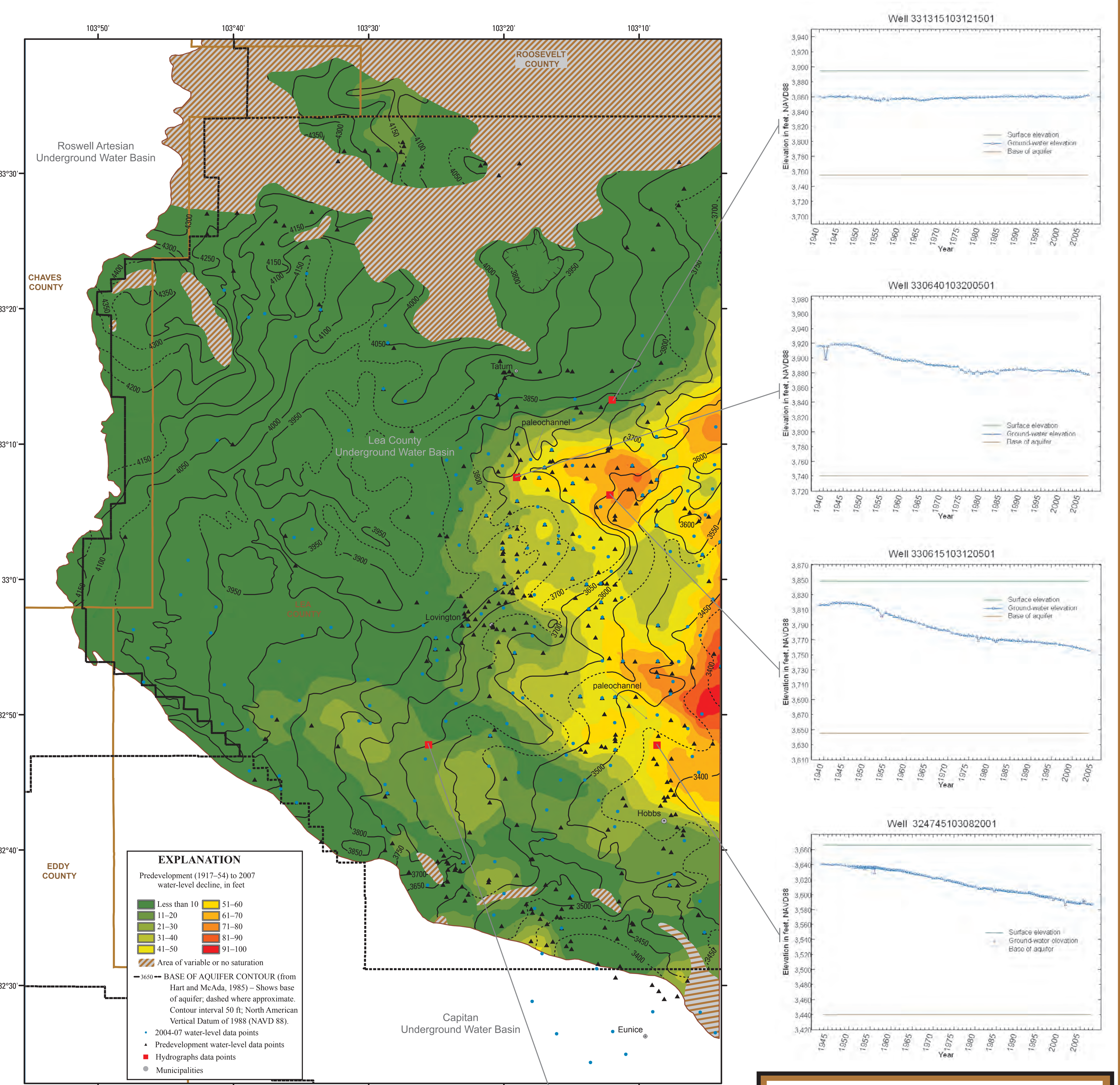
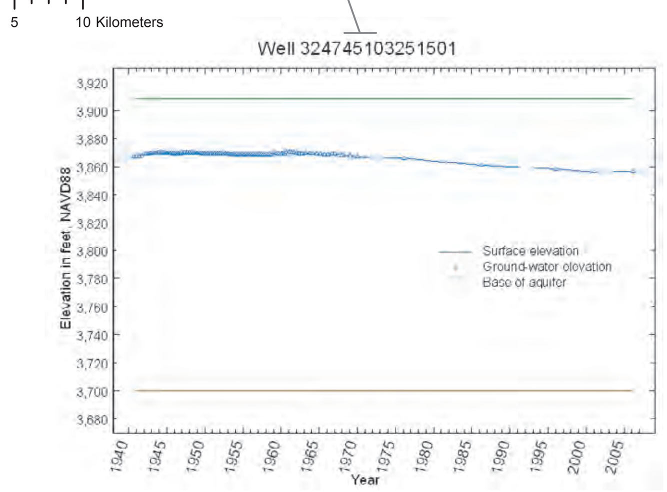


