Antelope Valley Area of Adjudication Basin Characteristics:
Single Ground-water Basin

The Antelope Valley Area of Adjudication (AVAA) consists of a single ground-water basin. While faults and other structural features have been used in the past (most notably by Bloyd, 1967) to subdivide the alluvial portions of the Antelope and adjacent Fremont valleys into ground-water subunits, these subunits are hydraulically interconnected, with no subunit or subbasin being hydraulically isolated from the others.

Definition of subbasin

There is no clear definition of the term “hydrogeologic subbasins”. Subbasins have been defined within ground-water basins based on a broad range of criteria including political boundaries, purposes of investigation, groundwater divides, and flow restrictions. This means that subbasin boundaries are flexible and can change over time and with the intent of the subdivision.

In the absence of a clear definition and in the context of this discussion, the term “hydrogeologic subbasin” is defined as a geographic region within a ground-water basin which is so hydraulically isolated that recharge or discharge within that hydrogeologic subbasin has essentially no effect on adjacent hydrogeologic subbasins. This definition of a “hydrogeologic subbasin” is essentially the same as that of a groundwater basin. The term “hydrogeologic subbasin” will be used in the context of the AVAA discussion where the issue of subbasins is being posed from the perspective of whether any subbasin is sufficiently isolated that it can be managed independently of other subbasins. Under this stated definition, there are no hydrogeologic subbasins within the AVAA. This does not mean that one couldn’t identify “ground-water areas” with similar hydrogeologic characteristics or that at some point in the future it might not be convenient to subdivide the basin for management purposes.

Bloyd subdivided the alluvial portion of the Antelope Valley ground-water basin into eight ground-water subunits (Figure 1). These subunits cover a somewhat different area than the AVAA (which contains the Willow Springs and part of the Oak Creek subunits, which Bloyd included in the Fremont Valley and excludes the Peerless subunit which Bloyd included in the

Antelope Valley). Bloyd called the subdivisions containing alluvial aquifer material "subunits" and the subdivisions containing bedrock material "ground-water areas". These "subunits" have persisted with only minor modifications in the U.S. Geological Survey (USGS) literature, with later USGS investigators (ex., Durbin, 1978; Leighton and Phillips, 2003) referring to them as subbasins rather than subunits. Bloyd made the divisions based on "faults, bodies of consolidated rock, ground-water divides, and, in some instances, by convenient and arbitrary boundaries" (Bloyd, 1967).

Faults and Other Structures as Partial Impediments to Groundwater Flow

Bloyd (1967) discussed how faults could create partial barriers to ground-water flow:

> The presence of faults in unconsolidated alluvial deposits can influence the occurrence and movement of ground water. Cementation and frictional heat and pressure, caused by faulting, can make unconsolidated materials along the fault plane less permeable. In some cases the fault-affected materials are nearly impermeable to water.
>
> Many faults in the AVEK area transect the ground-water basins, forming barriers to ground-water movement. Although many of the faults are not everywhere visible at the surface of the ground, their presence may be indicated by differences in ground-water levels on adjacent sides of the fault. Therefore, where reliable data on water levels in wells are available, fault traces often can be mapped.

In fact, several of the boundaries drawn by Bloyd were postulated as faults based on significant disparities in ground-water elevations on either side of the boundary, rather than on observable fault traces or other evidence of faulting. Some boundaries were identified as named faults, and others are unnamed.

Durbin (1978) also identified some of the boundaries as flow-impeding faults:

> Major faults in the Antelope Valley, especially the Randsburg-Mojave fault, act as partial barriers to the movement of ground water. Water-level differentials of as

> much as 300 ft (91 m) occur across the Randsburg-Mojave fault. Along several other faults that cross the Antelope Valley ground-water basin the water table is several tens of feet higher on the upgradient side of the fault than on the downgradient side.

While faults may create partial barriers to ground-water flow, the hydraulic head builds up on the upgradient side of the fault to a sufficient degree to drive flow cross the fault from one subunit to the next. In a "steady-state" flow system, such as in the Antelope Valley prior to ground-water development, a quasi-equilibrium would have been established between inflow into the subunit and the head difference across the downgradient fault or structural feature to produce an equivalent outflow to an adjacent subunit.

In addition to faults, other physical evidence was used to delimit boundaries. Thayer's (1946) original division of the Antelope Valley, which Bloyd (1967) built upon, was into "ground water basins" (although he also sometimes uses the word "sub-basins" interchangeably with "ground water basin") that were based almost entirely on water levels obtained in November 1945. He spoke of higher water levels as raising "a suspicion that there is a break in hydraulic continuity". Thayer did not identify these basin boundaries as faults, but rather in two cases as "partly buried bed rock ridges" (Thayer, 1946).

The types of subunit boundaries in the Antelope Valley, as identified by Bloyd (1967), are summarized in Table 1. None of the subunit boundaries was identified as being completely impermeable by Bloyd, although significant water level differences across the barriers were recognized or were actually used to identify the barrier. The water level differences created across these subunit boundaries can be observed in figures 2 through 4 for years 1951, 1961, and 1990.

Table 1. Subunit boundaries identified in Bloyd (1967) for the alluvial portions of the Antelope Valley.

