NEW MEXICO WATER LAW CONFERENCE
AUGUST 26 – 27, 2002

Ogallala Aquifer:
Where's The Water?

By W. Peter Balleau

Introduction

The Ogallala Aquifer is part of the High Plains Aquifer system which is reported to be the largest single source of irrigation water on the planet. Much of the eastern boundary of New Mexico is underlain by the aquifer. New Mexico supports about 300,000 acres, and Texas about 2,500,000 acres of irrigation from the shared aquifer system.[1,2,3] Figure 1 shows the use areas from LANDSAT imagery in years 1992 and 1993. Vegetated areas are shown totaling irrigated and non-irrigated areas of 400,000 acres in New Mexico and 3,000,000 acres in Texas. The lifetime of the stored resource has been a concern to users since the aquifer was developed after World War II.

A general inventory of the aquifer condition was published by the U.S. Geological Survey (USGS) in Gutentag and others (1984)[4] and Weeks and others (1988)[5] and has been updated annually (McGuire, 2001)[6] for a report to Congress. The regional data compiled by the USGS provides the context for site-specific data held by water users.

Regional Water

The question to this panel is "Where's the Water" and how can users manage to extend the service life?

USGS maps (McGuire and Fischer, 1999)[7] (McGuire and Fischer, 2000)[8] are attached to show where the Ogallala water is in New Mexico and in Texas in terms of the remaining saturated thickness as of 1997 (Figure 2), and depth-to-water in 1998 (Figure 3). The High Plains Aquifer south of the Canadian River displays 0 to 200 feet of saturated thickness. New Mexico has large areas of little or no saturated thickness, but has over 200 feet of remaining saturated thickness in Lea County and parts of

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[1] Lacewell, R.D., 1998, Water and the Economy of the Great Plains Region, in The Great Plains Symposium 1998: The Ogallala Aquifer "Determining the Value of Water," The Great Plains Foundation.

[2] Robson, S.G. and Banta, E.R., 1995, Groundwater Atlas of the United States Segment 2 Arizona, Colorado, New Mexico, Utah: U.S. Geological Survey Atlas 750-C.

[3] Kromm, D.E. and White, S.E., 1992, The High Plains Ogallala Regions, in Groundwater Exploration in the High Plans: University Press of Kansas.

[4] Gutentag, E.D., Heimes, F.J. Krothe, N.C., Luckey, R.R., and Weeks, J.B., 1984, Geohydrology of the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Professional Paper 1400-B, 63 p.

[5] Weeks, J.B., Gutentag, E.D. Heimes, F.J. and Luckey, R.R., 1988, Summary of the High Plains Regional Aquifer-System Analysis in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Professional Paper 1400-A, 30 p.

[6] McGuire, V.L., 2001, Water-Level Changes in the High Plains Aquifer, 1980 – 1999: U.S. Geological Survey Fact Sheet 029-01.

[7] McGuire, V.L. and Fischer, B.C., 1999, Water-Level Changes, 1980 to 1997, and Saturated Thickness, 1996 – 97, in the High Plains Aquifer: U.S. Geological Survey Fact Sheet 124-99.

[8] McGuire, V.L. and Fischer, B.C., 2000, Water-Level Changes in the High Plains Aquifer – 1980 to 1998 and 1997 and 1998: U.S. Geological Survey Fact Sheet-Unnumbered.

Roosevelt and Curry Counties. North of the Canadian River, Texas has the greatest remaining resource. Depth-to-water can be more than 300 feet northeast of Clovis, New Mexico, and in the range of 50 to 100 feet in Lea County. New Mexico in 1980 had an Ogallala resource base of about 50 million acre feet (AF) and Texas had about 390 million AF as drainable water in storage (Gutentag and others, 1984).[4 above] New Mexico pumped 0.67 million AF from the southern High Plains aquifer for irrigation in 1990 at a rate of 2.3 feet per acre (Woodward, 1998).[9] About ten inches of the applied water is returned to the water table at the irrigation sites studied by Stone (1990).[10] Wilson (1997)[11] estimated that the remaining lifetime may extend past year 2030 throughout the Ogallala areas in New Mexico.

As relevant as the thickness remaining, is the decline rate in that thickness. Figure 4 shows the water-level decline from the earliest records to 1980. By 1980, more than 100 feet of decline had been recorded northeast of Clovis and adjacent areas in Texas. Figure 5 shows additional decline from 1980 to 1998 (McGuire and Fischer, 2000).[8 above] Over 40 feet of additional decline was seen in the last decades of the century, but some areas of rising water level are also seen. Up to 155 feet of overall decline has been recorded in New Mexico.

Local Water

The aquifer saturated thickness is highly variable locally, and water levels are declining at various rates. Figure 6, based on 1994 – 2000 data, shows that the water levels between Clovis and Portales are declining at rates up to eight feet per year, but are rising outside the areas of agricultural and municipal use.

In view of the local variability, how does a particular water user project his future? A site-specific analysis is needed based on decline trends and remaining saturated thickness. An amount of water is reserved unused in the bottom of the well for pump submergence and operation. As Figure 7 indicates, about 35 feet of water is necessary for a typical irrigation well or 20 feet for a smaller-capacity well. It is difficult to remove the last few tens of feet using large-capacity wells. Domestic wells may last longer into the future. The remaining saturated thickness in feet above 20 to 35-foot operating threshold is compared to the prevailing decline rate in feet per year to give the remaining years of expected service life for large-capacity irrigation or municipal/industrial wells.