Base from U.S. Geological Survey digital data, 1:24,000

Figure 1. Water-level decline for Lea County Underground Water Basin.



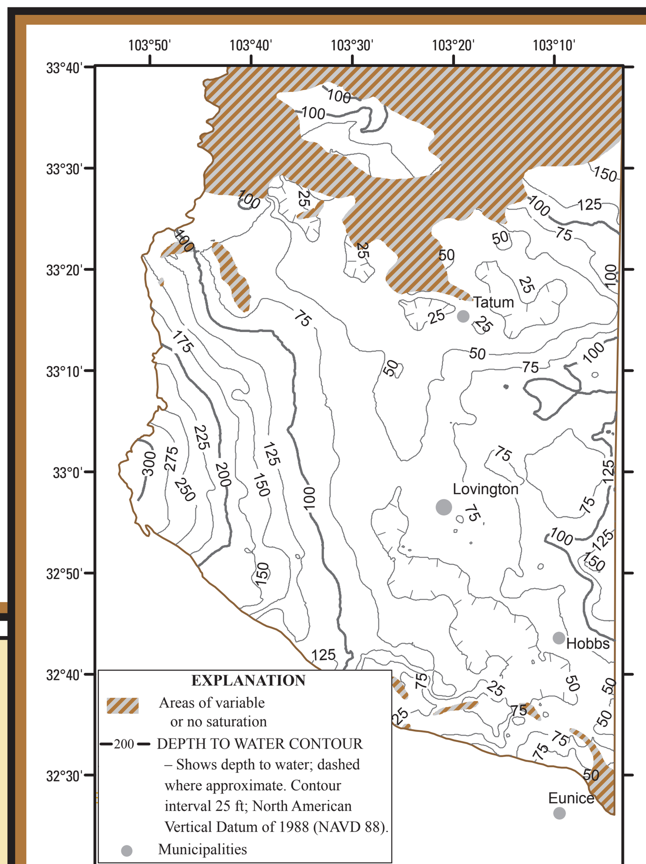


Figure 3. Depth-to-water map.

