recharge project.

3.1.2 Local Hydrogeology

An analysis of the local hydrogeologic conditions at each recharge site was conducted to assess the suitability of the subsurface for groundwater recharge. Data was provided by local agencies and the USGS, including well completion reports, groundwater levels, groundwater quality, and local groundwater knowledge. In addition, existing reports that summarize the general geologic and hydrogeologic conditions within the Antelope Valley were reviewed during this evaluation. More specifically, the following hydrogeologic conditions were reviewed as part of the recharge area siting and evaluation:



- **Primary aquifer characteristics**

  Hydraulic conductivity, specific yield, and transmissivity were used to evaluate the suitability of the subsurface for groundwater recharge. These values were obtained from the USGS groundwater model (USGS, 2003).

- **Near surface impermeable layers**

  Areas with exposed bedrock or other near-surface impermeable material were eliminated from consideration.

- **Groundwater flow direction**

  The current (spring 2006) regional groundwater flow direction was considered in site selection, as recharged water should ultimately move towards areas of future extraction and use.

- **Groundwater depth**

  The depth to groundwater was considered to assure that the vadose zone was sufficiently thick for soil aquifer treatment, groundwater storage, and mound accommodation.

- **Groundwater quality**

  Groundwater quality was considered to assure that recharged water was not placed in areas where water quality has been degraded below drinking water standards.

- **Groundwater barriers**

  Groundwater barriers were considered to assure that recharged water would move towards recovery (pumping) areas.

3.1.3 Land Size Requirements

Another criterion in the selection of recharge sites was the availability of sufficient undeveloped or developable land upon which a recharge project could be built. Therefore, sites within the Palmdale area with at least 1,000 acres of available land were considered during the initial siting process in order to accommodate recharge projects of approximately 50,000 afy.

3.1.4 Proximity to Recycled Water and Diluent Water Sources

The proximity of the basin to recharge water sources (recycled water and SWP water) was considered in order to minimize the costs associated with the delivery of recharge water to recharge areas. Planning documents and data that were supplied by local agencies were loaded into a database, and geographic information system (GIS) technology was used to project the data onto a map and optimize the distance to the recharge areas.



3.1.5 Land Use Consistency, Permitting, and Ownership

These criteria were the final basis for recharge area site selection. Areas that could not be disturbed—such as "blue line" streams, sensitive habitat, or other areas set aside as ecologically sensitive—were excluded.

3.2 Recharge Site Identification and Evaluation

The siting criteria defined in Section 3.1 were applied to several areas in the vicinity of the Palmdale WRP. For the most part, these areas were previously identified[13] as potential groundwater recharge sites. Three recharge areas were selected for further evaluation, including Lower Amargosa Creek (LAC), Upper Littlerock Creek (ULRC), and Lower Littlerock Creek (LLRC). Table 3-1 and Figure 3-1 provide an overview of the recharge sites selected for further evaluation.

TABLE 3-1: POTENTIAL RECHARGE SITES

Recharge Site Name	Acres
Lower Amargosa Creek (LAC)	1,670
Upper Littlerock Creek (ULRC)	1,137
Lower Littlerock Creek (LLRC)	1,680

3.2.1 Lower Amargosa Creek

The LAC recharge area is roughly bounded by Highway 14 and Sierra Highway to the west and east, and Avenues M and O to the north and south. The site is west of Air Force Plant 42 in the City of Palmdale, and it occupies roughly 1,600 acres of vacant land along Amargosa Creek. The area ranges in elevation from approximately 2,550 to 2,600 feet above msl with a surface gradient towards the north.

The USGS NWIS database contains information on several wells within the vicinity of the LAC recharge area. The status and use of these wells is unknown. There are also several mutual water companies with service areas that are within 500 feet of the LAC recharge area as shown in Figure 3-2. The exact location of their wells is unknown and will need to be verified if this site is selected for future consideration.

The aquifer characteristics proximate to this recharge area are summarized in Table 3-2. The USGS has assigned hydraulic conductivity values ranging from 5 to 24 ft/day and a specific

13 Kennedy/Jenks, 1999, and Stetson, 2002



yield of 12-14% to this area. Transmissivity was calculated using spring 2006 groundwater elevations and ranges from 750 to 3,600 ft^2/day. There are no known near-surface impermeable layers with a sufficient regional extent that could preclude the recharge of groundwater through surface spreading operations.

Groundwater within this area occurs at a depth of approximately 400 to 500 feet below ground surface and flows in a southwest direction at a gradient of approximately 0.006. The influence of groundwater recharge on the groundwater flow direction is dependant on the size of the recharge program and groundwater production both near the recharge project and regionally. Groundwater movement in this area is heavily influenced by the pumping depression within the Palmdale area.

The LAC is in the south-central portion of the Lancaster subbasin, which is locally defined by the San Andreas Fault Zone approximately 3 miles south of the site. The San Andreas Fault Zone is a barrier to groundwater movement, but is not expected to affect groundwater recharge negatively at this location.

Limited data exists on the groundwater quality beneath this recharge area. The USGS database was queried for TDS and nitrate in wells within the Study area to supplement the data provided by the PWD and WWD No. 40. The results of our water quality analysis agree with analyses performed by others (Duell, 1987), indicating that TDS concentrations are in the range of 250-350 mg/L and nitrate concentrations are typically less than 1 mg/L as N. No other significant water quality issues are known to exist in the vicinity of this area.

The Palmdale WRP is approximately 3.25 miles southeast of the LAC recharge area, and the California Aqueduct is approximately 4.25 miles south.

This site is not within any known ecologically sensitive areas.

3.2.2 Upper Littlerock Creek

The ULRC recharge area is on the southeastern edge of the City of Palmdale and just north of Highway 138 along the western bank of Littlerock Creek. This area encompasses approximately 1,100 acres of active and inactive aggregate mines. The area ranges in elevation from approximately 2,680 to 2,850 feet above msl with a surface gradient towards the north.

There are several wells within the vicinity of the ULRC recharge area, although the status and use of these wells is unknown. Both the PWD and the Littlerock Creek Irrigation District (LCID) own and operate wells to the west and east of the recharge basin, respectively, but none are within 500 feet of the recharge area (Figure 3-2). The exact location and use of nearby wells is unknown and will need to be verified if this site is selected for future consideration.

The aquifer characteristics proximate to this recharge area are summarized in Table 3-2. The USGS has assigned a hydraulic conductivity value of 15 feet/day and a specific yield of 10% to



this area. Transmissivity was calculated using spring 2006 groundwater elevations and ranges from 3,000 to 9,000 feet^2/day. There are no known near-surface impermeable layers with a sufficient regional extent that could preclude the recharge of groundwater through surface spreading operations.

Groundwater within this area occurs at a depth of approximately 250 feet below the ground surface and flows northwest at a gradient of approximately 0.006. The influence of groundwater recharge on the groundwater flow direction is dependant on the size of the recharge program and groundwater production both near the recharge project and regionally.

This area is within the Pearland subbasin, which is defined by the San Andreas Fault Zone to the south and faults inferred by abrupt groundwater elevation changes on the west and north. This provides a physical containment of recharge water within the Buttes subbasin, although some hydraulic communication between adjacent subbasins is likely.

Based on data provided by the PWD and the USGS, there are no significant water quality issues that could adversely affect groundwater recharge. TDS and nitrate (as N) are typically less than 250 mg/L and 1 mg/L, respectively. There are two wells (PWD-22 and PWD-26) that have nitrate concentrations around 3 mg/L, which is slightly above the average for the subbasin, but well below the MCL of 10 mg/L.

The Palmdale WRP is approximately 5.3 miles northwest of the ULRC recharge area, and the California Aqueduct is approximately 0.3 miles to the south.

This site is not within any known ecologically sensitive areas.

3.2.3 Lower Littlerock Creek

The LLRC recharge area encompasses approximately 1,700 acres in the northeastern portion of the City of Palmdale at the intersection of East 70th Street and Avenue N along the eastern bank of Littlerock Creek. The area ranges in elevation from approximately 2,480 to 2,550 feet above msl with a surface gradient towards the north.

The USGS NWIS database contains several wells within the vicinity of the LLRC recharge area. The status and use of these wells is unknown. There are no known municipal water purveyors or wells within 500 feet of the LLRC recharge area (Figure 3-2). The exact location and use of nearby wells is unknown and will need to be verified if this site is selected for future consideration.

The aquifer characteristics proximate to this recharge area are summarized in Table 3-2. The USGS modeled this area with a hydraulic conductivity of 24 feet/day and a specific yield of 12 to 14%. Transmissivity was calculated using spring 2006 groundwater elevations and is approximately 6,500 feet^2/day. There are no known near-surface impermeable layers with a



sufficient regional extent that could preclude the recharge of groundwater through surface spreading operations.

Groundwater within this area occurs at a depth of approximately 300 feet below ground surface and flows northwest at a gradient of approximately 0.007. The influence of groundwater recharge on the groundwater flow direction is dependant on the size of the recharge program and groundwater production both near the recharge project and regionally.