Subunit	Boundary	Boundary Type
Lancaster	Northern	Rosamond fault and bedrock
	Eastern	Bedrock
	Southeastern	Unnamed fault with large water-level disparity
	Southern	Unnamed fault, concealed and postulated from water level data
	Northwestern	Neenach fault
Buttes	Northwestern, northeastern, and southwestern	Unnamed faults, postulated from water level data
	Southeastern	Ground-water divide with El Mirage dry lake drainage area
Pearland	Northern and western	Unnamed faults
	Southern	Unnamed fault with large water-level disparity
	Southeastern	Bedrock
Neenach	Southern	Neenach fault
	Northern	Rosamond fault
	Northwestern	Randsburg-Mojave fault
West Antelope	Southwestern	Bedrock
	Southern and southeastern	Randsburg-Mojave fault
	Northern	Unnamed fault, position not know precisely
Finger Buttes	Southern	Unnamed fault
	Eastern	Randsburg-Mojave fault
	Northeastern	Cottonwood fault
	Western and northwestern	Bedrock
North Muroc	Southern	Bedrock ridge, stated by Bloyd to be covered by a feet of saturated aquifer; bedrock was later shown in Rewis (1992) to be overlain by over 100 ft of saturated alluvium
	Northern, western, eastern, and southeastern	Bedrock, with gaps to Fremont Valley and Peerless subunit
Peerless	Southern	Alluviated gap with North Muroc subunit
	Western and northern	Bedrock
	Eastern	Limit of important water-bearing deposits

Continuity of Flow from Recharge to Discharge Areas

Recharge of the Antelope Valley groundwater basin occurs along the mountain front of the San Gabriel and Tehachapi mountains. Prior to development, all the recharged ground water flowed from the margins of the valley to the primary discharge areas in the topographic lows near Rosamond and Rogers (dry) lakes (Bloyd, 1967; Durbin, 1978, Carlson et al., 1998, among other USGS investigators). This continuity of flow from recharge to discharge areas (Figure 2) means that groundwater needed to traverse the leaky barriers to migrate along the pathways between them. Since the primary discharge areas are in the Lancaster subunit and many of the primary recharge areas are located in subunits to the southeast and west, the ground water had to flow across whatever faults or bedrock highs would have acted as partial impediments to flow.

With the development of ground water for agricultural and other uses, the natural discharge areas near the two dry lakes dwindled and ceased as primary discharge areas, and the regions of major pumping discharge shifted. Large cones of depression caused by pumping can be observed in figures 3 and 4; they primarily occur in the Lancaster subunit. Even under development conditions, much of the ground water must flow across many of the presumed “barriers” to migrate from the recharge to the discharge areas.

Representation of Partial Barriers and Continuity of Flow in Regional Groundwater Flow Models

The two phenomena supporting the existence of a single groundwater basin with no separate hydrogeologic subbasins (i.e., the leaky nature of the partial barriers and the continuity of flow from recharge to discharge areas) have been represented in the two regional, ground-water flow models developed for the Antelope Valley by the USGS. The flow models are mathematical representations of the physical ground-water system, including representations of some of the physical features which have been used to establish subunit boundaries. In both models, the partial barrier boundaries have been treated as conductive. They do not produce sufficient isolation to create separate hydrogeologic subbasins.

In his finite element flow model, Durbin (1978) represented the effect of the faults by assigning low transmissivity values (approximately two to twenty times lower than the adjacent aquifer material) along thin groups of elements representing five faults (Figure 5). The faults were present in the western and southern portions of the Principal (upper) Aquifer. No faults were represented as being present in the Deep (lower) Aquifer. The low-transmissivity, narrow finite elements allowed flow to occur from one subunit to another.

Similarly in their finite difference model of the Antelope Valley, Leighton and Phillips (2003) represented nine faults as leaky hydraulic barriers (Figure 6). The simulation of leaky barriers was performed in MODFLOW using the Horizontal Flow Barrier (HFB) package. The nine partial barriers were distributed throughout the basin. The hydraulic characteristics of the HFBs were determined through model calibration. Each HFB allowed flow to occur across it although water level differences from a few feet to tens of feet were created by the partial barriers.

Recharge and natural discharge areas, as presented in Durbin's (1978) model, are shown in Figure 7. The location of major pumping under development conditions is shown in Figure 8. Similar illustrations for recharge (Figure 9), natural discharge (Figure 10) and pumping (figures 11 and 12) can be shown for the Leighton and Phillips (2003) model. Much of the recharge in both models needs to cross the leaky barriers under both pre-development and development conditions.

While partial barriers between subunits have been identified, they have been represented in the groundwater models as leaky barriers which allowed flow to occur between subunits, with flow moving from recharge areas to discharge areas. This hydraulic connection means that what occurs with water levels and the water budget in one subunit will have an effect on the adjacent subunit, requiring the entire AVAA to be treated as a single basin with no isolated hydrogeologic subbasins.

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Thayer, W.N., 1946. Geologic Features of Antelope Valley, California, Los Angeles County Flood Control District, October.