Geographic Information System (GIS) methods are helpful in handling the variability in the data. The water-table position (Figure 8) is known for each year from published USGS sources. Saturated thickness in New Mexico (Figure 9) is calculated from so-called redbed elevation maps prepared by the New Mexico Office of the State Engineer (OSE). The remaining saturated thickness (Figure 10) is calculated by taking the 20 to 35-foot submergence threshold from the total thickness. Finally, the projected aquifer life for the area of interest is mapped as Figure 11. Longer remaining years of service life may be the product of a slow decline rate and a thin water column, a fast decline rate and a thick water column, or, in many areas, a negative decline rate (recovery). In this example, some areas between Clovis and Portales have no remaining lifetime, and others have over 40 years. Calculated in this way,

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[9] Woodward, D.G., 1998, The High Plains (Ogallala) Aquifer: Management and Development of the Water Resources in the Southern High Plains, New Mexico: New Mexico Journal of Science Volume 38, pp. 174 – 188.

[10] Stone, W.J., 1990, Natural Recharge of the Ogallala Aquifer Through Playas and Other Non-Stream-Channel Settings, Eastern New Mexico: Geologic Framework and Regional Hydrology: in T.C. Gustavson, ed., Upper Cenozoic Blackwater Draw and Ogallala Formations, Great Plains, Bureau of Economic Geology University of Texas at Austin, pp. 1980 – 192.

[11] Wilson, C.R. 1997, Overview of the Hydrology of Northeastern New Mexico: Proceedings 42nd Annual New Mexico Water Conference: Water Issues of Eastern New Mexico: Water Resources Research Institute Report No. 304, pp. 37 – 46.

the aquifer volume remaining for use in this area is 722,000 AF, which is being used by agriculture and municipal wells at the rate of 45,000 AFY. That works out to 16 years of average remaining lifetime.

The overall process is illustrated in Figure 12 showing the relationship of trends, well construction, pumping reserve, and redbed elevation. The well data required is illustrated in Table 1. Wellfield operators ordinarily keep track of such data for management purposes.

Management Action

Several factors may alter the trend-line projections. We should expect that water-level trends will flatten as the threshold for pump submergence is approached and increasing numbers of wells are retired. Decline rates may be altered by collective water-management action, climate trends, changes in porosity or permeability in the lower Ogallala sediments, and the delayed percolation of return flow. Decades worth of water may be in transit to the water table as return flow from irrigation operations. Wells are often reconstructed to draw from the basal gravels or to supply one center-pivot from multiple lower-yielding wells. Metering has been considered as a means of conservation. Limiting irrigation rates is likely to mean limiting return flow with no ultimate change in depletion of aquifer storage. Cheaper pumping cost or higher-value uses may extend the economic depth-to-water. Imported water (Ute Pipeline) is of interest for municipal uses. All of the management factors are under active research in Texas and New Mexico.

The decline trends are the result of all well operations in about a six-mile radius, i.e., the nearest 100-square miles. Accordingly, one user cannot affect regional conditions very much. The benefits or penalties of action at one well accrue to all users in the six-mile radius of influence. Collective action on the scale of four Townships is required if the rewards of conservation, for example, are to be allocated to all those involved in the action.

The OSE released in 1999 (Musharrafieh and Logan, 1999)[12] a computer simulation of the Clovis and Portales region. It illustrates that Texas pumping has an impact on New Mexico to about the same degree that New Mexico pumping affects Texas (Figures 13 and 14). The OSE model was prepared for the purpose of water-rights administration. It overstates dry areas around Clovis in 1990. The model projects the area of remaining saturated thickness in the future. Figure 15 shows that the OSE model projects zero remaining water in much of Curry and Roosevelt Counties by year 2020. The average New Mexico lifetime of the resource is significantly shorter in areas of concentrated use.

Conclusion

The response to dewatering the Ogallala Aquifer in New Mexico apparently cannot be left to future generations. The current community of water users will necessarily manage the transition to a less-widespread and less-productive aquifer in the next decade.

Figures and Table Attached:

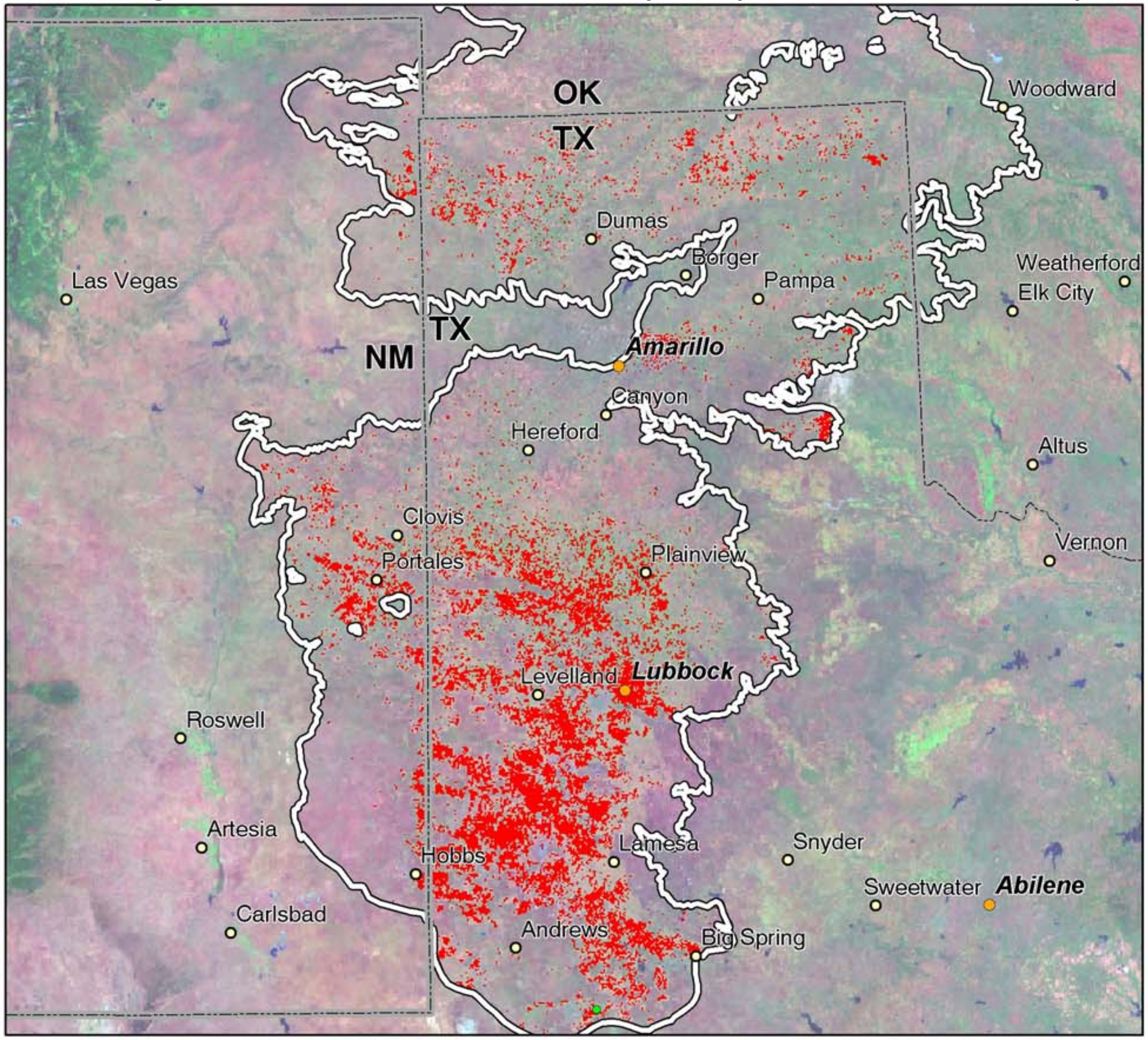
Figure 1. LANDSAT Imagery
Figure 2. Saturated Thickness of the High Plains Aquifer, 1996-97 (Adapted from McGuire and Fischer, 1999)