This area is within the far eastern edge of the Lancaster subbasin. The only known boundary to groundwater flow occurs on the southeast side of the recharge area and is defined by a fault that has been inferred by abrupt groundwater elevation changes. The physical containment of recharge water could be achieved through the existing groundwater pumping depression to the southwest of the recharge site.

Very limited data exists on the groundwater quality beneath this recharge area. Duell (1987) suggests TDS concentrations in the range of 250-350 mg/L and nitrate concentrations below the MCL (10 mg/L as N).

To the southwest of the LLRC recharge area, there are nitrate concentrations above the MCL (10 mg/L as N), related to Palmdale WRP effluent discharge practices. Data from Los Angeles County Sanitation District (LACSD) No. 20 monitoring wells at the Palmdale WRP historically have shown nitrate concentrations ranging from less than 1 mg/L to approximately 15 mg/L (Geomatrix, 2004). Figure 2-11 shows the extent of a nitrate plume with concentrations that exceed the MCL within the upper 50 feet of the water table. The plume area is approximately 2,200 acres and is in the northern portion of the Palmdale WRP effluent management site.

The Palmdale WRP is approximately 3.9 miles southwest of the LLRC recharge area, and the California Aqueduct is approximately 7 miles south.

This site is not within any known ecologically sensitive areas.



TABLE 3-2: HYDROGEOLOGIC CHARACTERIZATION OF LAYER 1 (SPRING 2006)

Site Name	S_y (%)	K_h (ft/day)	K_v (ft/day)	b (ft)	T (ft^2/day)	Flow Direction	Gradient (ft/ft)	Groundwater Depth (ft-bgs)
LAC	12-14	5-24	0.5-2.4	510	2,550-12,240	SE	.006	400-500
ULRC	10	15	1.5	700	10,500	W-NW	.006 - .01	150-200
LLRC	12-14	24	2.4	250	6,000	NW	.007	300

Notes:
S_y = Specific yield
K_h = Hydraulic conductivity (horizontal)
K_v = Hydraulic conductivity (vertical)
b = Saturated thickness beneath the recharge basin
T = Transmissivity
ft – bgs = feet below ground surface

3.3 Analytical Modeling of Site Recharge Capacity

This section summarizes the analytical modeling results for the recharge of water via surface spreading. Specifically, the modeling addressed how the water table and the vadose zone would respond to various recharge scenarios. The methodology and results are presented below.

3.3.1 Model Parameters and Preparation

Multiple models were used in this Study to achieve the modeling goals. MODFLOW and MT3DMS were used to estimate the groundwater flow and transport of recharged water, respectively. Other models and codes were used to support MODFLOW and MT3DMS. Groundwater Vistas, Version 3 was the modeling design system, and was used as a graphical design and analysis system for MODFLOW and MT3DMS. ArcMAP 9.2 was used as a pre- and post-processing tool to manipulate input data and display simulation results. Each model is summarized below:

- MODFLOW – is a modular three-dimensional finite-difference groundwater flow model. Several versions of MODFLOW have been developed by the USGS and released to the public domain. The most recent version is MODFLOW-2005. Comprehensive documentation of MODFLOW-2005 can be found at:

  http://water.usgs.gov/nrp/gwsoftware/modflow2005/modflow2005.html.

  Of particular note, the estimates discussed below were determined using a MODFLOW groundwater model (hereafter, the groundwater model) of the Antelope Valley



developed by the USGS in 1995. A detailed description of the groundwater model can be found in *Simulation of Ground-Water Flow and Land Subsidence, Antelope Valley Ground-Water Basin, California: USGS Water-Resources Investigations Report 03-4016* (Leighton, 2003). This groundwater model was not created by Wildermuth Environmental, and the accuracy of the data used to create the model cannot be verified. A more detailed model could provide different results, and a more rigorous model will be necessary to meet the requirements of a Title 22 engineering report for recycled water recharge.

- MT3DMS – also developed by the USGS, MT3DMS is a modular three-dimensional multi-species transport model for the simulation of advection, dispersion, and chemical reactions of contaminants in groundwater systems. MT3DMS works with output files from steady-state or transient groundwater flow simulations by MODFLOW. Comprehensive documentation of MT3DMS can be found at:

  http://water.usgs.gov/software/mt3dms.html.

- Groundwater Vistas – is a groundwater modeling environment that was created for the Microsoft Windows platform. In this investigation, it served as the modeling design system and a graphical analysis tool for MODFLOW and MT3DMS. Groundwater Vistas can read and export ArcGIS shapefiles, which allows for the creation of input data and the display of output results in ArcMAP 9.2. Comprehensive documentation of Groundwater Vistas can be found on at:

  http://www.groundwater-vistas.com.

For MT3DMS, it was assumed that there was no soil adsorption and reactivity of recharged water in the percolation and migration process, which is a conservative assumption. Longitudinal dispersivity was set to 100 feet, and the transverse dispersivity was set to be one-third of the longitudinal dispersivity. The dispersivity value used herein is based on a measured solute breakthrough curve in a similar groundwater basin and is a conservative value.

To provide more accurate and useable data for this Study, several refinements were made to the MODFLOW model, including the following:

- The model grid size was reduced from 1-mile by 1-mile to 1,320-feet by 1,320-feet; 1/16th of the original size.
- All hydraulic parameters specified in the model were kriged based on the new grid cell size.
- The ground surface elevation was re-specified based on the refined grid cells and the 30-meter digital elevation model for storage estimates (described in Section 2.3).
- Natural recharge, evapotranspiration rate, and pumping volumes and distributions were adopted from the USGS model.



- Model Layer 1, defined in Section 2.3, was modified to an unconfined condition for the purpose of artificial recharge.
- The spring 2006 groundwater elevations, as shown in Figure 2-7, were used as the initial groundwater level.

3.3.2 Effects of Recharge on the Water Table and Vadose Zone

The goal of this effort was to determine how the water table and vadose zone respond under various recharge scenarios. The concern is that the water table beneath a recharge basin will rise or mound until the water table mound reaches the ground surface or becomes sufficiently close to the ground surface such that liquefaction becomes an issue.

Mounding results from the inability of the recharged water to move away from the recharge area and redistribute within the aquifer. This movement, or getaway capacity, is primarily a function of the vadose zone thickness, aquifer thickness relative to the size of the recharge basin, and the hydraulic conductivity of the underlying sediments.

The thickness of the vadose zone plays a significant role in the amount of water that can be applied to a recharge area. A relatively thick vadose zone will allow more recharge than a thin vadose zone (assuming all other factors are the same) as there is simply more available pore space (porosity) that can receive recharged water. The vadose zone thickness in the LAC, ULRC, and LLRC recharge areas is approximately 450, 175, and 300 feet, respectively. In addition, soil aquifer treatment (SAT) increases with increased vadose zone thickness.

The thickness of the aquifer also affects groundwater mounding beneath a recharge site. As with the vadose zone, a relatively thick aquifer will allow a faster redistribution of recharge water, reducing the duration and severity of mounding beneath a recharge basin. The aquifer thickness values used in this Study were based on USGS groundwater model layers. For the model, bedrock was set at a uniform elevation of 1,000 feet above msl except where bedrock was observed above this elevation. The depth to bedrock and the aquifer thickness of each recharge area is as follows:

- **Lower Amargosa Creek**: Bedrock occurs at a depth of approximately 1,590 feet above msl with an aquifer thickness of approximately 510 feet.
- **Upper Littlerock Creek**: Bedrock occurs at a depth of approximately 1,950 feet above msl with an aquifer thickness of approximately 700 feet.
- **Lower Littlerock Creek**: Bedrock occurs at a depth of approximately 1,000 feet above msl, but the area is reportedly (Leighton, 2003) underlain by lacustrine deposits at a depth of 1,950 feet above msl; therefore, the effective aquifer is considered to consist of the saturated materials between the water table (2,200 feet above MSL) and the lacustrine deposits (1,950 feet above MSL), resulting in an aquifer thickness of 250 feet.



The hydraulic conductivity of the aquifer also determines how quickly recharge water can move away from a recharge area and be redistributed. Low hydraulic conductivity values result in a slow rate of groundwater redistribution. The hydraulic conductivity of the recharge areas ranges from 5 feet/day in the southern half of the LAC recharge area to 24 feet/day in the LLRC recharge area and in the northern half of the LAC recharge area. These hydraulic conductivity values are typical of unconsolidated fine to coarse grain sands (Fetter, 1988).

Table 3-4 summarizes the modeling results for each recharge scenario.

3.3.2.1 Recharge Scenario 1

The first recharge scenario (Scenario 1) entailed the application of 50,000 af of water to each recharge area over a 4-month (120 day) period. This scenario was the simplest: it involved the application of the same volume of water (50,000 af) to each basin.

The results of Scenario 1 show groundwater mounding to the ground surface within the first year in the ULRC, within 10 years in the LLRC, and within 20 years in the LAC.

