6. WATER RESOURCES ASSESSMENT FOR THE PLANNING REGION

6.1 WATER SUPPLY

6.1.1 Surface Water

Developed surface water is rare in Lea County due to meager storm runoff and the presence of only a few small springs. The surface water that is used goes to stock watering, supplemental domestic service and irrigation. There are no surface water supply facilities for community, municipal, or industrial uses.

6.1.1.1 Precipitation Data

Through the 1950's the mean annual precipitation in Lea County ranged from 12.5 inches to 15.5 inches per year [1]. From 1951 to 1980 this amount dropped to between 10 and 14 inches[2]. From 1951 to 1980 this amount dropped to between 10 and 14 inches. Recent data[3] for 1981 to 1992, show Lea County receiving an average annual precipitation of 16 to 20 inches, 6 inches greater than the average over the 1951 to 1980 span. This follows a similar trend in much of the eight-state area encompassing the U.S. high plains. Most precipitation is received in May and October in the form of heavy showers with limited durations and small coverage areas. Rainfalls lasting longer than 24 hours are rare, averaging one to four times a year. Snowfall in the area is light.

Climatological data were collected from eight National Oceanic and Atmospheric Administration (NOAA) weather stations in Lea County. Station locations, elevations, and available parameters are shown in TABLE 6-1. TABLE 6-2 shows the average temperature and annual precipitation for each station. The average temperature and precipitation of locations in Lea County depends largely on their elevation (see FIGURE 7). The western – higher – part of the County is slightly cooler and wetter that then eastern – lower – part . APPENDIX G contains summaries and additional statistical analysis of these parameters.

TABLE 6-1: LEA COUNTY CLIMATE RECORDING STATIONS

NOAA Station Name	Coop ID	Elevation (feet msl)	Latitude	Longitude	Parameters Recorded
Crossroads #2	292207	4,148.9	33º 31' N	103º 21' W	precipitation, min. temperature, tmax. temperature, snowfall
Hobbs	294026	3,614.2	32º 42' N	103º 08' W	
Jal	294346	3,059.3	32º 07' N	103º 11' W	
Lovington 2 WNW	295204	3,902.9	32º 58' N	103º 23' W	
Maljamar 4 SE	295370	3,999.0	32º 49' N	103º 42' W	
Ochoa	296281	3,459.1	32º 11' N	103º 26' W	
Pearl	296659	3,798.9	32º 39' N	103º 23' W	
Tatum	298713	4,099.0	33º 16' N	103º 19' W	

Source: WRCC web-site, January 1999

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[1] Nicholson and Clebsch, 1961
[2] Dugan and Cox, 1994
[3] Dugan and Cox, 1994

TABLE 6-2: LEA COUNTY AVERAGE PRECIPITATION

Station Name	Average Precipitation* (in/yr)	Average Temperature* (in/yr)
Crossroads #2	15.57	58.22
Hobbs	16.06	61.91
Jal	12.76	63.79
Lovington 2 WNW	14.58	59.62
Maljamar 4 SE	14.77	60.32
Ochoa	10.82	61.5
Pearl	14.19	60.78
Tatum	16.00	58.39

Source: WRCC web-site, January 1999
* record through 1995

6.1.1.2 Drainage Basins and Watersheds

In Lea County neither of the two major drainage basins, the Texas Gulf Basin in the north and the Pecos River Basin in the south, contain large-scale surface-water bodies or through-flowing drainage systems. The surface water supplies that exist are transitory and limited to quantities of runoff impounded in short drainage ways, shallow lakes, and small depressions, including various playas and lagunas. The Texas Gulf Basin contains a lakes, the Llano Estacado, and the Simona Valley. The Pecos River Basin contains the Querecho Plains, the Eunice Plains, and the Antelope Ridge.

Six perennial lakes are located in the Texas Gulf Basin. They include Lane Salt Lake, Ranger Lake, and a cluster of four smaller lakes located approximately 10 miles northeast of the Town of Caprock. Water in the lakes is brackish and is derived from both surface runoff and ground-water discharge. Northwest of Tatum the Simanola Valley represents the Texas Gulf Basins only semblance of a through-flowing drainage feature; though it is only discernable for a few miles, it can concentrate surface flows for large storms.

In the Llano Estacado the drainage areas of the numerous playas capture 80 to 90 percent of the area's rainfall [4]. Most of the playas average less than one-acre in area, but can be as large as 150 acres; depths range from 1 to 50 feet. The playas only temporarily impound water; clay accumulations in their bottoms retard percolation, resulting in extended seasonal or perennial impoundment during wet years. It's thought that many of the depressions may have been formed by leaching of the caliche cap and subsurface calcareous sandstones of the Ogallala Formation, with subsequent removal of the loosened material by wind[5]. Deep-seated collapse of underlying strata has also been suggested as a mechanism for some. Surface interconnection of the wallows, particularly in the eastern part of the

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[4] Musharrafieh and Chudnoff (1999)
[5] Nicholson and Clebsch, 1961

county, results in some poorly defined drainage patterns. The interconnections are possibly the result of original surface irregularities.

The heads of several well-developed gullies are found in the Eunice Plain area, but the gullies do not persist through the sand-covered South Plain region of southern Lea County. Instead there are areas of internal drainage, such as San Simon Swale that reflect deep-seated dissolution and collapse. South of the Mescalero Ridge there exist several ephemeral stream valleys, which when flowing, do so to the south-southeast. The valleys are locally referred to as draws (Monument Draw, Cheyenne Draw, Dogie Draw, Iron Horse Draw, and Seminole Draw). Only Monument Draw covers a significant length, approximately 35 miles. Monument Draw also is the only major drainage-way that deviates from a southeast bearing, possibly due to character of the underlying sediments crossed where the draw makes a southerly bend.

A cluster of four saline playas is located in the Querecho Plain area of the west-central part of the county. These playas, which retain runoff temporarily, are referred to locally as lagunas. Laguna Plata covers the largest area, about 2 square miles. Laguna Toston, the smallest of the four with a surface area of approximately one-quarter mile, is completely filled with sediments; the other three all contain accumulations of clastic sediments and salts (halite, gypsum).

The lagunas help to create shallow saline ground-water which exists under much of the Querecho Plain[6]. The lagunas help to create shallow saline ground-water which exists under much of the Querecho Plain. The presence of the shallow saline water has been recognized to the extent that the New Mexico Oil Conservation Commission Order No. R-3221, banning the surface disposal of Aroduced water into unlined pits within the State was amended (OCC Order No. R-3221-B, July 25, 1968) to exclude much of the area[7]. The presence of the shallow saline water has been recognized to the extent that the New Mexico Oil Conservation Commission's Order No. R-3221, banning the surface disposal of produced water into unlined pits within the State was amended (OCC Order No. R-3221-B, July 25, 1968) to exclude much of the area.

Two playa lakes, including Bell Lake, are located in the Antelope Ridge area of southwest Lea County. Both are associated with dune-fields of gypsum sand, although gypsum deposits do not exist nearby. The locations of the playas may be controlled by underlying collapse depressions. Head-driven brines of concentrated chloride and sulfate may have followed fractures to the surface to result in earlier precipitation of these deposits.

Though southern Lea County is part of the Pecos River Basin, there is no connecting drainage to the Pecos River. Still, the Pecos River is the most significant surface water body in southeastern New Mexico. The Pecos carved its present valley in Eddy County thousands of years ago during Quaternary time. In doing so, the River isolated both the Ogallala Formation and the Dockum Group sediments in Lea County from their ancient upland recharge areas. In the eons since this occurred, ground-water flow in these aquifers attained a balance with the more limited recharge provided by the High Plains. Since the advent of large-scale ground-water development in the early to mid part of this century, this equilibrium has been lost. Aquifer levels in Lea County are now declining (see Section 6.1.2), as ground-water is mined from storage. Lower aquifer levels limit the ability of ground-water to sustain springs historically dependent on subsurface water for their existence.

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[6] It is also thought that the saline aquifers receive subsurface discharge from the Permian Rustler Formation; dissolutioned evaporite beds within the unit have resulted in collapse of the Magenta Dolomite Member to close proximity with the Culebra Dolomite Member, resulting in a vigorous saline flow zone. San Simon Sink origination is also related to deep-seated dissolution of Permian evaporite beds and subsequent unit collapse. The depression is approximately one half mile in area and 100 feed deep. A secondary collapse, with noticeable active subsidence in the mid-1930s is also evident. Runoff from heavy rainfall flows into the sink, which is otherwise dry.

[7] Specifically, 18 square miles within Lea County and a substantially larger area in Eddy County (Fig. 33) have been determined to contain extremely high concentrations of chlorides, therefore the oil-fied practice of disposal of produced water into unlined pits has been allowed to continue.

6.1.1.3 Streamflow Data

The U.S. Geological Survey (USGS) does not have gages in Lea County which measure daily surface flows. However, peak flow rates have been spot measured at Monument Draw (near Monument) and Antelope Draw (near Jal). Each of these Draws can occasionally convey sizable flows. In June of 1972, a flow of 1280 cubic feet per second (CFS) (the highest recorded) occurred at Monument Draw. In July of 1994, a flow of 53% (CFS) (also the highest recorded) occurred at Antelope Draw. These flows should be considered indicative of flows that can occur at other gullies and swales in Lea County. APPENDIX I contains detailed flow measurements recorded at these gages.

6.1.1.4 Evaporation & Evapotranspiration Data

The region's total annual pan evaporation potential is estimated to range from 32.9 inches to 131.5 inches, depending on season and location [8]; a good average value appears to be 100 inches [9]. Evaporation potential from larger standing water bodies is estimated at appproximately 70 inches [10], but lower values in the 39 to 52 inches per year range have been used[11]. The months of greatest evaporation potential are April through August.

Water loss through evaporation occurs from both the playas and lakes of Lea County. The playas on the High Plains (i.e. Llano Estacado) have been studied to determine the fate of impounded runoff. Some studies suggest the majority of the playas water is lost to evaporation, while others have found infiltration prevails. Its estimated that approximately 100,000 acre-feet of water accumulates in the playas, in years of normal precipitation, and that 20 to 80% of the impounded water infiltrates into the subsurface [12]. If a maximum 18-inches per year evapotranspiration at ground level (with a linear decrease to nil at 20 feet below ground) is assumed, the average annual evaporation from shallow reservoirs can be calculated to be approximately 72 inches [13]; and evaporation rates in the playas may actually approach that of the pan device. Because of these high evaporation rates, the small lakes of northern Lea County, which intersect the water table, probably produce a net discharge of ground-water to the atmosphere.

In most of Lea County the water table lies below the depth at which evapotranspiration occurs. The depth of evapotranspiration appears to be 20 feet with the rate decreasing linearly with distance below the surface [14, 15]. In areas around Monument, the water table is close enough below the surface for ground-water to be lost by evapotranspiration[16]. The Four Lakes Area may also contain places of shallow water table prone to evapotranspiration losses. Evapotranspiration by crops common to Lea County is approximately 60 to 80 percent of evaporation from a free water surface.[17] Evapotranspiration from natural/native vegetation occurs at lesser rates. Most transpiration by native vegetation occurs near the perennial lakes, and springs and seeps.

Evaporation from playa lakes in Lea County in 1975 was estimated at 8,900 acre-feet[18]; the NMOSE discontinued including evaporation from playa lakes as a separate water-use category in 1980. Stockpond evaporation estimates

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[8] Havens (1966)

[9] Nicholson and Clebsch (1961) reviewed (undated) evaporation data from Portales, New Mexico, and Red Bluff Dam and Grandfalls, Texas.

[10] Nicholson and Clebsch (1961)

[11] Havens, (1966)

[12] Havens, (1966)

[13] Hale, Reiland, and Beverage (1965)

[14] Hale, et al. (1965) and McAda (1984)

[15] Bjorklund and Motts (1959) report that although depths from which plants can lift ground water vary greatly with species, consumption has been noted to occur at depths to 50 feet.