[12] Musharrafieh, G.R. and Logan, L.M., 1999, Numerical Simulation of Groundwater Flow for Water Rights Administration in the Curry and Portales Valley Underground Water Basins, New Mexico: New Mexico Office of the State Engineer Technical Division Hydrology Bureau Report 99-2.

Ogallala Irrigation

1992-1993 Vegetated Acres: NM = 408,000 TX = 3.05 million

Irrigated Acres: NM = 320,000 (1990)[2] TX = 2.6 million (1987)[3]



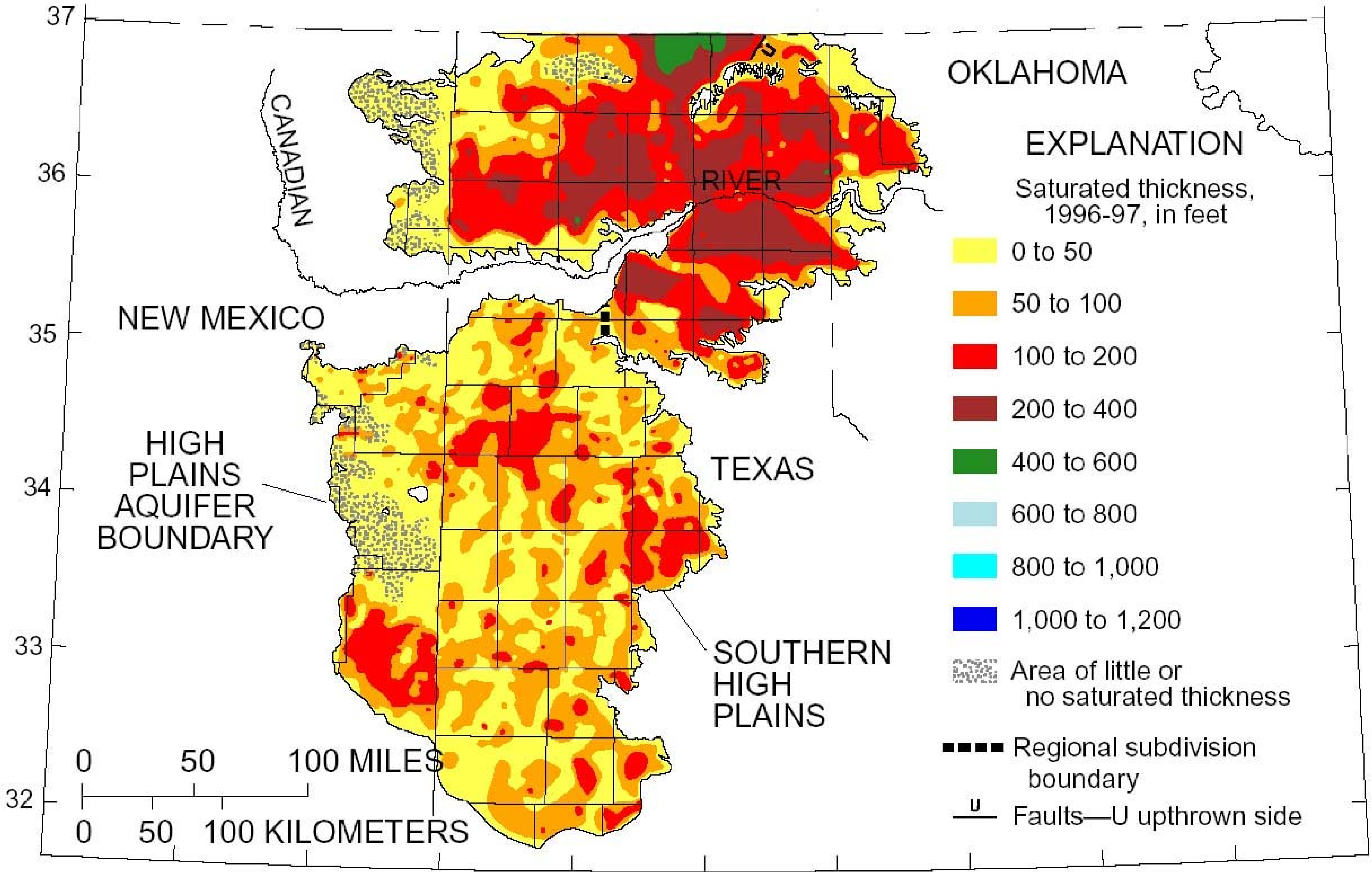
[2] Robson, S.G. and Banta, E.R., 1995, Groundwater Atlas of the United States Segment 2 Arizona, Colorado, New Mexico, Utah: U.S. Geological Survey Atlas 750-C.