3.3.2.2 Recharge Scenario 2

Because Scenario 1 modeling results for the ULRC recharge area indicated that groundwater would mound to the ground surface within the first year of recharge, Scenario 2 was developed and run for ULRC only. Scenario 2 was developed to determine the volume of water that could be sustainably recharged at ULRC with no additional groundwater extraction.

The Scenario 2 results show that approximately 10,000 af of water could be recharged into the ULRC recharge area for 18 years prior to prohibitive mounding without any additional groundwater extraction.

3.3.2.3 Recharge Scenario 3

Recharge Scenario 3 included 15,000 and 50,000 af recharge projects, occurring over a 4 month time frame. In addition, pumping was added to the model at a rate equal to extraction during the 8 months following recharge.

All of the recharge areas were able to sustain over 25 years of recharge and extraction for a 15,000 af project. The LLRC and LAC could also sustain over 25 years of recharge for a 50,000 af project. At the ULRC, however, mounding became prohibitive during the first application of 50,000 af.



TABLE 3-3: MODELING RESULTS FOR RECHARGE BASIN SCENARIOS

Basin	Area (acres)	Annual Recharge Volume (af)	Annual Pumping Volume (af)	Years to Mounding
Scenario 1				
LAC	1671	50,000	0	20
ULRC	1137	50,000	0	1
LLRC	1680	50,000	0	10
Scenario 2				
LAC	1671	50,000	0	20
ULRC	1137	10,000	0	18
LLRC	1680	50,000	0	10
Scenario 3				
LAC	1671	15,000	15,000	>25
		50,000	50,000	>25
ULRC	1137	15,000	15,000	>25
		50,000	50,000	1
LLRC	1680	15,000	15,000	>25
		50,000	50,000	>25

3.3.3 Underground Retention Time of Recharged Water

A necessary step in the implementation of a groundwater recharge program that uses recycled water is to determine the underground retention time (URT) of recycled water in the vadose and saturated zones from beneath the recharge basin to the nearest down gradient domestic or municipal groundwater supply well. The URT can be estimated as the sum of the travel time through the vadose zone and the travel time in the saturated zone from beneath the recharge basin to the nearest domestic supply well. The exact location and status of all down gradient domestic and municipal wells is not know at this time; therefore, instead of determining the



URT to down gradient wells, the extent of the recharged water plume was estimated for time intervals of 6 months and 5 years after recharge water was applied.

Travel time estimates in the vadose zone are based on the application of Darcy's equation, using the aquifer properties applied in the groundwater model. Travel times in the saturated zone are based on groundwater model predictions, using the simulated recharge plans defined herein and the USGS model parameters previously described.

3.3.3.1 Travel Time in the Vadose Zone

Under fully saturated conditions, the travel time in the vadose zone is calculated by dividing the depth to groundwater under each recharge basin by an estimate of the seepage velocity through the vadose zone:

$$Ttv = \frac{Sv}{Vv}$$

Where:

- Ttv is the travel time through the vadose zone from the ground surface to the water table (days)
- Sv is the distance through the vadose zone from the ground surface to the water table (feet)
- Vv is the seepage velocity in the vertical direction (feet/day)

The seepage velocity is estimated with Darcy's equation:

$$Vv = \frac{Kv * Iv}{\theta}$$

Where:

- Kv is the vertical hydraulic conductivity of the vadose zone and ranges between 0.5 and 3.0 feet/day (Leighton, 2003)
- Iv is the vertical hydraulic gradient assumed to be unity or "1" (dimensionless)
- θ is the effective porosity of the vadose zone, assumed to be 0.20, which is typical of unconsolidated fine to coarse sediments (dimensionless)

Using the value ranges for Kv and an average vadose zone thickness (Sv) of 333 feet, the calculated travel time in the vadose zone ranges from approximately 20 to 130 days.



3.3.3.2 Travel Time in the Saturated Zone

Travel time in the saturated zone is based on groundwater model predictions using the recharge scenarios defined herein and the USGS estimates of groundwater recharge and extraction defined in its model. The modeling strategy that was used to estimate travel time in the saturated zone from the recharge basin to the nearest down gradient wells is as follows:

- Using MODFLOW, estimate the groundwater hydraulic response to future groundwater management plans including the recharge projects described herein.
- Using MT3DMS, estimate the transport of recharged water in the saturated zone.

The travel time in the saturated zone is estimated by calculating the elapsed time between the start of recharge and the arrival of the recharged water plume at a domestic supply well, as determined when the recycled water content at the well exceeds 0.02 percent (the value at which numerical dispersion is negligible). As previously addressed, the exact location of domestic supply wells in the vicinity of the recharge basins is not known, therefore the distance the recycled water will travel away from the recharge site was estimated.

The extent of the recharged water plume following 6 months and 5 years of recharge at each site is approximately 1,900 and 3,900 feet, respectively (Figures 3-2 and 3-3). The shape of the recycled water plume is controlled within the model by the distribution of 15 extraction wells around the recharge site and the size of the model grids.

The recycled water plume in the southern portion of the ULRC recharge area is truncated as a result of the model boundaries. Refinement of the model is recommended during subsequent site analyses.

3.4 Preferred Site

Table 3-4 presents a qualitative ranking of each recharge site, based on siting criteria and groundwater modeling results. Each site was ranked on a scale of 1 to 3, with 1 being the highest rank for the given criterion. If the areas were considered equal on a particular criterion, they were given the same score. The site with the lowest score is the best qualified site relative to the others.



TABLE 3-4: SITE EVALUATION SUMMARY

Site Name	Lower Amargosa Creek	Upper Littlerock Creek	Lower Littlerock Creek
DHS Regulations	3	1	2
Local Hydrogeology	1	2	3
Land Size Requirements	2	3	1
Proximity to Water Sources	2	1	3
Land Use Consistency, Permitting, and Ownership	3	1	2
Groundwater Modeling	1	2	1
Total	**12**	**10**	**12**

The ULRC recharge area ranks highest among the sites; and although the scoring is close enough for each site to be considered equal, it is our recommendation that the ULRC be considered the preferred site for initiating recycled water groundwater recharge. In addition to its ranking, the existing and historic aggregate mining within the area was a major factor in the selection of this recharge area. This type of land use results in open excavations that are well suited for recharge basins. And, once mining operations cease, the land must be reclaimed in accordance with the Surface Mining and Reclamation Act of 1975, devaluing the land for virtually any future use other than an open recharge basin. Hence, the future use of this land for a recharge project benefits both the current land owner and the PWD.

The ULRC recharge area is comprised of 36 parcels of land as shown in Figure 3-3. The majority of these parcels are currently or were historically used for aggregate mining operations. Table 3-5 summarizes the parcels overlain by the ULRC recharge area, including land values, improvement values, and parcel sizes.

As previously stated, there are active aggregate mines in the vicinity of the ULRC recharge area, and any recharge plans in the area will have to consider and mitigate potential adverse impacts on existing mining operations. The most likely impact on existing mining operations would be rising groundwater in the bottom of mine excavations.