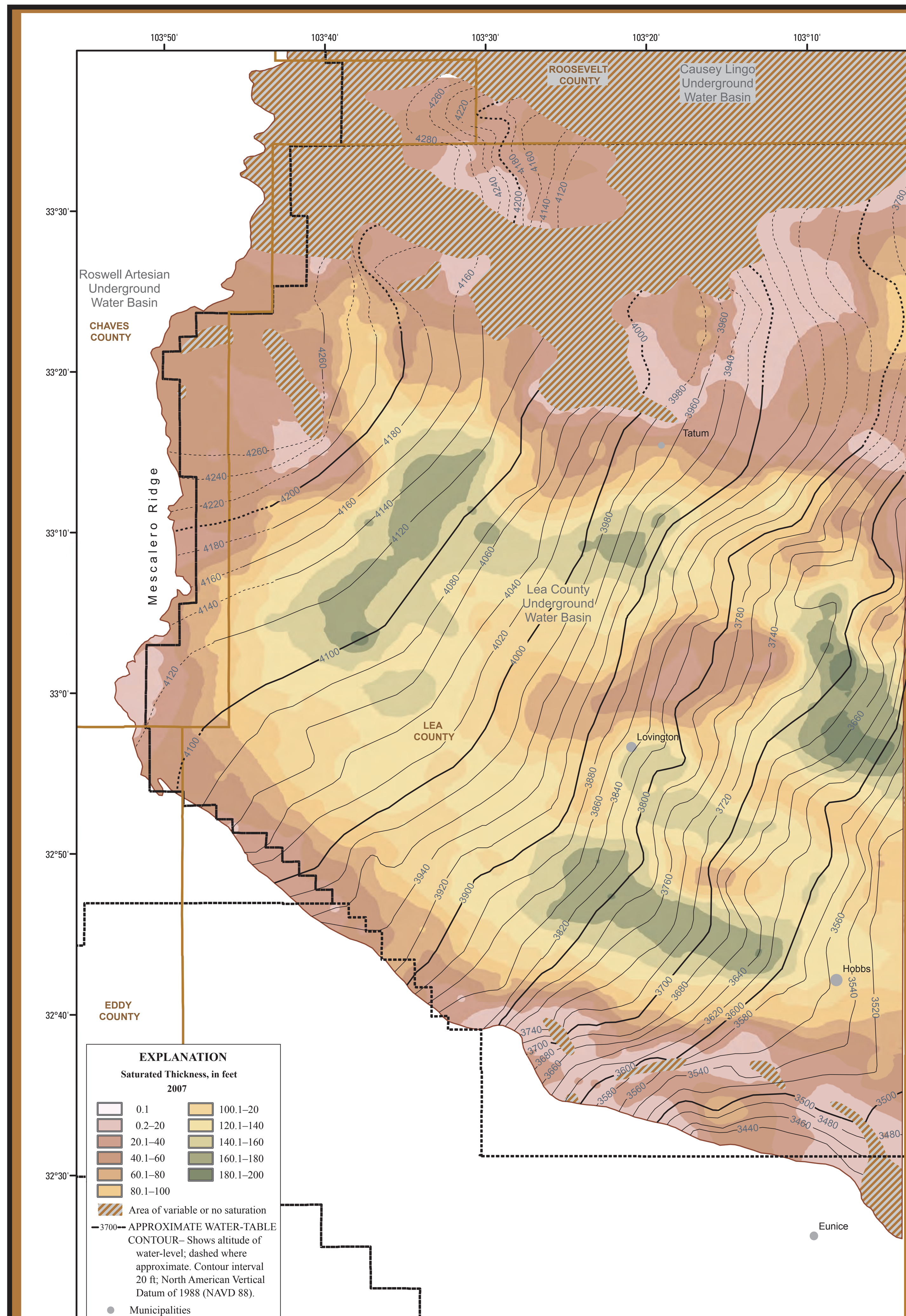


Figure 2. Current (2007) water-table levels and aquifer-saturated thickness in Lea County Undergournd Water Basin based on 2004–07 ground-water level measurements.

Introduction

The Southern High Plains aquifer extends across parts of southeast New Mexico and northwest Texas and is part of the larger High Plains aquifer that extends from South Dakota to Texas (Hart and McAda, 1985). The Lea County Underground Water Basin, originally designated by the New Mexico Office of the State Engineer (*www.ose.state.nm.us*) in August 1931, encompasses the Southern High Plains aquifer in the northern half of Lea County and small parts of Chaves and Eddy Counties in southeast New Mexico (fig. 1).

The Southern High Plains in New Mexico is bounded on the north by the Canadian River Valley and on the east and west by prominent escarpments that define a plateau rising 300 feet (ft.) or more above the lower lands. In Lea County, the Southern High Plains is bounded by the Mescalero Ridge escarpment on the west and south and the Texas State line on the east and extends as far as the Roosevelt County line on the north (McAda, 1984). The Southern High Plains has been described as having gently sloping plains, fertile soil, abundant sunshine, few streams, and frequent winds (McGuire and others, 2000). The physiography of the Southern High Plains includes numerous shallow depressions, playa lakes, sand dunes, and shallow swales. There are no perennial streams on the plateau. The surface of the plateau generally slopes east-southeast at rates ranging from about 8 to 20 ft per mile (mi.)(Cronin, 1969). The climate of the Southern High Plains area in New Mexico is semiarid, with low average annual precipitation (15.9 inches [in.] in Hobbs, 14.9 in. in Lovington; Western Region Climate Center, 2008), low relative humidity, high rate of evaporation (110 in./year; Western Region Climate Center, 2008), warm to hot summers, and moderate winters.