[3] Kromm, D.E. and White, S.E., 1992, The High Plains Ogallala Regions, in Groundwater Exploration in the High Plains: University Press of Kansas.

Figure 1

Image Date: 1992 and 1993

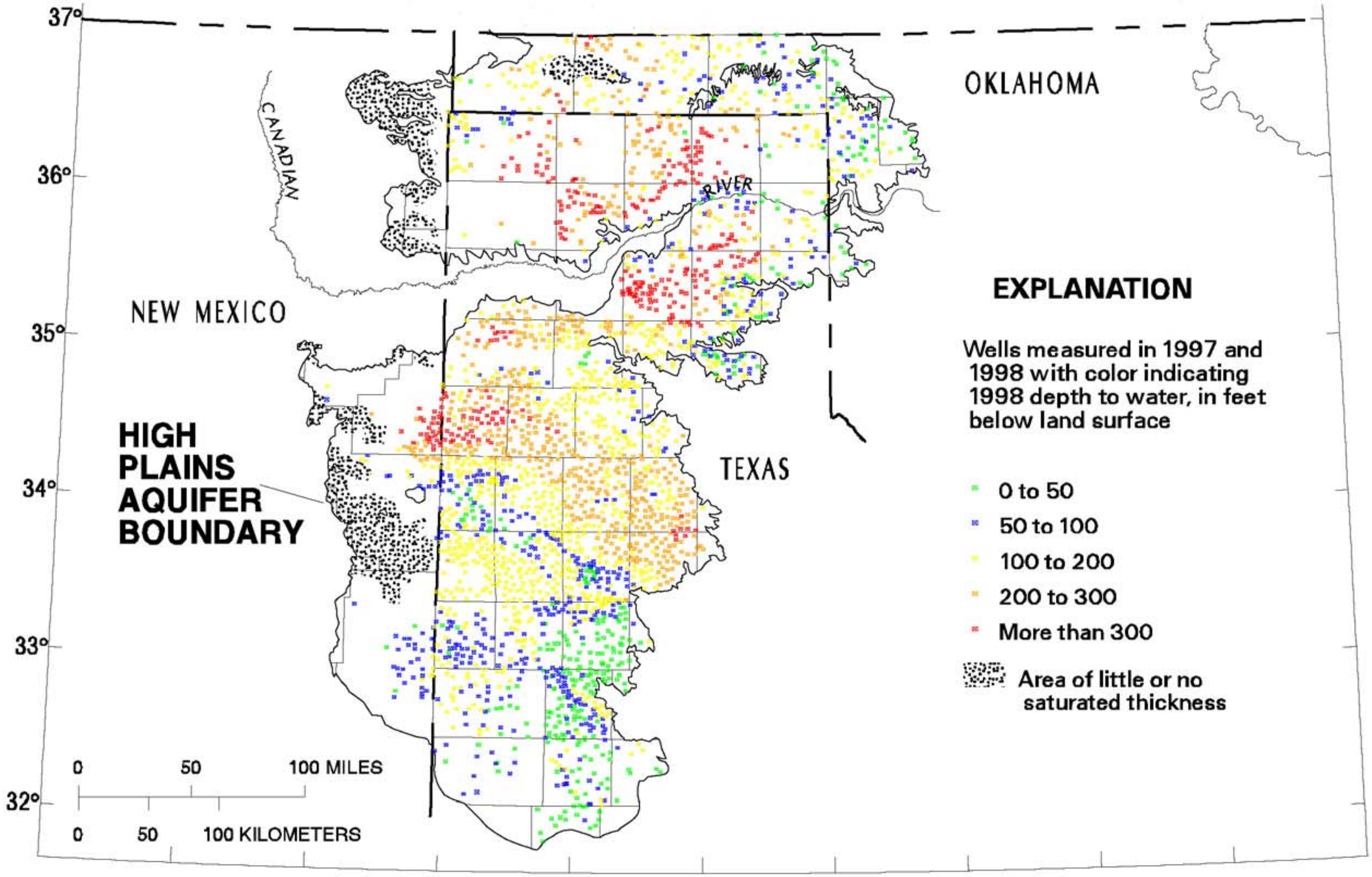
BALLEAU GROUNDWATER, INC.



Saturated thickness of the High Plains aquifer, 1996-97.

(Adapted from McGuire and Fischer, 1999)