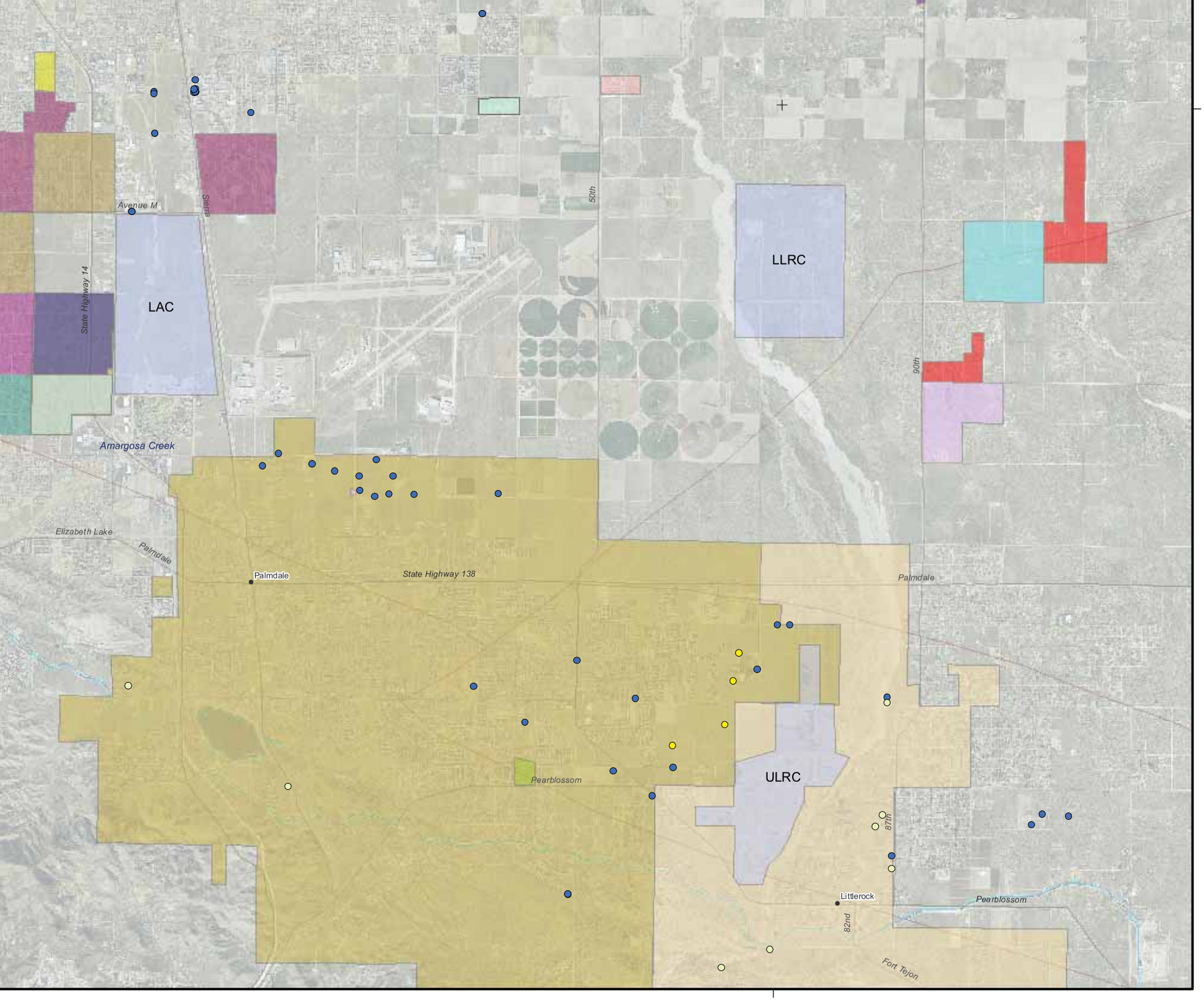


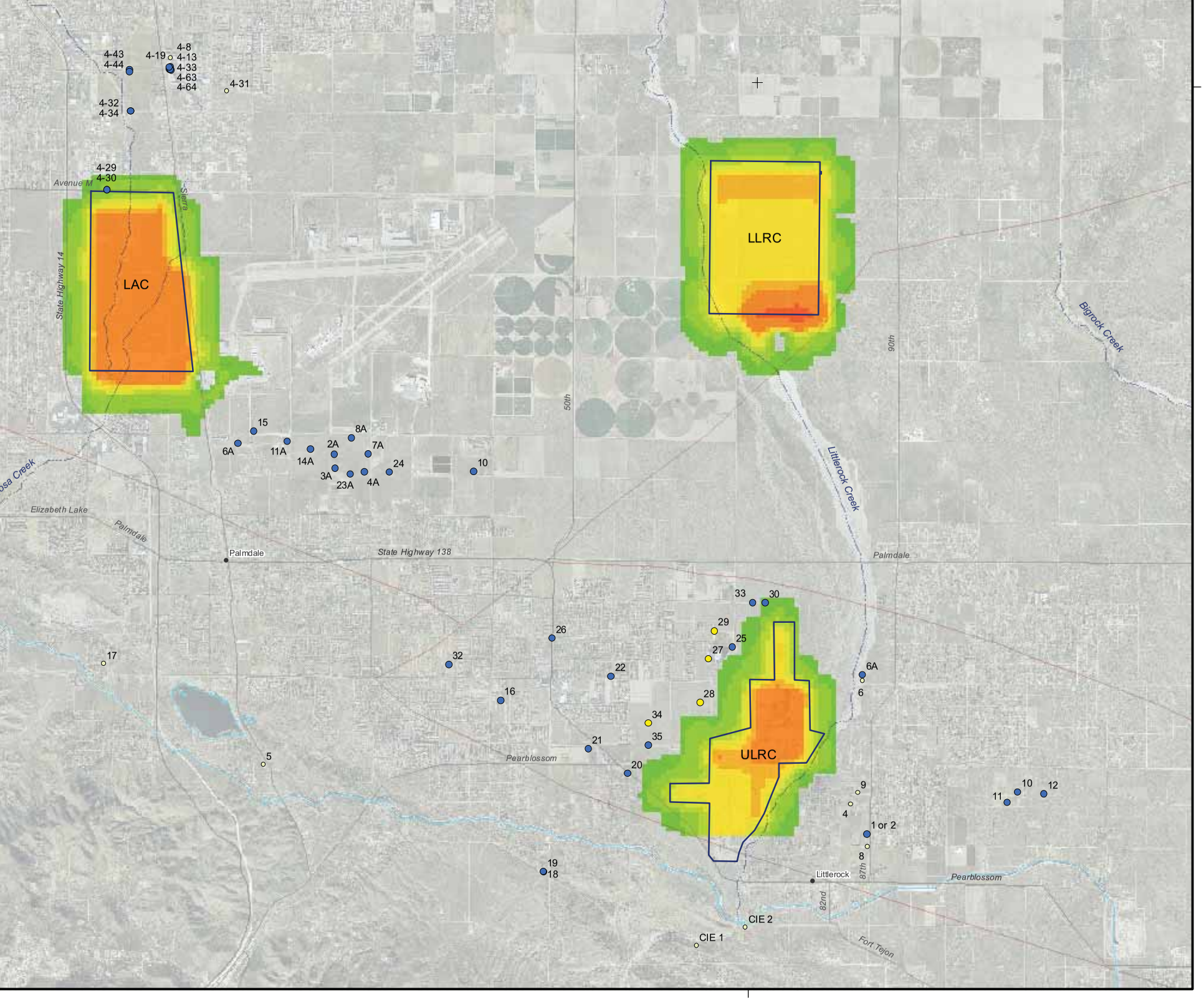
TABLE 3-5: SUMMARY OF ULRC PARCEL OWNERS