The unconfined Southern High Plains aquifer is composed primarily of the Ogallala Formation of late Tertiary age and alluvial sediments of Quaternary age (Langman and others, 2004). The Ogallala Formation consists of valley-fill deposits of clay, silt, fine-to-coarse-grained sand, gravel, and caliche, the distributions of which vary both vertically and horizontally. The formation is mostly unconsolidated although locally the sediments are cemented with calcium carbonate near the land surface. The formation ranges in thickness from zero to as much as 350 ft along parts of the Mescalero Ridge (McAda, 1984).

The ground-water reservoir in the Ogallala Formation is continuous throughout most of the Southern High Plains aquifer in southern New Mexico. The aquifer is typically underlain by impermeable clays and shales although in some places the underlying geologic units of Cretaceous age are hydraulically connected to the aquifer. The principal source of recharge to the aquifer is infiltration of precipitation on the land surface. An unknown amount of water pumped from the formation for irrigation may percolate back into the aquifer in some areas and constitute some reduction in net discharge in those areas. Annual recharge estimates range from 0.5 to 1 in. (Cronin, 1969).

Irrigation from wells in the Lea County parts of the Southern High Plains aquifer started as early as 1920, but it was not until the 1930s that development began on a substantial scale. By the 1940s irrigation using ground water from the Southern High Plains aquifer was extensive (McGuire, 2007). Irrigation expanded during the following years, especially during the drought years of the early 1950s. Irrigated acres have increased from initial development through the early 1990s in Lea County (table 1, fig. 1).

Table 1. Acres of irrigated cropland, including idle, fallow, and diverted acreage in Lea County, New Meixco.

[from New Mexico Office of the State Engineer, technical reports on water use by categories in New Mexico counties and river basins, and irrigated acreage (Sorensen, 1977; Wilson, 1992; Wilson and Lucero, 1997; Wilson and others, 2003)]

	1940	1950	1960	1970	1975	1990	1999
Lea County	3,200	73,000	100,000	100,000	100,000	119,240	59,818

Ground-water withdrawals in the New Mexico part of the Southern High Plains aquifer exceeded ground-water recharge by 1953; therefore, water levels had already declined and would continue to decline (McGuire, 2007). A study of ground-water levels completed in 1978 (Hart and McAda, 1985) indicated that levels had declined from 20 ft to more than 100 ft below land surface since predevelopment (defined as pre-1940) years. By 2005, the estimated change of ground water in storage in the New Mexico part of the High Plains aquifer since predevelopment was -9.7 million acre-feet, and water-level declines were continuing (McGuire and others, 2000).

The Southern High Plains aquifer is the principal aquifer and primary source of water in southeastern New Mexico (Hart and McAda, 1985). The Lea County portion of the aquifer covers approximately the northern two thirds of the 4,393-square-mile county. Successful water-supply planning for New Mexico's Southern High Plains requires knowledge of the current aquifer conditions and a context from which to estimate future trends given current aquifer-management policy

Maps representing water-level declines (fig. 1), current (2007) water levels (fig. 2), aquifer saturated thickness (fig. 2), and depth to water (fig. 3) accompanied by hydrographs from representative wells for the Southern High Plains aquifer in the Lea County Underground Water Basin were prepared in cooperation with the New Mexico Office of the State Engineer. The predevelopment water levels used in this project correspond to predevelopment water levels created for the entire aquifer at a larger scale by Cederstrand and Becker (1999).

Methods of Map Generation

Maps of water levels in the study area in predevelopment (1914-54) and current (2004-07) time periods were constructed from 548 water-level measurements at 543 wells. Measurements were compiled from the USGS National Water Information System database of ground-water sites (*waterdata.usgs.gov/nwis*) containing information on historical and current ground-water levels throughout the State. Measurements were collected as part of a Federal, State, and local cooperative observation-well program in New Mexico.

