GIS; A Tool for Determining Long-term Changes in Groundwater Storage
A Case Study, Lucerne Valley Groundwater Basin

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Groundwater level change maps are useful in determining areas of greatest changes in storage across basin-wide systems. Geographical Information Systems (GIS) have been used for a variety of groundwater studies. In order to obtain long-term groundwater level change maps, GIS was used in this study to visually and spatially analyze water level data obtained from the U. S. Geological Survey (USGS) and Department of Water Resources (DWR). Change maps were only constructed for areas of overlapping data from associated time periods. This limited the overall coverage; however, based on an assumption of homogeneity, an overall average change per year was calculated for the main portion of the Lucerne Valley groundwater basin.

The Lucerne Valley groundwater basin is located at the northern foot of the San Bernardino Mountains in the south-central Mojave Desert region, San Bernardino County, California. The groundwater basin is bordered by the Ord Mountains to the north, Fry and Cougar Buttes Mountains to the east, the Granite Mountains to the west, and to the south by the San Bernardino Mountains.

Groundwater level change maps were developed by overlaying two individual groundwater contour maps and subtracting the most recent values from older ones within the intersected area. Using this data, a change in volume can be calculated. This was done for Lucerne Valley groundwater basin between the water years 1954 to 2002 on a seasonal and annual basis where enough data existed. The following steps were taken for this analysis:

1. Compiled data from a review of USGS National Water Information System (NWIS) and DWR level data for the years of 1954 to 2002;
2. Utilizing these data, determined periods in which data could be compared from one year to another or one season to another;
3. Contoured groundwater levels for the individual years 1954, 1962, 1970, 1996, 1998, and 2002 across the Lucerne Valley groundwater basin; and,
4. Compared the associated plots to create change maps of groundwater elevations across the sub-basin. This was done for water levels within each year (fall to fall and spring to spring) and between subsequent time periods, i.e. fall 1954 to fall 1962.

The volume changes were then divided by the *area of interest* between the two groundwater elevation contour maps and an average groundwater level change was obtained. This value is then assumed to be the average change across the entire study area. This value is then multiplied by the actual basin area (approximately 58,500 acres). Based upon published data from DWR [1967], a 10% specific yield was used in adjusting the change in volume of water across the sub-basin to account for an estimated average sediment porosity of 20%.

Changes in groundwater storage were then calculated by multiplying the calculated change in volume by the specific yield. Goodrich [1976] estimated the change between 1954 and 1976 to be a loss of 194,975 acre-feet, with an average annual loss of 8,900 acre-feet. DWR [1967] estimated a loss of 79,000 acre-feet between 1936 and 1961. Our data suggests an average annual loss of 9,384 acre-feet between 1954 and 2002 (Figures 1 & 2), or an average annual drawdown of 1.6 feet throughout our 58,500 acre study area. We estimate an average loss of 450,450 acre-feet from 1954 to 2002 (Table 1 and Figures 1 and 2).

The aquifer thickness (716 feet on average) was determined from cross-sections developed from geologic maps and drillers' logs. The area (58,500 acres) was determined through analysis of existing published regions [DWR, 1967; and Goodrich, 1978] and cross-sectional overlays. Based on this analysis, Lucerne Valley groundwater basin has an estimated storage capacity of 4,188,600 acre-ft.

Table 1: Lucerne Valley Groundwater Basin Change in Storage Calculations.

Lucerne Valley groundwater basin		
Period	**Average Change in Groundwater Elevation (Feet)**	**Change in Storage (Acre-Feet)**
1936 to 1961 (DWR*)	-6	-79,000
Spring 1954 to Spring 1962	-10	-60,261
Fall 1954 to Fall 1962	-15	-87,582
Spring 1962 to Spring 1970	-10	-60,452
Fall 1962 to Fall 1970	-8	-44,757
Spring 1954 to Spring 2002	-74	-431,311
Fall 1954 to Fall 2002	-80	-462,066

Note: Spring is defined as all data from February to April, and Fall is defined as all data from September to November.

Note: (-) sign denotes a decrease in storage or elevation.

Note: A 10% Specific Yield is assumed DWR Bulletin 84).

Note: * denotes data from DWR bulletin 84. Average change in groundwater elevation is calculated using 138,000 acres (determined from map) for Lucerne Valley groundwater basin; all other values reflect 58,500 acre feet as estimated by CSUF, 2004.

Changes in storage for Lucerne Valley groundwater basin were compared to the differences in volumetric values for change in storage by various authors [DWR, 1967; Goodrich, 1978; Brose, 1987; and CSUF, 2004.

Table 2: Change in Storage Lucerne Valley Groundwater Basin.

Period	**Lucerne Valley groundwater basin**			
	Average Drawdown (feet)	**Average Annual Drawdown (feet/year)**	**Area (acres)**	**Change in Storage (acre-feet)**
1954-2002	77	1.6	58,500	450,450

Water levels have fluctuated throughout the Lucerne Valley basin since its early development. Based on these known changes in groundwater level, longer time periods were deemed better for analysis in order to not be subject to small fluctuations in climate change and/or groundwater production. Based on this analysis, it seems reasonable that Lucerne Valley groundwater basin has experienced a net loss of 450,450 acre-feet of storage over the past 48 years or approximately 10% of original storage. Several areas have seen steady water levels and other have seen substantial decreases in overall groundwater level. Calculating the change in storage provides a useful way of determining the overall change for a basin. Change maps such as this provide a useful tool in long-term planning and management of our vital groundwater resources.