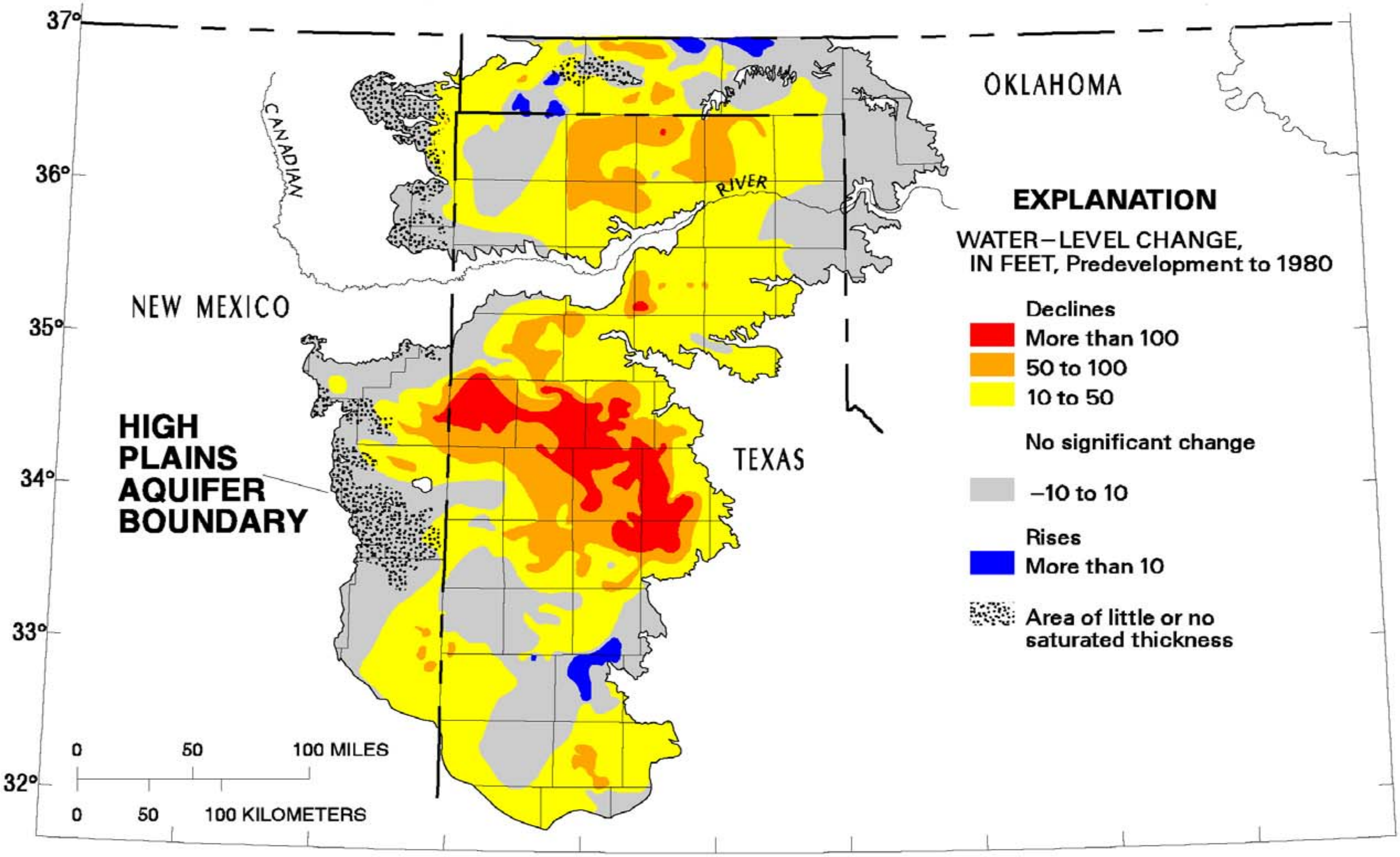
Figure 2



Wells measured in 1997 and 1998.

(Adapted from McGuire and Fischer, 2000)