[16] McAda (1984)

[17] Gray (1973)

[18] Sorensen (1977)

for 1975, 1980, and 1985 were 137 acre-feet, 279 acre-feet, and 279 acre-feet, respectively[19;] the NMOSE compiled data for stockpond evaporation until 1990, when it was removed as a separate category. Reservoir evaporation in Lea County was estimated at 100 acre-feet in 1975[20]. Reservoir evaporation withdrawals in Lea County for 1980, 1985, 1990, and 1995 were zero[21]. This is because the NMOSE reduced the scope of reservoir evaporation to only included major reservoirs with a capacity of approximately 5,000 acre-feet or more[22].

6.1.1.5 Surface Water Yields

Surface water yields in Lea County occur as spring flow. The USGS has inventoried numerous springs throughout New Mexico, including two within Lea County. Spring information from the USGS is in APPENDIX I. Notable discharge occurs at Monument Spring[23] and other lesser springs, but flows have decreased drastically since the initiation of large scale pumping. Some spring and seep discharge has been noted along the Mescalero Ridge and at the contact between Tertiary and Triassic sediments about 26 miles due west of Tatum. Other springs are known to discharge into the lakes of the northern County. Ranger Lake and North Lake appear to receive the majority of this discharge.

6.1.2 GROUND-WATER

6.1.2.1 Geologic Data

Geologic data for the Lea County area are described in this Section according to ascending geologic age. The objective of the discussion is to provide a brief and general summary of the County's lithology, the type of rocks present that may produce water, and the approximate thickness of water bearing strata. The summary is not intended to provide a complete overview of the depositional environments and geologic structure of the County. Geologic units deposited prior to the Permian age are not addressed in this document because they are present at relatively great depths, produce water with high total dissolved solids concentration, and have little possibility of being used for purposes other than oil and gas exploration and production. Some of the geologic units in the study area are present in more than one underground-water basin (UWB) and may be used as a water source in each basin in which they are present. APPENDIX D contains a geologic time scale and stratigraphic nomenclature chart. FIGURES 11 through 14 depict Lea County geology in cross-sectional format. FIGURE 10 shows the location of the cross-section lines.

Quaternary (present to 2 MYBP)

Quaternary-age alluvial material is present throughout Lea County and unconformably overlies the Ogallala Formation and Triassic-age rocks, which were eroded to varying degrees prior to the deposition of the alluvium. The erosion occurred during the Cenozoic Era, after the Ogallala Formation had been locally eroded away[24]. The alluvial material consists of unconsolidated, interbedded layers of clay, sand, silt, and gravel. Thickness of the alluvial material generally ranges from zero to about 30 feet above the Ogallala Formation, zero to about 40 feet above the Triassic-age rocks, and in excess of 750 feet in the Jal UWB[25]. Erosional channels can be responsible for increases in alluvium thickness. In places, the saturated thickness of the alluvium is sufficient to be an aquifer, but in only used as a public water source in the Jal UWB. The alluvium is used to lesser degrees for water- supply wells in the Capitan UWB. Most of the Capitan UWB wells are completed near the Mescalero Ridge's Monument Draw area, but

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[19] Sorensen (1977, 1982) and Wilson (1986)
[20] Sorensen (1977)
[21] Sorensen (1977, 1982) and Wilson (1986, 1992, and 1997)
[22] Wilson (1992)
[23] Musharrafieh and Chudnoff (1999)
[24] Ash (1963)
[25] Nicholson and Clebsch (1961)

some exist scattered across the Querecho Plains, at the northeast San Simon Swale, and at Dogie Draw. A red dune sand cover is present in areas as extensive as 80 percent of southern Lea County, and beyond into Eddy County, New Mexico, and Texas. The sand dunes are stable to semi-stable over most of the area, but are drifting in a few places.

Tertiary (2 to 67 MYBP)

The Tertiary-age Ogallala Formation unconformably overlies Tertiary- and Cretaceous-age rocks. The Ogallala is the predominant aquifer throughout the Lea County UWB. The Ogallala Formation, deposited to the east of the southern ancestral Rocky Mountains, has retained an eastward slope typical to such a deposition. Limited portions of the Ogallala Formation exist west of Lea County in Chaves and Roosevelt Counties, New Mexico. The aquifer extends eastward into Texas where it is a major source of ground-water for irrigation. It is also used to some extent in the undeclared basin at the north end of the County and in the Capitan UWB. The thickness of the Ogallala ranges from 0 to 350 feet and contains an upper caliche layer that ranges from a few feet to 60 feet thick. It appears that most of the variations in the overall thickness were due to irregularities in the underlying depositional surface rather than the result of post-depositional erosion to the Ogallala[26]. These irregularities consist of eroded stream channels cut into the Tertiary- and Cretaceous-age rocks by ancestral streams prior to the deposition of the Ogallala. The erosional channels can locally account for increased thickness of the Ogallala Formation. The channels generally trend to the southeast[27].

The caliche layer ranges from being very soft to hard, depending on the degree of cementation. Where the layer is very hard, it is resistant to erosion and locally known as Caprock. Caprock forms the higher promontories and the cliff-forming unit of Mescalero Ridge. Cementation tends to be greater toward the top of the formation, becoming poorly cemented with depth[28]. Interbedded layers of fine- to medium-grained sand and gravel underlie the caliche layer and compose the remaining thickness of the Ogallala. The sand and gravel layers are the primary water bearing strata of the formation. Cretaceous and Triassic rocks underlying the Ogallala form a relatively impermeable barrier that restrict downward movement of water. Where the Ogallala is absent, underlying Triassic- or Cretaceous-age rocks are exposed or are the unit lying directly below alluvial cover. FIGURE 8 shows the base of the Ogallala Formation.

Cretaceous (67 to 140 MYBP)

Cretaceous-age Tucumcari Formation rocks were deposited in southern Lea County, but were subsequently almost entirely removed by erosion[29]. The Tucumcari is approximately 150 feet thick in northeastern Lea County and thins to the southwest. The Tucumcari Formation generally consists of fossiliferous dark gray siltstone and thin beds of brown sandy limestone, and gray limestone and sandstone. Outcrops of the Tucumcari are reported along the shores of North Lake[30], Ranger Lake, and Middle Lake in northern Lea County. There the maximum exposed thickness is approximately 17 feet, and the contact with the overlying alluvium is unconformable. The North Lake locality represents the basal part of the Tucumcari Formation. The North Lake outcrop is part of a sequence that is known to extend from west Texas, across northern Lea County and southeastern Roosevelt County, although there exists some thinning and pinching-out north of Lovington, which disrupts continuity of the unit[31]. Tucumcari Formation rocks are described about 3/4 miles east of Eunice in a Lea County Concrete Company gravel pit[32].

Triassic (200 to 250 MYBP)

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[26] Nye (1930)
[27] Ash (1963)
[28] Ash (1963)
[29] Nicholson and Clebsch (1961)
[30] Theis (1934)
[31] Kues and Lucas (1993)
[32] Nicholson and Clebsch (1961)

The Triassic-age rocks in the study area are generally referred to as the Dockum Group[33], which includes the basal Santa Rosa Sandstone and the overlying Chinle Formation. Recent stratigraphic work refers to the basal Triassic-age rocks in the study area as the Santa Rosa Formation and the overlying Triassic-age rocks as the San Pedro Arroyo Formation, both of the Chinle Group[34]. Since the Dockum Group is the most common nomenclature in this area, when referring to more than one specific formation of Triassic-age rocks, other sections of this report will refer to the combined formation as the Dockum Group or as the Upper and Lower Dockum Group units.

The Upper Dockum Group is thought to conformably overlie the Lower Dockum sediments. Thickness of the formation is reported to be at least 165 feet. The San Pedro Arroyo Formation consists of variegated mudstone and siltstone, with minor interbeds of sandstone and conglomerate[35]. Triassic-age beds dip, or tilt, to the east or southeast[36].

The Lower Dockum Group sediments consist of interbedded sandstone, mudstone, and clay beds, which as a unit, unconformably overlie Permian-age rocks. The Santa Rosa Sandstone is a specific, largely sandstone and conglomerate sequence within the Lower Dockum Group. Thickness of the Santa Rosa is reported to be about 85 feet.

Permian (250 to 290 MYBP)

The major deep structural province of southern Lea County, the Delaware Basin, is formed from Permian sediments. Much of the Delaware's circumferential carbonate complex lies within Texas. Deposition of Delaware Basin sediments began early during the Permian era and by the middle Permian a reef primarily composed of dolomite and limestone began forming at the basin margins. This reef complex consists of the Goat Springs and Capitan Limestones, which make up what is known as the Capitan Aquifer[37]; the geologic units forming the aquifer were deposited as either a fringing reef or a shelf-margin complex of organic mounds or banks ringing the structural Delaware Basin[38]. Subsequent deposition included sandstones and shales, which were overlain by evaporite beds and limestone, known as the Castile and Salado Formations. Through later episodes of mountain-building, parts of the unit have been raised well above surrounding land as the Guadalupe Mountains near Carlsbad, and the Glass Mountains near Fort Stockton, Texas. The Rustler Formation overlies the Salado Formation and consists of interbedded layers of limestone, dolomite, sand, and shale[39]. The Capitan Aquifer and Rustler Formation are the only major aquifers of the areas Permian-age rocks. The Capitan Aquifer is about 1,500 feet thick, although in an arc only 10-12 miles wide (FIGURE 9), and the Rustler Formation is about 200 to 300 feet thick in Lea County[40].

6.1.2.2 Hydrology Data by Aquifer

Alluvial Aquifer

The Allluvial Aquifer of the underlies most of southern Lea County and represents the northernmost extension of thick alluvial water-bearing deposits, common to Winkler, Ward, Loving, and Reeves Counties in Texas. In Lea County the Alluvial Aquifer is unconfined. At its extremities, areas such as Monument Draw, Querecho Plains, San Simon Swale, and Dogie Draw and along the Mescalero Ridge, the Alluvial is not continuous. The saturated thickness is substantial in places, such as in the Jal UWB, but thin at most other locations. Deep-seated dissolution and collapse

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[33] Ash (1963)
[34] Lucas and Anderson (1993)
[35] Lucas and Anderson (1993)
[36] Ash (1963)
[37] Hiss (1973)
[38] Hiss (1973)
[39] Richey, et al. (1985)
[40] Hiss (1973)

of salt-rich geologic units, not erosion, is believed the reason for the trough extending from the Winkler Alluvium in Ward County into the Jal UWB. The Winkler alluvium is deeper than that in the adjacent Jal UWB, creating potential for future ground-water development in Texas that could increase the rate of drawdown of the JAL UWB in Lea County.

Even at locations where it is thin, the Alluvial Aquifer is capable of producing adequate supplies of water for livestock and domestic uses. The greatest production from the Alluvial Aquifer is in the Jal UWB for the City of Jal. The transmissivity for the aquifer ranges from 2,140 to 3,075 ft2/d (16,000 to 23,000 gpd/ft)[41] with depth to water ranging from 50 to 100 feet[42]. In the Jal Water Well Field, the saturated thickness of the alluvial aquifer is reported to exceed 500 feet, with a transmissivity of 2,400 ft2/d (18,000 gpd/ft), and an average effective porosity of 16 percent[43]. One of the City of Jal wells was pump tested at 450 gallons per minute for 36 hours[44].

Water depths in the Alluvial Aquifer have decreased in some areas by 10 feet in the last 24 years[45]. Ground-water pumping is the most significant discharge. Where the water table lies close to land surface, evapotranspiration constitutes another source of discharge[46]. Recharge is from infiltration of surface water from surrounding uplands and along channels of ephemeral streams. Regional percolation is not a factor unless storms are of long duration or frequent occurrence, in which case the soil can fully hydrate - allowing deeper percolation[47]. Subsurface recharge may occur through flow from adjacent artesian formations. This is problematic in Reeves County, Texas, where the Rustler Formation may be recharging the alluvium with saline water because the low permeability rock of the Dewey Lake Red Beds, is not present to separate the two units.