Exhibits

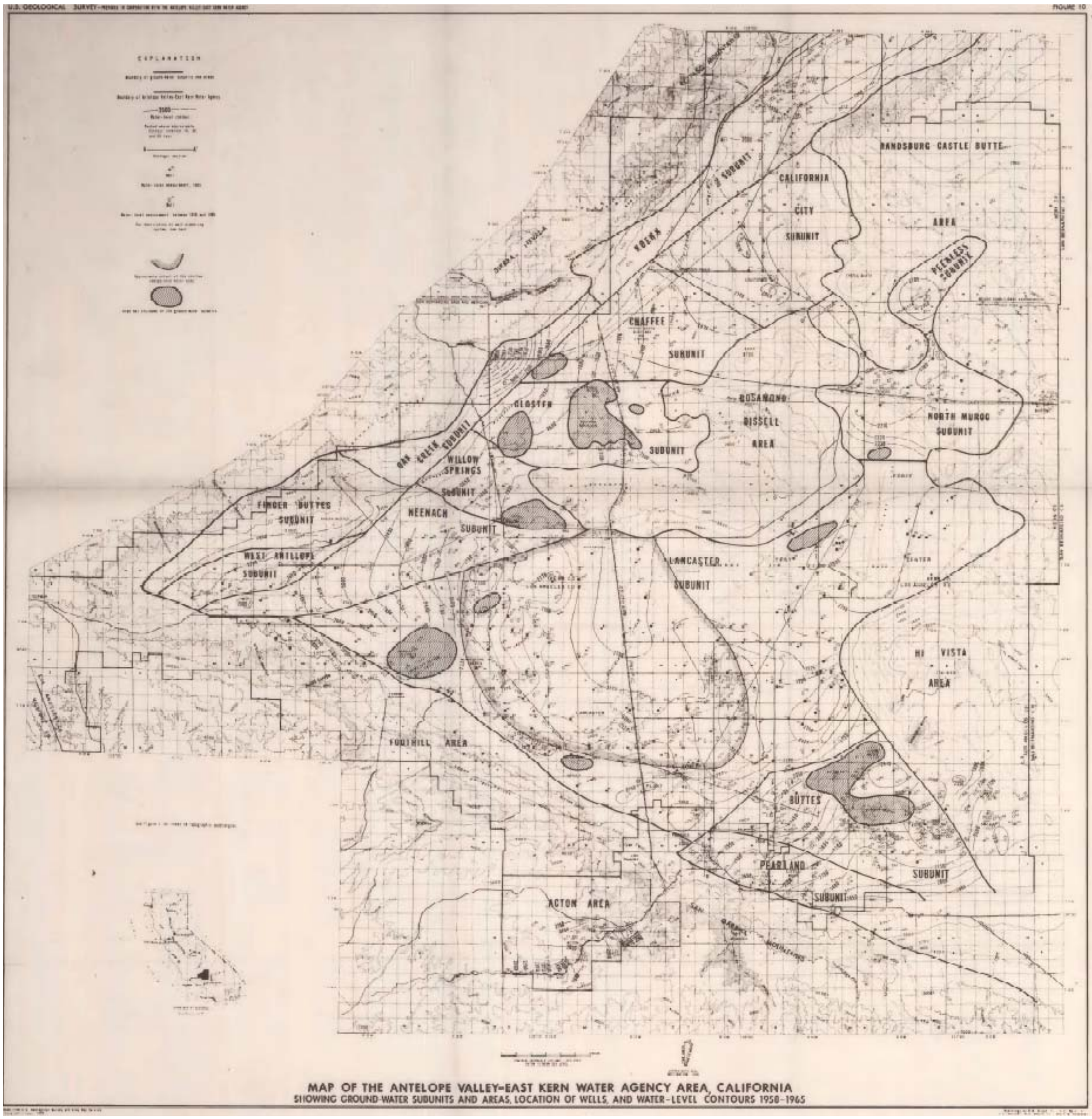

Figure 1. Subdivisions of the Antelope Valley and Fremont Valley (Bloyd, 1967).

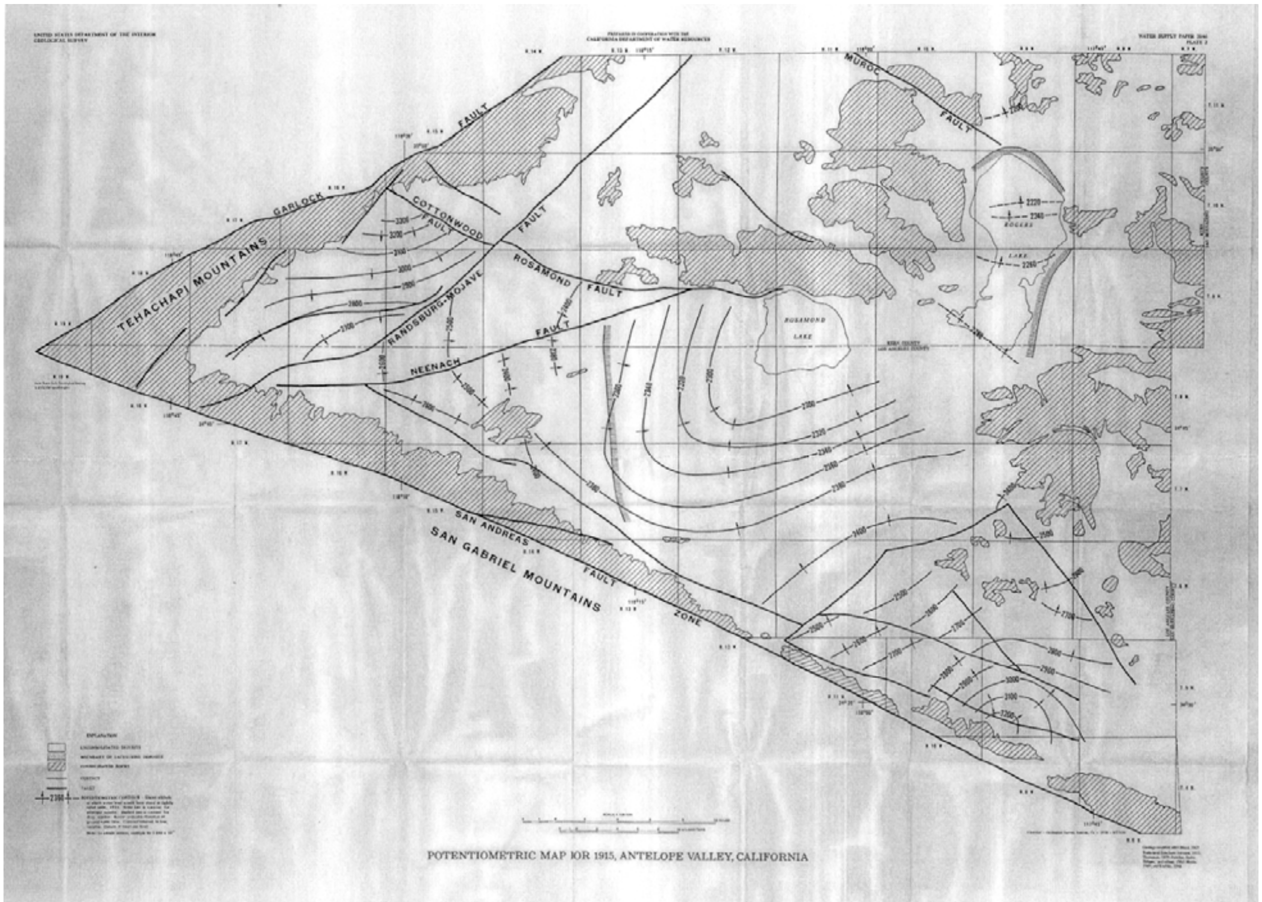

Figure 2. Water level contour map for the Antelope Valley, 1951 (Durbin, 1978).