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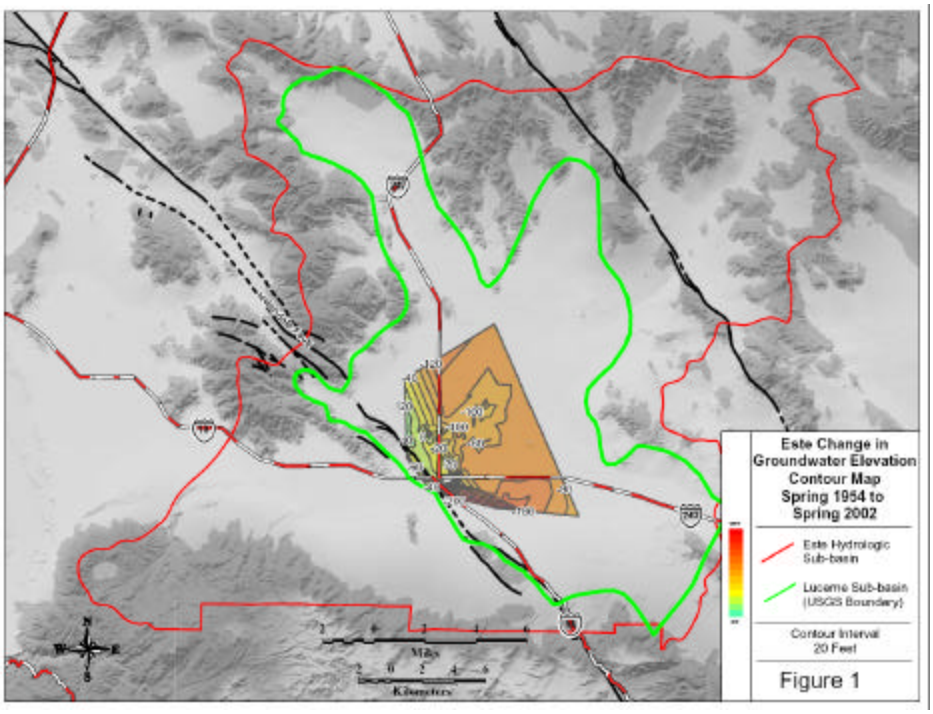
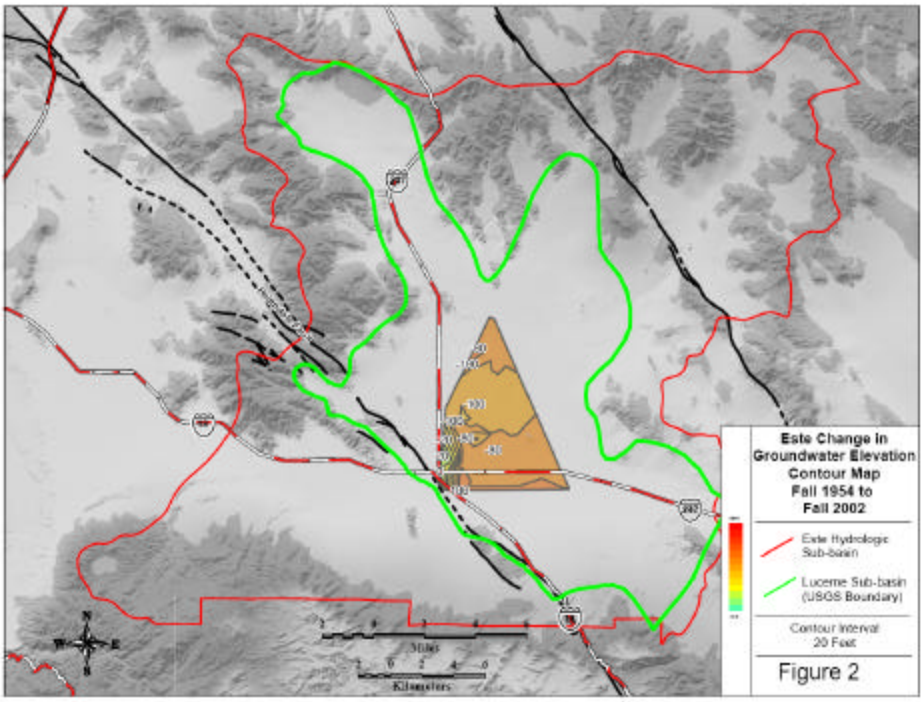

Este Change in Groundwater Elevation Contour Map Spring 1954 to Spring 2002
Este Hydrologic Sub-basin
Lucerne Sub-basin (USGS Boundary)
Contour Interval 20 Feet
Figure 1
Kilometers


Este Change in Groundwater Elevation Contour Map Fall 1954 to Fall 2002
Este Hydrologic Sub-basin
Lucerne Sub-basin (USGS Boundary)
Contour Interval 20 Feet
Figure 2
Kilometers