It is not possible to estimate the total amount of ground-water in storage in the Lea County's portion of the Alluvial Aquifer, because of the Aquifer's discontinuity and because the horizontal and vertical extent of smaller areas of saturated alluvium are poorly defined. The only portion of the County in which an estimate of ground-water in storage can be made with accuracy is within the Jal UWB. Estimated ground-water in storage[48] in the Jal UWB is shown in TABLE 6-3.

TABLE 6-3: ALLUVIAL AQUIFER

Area (acres)	Average Saturated Thickness (feet)	Specific Yield	Estimated Ground water in Storage (acre-feet)
9,600	310	0.16	476,160

Source: Miller (1994)

Ogallala Aquifer

The Ogallala Aquifer is the main source of water in the Lea County, where it underlies about 2,800 square miles; it almost completely underlies the area covered by the Lea County UWB and the undeclared basin-area in the north part of the County. The Ogallala only provides limited amounts of water to wells in other portions of the county

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[41] Nicholson and Clebsch (1961)
[42] Miller (1994)
[43] Engineers, Inc. (1998)
[44] Miller (1994)
[45] Miller (1994)
[46] See Section 6.1.1.4
[47] Richey, et al., 1985
[48] Not all ground water in storage can be pumped from an aquifer. Water is retained in an aquifer by surface-tension forces associated with the grains of clay, silt, sand, gravel, or other particles. The smaller the grain size, the greater the amount of water that will be retained.

because the saturated thickness is fairly small or non-existent in those areas. The Ogallala is unconfined and therefore flows east-southeast in response to gravity, following the inclination of Ogallala beds and the top of the underlying confining stratum.

The hydraulic conductivity reported for various portions of the Ogallala Aquifer in the Lea County UWB has been evaluated by a number of different authors using different techniques. The techniques include aquifer tests and laboratory analysis[49], and model calibration[50]. Values reported range from 3 to 262 ft/d. Reported values from ground-water flow models indicate areas with higher hydraulic conductivity near the central portion of the basin, between Tatum and Lovington - eastward to the Texas border and near Hobbs - eastward to the Texas border. Specific yields reported range from 0.10 to 0.28[51, 52]. Depth to water ranges from about 20 feet near Monument and the Four Lakes area to about 250 feet along the edge of Mescalero Ridge[53]. Saturated thickness of the aquifer ranges from a few feet along the northeast portion of the UWB and along portions of the Mescalero Ridge, to about 250 feet near the Texas State Line. Irrigation well yields range from about 200 to nearly 2,000 gallons per minute.

Under pre-pumping conditions, recharge of the Ogallala was in equilibrium with natural discharge. The greatest amount of natural discharge has always been through subsurface flow across the Texas Line. Some natural discharge also occurs through springs, seeps, lakes[54], and evapotranspiration[55]. Pumping for irrigation, municipal supply, domestic use, industrial use, and stock causes a large artificial discharge. Because pumping is in excess of the Ogallala's recharge rate the elevation of the top of the aquifer has declined or experienced drawdown. A recent ground-water flow model[56] indicated that, in response to heavy pumping in Texas, the most severe drawdowns occur along Lea County's east border, the Texas Line. In this area drawdowns in excess of 60 feet have occurred since 1940. The model predicts that the saturated thickness will decrease another by 50 to 100 feet in the area between the State Line and the communities of Hobbs, Lovington, and Tatum in the next 40 years. Actual drawdowns could be much greater than this amount[57]. As the model use County Water demand for 1995, not predicted

Recharge to the Ogallala occurs when precipitation[58], flows in ephemeral streams and arroyos, and water retained in playas and lakes infiltrates into the subsurface[59]. Recharge rates vary with changes in precipitation, soil type, and the hydraulic properties of underlying sediments and rocks. Estimates of recharge range from 0.25 to 0.5 inches per year[60, 61]. It follows then that the amount of annual rechargeto the Ogallala in Lea County is between 37,500 to

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[49] Theis (1934)

[50] McAda (1984), and Musharrafieh and Chudnoff (1999)

[51] The specific yield for an unconfined aquifer is the volume of water that will drain from a unit of surface area per unit of decline. The value is expressed in percent.

[52] Musharrafieh and Chudnoff (1999) provide a thorough summary of hydraulic conductivity and specific yield data for the Ogallala aquifer in the Lea County UWB and other nearby areas.

[53] Musharrafieh and Chudnoff (1999)

[54] See Section 6.1.1.5

[55] See Section 6.1.1.6

[56] Prepared by Musharrafieh and Chudnoff (1999)

[57] Drawdown projections are based on all demands although irrigation is most significant on the present irrigation of approximately 51,000 acres. Lea County had about 150,000 acres of iffigable land with permitted water rights. The role and rate of aquifer decline will be greater if more acres are irrigated.

[58] The greatest amount of recharge from precipitation comes in areas covered by dune sand, and in areas well covered by playa lakes.

[59] Some investigators in the area have suggested that irrigation return flow is recharge. Water returned to the aquifer from irrigation is more appropriately recycled water, because the water is simply returning to the same awuifer from which it was pumped. Return flow to the aquifer from irrigation was estimated by Stone (1984) to be 10.3 inches per year per irrigated acre.

[60] Theis (1934) and McAda (1984)

[61] Dugan and Cox (1994) estimate that 0.5 inches is recharged to the aquifer each year. They note that the Department of Agriculture Conservation Reserve Program (CRP) may reduce the amount of recharge, because the

75,000 acre-feet per year, on average[62]. The average annual recharge to the Lea County UWB is between 29,000 to 58,000 acre-feet, on average[63]. Additional recharge can be expected from precipitation falling on small areas of the Llano Estacado outside County boundaries to the north and west. Also, a small amount ground-water in the Ogallala Formation in adjacent parts of Roosevelt and Chaves Counties flows southeasterly, and likely enters the area along the County's northern border.

A study of the potentiometric surface data over the last 46 years shows large declines in the Ogallala and a decrease in its natural flow potential. Potentiometric surface[64] elevation data from 1952, shown in **FIGURE 15**, indicate the ground-water flow direction was about 30 degrees south of east, with a gradient of 15.8 feet/mile in north and central Lea County[65]; in the southeast part of the County flow was apparently more southerly. Potentiometric elevation data for 1968 are shown on **FIGURE 18**; the direction of ground-water flow was southeast and the gradient averaged about 15 feet/mile. Changes in the potentiometric surface elevation from 1952 to 1968 indicate decreasing water levels throughout much of the Ogallala[66]. Potentiometric surface elevation contours for 1981[67] are shown on **FIGURE 19**; the contour lines tend to be more sinuous than those of earlier years, but this is probably because a greater amount of data - with a larger spatial distribution, were available. The location of the contours changed little from 1968 to 1981, indicating only small changes in water levels for the period; the direction of flow was southeast and the gradient averaged about 13.7 feet/mile. Potentiometric surface elevation contours for the combined years 1995 through 1998[68] are shown on **FIGURE 21**. The general flow direction and location of the contours changed little from 1981, indicating only small changes in water levels; the direction of ground-water flow was southeast and the gradient was about 13 feet/mile.

Declines in the Ogallala's thickeness, in excess of 8 feet, occurred from 1940 to 1950 in the area from McDonald to Prairieview, and at Lovington, Humble City, and Hobbs (**FIGURE 16**); the areal extent of declines were greatest around Lovington, reaching about 25.5 square miles[69]. Larger declines of up to 25 feet occurred from 1950 to 1960, as ground-water development increased; measurable declines were noted throughout most of the County (**FIGURE 17**), with the greatest decline occurring about 2 miles northeast of Prairieview[70]. Depth to water measurements from wells during 1968 to 1981 (**FIGURE 20**) reveal additional declines in excess of 25 feet along the State Line, with declines exceeding 10 feet in other locations. Then again during the interval between 1981 and 1998 depth to water measurements showed declines exceeding 25 feet at the State Line (**FIGURE 22**); however, during this last period ground-water levels actually rose throughout the north and west parts of the County[71]. Drawdowns are localized

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CRP takes land out of irrigation for ten years, allowing the vegetation to revert to grassland. Grasses have larger water requirements than most cultivated crops. This decrease will be more than offset by the corresponding decrease in irrigation pumping.

[62] = (0.25-0.5 inches) X (2,800 sq. mi.)

[63] = (0.25-0.5 inches) X (2,180 sq. mi.)

[64] The potentiometric surface of an unconfined aquifer, such as the Ogallala, is essentially the water table surface.

[65] Ash (1963)

[66] This is noted by westward shifts in equal elevation contours in the eastern, central, and southern portions of the basin between the two time periods. For example, east of Lovington, the 3,700 foot contour was present about 1.4 miles farther east in 1952 than in 1968. Since the water table elevations increase to the west, the westward shift indicates a decrease in the water levels in the area. Comparison of data east of Tatum for the two time periods indicates a similar trend.

[67] The contours were made using significantly more data than were available for 1968. The data came from water-level measurements at individual wells.

[68] This is the most recent water level data available for this report.

[69] Ash (1963)

[70] Ash, (1963)

[71] Dugan and Cox (1994) indicate that decline rates from 1980 to 1993 could have been greater, except the annual precipitation from 1981 to 1992 was more than 6 inches above normal. The above average annual precipitation could likewise be responsible for the water level rises experienced throughout much of the north and west parts of the County during the same time period.

along these main pumping centers. In order to meet future demands, well fields may need to be drilled into areas where less drawdown has occurred, generally the western portions of the basin.

Pumping in Texas, along the Texas-New Mexico State Line is in large part responsible for more than 80 feet of localized declines in the water-level since 1940. Continued pumping along the Line will continue to drop the water-level and increase the hydraulic gradient in the area. Estimated flows across the New Mexico-Texas Line have been calculated and are shown in the graph below and in TABLE 6-4. Although the hydraulic gradient from New Mexico to Texas has increased over time, the amount of water flowing from New Mexico to Texas has decreased from 1967 to present. This is because the saturated thickness of the aquifer along the New Mexico-Texas border has decreased[72]. In the future, the flow across the Line should continue to decrease as the thickness of the aquifer declines and there is less water to pump.

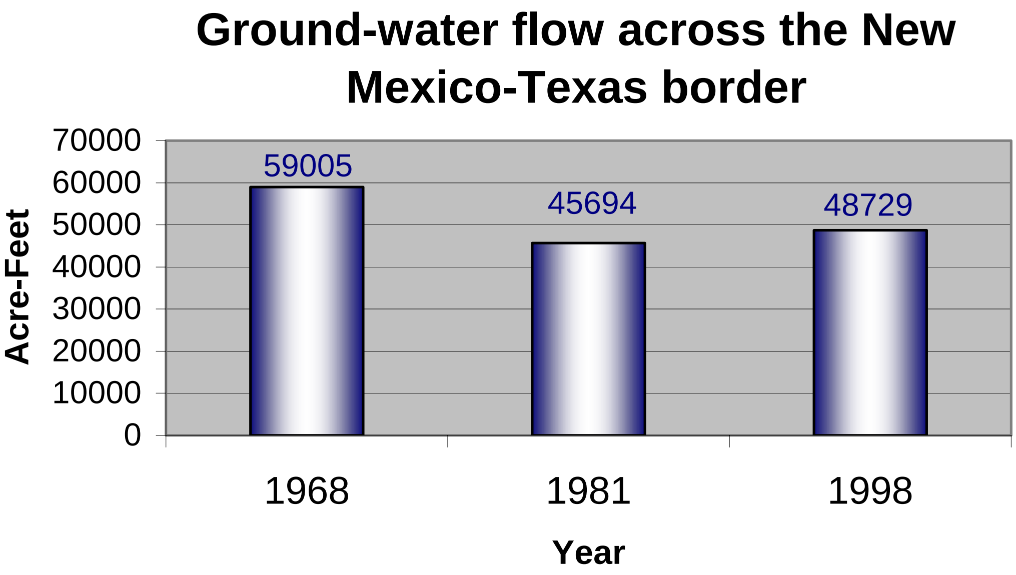

TABLE 6-4: FLOW ACROSS

Time Period	SaturatedThickness Length Along NM-TX Line, In Miles	Flow In Acre-Feet/Year
1967-1968	61.9	59,005
1981	61.9	45,694
1995-1998	61.9	48,729

Source: estimated from hydraulic conductivity values.