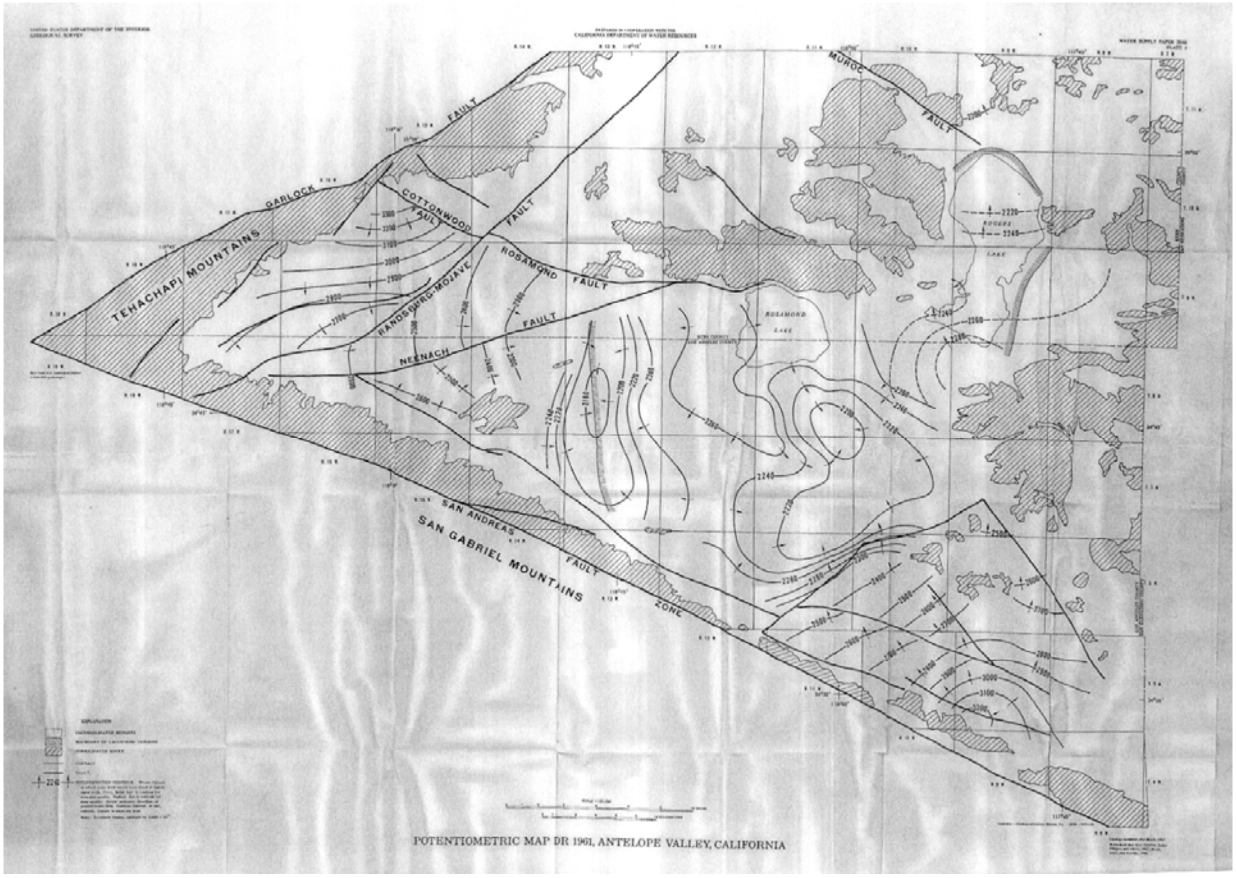

Figure 3. Water level contour map for the Antelope Valley, 1961 (Durbin, 1978).