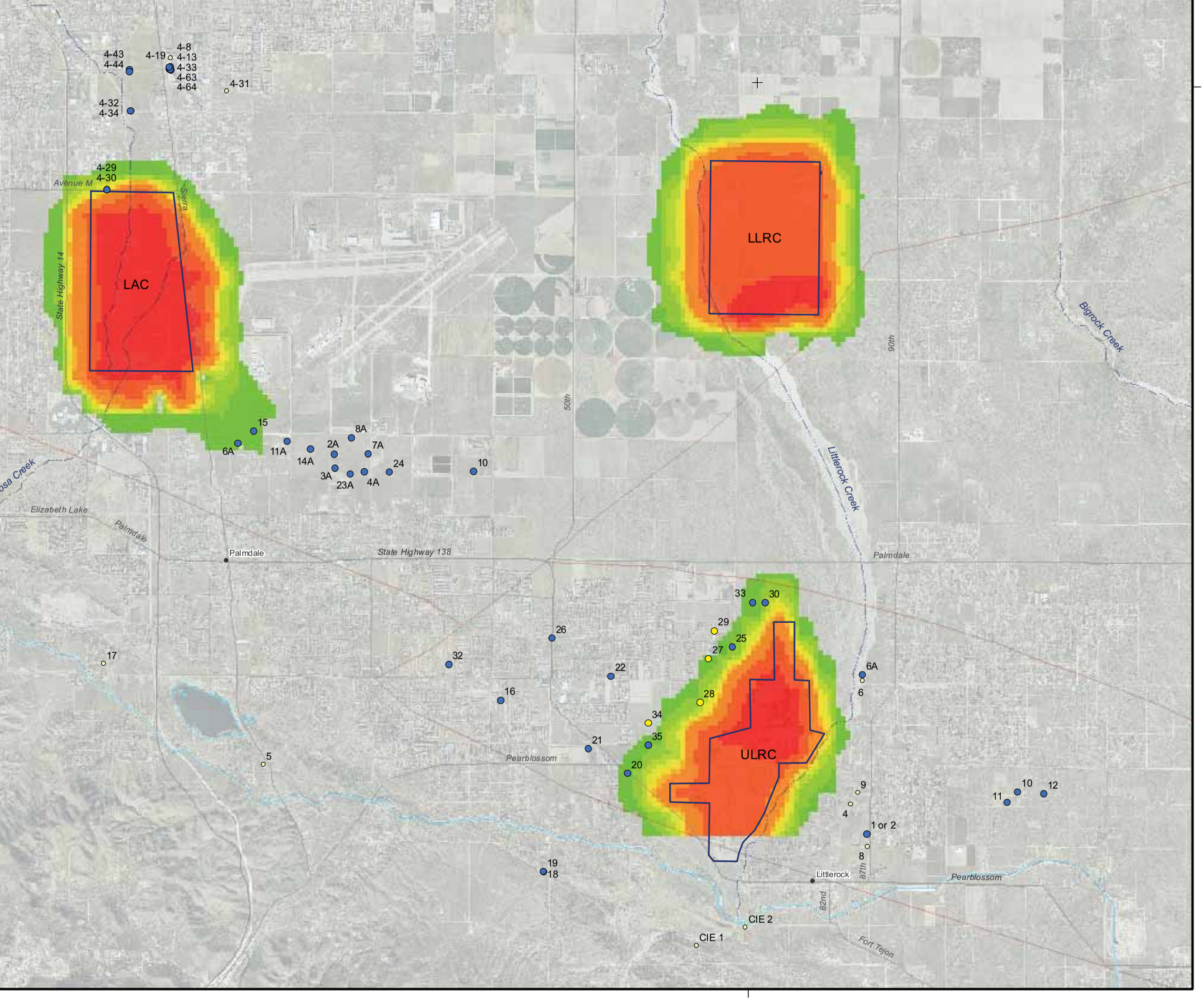
Site No.	AIN	Area (sq. ft.)	Land Value	Improvement Value	GPP Value	Fixture Value
0	3024015055	3,527,274	$ 3,370	$ 20,079	$ -	$ -
1	3024016001	3,584,148	$ 64,573	$ -	$ -	$ -
2	3050011028	200,315	$ 17,844	$ -	$ -	$ -
3	3050011027	417,421	$ 24,985	$ -	$ -	$ -
4	3050011008	216,312	$ 14,334	$ -	$ -	$ -
5	3050022013	1,736,315	$ 68,883	$ -	$ -	$ -
6	3050010015	6,917,452	$ 274,045	$ -	$ -	$ -
7	3050011009	212,732	$ 74,393	$ 74,515	$ -	$ -
8	3050011023	1,699,611	$ 67,316	$ -	$ -	$ -
9	3050010006	868,438	$ 3,243	$ -	$ -	$ -
10	3050022014	835,498	$ 31,556	$ -	$ -	$ -
11	3050022015	848,655	$ 38,578	$ 5,720	$ -	$ -
12	3050022016	835,283	$ 186,415	$ 1,261,904	$ -	$ -
13	3050028015	3,407,588	$ 42,699	$ -	$ -	$ -
14	3050011029	849,349	$ 51,824	$ -	$ -	$ -
15	3050011026	636,400	$ 75,655	$ -	$ -	$ -
16	3050011004	849,217	$ 52,007	$ -	$ -	$ -
17	3050010016	2,475,238	$ 8,815	$ -	$ -	$ -
18	3050011001	851,685	$ 52,007	$ -	$ -	$ -
19	3051008002	3,658,958	$ 3,379	$ -	$ -	$ -
20	3051008003	1,808,703	$ 82,511	$ -	$ -	$ -
21	3050022010	2,441,153	$ 76,415	$ 59,186	$ -	$ -
22	3050008029	4,996,947	$ 203,906	$ -	$ 1,341,342	$ 3,580,236
23	3051008004	1,800,961	$ 1,657	$ -	$ -	$ -
24	3051008013	6,353,938	$ 63,610	$ 169,701	$ 180,990	$ 1,100,422
25	3051008800	269,553	$ -	$ -	$ -	$ -
26	3051008011	2,053,388	$ 10,497	$ -	$ -	$ -
27	3051007903	312,777	$ 5,607	$ -	$ -	$ -
28	3051007008	440,286	$ 2,349	$ -	$ -	$ -
29	3051008006	1,868,991	$ 1,802	$ -	$ -	$ -
30	3051008001	1,794,688	$ 30,480	$ -	$ -	$ -
31	3051008012	266,007	$ 17,923	$ -	$ -	$ -
32	3051008010	1,205,978	$ 32,630	$ -	$ -	$ -
33	3051009014	5,623,800	$ 330,689	$ -	$ 934,085	$ 1,372,234
34	3051008801	267,308	$ -	$ -	$ -	$ -
35	3051007015	1,679,931	$ 8,880	$ 3,745	$ -	$ -

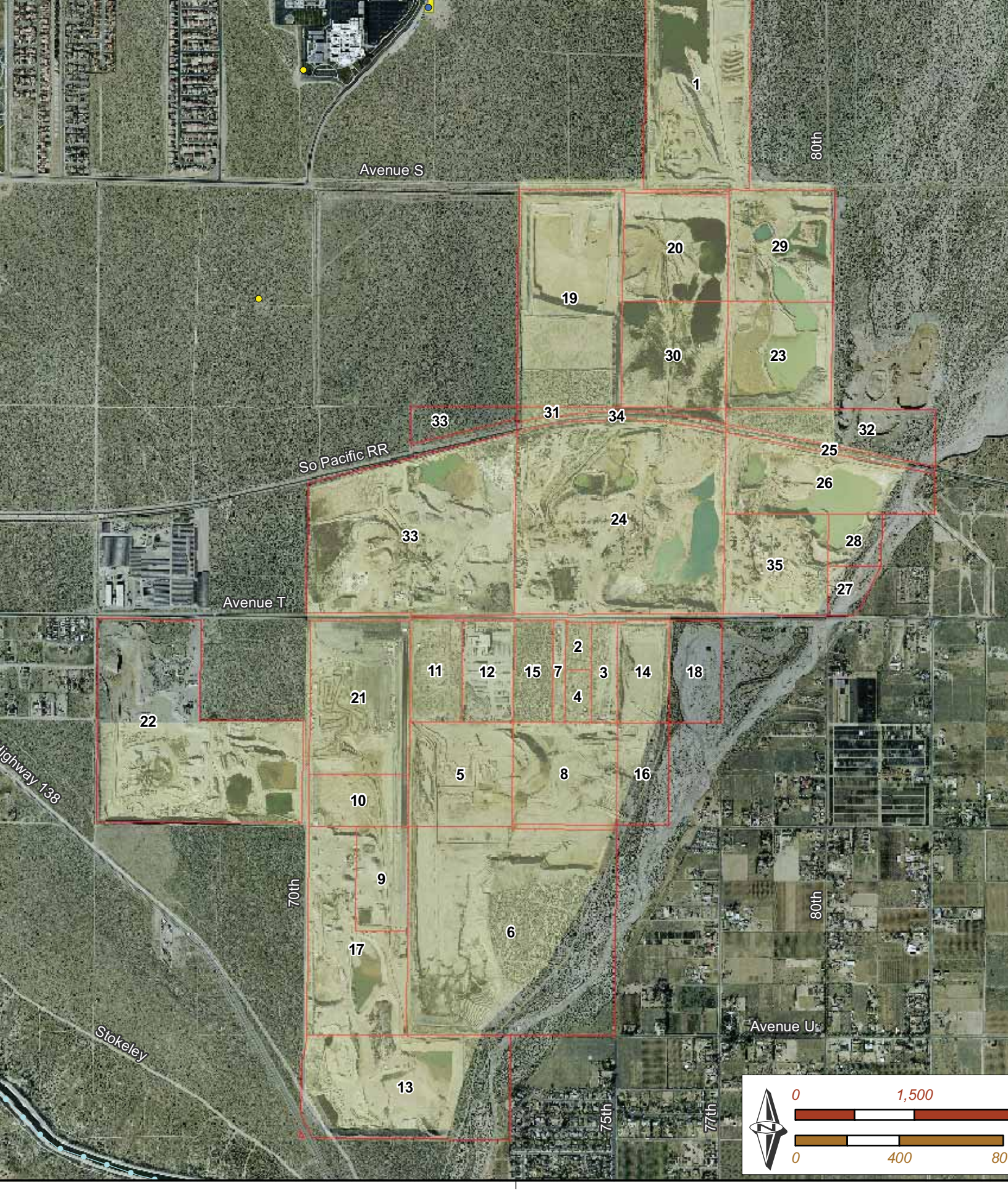
Note:
GPP = Gross personal property




LAC
LLRC
ULRC
Avenue M
Sierra
50th
90th
State Highway 14
Amargosa Creek
Elizabeth Lake
Palmdale
State Highway 138
Pearblossom
Littlerock
82nd
87th
Fort Tejon
34°40'0"N
118°0'0"W
Municipal
Active
Inactive
Planne
Palm Ra
Littlerock
Quartz H
California
Evergree
Reesdale
Agua J M
Antelope
Fortieth S
Tierra Bo
Great We
Kebb Co
Deep We
Joshua A
White Fe
Sunnysic
White Fe
El Dorad
Shadow
Westside

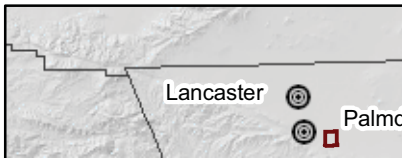

LAC
LLRC
ULRC
4-43
4-44
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4-8
4-13
4-33
4-63
4-64
4-31
4-32
4-34
4-29
4-30
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6A
11A
14A
2A
8A
7A
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CIE 1
Avenue M
Sierra
State Highway 14
50th
90th
Bigrock Creek
Littlerock Creek
Elizabeth Lake
Palmdale
State Highway 138
Pearblossom
Littlerock
87th
82nd
Fort Tejon
34°40'0"N
118°0'0"W
Municipal
Active
Inactive
Planne


LAC
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23A
8A
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4A
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Littlerock Creek
90th
Bigrock Creek
Elizabeth Lake
Palmdale
State Highway 138
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9
4
1 or 2
8
11
10
12
19
18
87th
82nd
Littlerock
Pearblossom
CIE 2
CIE 1
Fort Tejon
34°40'0"N
118°0'0"W
Municipal
Active
Inactiv
Planne



118°0'0"W

Groundwater Production Wells



4 RECONNAISSANCE-LEVEL ENGINEERING AND COST ESTIMATES

4.1 Facility Description and Operations Plan

Reconnaissance-level facilities and operations plans for the delivery of recycled and diluent water were prepared for the ULRC recharge area. Modeling efforts have indicated that a 15,000 af recharge project is feasible for this area. Recycled water would be tertiary treated effluent from the Palmdale WRP, and diluent would be storm and SWP water. Conceptual level facility plans for the delivery of recycled water for direct and indirect reuse within the Antelope Valley were prepared by the Los Angeles County Sanitation Districts and WWD No. 40 (Kennedy/Jenks, 2006). Phases 2 through 4 of the facility plans include recycled water distribution facilities for the Palmdale WRP. The ULRC facilities and operations plan discussed herein incorporates the regional facility plans.