Pumping rates and costs are affected by the depth of water and the thickness of the aquifer. As the water-table depth increases the energy required to lift water increases; to raise water to the surface, one additional unit of power is required for each additional 10 feet of water depth[73]. Depth to Ogallala water in 1952 was about 40 feet in the

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[72] As the thickness of the aquifer decreases, there is less saturated area through which water can flow. For similar reasons the rate at which water can be pumped from an aquifer is related to its thickness.

[73] Power = $(\text{Depth}_{\text{watertable}} \text{ X } \text{Pump}_{\text{discharge}} \text{ X Efficiency})/3956$

central and south-central parts of the County. Current depth to water for the Ogallala ranges from 50 feet to 200 feet along the Texas Line. Depths to water in 1968, 1981, and present are shown on FIGURES 23, 24, and 25, respectively. Hydrographs from wells in the Lea County portion of the Ogallala, showing historic water level changes, are included in APPENDIX J.

As the saturated thickness of an aquifer decreases, well yields (the amount of water available) from vertical wells also decreases. Due to the nature of the Ogallala, it is not feasible to produce large quantities of water from vertical wells in Lea County when less than 70 feet of saturated thickness exist. FIGURES 26, 27 and 28 show approximate saturated thicknesses for the Ogallala Formation for 1952, 1967 and present, respectively.

At various times, estimates of ground-water in storage have been made for the Ogallala in Lea County. The estimates are made by assuming specific yields and saturated thicknesses. Ground-water in storage estimates are shown in TABLE 6-5. As noted for the Alluvial Aquifer, not all ground-water in storage can be withdrawn. About 40 percent of the total stored water in Lea County's portion of the Ogallala (approximately 20,000,000 acre-feet in 1952) was considered recoverable for large-scale users. This equals about 100 years of supply at 1960 pumping rates. Because about 45 percent of the water in the basin is in areas where the saturated thickness is 140 feet or greater, this Plan has determined that 45 percent (approximately 14,000,000 acre-feet) of the water presently in storage can be recovered. It follows that approximately only 8,000,000 acre-feet of recoverable water will exist in 2040 if a continuation of 1998 pumping rates occurs. The bulk of this figure will also probably be located away from existing well fields due to drawdown in the aquifer.

TABLE 6-5: OGALLALA AQUIFER – STORED WATER IN LEA COUNTY

Aquifer Area	Average Specific Yield	Estimated Ground water in Storage (acre-feet)	Recoverable water	Date	Reference
1,400,000 acres	0.35	49,000,000	19,600,000[a]	1952	Ash, 1963
1,500,000 acres	0.20	48,000,000	21,600,000 [b]	1984	McAda, 1984
1,400,000 acres	0.21	31,100,000	14,000,000[b]	1995-1998	calculated from Musharrafieh and Chudnoff (1999)

[a] Assumes 40% of water is recoverable.
[b] Assumes 45% of water is recoverable.
[c] Calculations are for the Lea County UWB. Other parts of the Ogallala in Lea County are insignificant.

Dockum Group Aquifers

Dockum Group sediments exist throughout Lea County. While the Dockum Group has thick areas of sediments and large estimates of stored ground-water, the Group's aquifers are largely undeveloped due to the availability of shallower water and the high cost of producing the deep Dockum waters. The development that has occurred is limited specifically to the Santa Rosa sandstone unit. The Santa Rosa Aquifer is the principal source of ground-water for domestic and livestock uses in the southwestern portion of the County and was the principal aquifer for the City of Jal before 1954. The only community in Lea County that currently pumps part of its water from the Dockum Group is Oil Center.

The available hydraulic data for the Santa Rosa Aquifer are sparse and indicate a wide ranges of values. Well yields range from 6 to 100 gpm[74]. Specific capacities range from 0.14 to 0.2 gallons per minute per foot of drawdown. Depth to water varies from 120 feet to 700 feet and the potentiometric surface elevation ranges from 2,820 to 3,400 feet above mean sea level (msl). The saturated thickness varies from 200 to 250 feet; the saturated thickness of the

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[74] Nicholson and Clebsch (1961)

Dockum Group sediments as a whole can be much thicker, up to 2,400 feet in northern Lea County[75]. The direction of flow varies from south in the south-central part of the Lea County to southwest towards Eddy County in Lea County's southwestern part; it has been suggested that water from the Dockum Group is also flowing downward from the Santa Rosa Sandstone into underlying Permian rocks[76].

Discharge from the aquifer is through pumping or subsurface flow into other underlying formations. Recharge to the Dockum occurs through precipitation on overlying sand dunes, precipitation directly on the Group's outcrop, and runoff flowing over the outcrop. It is also possible that some vertical migration of water from the overlying Ogallala and Alluvial Aquifers contribute[77]. Major recharge areas for the Dockum Group are in the southwest part of the County, where Tertiary formations are not significant overlying structures. Recharge areas can be seen in the potentiometric surface elevation data of FIGURE 15.

Changes in water level from 1968 to 1981 for the south parts of the Dockum Group can be seen on FIGURE 20. Data south of Mescalero Ridge are primarily from the Dockum Group aquifer, but do include some wells in the Alluvial and Ogallala aquifers. Declines of up to 50 feet occurred in spots, but increases of up to 15 feet also occurred. Water level changes for the same area from 1981 to 1998 can be seen on FIGURE 22. Ground-water declines of 10 to 50 feet occurred and increases of 10 to 30 feet are indicated. Hydrographs showing historic water level changes for the southern portion of the county are included in APPENDIX-J.

Tucumcari Formation

The Cretaceous Tucumcari Formation exists in a limited area of northeastern Lea County. The Tucumcari is overlain by sediments of the Ogallala Formation. Close to one-third of Lea County's known Tucumcari has part of its strata above the water table[78]. Lithologically, the Tucumcari is characterized as a shale with lesser limestone and sandstone beds. Basal sandstone beds provide limited amounts of water from within the Tucumcari Formation, but only limited exploration of the unit's ground-water has occurred.

Several well completions into Cretaceous beds in northern Lea County are reported. Prior to the 1940's, some beds contained sufficient hydrostatic head to provide large flows at the ground surface[79]. Cretaceous-zone water wells ceased being artesian at the surface due to widespread drilling of uncased seismic shot-holes. The shot-holes made hydraulic connections to the overlying Ogallala Formation, providing a path for excess head in the Tucumcari to dissipate into the unconfined Ogallala Aquifer. Ground-water flow could occur through natural pathways between the Cretaceous rocks and the Ogallala aquifer[80]. In the area near Ranger Lake, the Ogallala is known to gain water from the Cretaceous units rising to the west and northwest.

The fine-grained character of most of the thickness of the Tucumcari Formation in Lea County will likely impede development of substantial amounts of water from this unit without the occurrence of secondary permeability features (i.e. fractures, limestone solutioning, etc.). Estimates of ground-water in storage for the Tucumcari are presented in TABLE 6-6, The percent of the storage that is economically feasible to develop has not been determined.

Rustler Formation

The Permian Rustler Formation is believed to underlie all of Lea County at depth. Like other Permian units lacking nearby fresh-water recharge, the Rustler produces brackish to saline water. Lithologically, the majority of the unit is composed of evaporite beds (halite, gypsum) which are poorly permeable unless solutioned, and have obvious water

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[75] Dutton and Simpkins (1986)
[76] Nicholson and Clebsch (1961)
[77] Nicholson and Clebsch (1961)
[78] Any overlying Ogallala Formation beds in these areas would also be unsaturated.
[79] Ash (1963) reported one well with a potentiometric surface elevation 14 feet above the ground surface.
[80] McAda (1984)

quality limitations for potable or agricultural use. Two marker beds within the Rustler, the Culebra and Magenta Dolomites are acknowledged as the formation's main production beds. Near-surface flow from these units has contributed to the saline shallow ground-water found in Nash Draw in Lea and Eddy Counties.

Ground-water produced from the Rustler Formation is primarily used for stock watering and secondary recovery of oil. Water in the formation is generally present under confined (artesian) conditions. Depth to water ranges from about 240 to 355 feet below ground surface and the potentiometric surface elevation ranges from 2,835 to 2,765 feet above msl, sloping to the southwest[81]. The formation's thickness has been estimated to range from 90 to 450 feet[82]. Depth to the top of the formation may range from 900 to 1,100 feet.

Little data regarding the hydraulic properties of the Rustler in Lea County are available. The nearest data concerning hydraulic properties of the Formation are from Eddy County, where the transmissivity of the Culebra Dolomite Member at the Project Gnome Site was reported as 468 ft2/day[83], 0.001 to 140 ft2/d at the Waste Isolation Pilot Plant (WIPP), and 18 to 1,250 ft2/d at Nash Draw. Transmissivity of the Magenta Dolomite Member at the WIPP site ranges from 0.004 to 0.1 ft2/d[84]. Well yields in Lea County are reported to range from 10 to 100 gpm[85]. Surface recharge to the formation occurs from infiltration of precipitation and surface water flow on outcrops. Recharge probably occurs at some distance from Lea County because the closest outcrops are in Culberson County, Texas[86]. Subsurface discharge exists in Eddy County, where the Rustler is in places found to be in hydraulic connection with the Pecos River. Discharge from the aquifer in Lea County is from wells and ground-water flow out of the county.

TABLE 6-6: LEA COUNTY AQUIFERS - GROUND-WATER IN STORAGE

Aquifer	Aquifer Area (acres)	Specific Yield	Estimated Ground water in Storage (acre-feet)	Water Level Data	Reference, Formation Geometry
Ogallala Formation (unconfined)	1,441,000	0.12	17,200,000	1995-98	this report using 1995 to 1998 data
Ogallala Formation (unconfined)	1,440,000	0.21	31,400,000	1995-98	this report using 1995 to 1998 data, NMSEO January 1999 model
Tucumcari Formation (unconfined)	493,000	0.05	1,170,000	1995-98	Ash, 1963
Tucumcari Formation (unconfined)	493,000	0.1	2,340,000	1995-98	Ash, 1963
Upper Dockum Group (unconfined portion)	143,000	0.05	19,400,000	1995-98	Dutton and Simpkins, 1986 Nicholson and Clebsch, 1961
Upper Dockum Group (unconfined portion)	143,000	0.1	19,400,000	1995-98	Dutton and Simpkins, 1986 Nicholson and Clebsch, 1961
Upper Dockum Group (confined portion)	2,000,000	.000001	1,060	1995-98	Dutton and Simpkins, 1986 Nicholson and Clebsch, 1961
Lower Dockum Group (unconfined portion)	122,000	0.05	2,770,000	1995-98	Dutton and Simpkins, 1986 Nicholson and Clebsch, 1961

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[81] Richey, et al. (1985)
[82] Richey, et al. (1985), and Hiss (unpublished, 1975)
[83] Cooper and Glanzman (1971)
[84] Mercer (1983)
[85] Richey, et al. (1985)
[86] Richey, et al. (1985)

Lower Dockum Group (unconfined portion)	122,000	0.1	5,540,000	1995-98	Dutton and Simpkins, 1986 Nicholson and Clebsch, 1961
Lower Dockum Group (confined portion)	2,690,000	.000001	2,770	1995-98	Dutton and Simpkins, 1986 Nicholson and Clebsch, 1961
Rustler Formation (confined)	2,810,000	.000001	633	1995-98	Wells, Richey, and Stephens, 1985
Rustler Formation (confined)	2,810,000	.000001	759	1995-98	Hiss, unpublished, 1975
Capitan Reef (confined)	374,000	.000001	467	1995-98	Hiss, unpublished, 1975

Capitan Aquifer

The Permian Capitan Reef Complex is a geologic unit found within New Mexico and Texas. The Capitan is positioned about the perimeter of the Delaware Basin as shown in FIGURE 9. Where adjacent to uplifted recharge areas, or in direct hydraulic connection with freshwater river systems, the aquifer can provide water for potable consumption and agriculture. Deeper portions of the Capitan Reef Complex without direct surface water connections form a productive, although typically saline, aquifer. Still further down gradient, the Capitan produces highly saline brine due to unflushed salts and proximity to bedded salt deposits. It is believed that the Capitan Reef complex functions as a single hydrogeologic unit and, therefore, is referred to as the Capitan Aquifer[87]. The geologic units surrounding the Capitan Aquifer generally have significantly less permeability than the Capitan and lower hydraulic conductivity, allowing the units to act as barriers to ground-water attempting to move in or out of the aquifer[88]. The main use of the Capitan Aquifer in Lea County is for re-pressurizing production zones in oil fields for secondary oil recovery. Due to elevated salinity concentrations, it is not used for potable water in Lea County. However, it serves as the municipal water supply for the City of Carlsbad (Eddy County) and as irrigation supply in portions of west Texas, because the water quality is better at these locations.