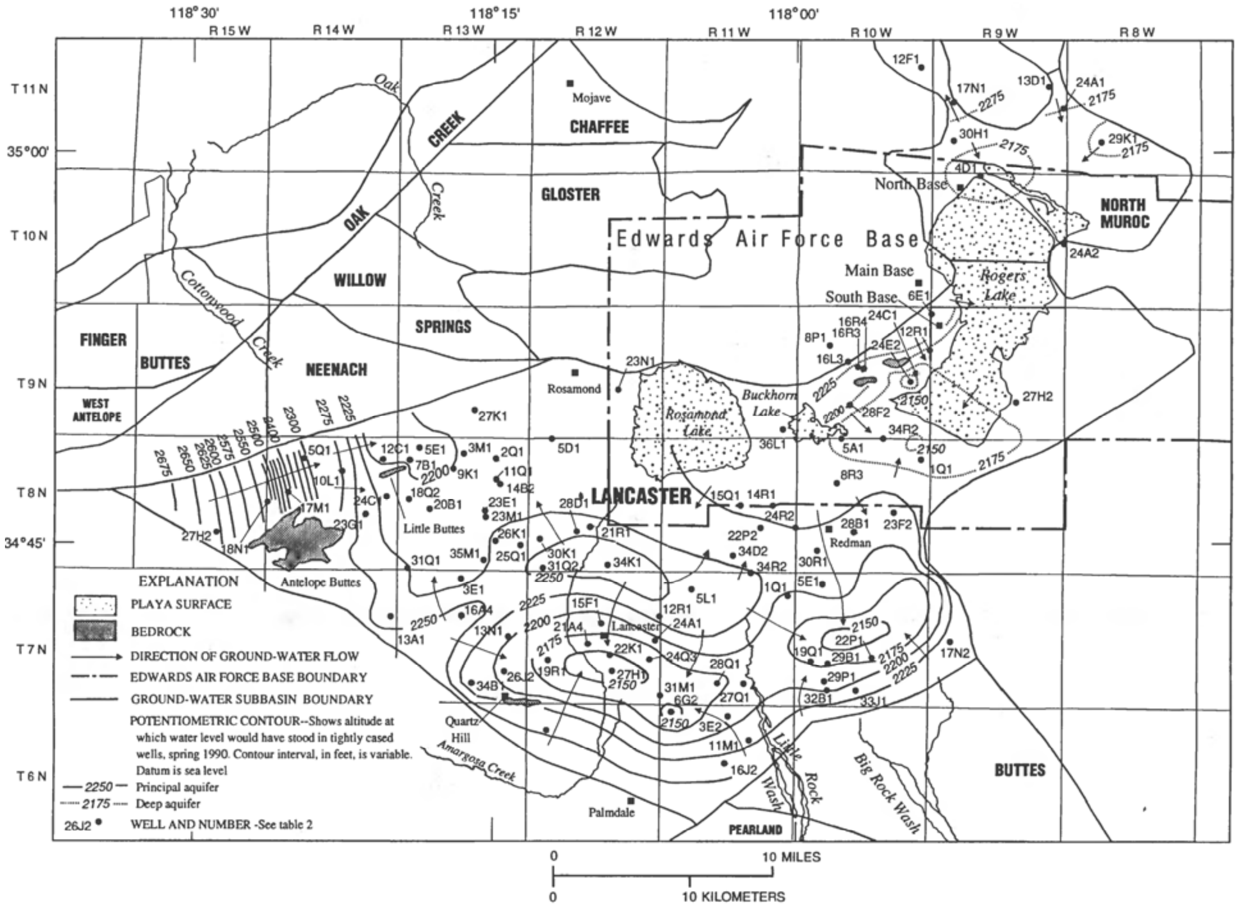

Figure 4. Water level elevation contours for the Antelope Valley, 1990 (Londquist et al., 1993).

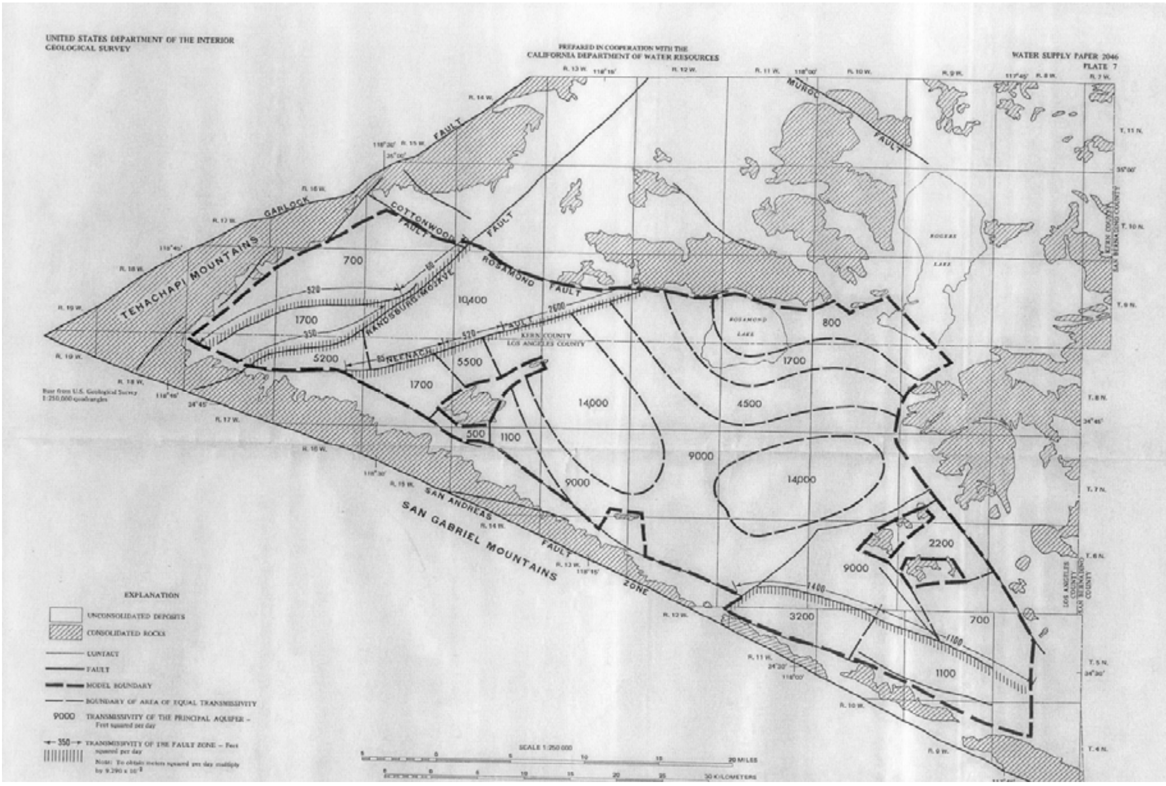

Figure 5. Transmissivity, including of finite elements along faults, for Durbin's finite element model of the Antelope Valley (Durbin, 1978).