Figure 4-1 presents an overview of the facilities for the ULRC project. In order to deliver the required volume of recycled water, modifications were made to planned regional facilities, including increased pipe diameters and pump capacity. Moreover, new facilities for the delivery of recycled and diluent water are presented, including pipelines, blending stations, an SWP turnout, and diversion structures.

Recycled water will be pumped from the Palmdale WRP Plant through the planned Phase 2, 36-inch diameter recycled water line and planned Phase 3, 36-inch diameter recycled water line. The planned Phase 3, 14-inch diameter line would be increased to an 18-inch diameter line in order to provide capacity for the ULRC recycled water recharge project. A new 18-inch diameter lateral will deliver recycled water from the planned Phase 3 pipeline to the recharge basin. A series of pipeline and diversion structures will deliver water to cells within the basin.

Under the in-basin dilution scenario, SWP water would be delivered to the recharge basin through at turnout on the aqueduct and a 36-inch diameter pipeline. The Littlerock Creek dilution scenario would require a turnout from the aqueduct at Littlerock Creek where SWP water would be applied.

We have prepared several operational concepts for this project, including 10,000 af and 15,000 af projects and in-basin SWP delivery or Littlerock Creek SWP delivery.

4.1.1 In-Facility Dilution

In-facility dilution assumes that all recharge water will be applied within an engineered recharge basin. Using this method, both recycled and diluent water are delivered to the recharge basin and allowed to recharge to the aquifer. The mixing of recycled and diluent water occurs either in the basin or, if applied independently, in the vadose zone and aquifer underlying the basin.



In-facility dilution is the approach used in the Chino Basin and is the most readily accepted method from a regulatory standpoint. Relative to Littlerock Creek dilution, in-facility dilution includes the following benefits:

- It is readily accepted by the DHS and RWQCB.
- It provides operational flexibility, as the facilities are owned by the operator.
- It provides control over the application of recharge water.

4.1.2 Littlerock Creek Dilution

Littlerock Creek dilution assumes that all recycled water is delivered to the recharge basin and diluent water is applied to Littlerock Creek directly from an SWP turnout. This method requires a demonstration that dilution is occurring in the subsurface.

Relative to in-basin dilution, Littlerock Creek Dilution includes the following benefits:

- The construction costs for SWP delivery are eliminated.
- The recharge basin size is reduced.

4.2 Cost Estimates

The costs estimates for implementing the ULRC project are for the new and/or upgraded facilities required to deliver recycled and diluent water to the ULRC area and exclude the costs of the facilities identified in the *Final Facilities Planning Report, Antelope Valley Recycled Water Project* (Kennedy/Jenks, 2006). Table 4-1 presents the costs associated with recharge facility construction, operation, and maintenance for four recharge scenarios: 10,000 afy and 15,000 afy projects with either in-basin dilution or Littlerock Creek dilution. The unit cost of recharge water ranges from $73/af for the 15,000 afy Littlerock Creek dilution scenario to $131/af for the 10,000 afy in-basin dilution scenario. The reconnaissance-level construction, annual, and unit costs of recharge for these projects are summarized in Table 4-2, and the following charts show the relationship between capacity and costs. The annualized cost is based on 5% interest over a 20 year amortization schedule.



TABLE 4-1: RECONNAISSANCE-LEVEL FACILITIES COST ESTIMATE FOR A RECHARGE PROJECT IN THE UPPER LITTLEROCK CREEK AREA THAT USES RECYCLED AND STATE WATER PROJECT WATERS

Cost Item	10,000 Recharge Project (2,000 Recycled and 8,000 SWP Waters)		15,000 Recharge Project (3,000 Recycled and 12,000 SWP Waters)	
	In-Facility Dilution	Littlerock Creek Dilution	In-Facility Dilution	Littlerock Creek Dilution
Facility Construction Costs				
Recycled Water Pump Station	$637,000	$637,000	$956,000	$956,000
Recycled Water Pipelines	$7,278,000	$7,278,000	$7,278,000	$7,278,000
SWP Water Turnout	$500,000	$0	$500,000	$0
SWP Water Pipelines	$1,426,000	$0	$1,426,000	$0
Recharge Basin Turnouts/Blending Station	$600,000	$300,000	$600,000	$300,000
Recharge Basin Land Acquisition[a]				
Recharge Basin Construction[b]				
Recharge Basin Internal Hydraulics[c]				
Subtotal Construction Costs	$10,441,000	$8,215,000	$10,760,000	$8,534,000
Contingency (25%)	$2,611,000	$2,054,000	$2,690,000	$2,134,000
Engineering and Administration (15%)	$1,567,000	$1,233,000	$1,614,000	$1,281,000
Total Construction Costs	*$14,619,000*	*$11,502,000*	*$15,064,000*	*$11,949,000*
Facilities Annual O&M Costs				
Recycled Water Pump Station	$58,000	$58,000	$87,000	$87,000
Recycled Water Pipelines	$30,000	$30,000	$30,000	$30,000
SWP Water Pipelines	$2,000	$0	$2,000	$0
Recharges Basins	$50,000	$10,000	$75,000	$15,000
Total Annual O&M	*$140,000*	*$98,000*	*$194,000*	*$132,000*
Annual Cost				
Annualized Capital Cost	$1,174,000	$923,000	$1,209,000	$959,000
Annual O&M Cost	$140,000	$98,000	$194,000	$132,000
Total Annual Cost	*$1,314,000*	*$1,021,000*	*$1,403,000*	*$1,091,000*
Recharge Capacity (acre-ft/yr)	10,000	10,000	15,000	15,000
Unit Cost of Recharge	$131	$102	$94	$73

Notes:
(a) Land cost is unknown as comparable values for similar distressed properties are not readily available
(b) Assumed to be equal to the mine reclamation costs although it could be more. This assumption should be validated or refined in subsequent investigations.
(c) Assumed negligible herein. This assumption should be validated or refined in subsequent investigations.