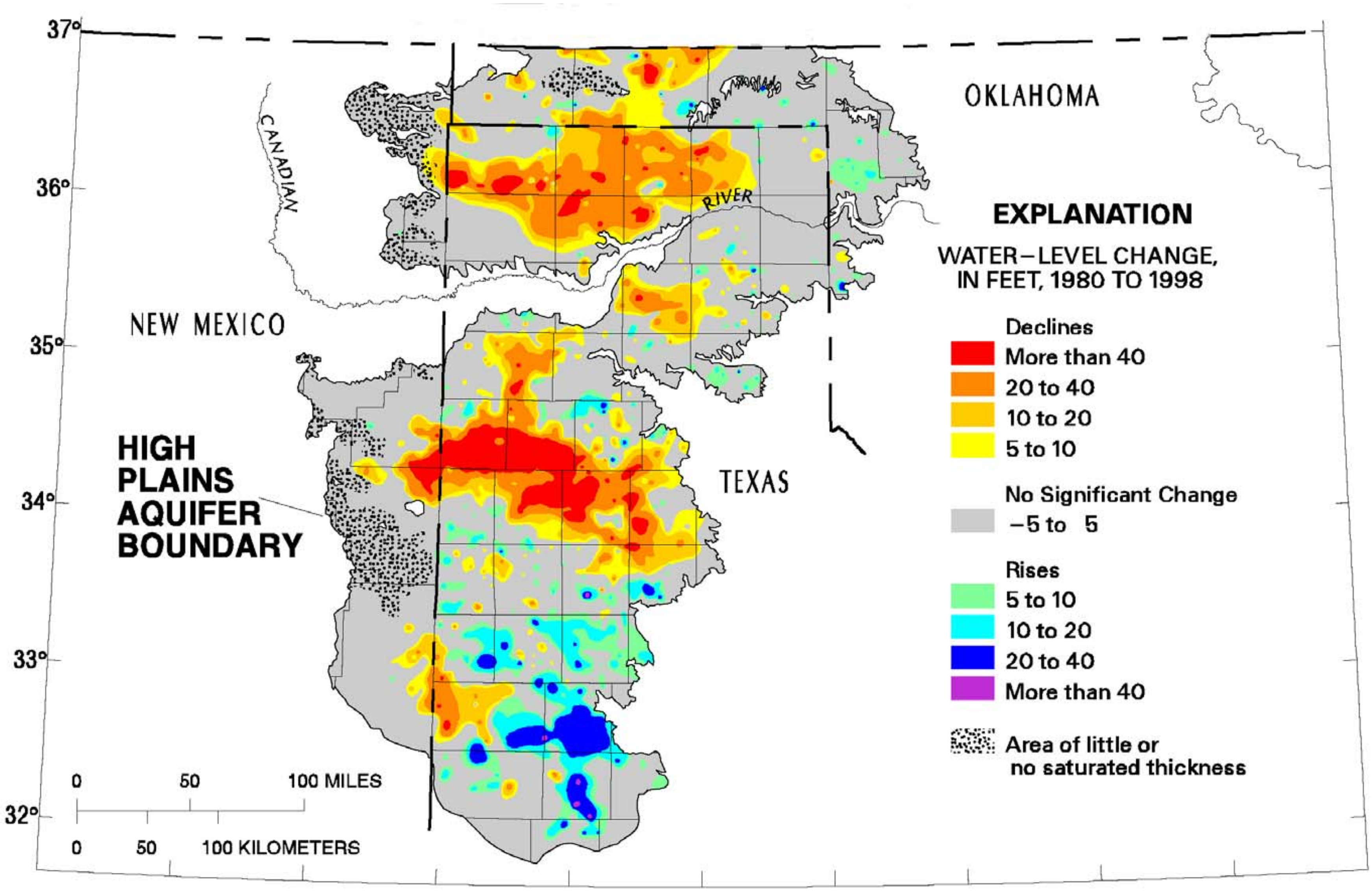
Figure 3



Water-level changes in the High Plains aquifer, predevelopment to 1980 (Luckey and others, 1981).

(Adapted from McGuire and Fischer, 2000)

Figure 4

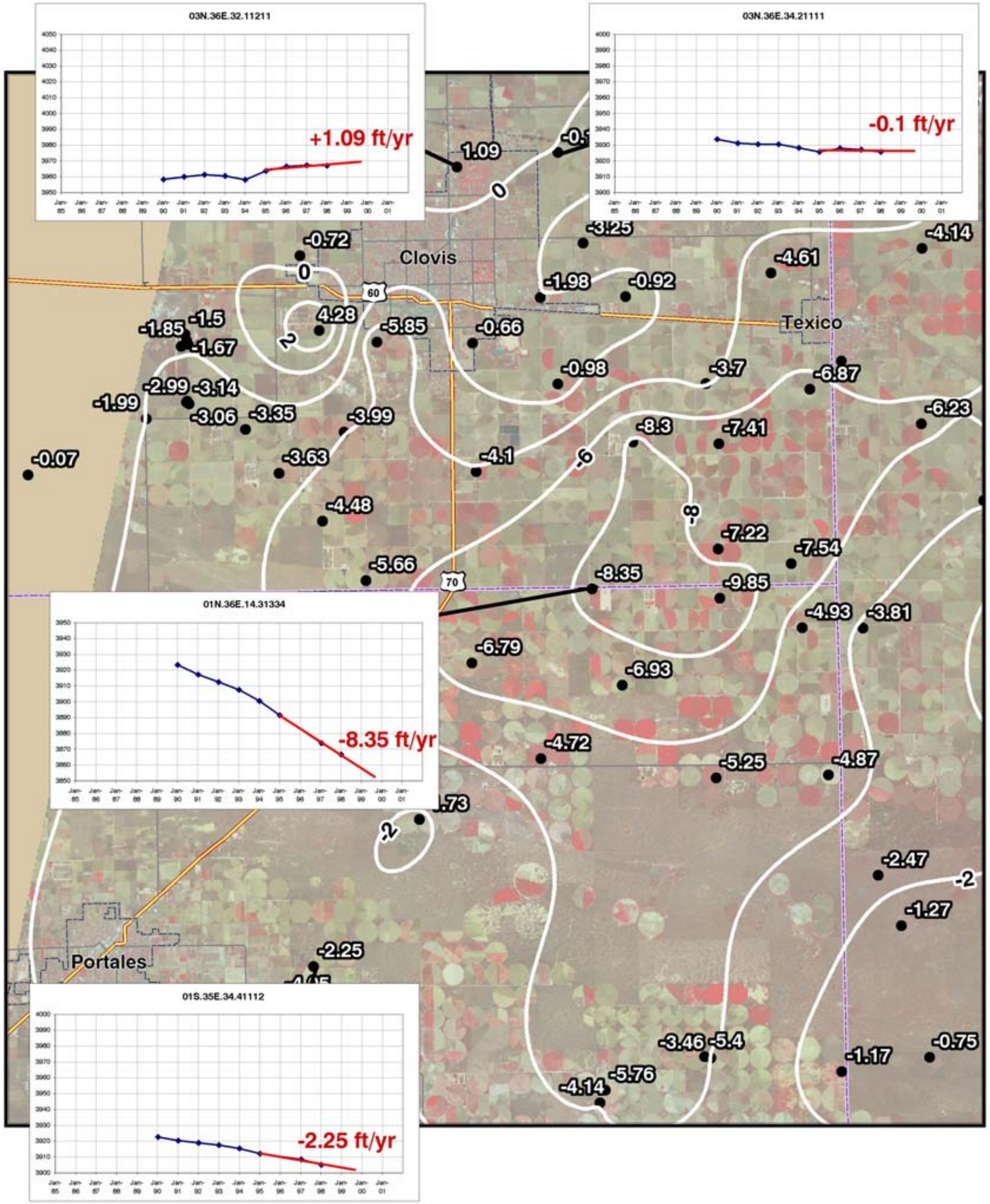


Water-level changes in the High Plains aquifer, 1980 to 1998.

(Adapted from McGuire and Fischer, 2000)

Figure 5

SELECTED WELL HYDROGRAPHS



EXPLANATION

CONTOURS OF OBSERVED 1994-2000 DECLINE RATES (ft/yr) -- Based on November 1994 - 2001 trendline. (Contour interval = 2 ft/yr)

Observed 1994-2000 decline rates (ft/yr). Red = trendline.