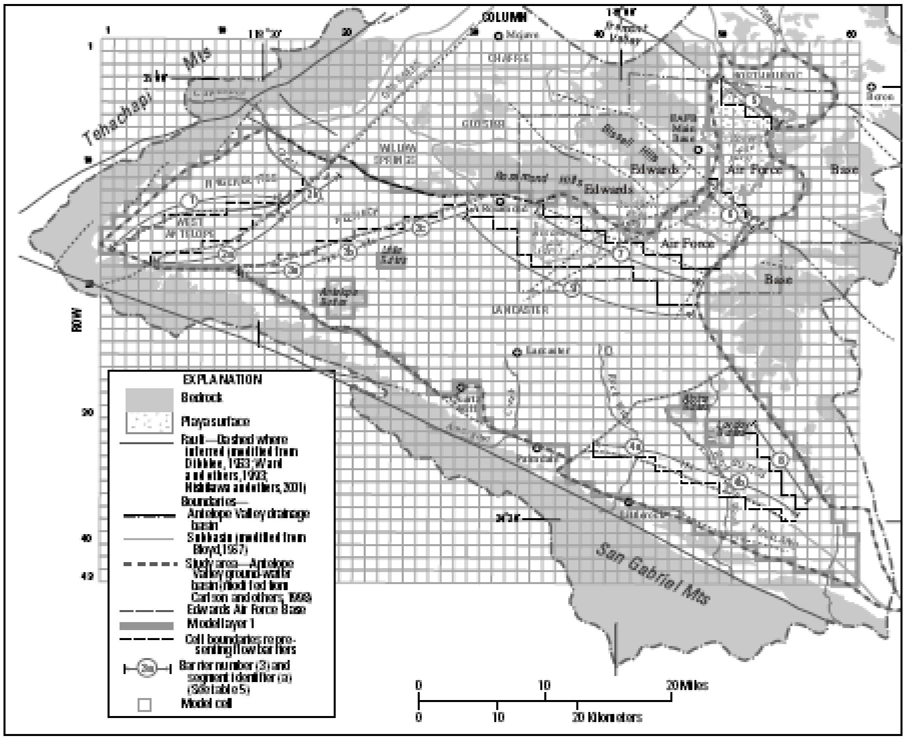

Figure 6. Location of nine barriers incorporated into Leighton and Phillips regional ground-water flow model of the Antelope Valley (Leighton and Phillips, 2003).

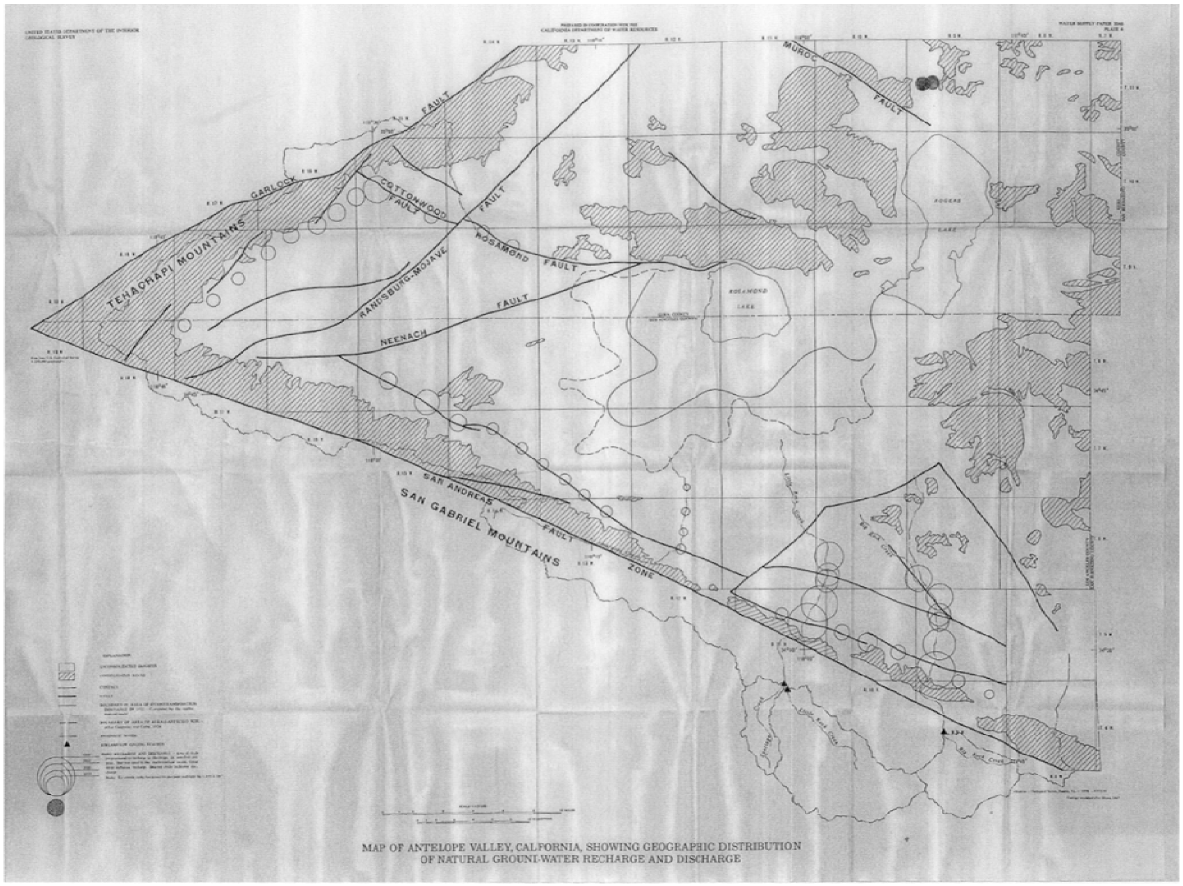

Figure 7. Location of recharge areas and natural discharge areas for Durbin's Antelope Valley regional ground-water flow model (Durbin, 1978).