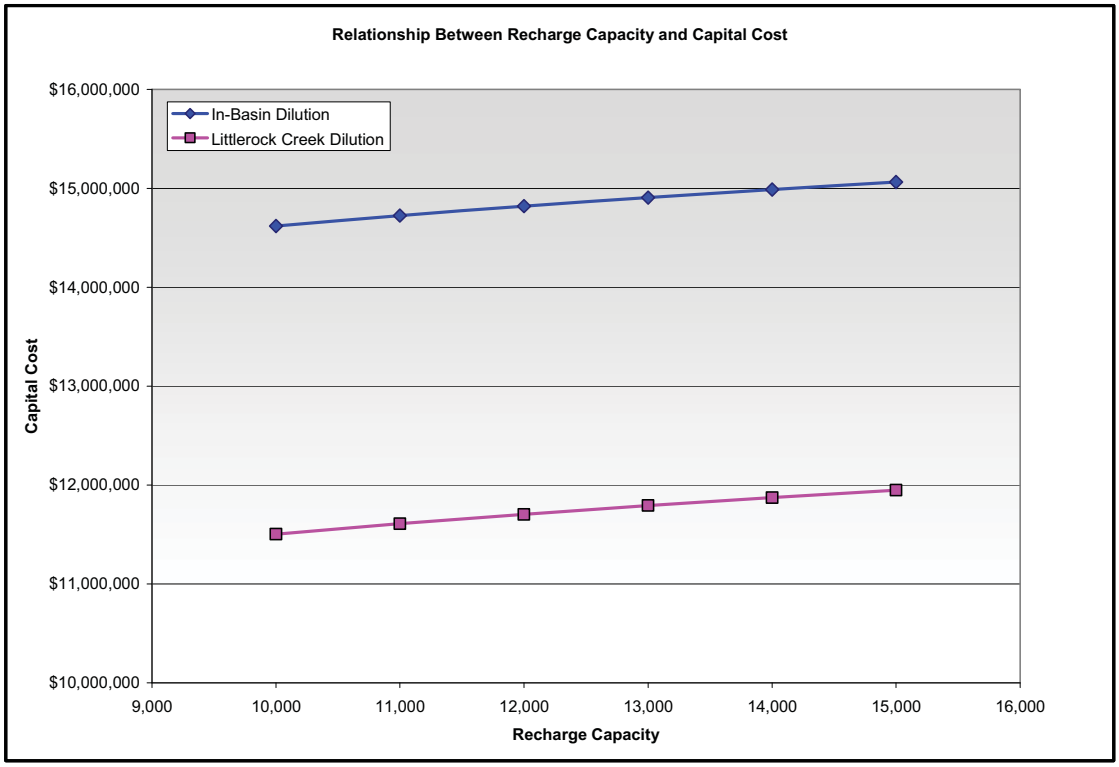


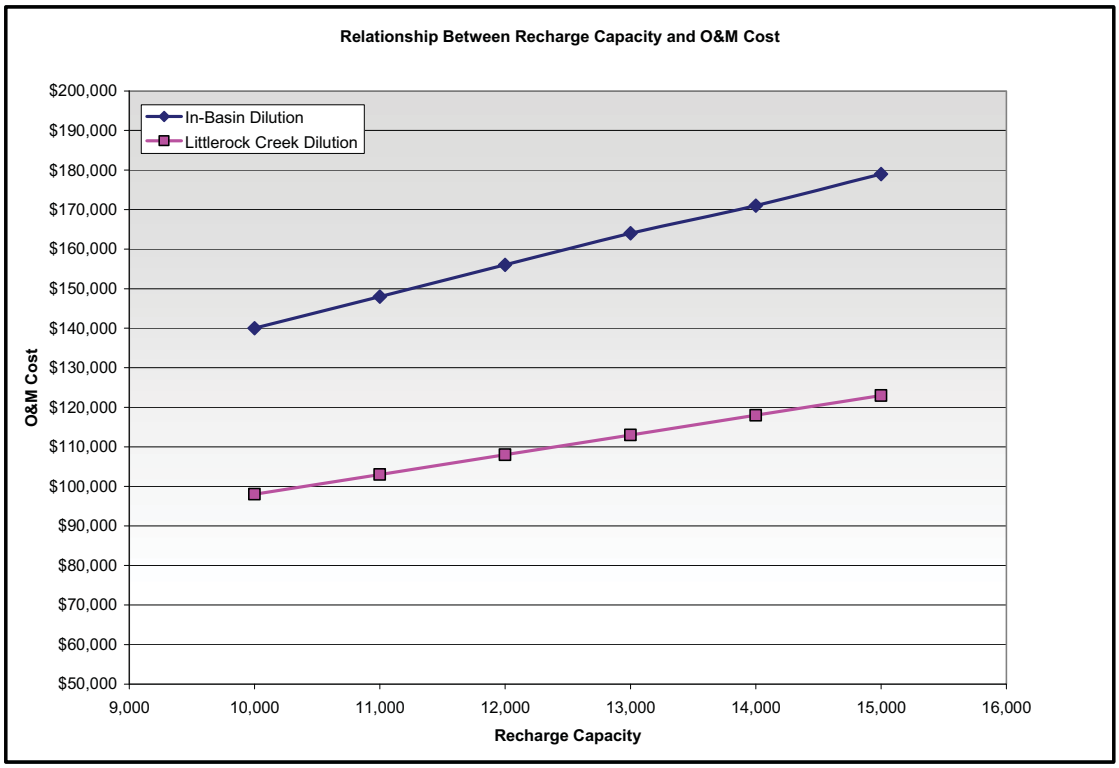
TABLE 4-2: RECONNAISSANCE-LEVEL CONSTRUCTION, ANNUAL AND UNIT COST OF RECHARGE FOR RECHARGE PROJECTS RANGING FROM 10,000 TO 15,000 AFY

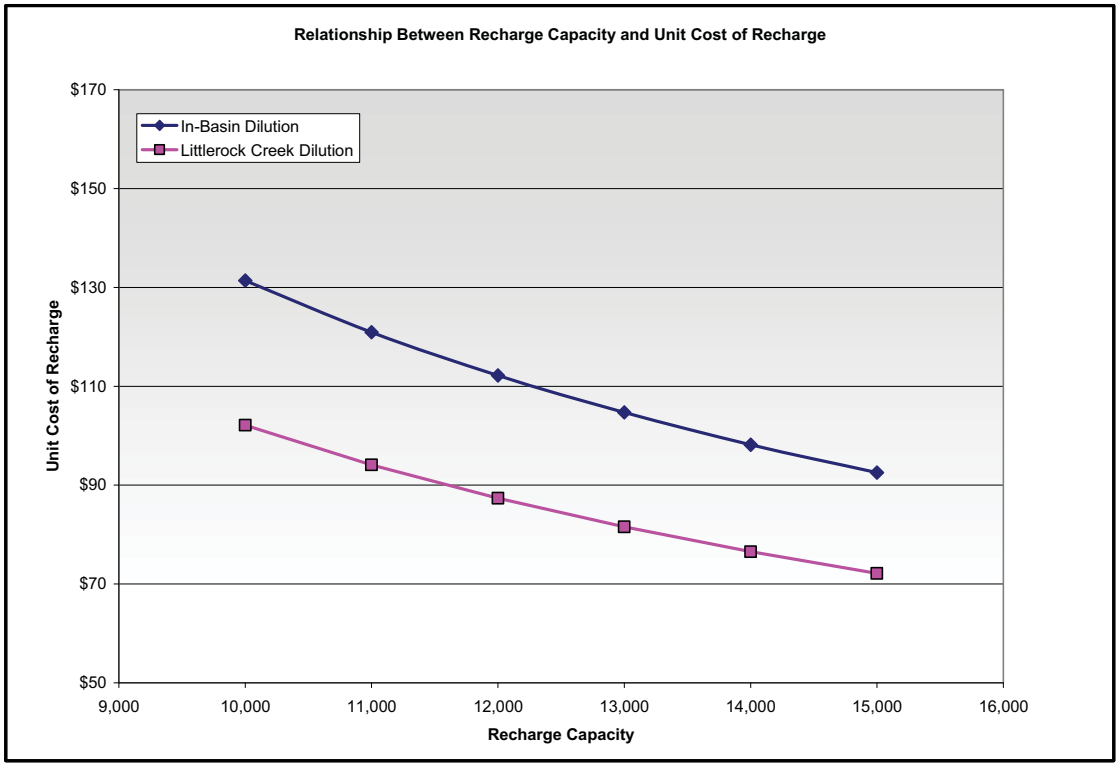
Recharge Capacity (acre-ft/yr)	Capital Cost	Annualized Capital Cost	Annual O&M Cost	Total Annual Cost	Unit Cost of Recharge
		In-Basin Dilution			
10,000	$14,619,000	$1,174,000	$140,000	$1,314,000	$131
11,000	$14,724,000	$1,182,000	$148,000	$1,330,000	$121
12,000	$14,820,000	$1,190,000	$156,000	$1,346,000	$112
13,000	$14,907,000	$1,197,000	$164,000	$1,361,000	$105
14,000	$14,989,000	$1,203,000	$171,000	$1,374,000	$98
15,000	$15,064,000	$1,209,000	$179,000	$1,388,000	$93
		Littlerock Creek Dilution			
10,000	$11,502,000	$923,000	$98,000	$1,021,000	$102
11,000	$11,608,000	$932,000	$103,000	$1,035,000	$94
12,000	$11,703,000	$940,000	$108,000	$1,048,000	$87
13,000	$11,792,000	$947,000	$113,000	$1,060,000	$82
14,000	$11,873,000	$953,000	$118,000	$1,071,000	$77
15,000	$11,949,000	$959,000	$123,000	$1,082,000	$72