Hydraulic properties of the Capitan Aquifer are variable and are a function of the degree and interconnectedness of fractures and solution channels within the rock. The average hydraulic conductivity of the Aquifer, in southern Lea County and for east of the Pecos River at Carlsbad, is approximately 5.0 feet per day. Values have been reported several orders of magnitude higher west of the Pecos at Carlsbad[89]. Within Lea County the Capitan Aquifer ranges in thickness from 800 to 2,200 feet, with a width of approximately six miles in the vicinity of Jal to approximately 12 miles in County's western part[90]. Ground-water flow in Capitan aquifer converges from north and south to an area approximately 20 miles southeast of San Simon Swale[91].

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Discharge from the aquifer is in the form of pumping for industrial purposes in Lea County, and in Ward and Winkler Counties, Texas[92]. Discharge also occurs through Carlsbad Springs along the Pecos River, north of Carlsbad. The Capitan aquifer is recharged by precipitation on its outcrop in the Guadalupe Mountains and Guadalupe Ridge along the New Mexico-Texas border. Recharge is by percolation of water through shelf deposits and infiltration into cavernous zones. Surface water also flows into the formation through caverns in part of the outcrop near Carlsbad and through Lake Avalon northwest of Carlsbad. It's estimated that 10,000 to 20,000 acre-feet per year of water leak

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[87] Hiss (1973) and Huff (1997)

[88] Hiss (unpublished, 1975)

[89] Richey, et al. (1985)

[90] Hiss (1973)

[91] This phenomenon may be related to a pumping centroid or a collapse-induced hydraulic connection to an aquifer of lower head.

[92] Hiss (unpublished, 1975)

through sediments under Lake Avalon into the Capitan[93].

In Lea County it is known, through the long term monitoring of five wells, that Capitan Aquifer water levels are declining. From 1967 through 1975 a constant decline in the aquifer occurred, with drops as great as 160 feet[94]. Withdrawal of water from adjacent Guadalupian-age formations, in hydraulic connection with the Capitan, is also thought to have contributed to Capitan declines. Examples of hydrographs in the Lea County portion of the Capitan Aquifer are presented in APPENDIX J.

Ground-water stored in Lea County's portion of the Capitan Aquifer is thought to be close to 500 acre-feet (TABLE 6-6).

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[93] Richey, et al., (1985)

[94] Four of the five monitored wells recorded slight rebounds between 1976 and 1977 – Huff (1997)

6.2 WATER-QUALITY ISSUES

6.2.1 Assess Quality of Water Sources

The most common indicator of water quality is the amount of total dissolved solids (TDS) the water contains. The less TDS a water sample has, the better the quality of the sample. The water quality data for this study has been measured and recorded by others and is reported as Specific Conductance (SC), because SC measurements are more easily made in the field[95]. SC multiplied by a value ranging from 0.55 to 0.75[96] will give an approximation of the TDS concentration. TABLE 6-7 lists SC data for a majority of the aquifers in Lea County. The higher values are usually associated with increased sulfate levels[97].

TABLE 6-7: SC & TDS OF WATER IN SELECT LEA COUNTY AQUIFERS

Aquifer	Specific Conductance (µmhos/cm)	Total Dissolved Solids (mg/l)	Comments
Alluvium	200 to 15,000[m]	130 to 9,750[e]	
Ogallala	419 to 21,500[m]	272 to 13,975[e]	
Santa Rosa Sandstone	1,030 to 2,840[m]	635 to 1,950[m]	depths from 350 to 747 feet
Dockum Group	350 to 9,180	228 to 6,377[e]	
Rustler	16,000 to 500,000[e]	10,347 to 325,800[m]	data from adjacent counties
Capitan	18,300 to 220,000[m]	12,800 to 173,448[m]	depths from 2,923 to 4,695 feet

[m]measured ¼ hos/cm (micromhos per centimeter)
[e]estimated mg/l (milligrams per liter)

In Lea County three aquifers, the Alluvial, the Ogallala, and the Dockum Group produce water of suitable quality for a wide variety of uses[98]. SC contour maps of the County were generated in order to assess historical changes in the ground-water quality[99] of these three aquifers. FIGURE 29 reflects SC measurements from 1948-1958[100]. FIGURE 30 was generated from data in the mid 1980's[101]. FIGURE 31 shows current data. FIGURE 32a shows changes in the SC from 1950 to the mid 1980's, when ground-water quality decreased by about 100 to 300 µmhos/cm (55 to 225 mg/l, TDS) across the County; some areas -- such as those west of Tatum, southwest of Hobbs, around Eunice, and east of Jal - experienced considerably worse reductions in quality, approaching 5000 µmhos/cm (2750 to 3750 mg/l, TDS) in places. FIGURE 32b shows changes in SC from the mid1980's to the late 1990's. In contrast to the earlier degradation trend, during this later period the quality of the ground-water -- in the north parts of the County, west of Tatum and below the Mescalero Ridge (Ogallala Aquifer) -- increased by as much as 500 µmhos/cm (275 to 375 mg/l, TDS). Only one area in the Ogallala, located along the Texas Line -- east-southeast of Tatum - shows decreasing water quality. Likewise, throughout most of the southern portion of the county - south of the Mescalero Ridge (Dockum Group and Alluvial Aquifers), water quality increased. The greatest improvement in quality, more than 2,000 µmhos/cm (1,100 to 1,500 mg/l, TDS), occurs 6 miles west of a point equidistant between Hobbs and

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[95] Specific Conductance is only a general measure of water quality and often does not account for the effects of pesticides and herbicides.

[96] This value depends on relative concentration of ions.

[97] Hem (1970)

[98] Aquifers in rocks older than the Triassic-age Dockum Group produce water high in total dissolved solids.

[99] The majority of ground water quality information is specific conductance data from the Ogallala Aquifer.

[100] The earliest water-quality data available for the Ogallala were collected from 1948 to 1958, with the majority of measurements being made around 1952 (Ash, 1963).

[101] Based on USGS and NMOSE electronic databases.

Eunice. A few localized decreases of as much as 1,200 µmhos/cm (660 to 900 mg/l, TDS) occurred between Eunice and Jal. Improved water quality from the mid 1980's to present, is probably attributed to changes in oil-field practices related to brine water. Before 1968 brine water had been discharged to unlined pits, often referred to as evaporation ponds, from which vertical migration into ground-water occurred. This infiltrated brine increased the TDS of the shallow ground-water. Regulations developed in 1967 and 1968, requiring evaporation ponds to be lined, appear to have been successful in reducing the brine water's migration into underlying aquifers. The mechanisms responsible for areas still experiencing decreasing water quality (since the mid 1980's) are unknown. It may be possible that water migrating from former unlined brine disposal pits is still occurring. Another possibility is that saline water from deeper aquifers is able to migrate into the shallow ground-water though poorly completed or failing oil field wells. Many different types of elements and molecules can be dissolved in water and contribute to the water's TDS, such as fluorides, chlorides, sodium, and sulfates. A TDS concentration of 500 mg/l is considered marginally acceptable for use in public supply and irrigation[102]. When concentrations above 500 mg/l are encountered treatment options and use restrictions are often considered. Fluoride concentrations of more than 1.6 mg/l are undesirable for drinking water and a slightly lower concentration of 1.0 mg/l is recommended for irrigation[103]. Irrigation use is not restricted when chloride concentrations are less than 150 mg/l and a concentration of no more than 250 mg/l is desirable for drinking water[104]. Sodium in concentrations exceeding 70 mg/l can indicate problems with irrigation usage. Sulfates are often indicative of water's hardness and concentrations in excess of 500 mg/l are not recommended for drinking water.

More detailed information on the quality of the water found in each of the major Lea County aquifers is presented below.

Alluvial Aquifer

Water from the Alluvial Aquifer varies widely in quality. In most locations the quality is good and the water can be used for a wide variety of activities. However, the quality is poor at some places and the types of activities which the water can support are restricted. TDS concentration in the Alluvial Aquifer is ranges from 200 to 15,000 mg/l, depending on the nature of the local sediments. Alluvial sediments having high portions of parent material (evaporite beds) will have high TDS concentrations. Fluoride concentrations[105] tend to be high, ranging from 0.3 to 10 mg/l. Chlorides can be very high, ranging from 5 to 7,500 mg/l[106]; Sodium concentrations approach 70 mg/l where they are acceptable, but very high. Sulfates are low ranging from 30 to 120 mg/l. Water is produced for the Jal distribution system from the Alluvial Aquifer. Quality information from Jal water sampling is shown in TABLE 6-8. The water produced from the Jal system is very hard.

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[102] Masters (1991) and Metcalf & Eddy (1991)

[103] Metcalf & Eddy (1991)

[104] Metcalf & Eddy (1991)

[105] Dissolved fluoride concentrations in children's drinking water of about 1 mg/l reduces cavities. Fluoride concentrations above 2 mg/l can cause dental fluorosis when teeth are developing. Concentrations exceeding 4.0 mg/l may result in crippling skeletal fluorosis, a serious bone disorder (NMED, 1995).

[106] Richey, et al. (1985)

TABLE 6-8: NATURALLY OCCURRING GROSS ALPHA CONCENTRATIONS FOR PUBLIC SUPPLY WELLS IN LEA COUNTY

Parameter	Concentration (mg/l)	NMWQCC Standard (mg/l)	EPA MCL (mg/l)
pH		6 to 9	6.5 to 8.5
specific conductance	1,004 µmhos/cm	none	none
total dissolved solids	768	1,000	500
alkalinity	188	none	none
bicarbonate	229	none	none
hardness	303	none	none
calcium	75	none	none
sodium	67	none	none
potassium	11	none	none
magnesium	28	none	none
chloride	59	250[a]	250 [a]
sulfate	118 to 291	600 [a]	250 [a]
fluoride	2.3 to 3.2	1.6	4.0
radon	132 to 323 pCi/l	none	300 pCi/l

reported concentrations from Engineers, Inc., 1988

[a]	aesthetic standard
NMWQCC	New Mexico Water Quality Control Commission
EPA	Environmental Protection Agency
MCL	maximum contaminant level
mg/l	milligrams per liter
µmhos/cm	micromhos per centimeter
pCi/l	picocuries per liter

Ogallala Aquifer

The waters of the Ogallala, while very hard, are consistently good quality and can be used for a variety of activities, including public supply and irrigation. TABLE 6-9 lists recent water quality testing results of public water systems that obtain water from the Ogallala Aquifer. TDS concentrations ranging from 300 to 415 mg/l are high, but acceptable - except at Tatum, where the TDS is very high - in excess of 700 mg/l. Fluoride concentrations are also high, but acceptable, ranging from 0.9 to 1.2 mg/l. Chlorides concentrations are moderate, at concentrations varying from 30 to 120 mg/l, and sulfates are low ranging from 50 to 120 mg/l.