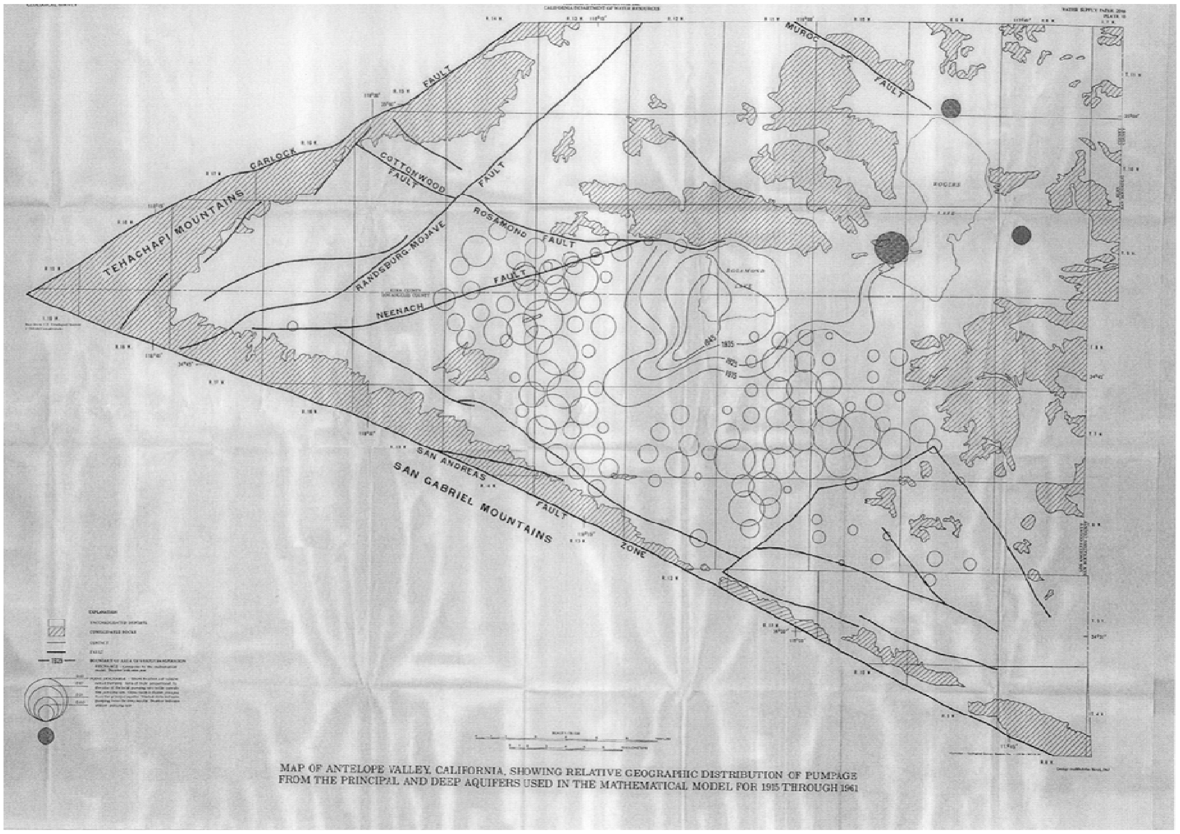

Figure 8. Location of major pumping in Durbin's regional flow model for the Antelope Valley (Durbin, 1978).

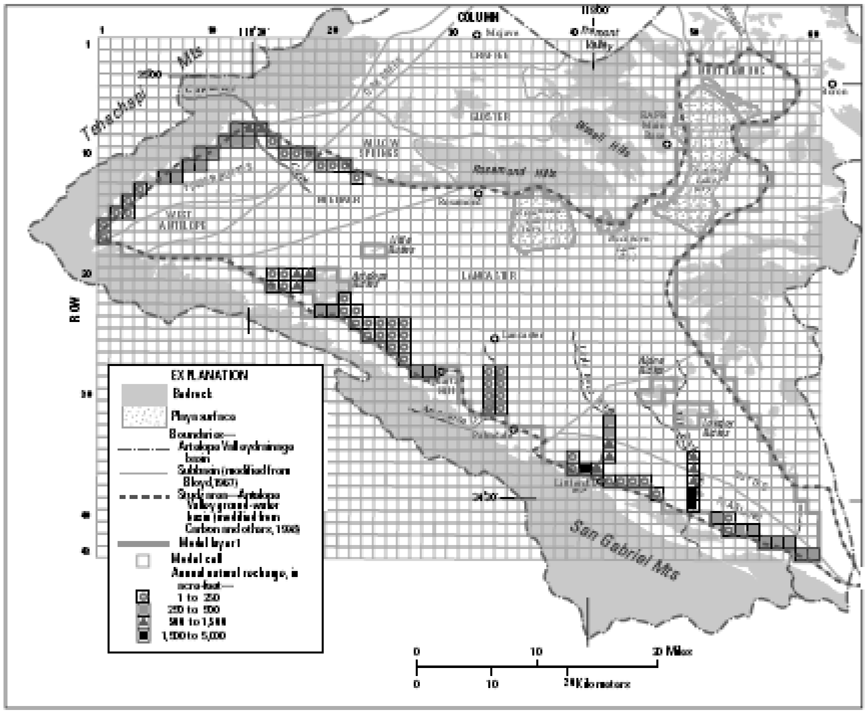

Figure 9. Distribution of natural recharge in Leighton and Phillips' regional ground-water flow model for the Antelope Valley (Leighton and Phillips, 2003).

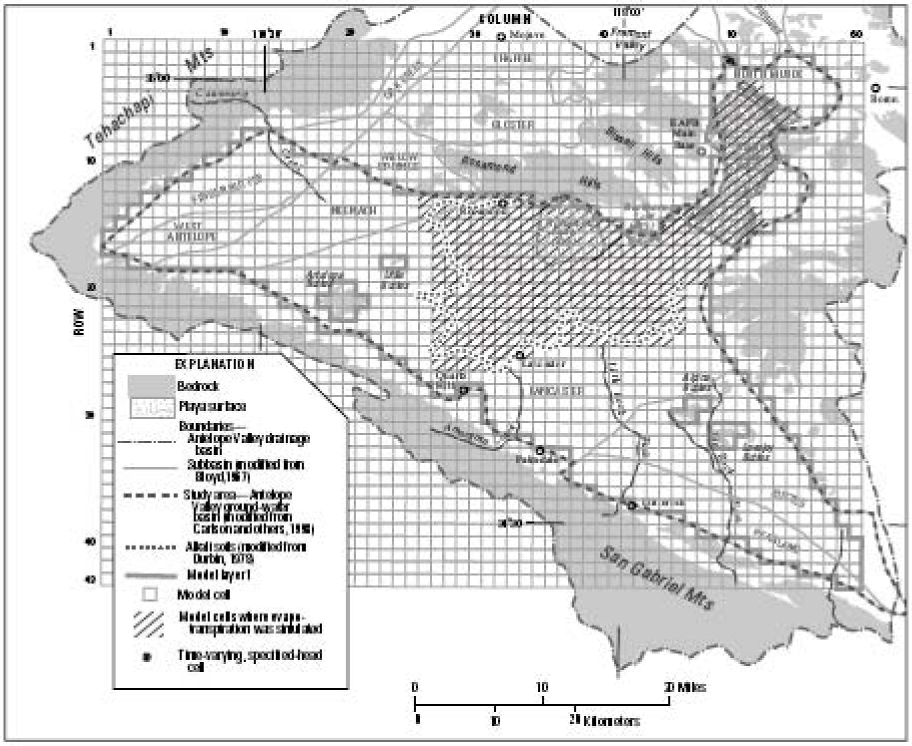

Figure 10. Areas of natural discharge in Leighton and Phillips' regional ground-water flow model for the Antelope Valley (Leighton and Phillips, 2003).