Ground-water levels were recorded in feet below land surface. Water levels were converted to elevation by using the elevation documented for the well from a USGS 7.5-minute topographic quadrangle map. Because of the flat terrain in the area, the maximum topographic interval encountered on topographic maps used was 10 ft. The uncertainty was calculated as one-half the topographic interval giving an uncertainty of 5 ft in the elevation estimates.

Water-level measurements collected during winter or early spring were given preference in developing contours to avoid having data affected by pumping-drawdown caused by irrigation withdrawals; however, to construct a map of predevelopment (1917-54) ground-water levels, measurements made during the irrigation season were used from 44 wells. In each case the well records were reviewed and the measurements were selected because they represented the earliest (prior to 1954) ground-water levels available at those locations and other data points were unavailable in the immediate area. Twenty-nine of these data points were in the northern section of the map where data coverage was generally lacking and the irrigation measurements used were the only data points available. The remaining 15 irrigation-season data points used were located along the southern edge of the aquifer in New Mexico. These data points were also either isolated geographically or were in general agreement with the nearest nonirrigation season data points. The specific error introduced by the addition of well measurements made during the irrigation season is difficult to quantify because most of these wells were measured infrequently or only once during the predevelopment (1917-54) time period. Throughout the period of record for continuously measured wells, the general and consistent decline of the water level is the dominant and most obvious trend in the data. The largest seasonal water-level change found in an investigation of the six wells that are currently measured semiannually in Lea County was 7 ft. Seasonal water-level changes were not distinguishable in the other five well records.

Water-level measurements from 339 wells were used to generate the predevelopment water-level map. All measurements obtained were between September 1917 and November 1954, with preference given to the earliest measurement on record. Ninety-six measurements were made prior to 1940, and 243 measurements were from 1940 through 1954. Because ground-water development for irrigation began during the 1940s, these water-level measurements represent the predevelopment to early development period.

The expanded time period for water-level measurements for the predevelopment water-level map was necessary because of the lack in geographic extent of historical data for the predevelopment time period. Well measurements prior to 1940 occurred mainly in the eastern part of the study area particularly around the towns of Lovington, Hobbs, and Tatum with just a few measurements in the south-central and northwest parts. The inclusion of water-level measurements from 1940 to 1945 improved the general coverage in the eastern half of the study area. In order to increase the coverage area in the western part of this map, it was necessary to include water-level measurements from 1950 to 1955.

Because of the irregular geographical distribution of predevelopment data points, interpolation for predevelopment water levels occasionally had to be extended across distances as much as 20 mi. The dates of the earliest water-level measurements in a particular area are indicative of the time period in which the aquifer in that area was developed.

Analysis of the 23 wells in Lea County that had continuous records from 1940 through 1954 indicates there was an average decline in water level of 6.8 ft and a median decline of 4.9 ft across the area during that 15-year time period of development.

Water-level measurements from 209 wells were used to generate the current ground-water-level map. All measurements were made between January 2004 and January 2007, with preference given to the most recent measurement made in each well. The current ground-water data are broadly distributed throughout the study area with the exception of some data gaps in the northeast corner, the northwest edge, and a region in the north-central part of the study area that is surrounded by unsaturated areas. The water-level change throughout the area from 2004 to 2007 ranged from a decline of 21.2 ft to an increase of 5.2 ft. The average decline was 2.4 ft, and the median decline was 0.76 ft.

To create the water-level contour maps, the ground-water-level data were plotted by using a geographic information system (GIS). A triangular irregular network (TIN) was generated representing the water-level data points, and potentiometric contours were generated in GIS by linear interpolation from the TIN. The interpolated contour lines calculated by GIS were smoothed by hand to remove contour irregularities unsupported by data and checked for inconsistencies with base of aquifer and topographic contours.