Figure 6

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CLOVIS / PORTALES WELL LIFE PLANNING FACTORS

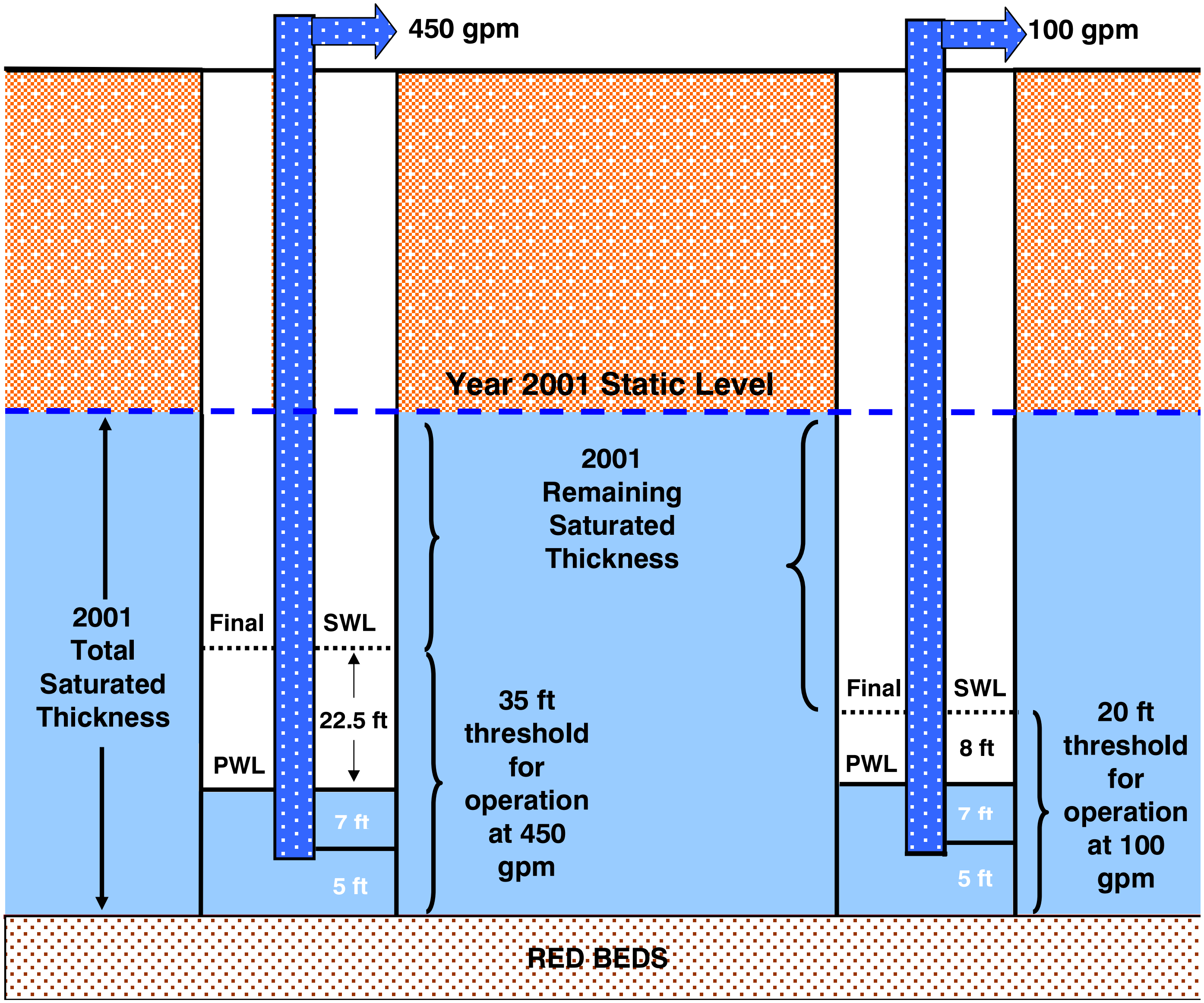
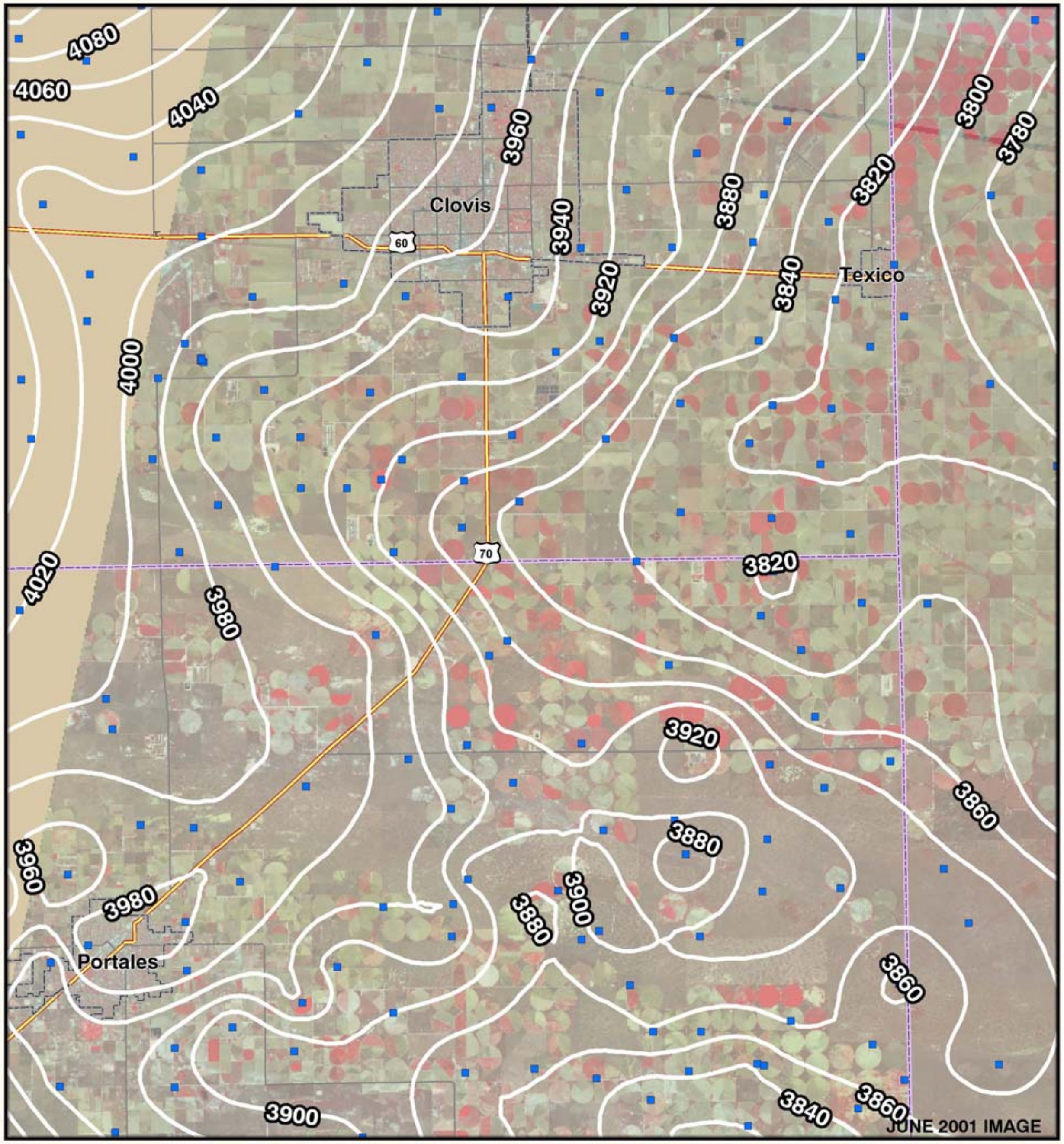