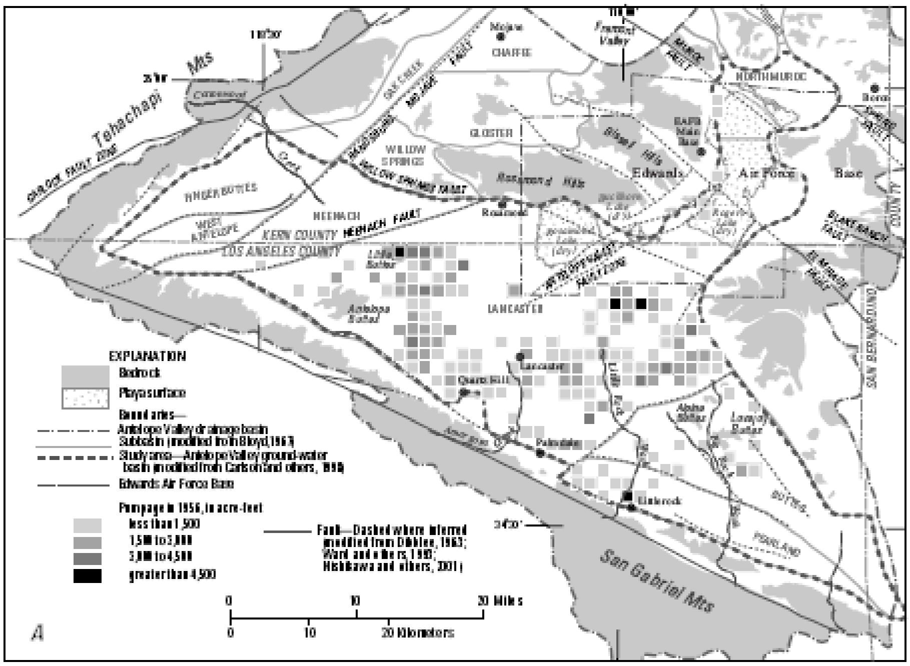

Figure 11. Distribution of pumping in 1956 in Leighton and Phillips' regional ground-water flow model for the Antelope Valley (Leighton and Phillips, 2003).

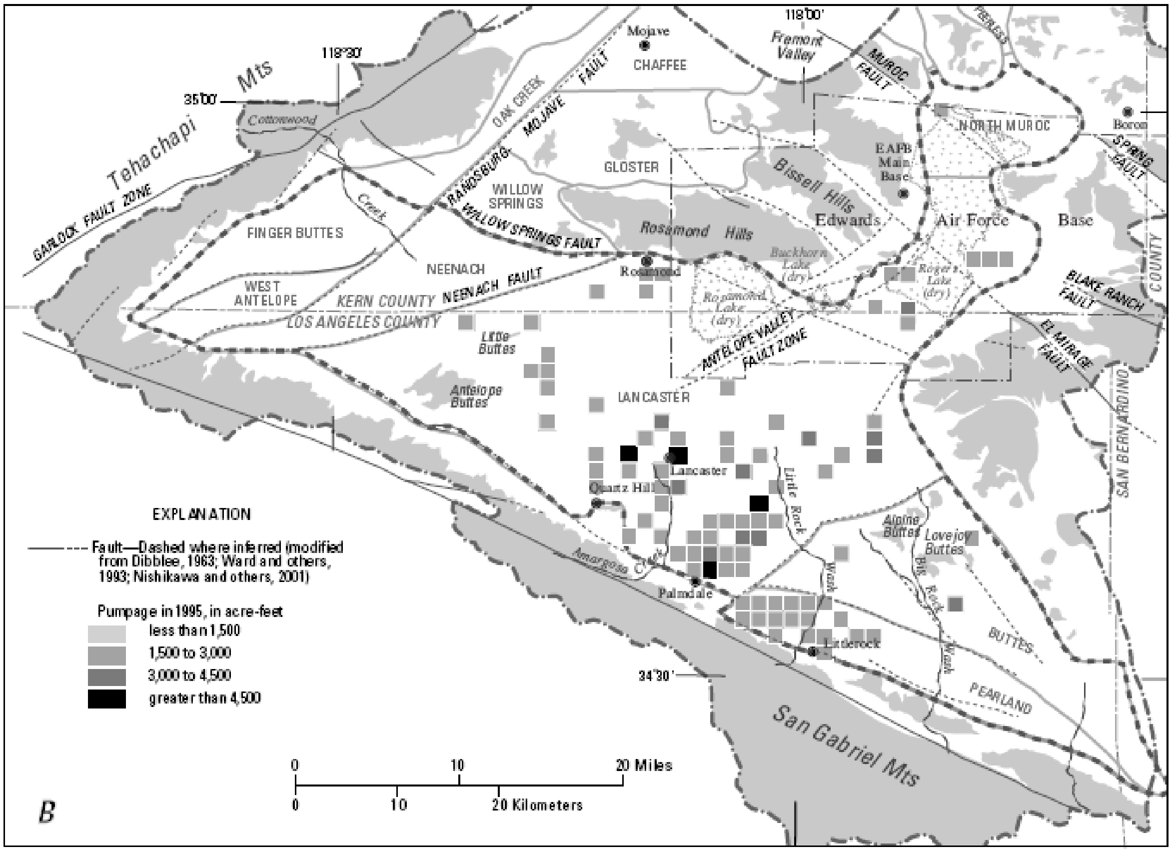

Figure 12. Distribution of pumping in 1995 in Leighton and Phillips' regional ground-water flow model for the Antelope Valley (Leighton and Phillips, 2003).