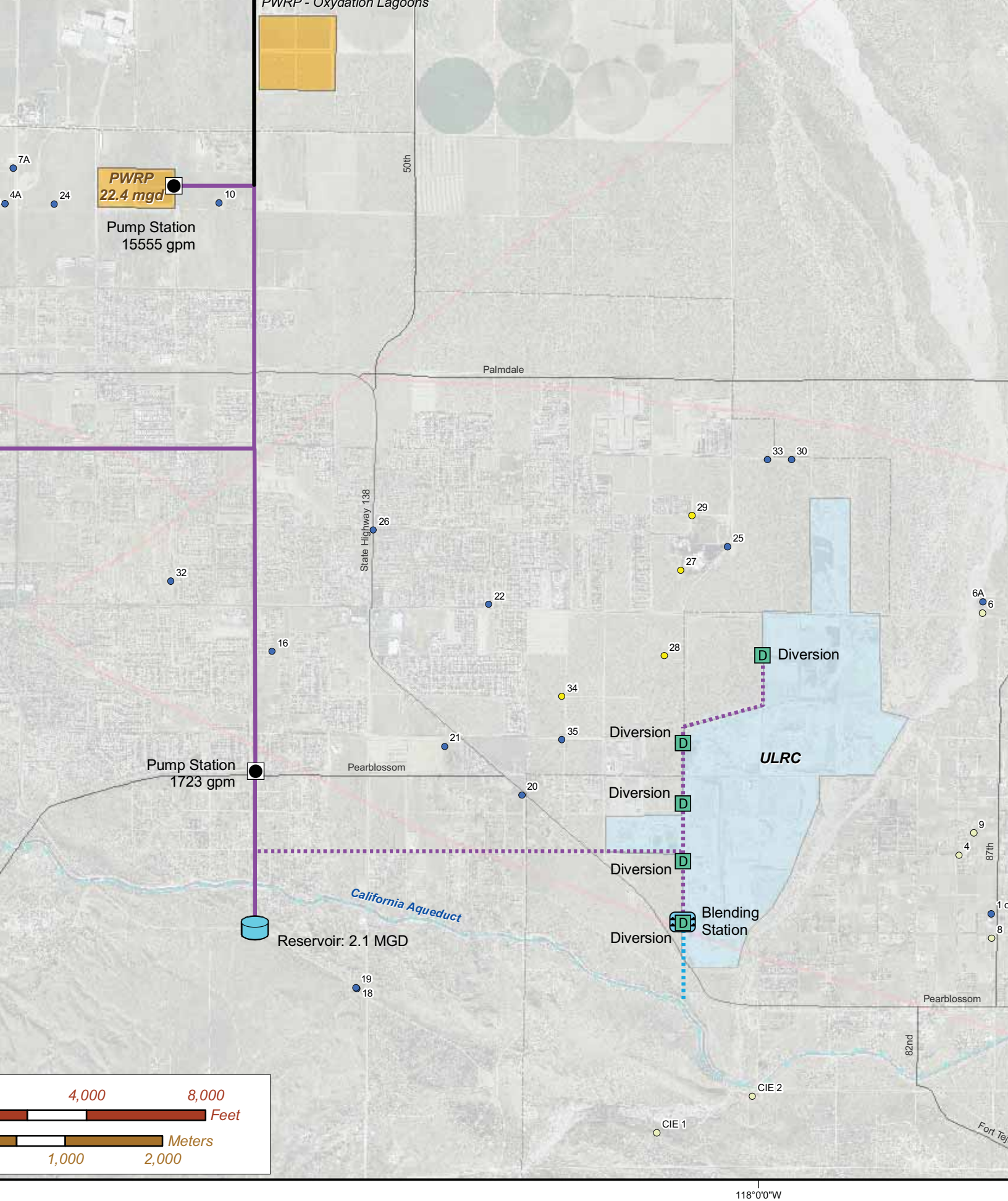
Based on non-linear interpolation of capital cost from Table 4-2 and linear interpolation of O&M cost from Table 4-2.




Relationship Between Recharge Capacity and Capital Cost
$16,000,000
$15,000,000
$14,000,000
$13,000,000
$12,000,000
$11,000,000
$10,000,000
Capital Cost
In-Basin Dilution
Littlerock Creek Dilution
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
Recharge Capacity


Relationship Between Recharge Capacity and O&M Cost
$200,000
$190,000
$180,000
$170,000
$160,000
$150,000
$140,000
$130,000
$120,000
$110,000
$100,000
$90,000
$80,000
$70,000
$60,000
$50,000
O&M Cost
In-Basin Dilution
Littlerock Creek Dilution
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
Recharge Capacity


Relationship Between Recharge Capacity and Unit Cost of Recharge
$170
$150
$130
$110
$90
$70
$50
In-Basin Dilution
Littlerock Creek Dilution
Unit Cost of Recharge
9,000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
Recharge Capacity


PWRP - Oxydation Lagoons
PWRP
22.4 mgd
Pump Station
15555 gpm
7A
4A
24
10
50th
Palmdale
State Highway 138
33
30
29
26
25
27
32
22
6A
6
16
28
D Diversion
34
35
Diversion
21
ULRC
Pump Station
1723 gpm
Pearblossom
20
Diversion
9
4
87th
Diversion
California Aqueduct
Blending
Station
Diversion
Reservoir: 2.1 MGD
8
19
18
Pearblossom
82nd
CIE 2
CIE 1
4,000
8,000
Feet
Meters
1,000
2,000
118°0'0"W
Groundwater Production Wells
Regional Planned Recycled Water Pipeline (K/J, 2006)
Proposed Recycled Water Pipeline
Kern County
Lancaster

5 IMPLEMENTATION PLAN OUTLINE

5.1 Technical Planning

The reconnaissance investigation reported herein suggests that recharge at the ULRC recharge area is promising and warrants additional investigations. These investigations should follow two tracks. The first track consists of researching the individual mining operations and properties to determine the future mining plans for each pit (limits of extractions, time lines, etc), reclamation plans, and other information that can be used to determine the availability and acquisition costs. The second track consists of scientific and engineering work and includes boring and cone penetration tests to characterize the near surface soils and aquifer beneath the potential recharge basins, the prioritization of recharge sites in the ULRC recharge area, the development of rough grading plans for the most promising recharge sites, the development of pipeline alignments and the other water conveyance features of this project, and the development of 30-percent design plans and costs.

In addition, the PWD should refine the project description, articulate alternatives, and conduct an initial investigation pursuant to the California Environmental Quality Act (CEQA). The purpose of this effort is to identify significant environmental issues and guide future engineering and subsequent environmental analyses.

5.2 Regulatory Strategy

In this reconnaissance-level investigation, we assumed that the recycled water with a TDS of 500 mg/L would constitute 20 percent of the recharge and that the remaining water would be SWP water with an average TDS concentration of 250 mg/L. The volume-weighted TDS concentration would be about 300 mg/L. If this recharge proceeds, it is likely that monitoring will show that the amount of recycled water could be increased to as high as 40 percent. In this case, the volume-weighted TDS concentration could reach 350 mg/L. The underlying groundwater has a lower TDS generally around 250 mg/L. The Lahonton RWQCB will use current or past ambient TDS concentrations (as measured at wells) as the TDS objective in the ULRC recharge area. Under this scenario, the recharge of recycled water cannot be permitted without either reducing the TDS in the recycled water or some other form of mitigation. An alternative approach would be to establish higher TDS objectives pursuant to SWRCB Executive Order 68-16 and Water Code Section 13241. This would need to be done for the area that would be influenced by the recharge project.

The PWD should seek to change the TDS and related mineral objectives if it plans to proceed with recycled water recharge and should seriously consider raising the TDS objectives if it plans to recharge only imported water from the SWP aqueduct.



5.3 Institutional Arrangements

The PWD should develop a memorandum of understanding (MOU) with LACSD to acquire up to 10,000 afy of recycled water. The purpose of this MOU is to provide a basis for the development of an agreement whereby the LACSD will provide recycled water to the PWD at a specified location, schedule, quality, and price. The MOU will provide the PWD with the certainty of access to the recycled water needed to proceed with the other investigations necessary to evaluate the feasibility of recycled water recharge and to implement the recharge program. The MOU will be a binding term sheet. If the PWD decides to proceed with the recharge project, the MOU would be used to develop the final agreement. Alternatively, the MOU could be the final agreement. A key term of the MOU should be that the PWD will own and be totally responsible for the recycled water once it passes into the PWD's pipelines, provided that the LACSD supplies recycled water within the specified water quality ranges for each constituent of interest.

There are significant economies of scale in this recharge project. The PWD should consider seeking partners for this project to take advantage of the economies of scale and share the risks.

5.4 Funding Arrangements

The PWD should develop an MOU with LACSD to fund recharge-related facilities. The purpose of this MOU is to provide the basis for the development of an agreement whereby the LACSD will help fund the recycled water recharge project, based on their avoided cost of recycled water disposal and as the LACSD currently proposes pursuant to their 2025 Facilities Plan. A key requirement of this MOU is that the LACSD will be able to reduce or offset their currently proposed disposal capacity by an amount equal to the recycled water recharge capacity at the PWD's recharge project. The MOU will provide certainty to the LACSD that the PWD will provide an alternative means to dispose of a fixed volume of recycled water. The MOU will provide the PWD with the certainty of funds to reduce the PWD's capital and operations and maintenance (O&M) costs. The MOU will be a binding term sheet. If the PWD decides to proceed with the recharge project, the MOU would be used to develop the final agreement. Alternatively, the MOU could be the final agreement.

5.5 Public Acceptance Strategy

The PWD should implement a public acceptance strategy that would create an open dialogue with the community, fostering an atmosphere of trust and understanding. This strategy should incorporate successful aspects of preceding projects, such as those implemented by the Orange County Water District and the Inland Empire Utilities Agency.



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