TABLE 6-9: OGALLALA AQUIFER WATER QUALITY[A]

Parameter	Units	Hobbs	Eunice	Tatum	Lovington	Monument Water Users Assoc.[i]	EPA MCL
Date (may vary for parameters)		1998 annual averages	03/05/97	see notes	February 1997	March 1997	
alkalinity – carbonate	mg/l	0.0	0.0	0.0[b]	0.0	184.4	n/a
alkalinity – bicarbonate	mg/l	183.7	197.6	193.0[b]	210.4	225.1	n/a
alkalinity – total	mg/l	163[c]	186.5	158[b]	172.4	0.0	
arsenic	mg/l	0.008	0.008[d]	0.009[e]	0.0127	0.011	0.050
calcium	mg/l	80.7	80.5	112.0[b]	85.4	58.4	n/a
chloride	mg/l	114.0	63.4	93.0[b]	67.6	28.1	250a
specific conductance	µmhos/cm	839.9	716.8	1,103[b]	651.5	562	n/a
fluoride	mg/l	1.1	1.0[f]	1.2[g]	1.02	0.9	4.0
hardness	mg/l	293.3	248	376[b]	262.9	190	n/a
iron	mg/l	0.05	<0.25[b]	<0.25[b]	<0.25[b]	<0.25[b]	0.3
color		not detected	0.25	not detected[b]	not detected	not detected	250a
magnesium	mg/l	44.4	11.5	23.4[b]	12.1	10.7	4.0
mercury	mg/l	not detected	<0.0002[d]	<0.0005[e]	<0.0002	<0.0005	n/a
nitrate	mg/l	3.8	2.6	3.4	2.7	2.2	10
pH	standard	7.5	7.2	7.86[b]	7.4	7.1	6.5-8.5
potassium	mg/l	3.4[c]	4.8	2.73[b]	0.92	5.3	
sodium	mg/l	38.0	42.6	82.8[b]	52.5	32.7	n/a
sulfate	mg/l	113.1[e]	67.2	181[d]	88.9	55	
total dissolved solids	mg/l	410.0	415.7	729[b]	406.1	312	500a
turbidity	NTU	not detected	1.0	0.3[b]	0.1	.08	n/a
gross alpha	pCi/l	3.1 ± 0.9 to 16.6 ± 2.9[h]	2.8 ± 1 to 6.6 ± 1[h]	2 ± .8 to 5.4 ± 1.4[h]	1.6 ± .8 to 5.8 ± 1.2[h]	5.4 ± .9[h]	15

[a] results are either annual averages for all wells in a system, at the entry point of a system, or averages of a all wells in a system for a particular sampling date

[b] samples taken from 1975 to 1979 (Source: *Chemical Quality of New Mexico Community Water Supplies 1980*)

[c] sampled at entry point, August 23, 1994

[d] sampled at entry point, March 1995

[e] sampled at entry point, February 1996

[f] sampled at entry point, March 1996

[g] average of three wells sampled December 4, 1995

[h] range in concentration, low and high; sampled 1994 through 1997

[i] only one well in the system

EPA	Environmental Protection Agency
MCL	maximum contaminant level
µmhos/cm	micromhos per centimeter
mg/l	milligrams per liter
pCi/l	picocuries per liter
NTU	nephelometric turbidity units
a	aesthetic
n/a	not available

Dockum Group

The limited information available for the Dockum Group comes from the Santa Rosa Aquifer and indicates the water quality to be marginal. TDS concentrations were high to very high, ranging from 635 to 1,950 mg/l for one well sampled in 1942 and three wells sampled in 1953[107]. Sulfate concentrations varied from low to high or from 71 to 934 mg/l, with deeper wells having higher concentrations. While these parameters range above suggested limits, they indicate the water may often be used for public supply purposes, albeit occasionally with aesthetic restrictions. Irrigation uses should be even less restricted.

Rustler Formation

The quality of water produced from the Permian-age Rustler Formation in Lea County is inferred from data collected in Eddy County, at the WIPP site, where the formation also exists. Rustler Formation water is extremely poor in quality and cannot be used for public supply or irrigation without treatment. The TDS concentration of water produced from the basal portion of the Rustler Formation, near the contact with the underlying Salado Formation, ranges from 311,000 to 325,800 mg/l - extremely high. The TDS concentration of water produced from Culebra Dolomite and the Magenta Dolomite Members of the Rustler Formation ranges from 23,721 to 118,292 mg/l, and 10,347 to 29,683 mg/l, respectively[108]. The extreme TDS concentrations are due principally to the presence of gypsum beds within the formation.

Capitan Aquifer

The Capitan aquifer is an important source of water for secondary recovery of oil. The concentration of TDS in the Lea County parts of the Aquifer is very high ranging from 10,065 to 165,000 mg/l[109]. The lowest concentrations reported occur in the western portion of the County and increase to the southeast. Because of the great depth to water and the high TDS concentration, the potential development of water from the Aquifer is severely restricted. TABLE 6-10 shows production intervals and corresponding TDS and SC of water in selected wells in the Capitan aquifer.

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[107] Nicholson and Clebsch, (1961)
[108] Richey, et al. (1985)
[109] Hiss (1973)

TABLE 6-10: CAPITAN AQUIFER QUALITY

Well Name	Location	Aquifer	Producing Depth (feet)	TDS (mg/l)	Specific Conductance (µmhos/cm)
Middelton Federal B1	19S 32E 31.110	Seven Rivers/Capitan	2,923 - 2,957	25,800	36,100
South Wilson Deep 1	21S 34E 23.310	Capitan	4,169 - 4,187	12,800	18,300
North Custer Mountain 1	23S 35E 28.120	Capitan	4,470 - 4,507	not reported	59,500
Federal Davis 1	24S 36E 20.210	Capitan	4,278 - 4,285	173,448	220,000
Southwest Jal Unit 1	26S 36E 4.230	Capitan	4,199 - 4,695	not reported	168,000

Source: Hiss (1973)

6.2.2 Identify Sources of Contamination

In general, existing wells in Lea County are not impacted by ground-water contamination. As of 1998 the ability of area aquifers to supply wells in Lea County has been limited in only a few places by contamination. Potential sources of contamination are determined by identifying discharges, leaks and spills and by recognizing industries, land uses, and enterprises that employ processes, materials and methods that have the ability to negatively impact water supplies. The activities that most commonly are sources of ground-water contamination in Lea County and the types of contaminants associated with the activities are:

- Petroleum Production Facilities - salts from oil well brine pits, hydrocarbons from leaks and spills;
- Agricultural Activities - residues from applied and stored pesticide and fertilizers;
- Wastewater Disposal Systems - leachate containing nitrogen from community wastewater treatment facilities and septic systems;
- Underground Storage Tanks - hydrocarbons from leaks and spills
- Mines and Quarries - heavy metals;
- Industrial Facilities - chemicals and heavy metals;
- Landfills - leachate containing nitrogen, chemicals, and heavy metals;
- Livestock Industry - wastewater and runoff from dairies and feed lots; and
- Radioactive Mineralization.

Actual and possible sources of contamination in the County were identified by studying State and Federal records[110].

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[110] Data were obtained from records, reports, and electronic databases available from the NMED Bureaus of Ground Water Quality, Drinking Water, Community Services, Solid Waste, and Underground Storage Tank, plus the Oil

Confirmed sources of ground-water contamination in Lea County, since 1986, are listed in APPENDIX M; the threat from some of these sites no longer exists. Current potential sources of contamination are plotted on FIGURE 33. To more fully assess the possibility of ground-water contamination for a certain location, several site-specific factors need to be considered. Such factors include: depth to ground-water, soil type and layer thicknesses, and the presence of fractures or channels in rocks.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) are two Federal programs that attempt to identify, catalogue and address contaminated sites and manage hazardous wastes. CERCLA sites are thought to already be contaminated and RCRA sites may be contaminated and/or have the potential to become contaminated. Currently in Lea County, there are two sites that have been been considered for participation in the CERCLA program; they are Highway 18 Solvents and Snyder Street PCE. Both sites have been assessed and are not on the National Priority List (NPL), which contains the worst cases. Several other sites have been investigated under CERCLA and are currently designated as having No Further Remedial Action Planned (NFRAP); a few of these

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Conservation Division (OCD) of the NMED. Secondary data were obtained from the U.S. EPA, the NMOSE, the USGS, and other geologic and hydrogeologic references pertaining to the study area. Databases researched for this section include the federal version of the Safe Drinking Water Information System (SDWIS), the NMED databases for Underground Storage Tanks and Public Water System Sampling Results, the federal CERCLA Information System (CERCLIS), and the Resource Conservation and Recovery Information System (RCRIS).

later sites are participating in the State of New Mexico's Volunteer Remediation Program (VRP), while others have been referred to the OCD and the RCRA program[111]. A list of sites investigated under CERCLA and their current status are shown in TABLE 6-11. Over 200 facilities are part of the RCRA program in Lea County. Most of these RCRA facilities are small quantity generators which may be conditionally exempt. However, some of the facilities are large quantity generators, storers, transporters, or disposers of hazardous waste. The RCRA program information documents list only facilities that deal with hazardous waste and do not track leaks, spills or other contamination. APPENDIX L lists the RCRA sites and some of the basic information regarding them.

TABLE 6-11: SITES INVESTIGATED UNDER CERCLA IN LEA COUNTY

Site Name and Location	Status	Last Action and Date	Comments
Highway 18 Solvents, Hobbs	discovery	discovery in 1998	listed on CERCLIS, not on NPL
Snyder Street PCE, Hobbs	discovery	discovery in 1998	listed on CERCLIS, not on NPL
AAA Feed Store, Lovington	NFRAP	preliminary assessment in 1995	
BLM – Kerr McGee Laguna Totson, Hobbs	NFRAP	site inspection in 1980	referred to GWQB AAS
BLM – Kerr McGee Potash Co., Hobbs	NFRAP	site inspection in 1980	referred to GWQB AAS
Cardinal Surveys Co., Hobbs	NFRAP	site inspection in 1981	
Chevron USA Maljamar	NFRAP	preliminary assessment in 1981	
Climax Chemical Co., Monument	NFRAP	site inspection in 1981	
Cueltar BL-1100 Site, Hobbs	NFRAP	preliminary assessment in 1991	VRP
Diamond Tank Rental, Hobbs	NFRAP	site inspection in 1986	referred to OCD
Gooch's Tank Farm, Tatum	NFRAP	preliminary assessment in 1992	referred to OCD
City of Jal Landfill	NFRAP	preliminary assessment in 1982	VRP and needs referral
McCasland Service (Oil)	NFRAP		may need OCD enforcement; may be in VRP
Mumford Properties, Hobbs	NFRAP	preliminary assessment in 1991	
National Potash Co.	NFRAP		referred to GWQB AAS; VRP
New Mexico Electric Co., Hobbs	NFRAP	site inspection in 1981	
Oil Processing Inc., Monument	NFRAP	site inspection in 1989	referred to OCD
Phillips Petroleum – Eunice Natural Gas Plant	NFRAP	site inspection in 1985	referred to OCD
Phillips Petroleum – Lee Plant, Lovington	NFRAP	site inspection in 1985	may need RCRA enforcement
Phillips Petroleum – Lovington (compressor station)	NFRAP	site inspection in 1985	VRP
Phillips Petroleum – Maljamar	NFRAP	preliminary assessment in 1981	
Southern Union Refinery Co., Hobbs	NFRAP	site inspection in 1981	referred to OCD
Southern Union Truck Facility, Hobbs	NFRAP	site inspection in 1981	
City of Tatum Landfill	NFRAP	preliminary assessment in 1982	inactive landfill
Tipperary Resources, Lovington	NFRAP	preliminary assessment in 1995	referred to ABQ
Two Mile Pit, Hobbs	NFRAP	site inspection in 1981	VRP
Warren Petroleum – Eunice	NFRAP	site inspection in 1985	referred to RCRA
Warren Petroleum – #118, Monument	NFRAP	site inspection in 1985	referred to RCRA
Warren Petroleum – #146, Saunders	NFRAP	site inspection in 1985	referred to RCRA
Warren Petroleum – #139 VADA, Tatum	NFRAP	site inspection in 1985	referred to RCRA
Waste Control of New Mexico, Hobbs	NFRAP	site inspection in 1981	
Western Oil Transportation Co. Shop, Hobbs	NFRAP	site inspection in 1985	
West Hobbs, T18S R38E and vicinity	NFRAP	site inspection in 1986	