The water-level declines were established by subtracting water-level changes at all locations where current and predevelopment data points overlap and by subtraction of GIS points from a surface for the remaining areas. The sum of the water-level uncertainties discussed previously (ground-surface elevation errors, period of record water-level variation, and seasonal water-level variations) and associated with the water-level decline map is +/- 19.2 ft not accounting for seasonal variation. The saturated-thickness map was developed by subtracting the base of the aquifer elevations of Hart and McAda (1985) from the current ground-water conditions (fig. 2) at each contour GIS node. The uncertainties associated with the base of the aquifer are not documented in Hart and McAda (1985). The contour interval, however, is 50 ft so the assumed uncertainty is +/- 25 ft. The sum of the base of aquifer elevation uncertainties (+/- 25 ft) and the current water-level uncertainties associated with the saturated thickness map (bedrock-elevation error, ground-surface elevation error and period of record water-level variation) is +/- 32.4 ft. The depth-to-water map was developed by subtracting the current (2007) ground-water levels contour nodes (GIS points) established for this project from the USGS 30-meter (m) digital elevation model (DEM). In some instances the base of aquifer elevations (Hart and McAda, 1985) were found to be in conflict with surface elevations derived from USGS 30-meter DEMs. In these situations, data from the surrounding area were used to interpolate across the area in conflict.

The method used to develop the water-level decline, water-table, saturated-thickness, and depth-to-water maps has inherent inaccuracy. Accuracy decreases with distance from common points as interpolation algorithms in the GIS produce surfaces with less influence from the known data. The results were checked at five wells where both predevelopment and current water-level measurements were available. The differences between water levels at these points were found to be in agreement (within 1 ft) with the estimates of water-level change created with GIS.

Ground Water in the High Plains Aquifer

The configuration of the water table in the Lea County Underground Water Basin approximated by ground-water levels measured during 2004-07 is shown in figure 2. The water table ranges in elevation from about 3,440 ft in the southernmost part of the aquifer north of the community of Eunice to an estimated 4,280 feet in the northwesternmost extent of the aquifer in Lea County (fig. 2). As a result, the water table has a general east-southeast slope towards the Texas State line (Gutentag and others, 1984; Hart and McAda, 1985,) and ground water generally flows in this direction. Two major southeast trending paleochannels are evident in the base of the aquifer contours. One paleochannel is south of Tatum and one extends from the City of Hobbs west and then northwest to the edge of the aquifer. A smaller paleochannel in the base of the aquifer starts at Lovington and joins the southern paleochannel just north of Hobbs.

Depth to ground water varies with surface elevation but is generally shallowest in a north-south band across the center of the study area and increasing east and west toward the edges of the county (fig. 3). The shallowest depth to ground water, about 25 ft, occurs in several areas along the north and central parts of Lea County. The deepest depth to ground water in the study area, greater than 300 ft, occurs in the western-most extent of the High Plains aquifer in Lea County.

As depicted on the map (fig. 2), the aquifer is not saturated in some areas or the saturation is laterally discontinuous with the principal water body within the aquifer (Gutentag and others, 1984). A few wells in these areas are drilled in areas delineated as having little or no saturated thickness and likely will not yield water unless they penetrate sediment in buried channels or depressions in the bedrock.

The water level has declined as much as 97 ft in the Lea County Underground Water Basin from predevelopment (1914-54) to 2007. Hydrographs of wells with continuous records from predevelopment to 2007 indicate rates of water-level changes from an increase of 0.03 ft/yr at well 331315103121501 east and slightly south of Tatum to a decrease of 0.88 ft/yr at well 330615103120501 halfway between Tatum and Lovington (fig. 1). The 2007 saturated thickness ranges from 0 ft in many areas to 200 ft east of Lovington, New Mexico, near the Texas State line. The area of maximum saturated thickness is generally near or coincident with the area of maximum water-level decline, north of Hobbs and near the Texas State line. There are also two other areas of large saturated thickness in the aquifer that are not near the area of maximum water-level decline. One follows the previously mentioned paleochannel northwest from city of Hobbs and one occurs in the western part of Lea County. As the ground surface and the top of the water table are both sloping fairly continuously to the east, the two areas of increased saturated thickness not associated with maximum water-level decline are likely created by a combination of the variations in the base of aquifer elevations and the lack of prolific well development as seen east of the city of Lovington.

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Current (2004–07) Conditions and Changes in Ground-Water Levels from Predevelopment to 2007, Southern High Plains Aquifer, Southeast New Mexico—Lea County Underground Water Basin

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