Source: NMED Ground Water Quality Bureau, Superfund Oversight, 2/99 and CERCLIS

6.2.2.1 Petroleum Production Facilities

Fresh water aquifers in Lea County are often underlain by oil reservoirs, particularly in the Permian Basin areas. The

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[111] It is important to note that petroleum contamination is exempt from CERCLA guidelines.

petroleum industry is beneficial to the Lea County economy, but it also poses environmental problems. A 1993 NMOSE memoranda states that the quality of fresh ground-water in Lea County oil fields has deteriorated[112]; some water wells can no longer be used because their water quality has been degraded by oil-field activities. Of the 197 reported cases of ground-water contamination in Lea County since 1986, 141 of them were caused by oil-field activity and petroleum processing[113]; approximately 64 percent of those are caused by brine waste water. Indications of brine contamination include elevated concentrations of chloride, sodium, calcium, magnesium, and other dissolved solids. Other contaminants related to petroleum production include hydrocarbons and solvents. TABLE 6-12 summarizes cases of contamination due to petroleum production. The most obvious potential source of ground-water contamination is brine production and disposal. Brine is almost always produced with oil, and as oil fields get older the relative proportions of saline water to oil tend to increase[114]. In Lea County about twice as much brine water is produced as oil, and some of older and larger oil fields produce six times as much brine water as oil[115]. Prior to 1969 when the use of unlined brine pits was discontinued, estimates based on data from the New Mexico Bureau of Mines and Mineral Resources (BMRR) place the amount of produced brine water to be about 180,000 ac-ft. During this time, approximately 96 percent of the brine discharged to unlined pits for evaporation instead seeped into the ground[116]. Remnant oil floating on the water surface of the pits inhibited evaporation and contributed to the high seepage amounts. Since 1969 the BMRR approximates the amount of produced brine water to be 2 million acre-feet. Most of this has been injected down salt-water disposal wells where the potential for contamination still exists, as brine plumes migrate into freshwater. Contamination from brine takes place where production of brine with oil has continued for a long time, as in the vicinity of Hobbs and Monument[117]. It is possible that brine plumes have already migrated to the bottom of general use aquifers and may become a problem as the aquifers continue to be depleted[118]. Saline water always has the potential to migrate into freshwater zones and this potential is increased due to oil production.

Much of the infrastructure, equipment, and piping in the petroleum fields of Lea County is old, deteriorated, and susceptible to leaks and failures. In August of 1989 alone, 46 oil field spills and leaks were reported in southeast New Mexico. Corrosion was responsible for nearly one-half of these leaks[119]. Brine and hydrocarbon contaminants can be introduced into fresh water aquifers through improperly constructed, poorly maintained, deteriorated, damaged, or corroded wells and other infrastructure. Poorly plugged and abandoned wells can also lead to ground-water contamination.

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[112] NMOSE (1993)

[113] GWQB (1999)

[114] Bingham (1986)

[115] Hiss, unpublished (1975)

[116] Nicholson and Clebsch (1961)

[117] Ash (1963)

[118] Much of the deeper aquifers in Lea County are saline and as freshwater aquifers decline, the likelihood of salt water intrusion into the freshwater zones increases.

[119] Boyer (1989)

TABLE 6-12: PETROLEUM PRODUCTION CONTAMINATION

petroleum production activity	reported number of cases	types of contaminants	source type
produced water (brine)	91	chloride and TDS	point source[a]
general petroleum production	23	Undifferentiated hydrocarbons, BTEX, and TDS	point source
gas plant processing	10	Methane, undifferentiated hydrocarbons, chloride, and TDS	point source
Pipeline	4	crude oil	point source
petroleum production plant	1	Undifferentiated hydrocarbons	point source
production well	1	crude oil	point source
injection well	1	chloride and TDS	point source
petroleum production activity: source not specified	10	Undifferentiated hydrocarbons and BTEX	point source
total petroleum production activity cases	141		
total non-petroleum production activity cases	56	Nitrate, hydrocarbons, explosives, TDS, chloride, pesticides, misc.	point and non-point sources
total number of cases of contamination reported since 1986	197		

Source: NMED GWQB, 1999

[a] produced water can also be described as non-point source pollution due to multiple injection wells / disposal ponds

[b] all cases reported since 1986

The City of Hobbs has taken two wells out of production because of hydrocarbon contamination. City Well No. 12 was removed from the system about 4 years ago, and Well No. 9 has been shut-off for over 10 years. Gasoline constituents (benzene, toluene, ethylbenzene, and xylene) have been detected in City of Hobbs Wells 10, 11, 14 and 17. Currently, benzene is routinely detected above drinking water standards in Well 25. Well 25 had a benzene concentration of 0.0105 milligrams per liter (mg/l) on June 6, 1999, which is slightly above NMED and EPA standards[120]. The water from Well 25 is combined into a reservoir with water from other wells and the hydrocarbon concentration at the entry point to the system is below action levels. However, the average benzene concentration at the reservoir is still 0.001 mg/l[121]. Analytical results for some of the City of Hobbs wells are presented in APPENDIX N. APPENDIX N also contains analytical results for other public water systems that are discussed in this section.

6.2.2.2 Agricultural Activities

Large quantities of ground-water return flow[122] originate from irrigation[123]. Most irrigation in Lea County occurs over the Ogallala Aquifer where sediments are permeable and depth to ground-water is shallow. The quality of water that returns to the Aquifer from irrigation is unknown, but -- in addition to being saline-- the return water probably contains residues from fertilizers, pesticides, herbicides, and fumigants. Due to the long history of irrigation in the area - and the fact that ground-water quality degraded between 1950 to 1995 - it can be assumed that irrigation return flow is contaminating the aquifer. The NMED lists only one ground-water contamination case resulting from agricultural pesticides. The case, called “DCPA Acid Metabolites,” regards a well sampled by the EPA during a National Pesticide Survey in June of 1989[124].

While groundwater contamination from irrigation return flow is occurring, the amounts of contaminants being generated are likely much less today than in the past. Decreases in the amount of acres irrigated, increased water-use efficiency, and better methods of chemical application, which have occurred since the 1970's, have reduced the sources.

6.2.2.3 Wastewater Disposal Systems

The leachate from community and onsite wastewater systems can cause elevated nitrate concentrations in ground-water[125]. Besides nitrates, wastewater can be a source of phosphorus, inorganic compounds, heavy metals, bacteria and viruses. Other sources of nitrate in ground-water, include feed lots, dairies, landfill leachate, and agriculture. The EPA and WQCC standard for nitrate in drinking water is 10 mg/l[126].

In 1979 the average nitrate concentration for all public water systems in New Mexico was 0.82 mg/l and for Lea County was 2.47 mg/l[127]. Between 1993 and 1998 the average nitrate concentration for 71 wells sampled on 13 Lea County public water systems[128] was 3.5 mg/l. Lea County’s current nitrate levels appear to be about 40% higher than

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[120] The New Mexico Water Quality Control Commission (NMWQCC) standard for benzene is 0.01 mg/l, and the EPA standard is 0.005 mg/l.

[121] Anne Dean, City of Hobbs Laboratory, personal communication (1999)

[122] Return flow is water that has been pumped from an aquifer and used, then allowed to discharge into the subsurface and return to the aquifer.

[123] Large quantities of return flow were also produced by oil field brine disposal before 1969. Wastewater disposal system leachate is also a form of return flow, but is small in comparison, the quantities resulting from irrigation.

[124] NMED GWQB database (1999)

[125] Earp and Koschal (1980) state that wells with Anitrate concentrations of greater than 5.0 mg/l indicate incipient contamination and should be investigated.

[126] High nitrate levels can be particularly harmful to young children and animals, causing serious health problems or death)Peavy, Rowe, and Tchobanoglous, 1985).

[127] Earp and Koschal (1986)

[128] NMED Public Water System – Sampling Results Database

in 1979 and about 400% higher than the State average in 1979. TABLE 6-13 shows current nitrate concentrations for public water systems in Lea County. The highest nitrate concentration in the recent data was 10.9 mg/l for the City of Hobbs Well 10, and the lowest concentration was 0.8 mg/l for Jal's EPNG well. Hobbs Municipal Well 10 consistently has had nitrate concentrations above 10 milligrams per liter since 1993. Five wells have concentrations over 5.0 mg/l and several more have concentrations over 4.5 mg/l.

TABLE 6-13: NITRATE CONCENTRATIONS

Public Water System	No. of Wells Sampled	Average Nitrate Concentration (mg/l)
Adobe Village	2	2.8
Chapperal MHP (Hobbs)	2	6.0
Continental MHP	1	4.3
Country Estates MHP	2	4.8
Eunice	7	2.6
Hobbs	28	4.2
Jal	1	1.6
La Siesta Retirement Center	1	4.4
Lovington	15	2.6
Monument WUA	1	2.2
Rancho Estates Subdivision	2	4.6
Tatum	3	3.4
Triple J Trailer Ranch	1	3.6

Source: NMED Public Water System Sampling Results Database

In all NMED lists 20 present cases of nitrate contamination, out of 197 total groundwater contamination cases in the County, which have impacted 137 water wells[129]. TABLE 6-14 summarizes information related to these 20 sites and FIGURE 34 shows known locations of nitrate contamination in Lea County.

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[129] GWQB database (1999)

TABLE 6-14: LEA COUNTY NITRATE CONTAMINATION CASES

Case	City	Twn/Rng Location	Type of Contaminant(s)	Source Type	Point or Non-point Source (NP or P)	Water Supply Wells Impacted
Lovington Dairy	Lovington		nitrate	dairy	P	0
Beetstra Family Dairy	Hobbs	17S.37E.34	nitrate	dairy	P	0
Jimmy Doom Well	Jal	23S.37E.33	nitrate	septic tanks	NP	1[a]
Larry B. Jenkins Well	Lovington		nitrate	septic tanks	NP	1[a]
Shelly Barica Well	Lovington		nitrate	septic tanks	NP	1[a]
Lovington, Sadelle	Lovington		nitrate	septic tanks	NP	2[a]
Hobbs Area	Hobbs		nitrate	septic tanks	NP	59[a]
Lea County WF 8/14/92			nitrate; anoxic conditions	septic tanks	NP	26[a]
Jal Sewage Treatment Plant	Jal	25S.37E.29.32	nitrate	WWT – PO	P	0
New Hobbs Sewage Treatment Plant	Hobbs	20S.38E.02	nitrate	WWT – PO	P	0
Old Hobbs Sewage Treatment Plant	Hobbs	19S.38E.02.320	nitrate	WWT – PO	P	40[a]
Lovington Sewage Treatment Plant	Lovington	16S.36E.10.421	nitrate	WWT – POLA	P	0
Eunice Golf Course	Eunice		nitrate	WWT – POLA	P	1[b]
Dan's Bar			nitrate	STP – PRO	P	1[b]
Hobbs Phillips #6	Hobbs	19S.38E.04.124	nitrate	STP – PRO	P	1[a]
Hobbs MHP	Hobbs		nitrate	STP – PRO	P	1[b]
Yellow Dawg Bar	Hobbs		nitrate	STP – PRO	P	1[b]
Hobbs Port of Entry	Hobbs		nitrate	STP – PRO	P	1[b]
Border Bar			nitrate	STP – PRO	P	1[b]
Custom Slaughter & Meat		19S.38E.05.1	nitrate	slaughter house or meat packing	P	0

Source: NMED GWQB database, 1999 (Jennifer Parker)
[a] impacted privately owned water supply well(s)
[b] impacted publicly owned water supply well

WWT - PO	publicly owned wastewater treatment plant
WWT - POLA	publicly owned wastewater treatment plant with land application
STP - PRO	privately owned sewage treatment plant

Nitrate contamination of ground-water has been an on-going problem for the City of Hobbs. FIGURE 34 shows locations of nitrate contamination around Hobbs. Several testing programs were carried out in the late 1960's and early 1970's[130]. Many private wells near the WWTP were found to have extremely elevated concentrations of nitrate. The New Mexico Water Quality Control Commission (WQCC) brought a lawsuit against the City of Hobbs in 1974 to halt its operation of the plant. Hobbs was required to improve operations, address the issues of contaminated ground-water, consider relocating the plant's discharge, and establish water service lines to residents impacted by the contamination[131]. Many private wells near the WWTP were found to have extremely elevated concentrations of

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[130] Fossmark Associates (1972)
[131] Clark (1987)

nitrate. In 1980 a new WWTP, with a monitoring well network, was completed by the City[132]. A second well network, 7 miles south of the plant, monitors the area where effluent water used to be discharged. The monitoring well network near the plant contains elevated concentrations of nitrate. The most recently installed well, the "New Well," was installed in the area where sewage sludge was disposed in past years. The New Well has nitrate concentrations of 30.6 milligrams per liter[133]. TABLE 6-15 summarizes the City of Hobbs monitoring well information. FIGURE 34 shows the general location of the monitor wells. Even though there have been several cases of ground-water contamination by community wastewater facilities in Lea County, they are not enough to account for the total amount of nitrate contamination occurring. In 1986 there were 40 cases of ground-water contamination in Lea County, caused by sewage disposal. These 40 cases accounted for 22% of all the ground-water contamination cases reported that year[134]. Since there are only a few community wastewater systems in the County, most cases are attributed to septic systems. It is estimated that Lea County contains between 3,500 and 4,000 residential septic systems[135]. Most septic systems produce little flow by themselves, but when combined together produce a substantial amount. The potential for contamination is highest when many septic systems are in close proximity to each other and the ground-water is shallow. Geologic and soil characteristics also play important roles. NMED has noted the problem of septic systems in the past and in a recent document has stated "[s]eptic tanks continue to insideously (sic) degrade Lea County's ground-water"[136]

TABLE 6-15: HOBBS WWTP MONITORING WELL DATA

Well (Sample Site)	Location	Sample Date	Nitrate Concentration (Mg/l)
Monitor Wells Near WWTP			
New Well	south and east of WWTP, on top of old disposal area for sewage sludge	9/29/99	30.6
Everglade	further south of the New Well	9/30/99	5.1
L-220-S-6	south and west of the WWTP	9/30/99	10.4
L-220-S-7	north of the WWTP	9/30/99	5.0
New Cemetery Well	directly east of the New Well	9/30/99	9.0
Monitor Wells Around Old Effluent Disposal Area[a]			
Nadine Monitor Well #1	7 miles south of the WWTP	9/30/99	4.1
Nadine Monitor Well #2	7 miles south of the WWTP	9/30/99	1.4

Source: analytical results from the City of Hobbs Lab., Anne Dean, 1999
[a] Nadine Monitor Wells 6, 9, and 12 were dry on 9/30/99

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[132] Presently, effluent from the WWTP is used by farmers for crop irrigation.

[133] Contrary to the experience of Hobbs, the City of Lovington analyzed 12 wells around the City's wastewater plant in September of 1998, and all the wells had nitrate concentrations below the detection limit (analytical results from Cardinal Laboratories, 1998).

[134] McQuillan (1986)

[135] From 1987 to October of 1999, 921 new permits for liquid waste systems were issued in Lea County. Based on an average of 70 permits per year, it can be estimated that 3,500 liquid waste systems have installed since 1950. The rural population of Lea County in 1995 was estimated at 11,880 people. At an average of 3 people per household, the number of households would equal 3,960. This correlates with the estimate of permits and indicates that Lea County contains between 3,500 and 4,000 households reliant on some form of liquid waste system.

[136] McQuillan (1986)

6.2.2.4 Underground Storage Tanks

The District 2 Office of the NMED, Underground Storage Tank Bureau (USTB) provided information on all reported underground storage tank leaks within Lea County. Possible contaminants associated with leaking underground storage tanks (LUSTs) include petroleum products, cleaning and degreasing compounds. Data regarding LUSTs and sites are provided in APPENDIX M. Sites listed as active are not necessarily in active remediation, but may be under investigation or undergoing monitoring.

The GWQB lists some of the same sites provided by the USTB. The GWQB also lists one leaking above ground storage tank in Tatum, at Lil's Truck Stop. The above ground tank has impacted two public supply wells with diesel contamination, and a leaking underground storage tank (LUST) at Lil s has impacted one public supply well. Tatum City Wells 2, 3, and 4 and two privately owned water supply wells have been contaminated by LUSTs at Cotton Texaco, 101 East Broadway. A LUST at the Firehouse in Tatum has impacted City Well 1, and a LUST at Simpson Fina, 108 East Broadway in Tatum, has impacted one privately owned well. Morris Oil, 1214 East Bender, has impacted one public supply well in Hobbs because of a LUST.

6.2.2.5 Mines and Quarries

Two mills, the National Compaction Plant (a potash operation) and National Tailings (a salt operation) - both located about 30 miles west-southwest of Hobbs (off Hwy. 62/180), are reported within Lea County. Seven gravel, rock, and caliche operations are also located in the County[137]. APPENDIX U provides information regarding specific mines, mills, pits, and quarries. The impact of current operations at these facilities on water quality has not been assessed. However, impacts from past mine tailings, waste disposal, and other mining operations are probable. National Potash Company, based in Carlsbad, is listed by the NMED as being the cause of TDS and chloride contamination[138].

6.2.2.6 Industrial Facilities

The NMED lists 8 cases of point source ground-water contamination due to industrial facilities, manufacturing plants, and a recycling plant. The contamination includes various petroleum hydrocarbons, TDS, chloride, heavy metals, organics, explosives, and nitrogen. Two public supply wells and three privately owned water supply wells were impacted by these incidents[139]. TABLE 6-16 summarizes the reported cases of ground-water contamination due to industrial facilities in Lea County and FIGURE 33 shows the location of the sites.

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[137] Hatton (1998)
[138] NMED GWQB database (1999)
[139] NMED GWQB database (1999)

TABLE 6-16: LEA COUNTY INDUSTRIAL FACILITIES CAUSING CONTAMINATION

Case	City	Address	Twn / Rng Location	Type of Contaminant(s)	Source Type	Water Supply Wells Impacted
Koch Industrial Inc. (900-gallon diesel spill in July 1992)	Hobbs			hydrocarbons	industrial facility	1[b]
Tatum Well #2	Tatum		12S.36E.29.222	waste oil	industrial facility	1[b]
Hobbs Gibbs Gasoline	Hobbs	Arkansas Junction		hydrocarbons and lead	industrial facility	1[a]
Axelson, Inc.	Hobbs	2730 W. Marland		hydrocarbons	industrial facility	0
Lovington Dominquez Well	Lovington		16S.36E.03	ethylene dichloride	industrial facility	1[a]
Ladshaw Explosives, Inc.	Hobbs	Hobbs Industrial Air Park	18S.37E.12	explosives, nitrogenous material	manufacturing plant	0
Monument Climax Chemical	Monument		19S.36E.35	TDS, chloride	manufacturing plant	0
Monument Oil Processing	Monument		20S.36E.09	TDS	recycling plant	1[a]

Source: NMED GWQB database, 1999 (Jennifer Parker)

[a] privately owned water supply well

[b] public water supply well

6.2.2.7 Landfills

The NMED lists five municipal landfills, one industrial waste landfill, and one municipal landfill (with limited industrial waste) in Lea County. Of the five municipal landfills, four are closed and one is under construction. The Town of Tatum has an inactive landfill, but the NMED does not have it listed. Additionally, no information was available for landfills in Maljamar or other small communities. No information on hazardous waste dumps in Lea County was found, although the industrial landfill may contain hazardous materials. Contamination from landfills is usually waste generated leachate. Landfill leachate can contain a variety of inorganic and organic compounds and heavy metals, including solvents. TABLE 6-17 summarizes the available Lea County landfill information.

TABLE 6-17: LEA COUNTY LANDFILLS

Location	Name	Type	Status	Estimated Depth to Water, feet
16S.36E.31.22	Lovington Landfill	municipal	closed 10/31/92	100
18S.38E.36.4	Hobbs: Waste Management Landfill	municipal and limited industrial waste	open, proposed closure in 1999	70-100
19S.39E.06.3	Old Hobbs Landfill	municipal	closed 1972	n/a
20S.32E.32.	Lea Land Company Landfill	industrial waste	open	n/a
21S.36E.36.	Eunice Landfill	municipal	closed 10/31/92	110
22S.38E.04.N1/2	Lea County Regional Landfill	municipal	under construction	n/a
25S.36E.24.4W1/2	Jal Landfill	municipal	closed 12/91	n/a

Source: NMED, Solid Waste Bureau, Fred Bennett, 2-12-99

6.2.2.8 Livestock Industry

Livestock operations can produce strong wastewater from operational and processing activities. Also, when precipitation comes into contact with animal feces and urea highly contaminated runoff can result. Two dairies (Lovington Dairy and Beetstra Family Dairy) and one meat packing operation (Custom Slaughter and Meat) are listed by NMED as having caused ground-water contamination (see TABLE 6-14). TABLE 22 lists other Lea County facilities, including 13 dairies and 3 feed lots, that are required to have discharge permits because they are potential sources of nitrate contamination.

6.2.2.9 Radioactive Mineralization

Public water system wells in Lea County area were tested in 1994 and 1997 for gross beta, radium-226, and radon. Hobbs Municipal Well 50 had a gross alpha concentration of 16.6 pCi/l 2.9. Given the plus or minus factor, this result may not be above the EPA and WQCC standard of 15 pCi/l[140]. Continental Mobile Home Park Well 1 and Country Estates Mobile Home Park Well 1 had gross alpha concentrations of 13.9 pCi/l ± 2.5 and 13.4 pCi/l ± 3, respectively. Given the plus or minus factors the gross alpha concentrations in these wells could be over the 15 pCi/l limit. TABLE 6-18 shows the gross alpha concentrations for public water supply systems in Lea County. Radium-226 is tested for if gross alpha concentrations are above 5 pCi/l. All radium-226 concentrations for the public water supply wells tested were below 3 pCi/l[141].

Gross beta concentrations in Lea County are from natural sources and consistent with background levels. Regulations for gross beta refer only to anthropogenic sources of which none exist in Lea County.

Radon is not a known contaminant of concern in Lea County. Only Jal Well 2, which has a radon concentration of 323 pCi/l 20, is above the proposed EPA standard of 300 pCi/l. An alternative radon standard of 4,000 pCi/l has been proposed which correlates radon in water with radon levels found in indoor air.

Naturally occurring radioactive deposits have been found in the Triassic-age Dockum Group and the Gatuna

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[140] Picocuries per liter is a measure of radioactivity. One curie is equivalent to 37 billion nuclear disintegrations per second and one picocurie is one trillionth of a curie, or 0.037 nuclear disintegrations per second.

[141] If the concentration was 3 pCi/l, then radium-228 would be tested for, and the result summed with the radium-226 result. Resulting sums above 5 pCi/l exceed the WQCC standard and are subject to compliance regulations.

Formation of Pleistocene age[142]. These deposits appear to be very small and are not reported to have affected ground-water. The radioactivity in most wells in Lea County is within the limits established by the EPA and WQCC.

TABLE 6-18: GROSS ALPHA CONCENTRATIONS IN LEA COUNTY PWSs

Public Water System	No. of Wells Sampled	Average Alpha Contamination (pCi/l)	Average Test Accuracy (pCi/l)
Adobe Village	2	3.4	1.1
Chaparral MHP (Hobbs)	2	5.1	1.2
Continental MHP	1	13.8	2.5
County Estates MHP	2	10.4	2.1
Eunice	6	4.5	1.1
Hobbs	26	6.2	1.9
Jal	5	10.9	2.0
La Siesta Retirement Center	1	5.3	1.3
Lovington	14	3.6	1.1
Monument WUA	1	5.4	.9
Rancho Estates Subdivision	2	3.1	1.0
Tatum	3	3.7	1.1

Source: NMED Public Water System Sampling Results Database

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[142] Finch (1972)