Figure 7

BALLEAU GROUNDWATER, INC.

YEAR 2001 WATER TABLE ELEVATION



EXPLANATION

PROJECTED WINTER 2001 WATER LEVEL CONTOURS -- Based on Winter 1997 water level data and observed 1994-2000 decline rates. (Contour interval = 20 feet, NGVD29)

WINTER 1997 USGS AND TXWDB WATER LEVEL DATA

Figure 8

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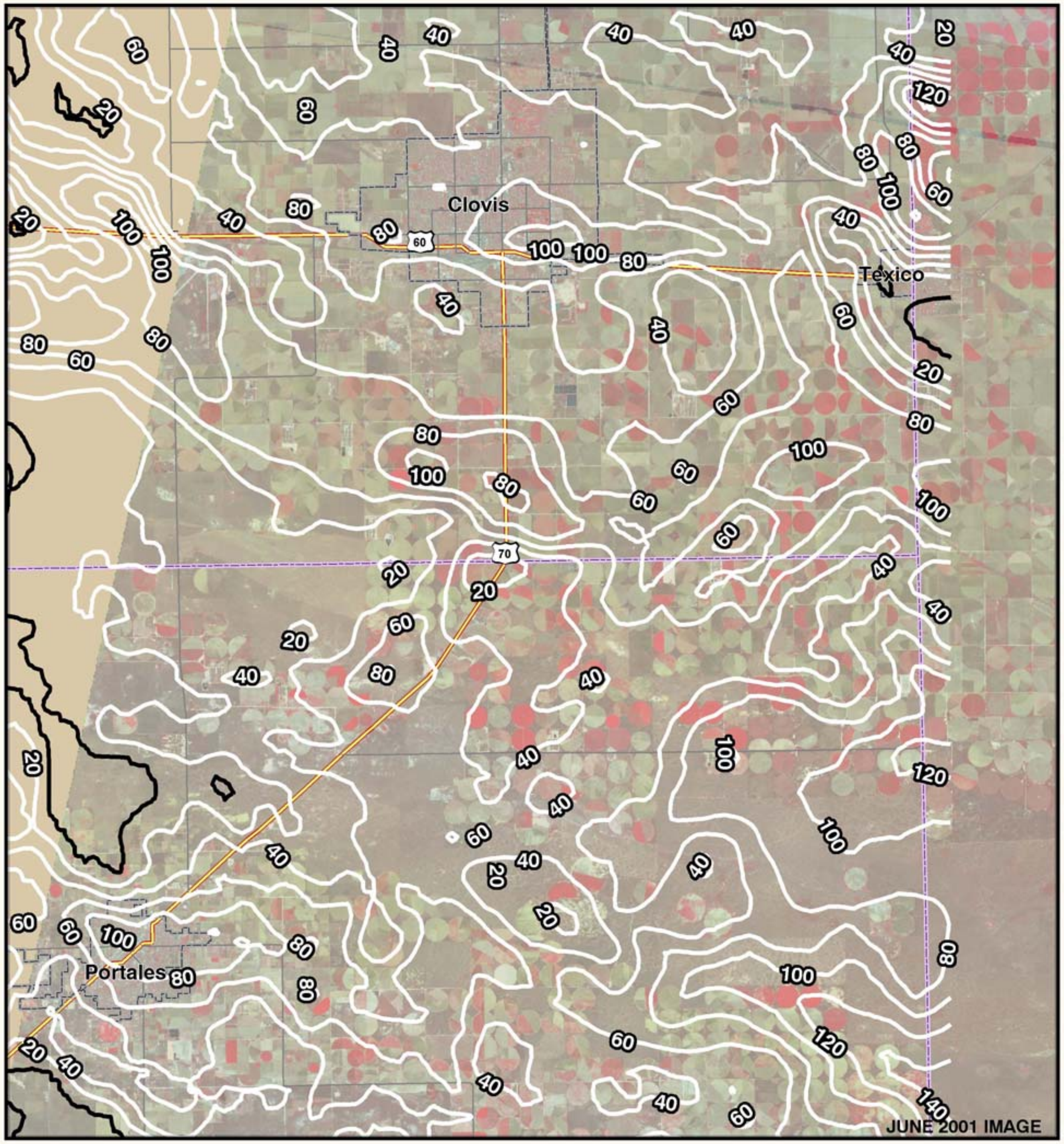
YEAR 2001 SATURATED THICKNESS



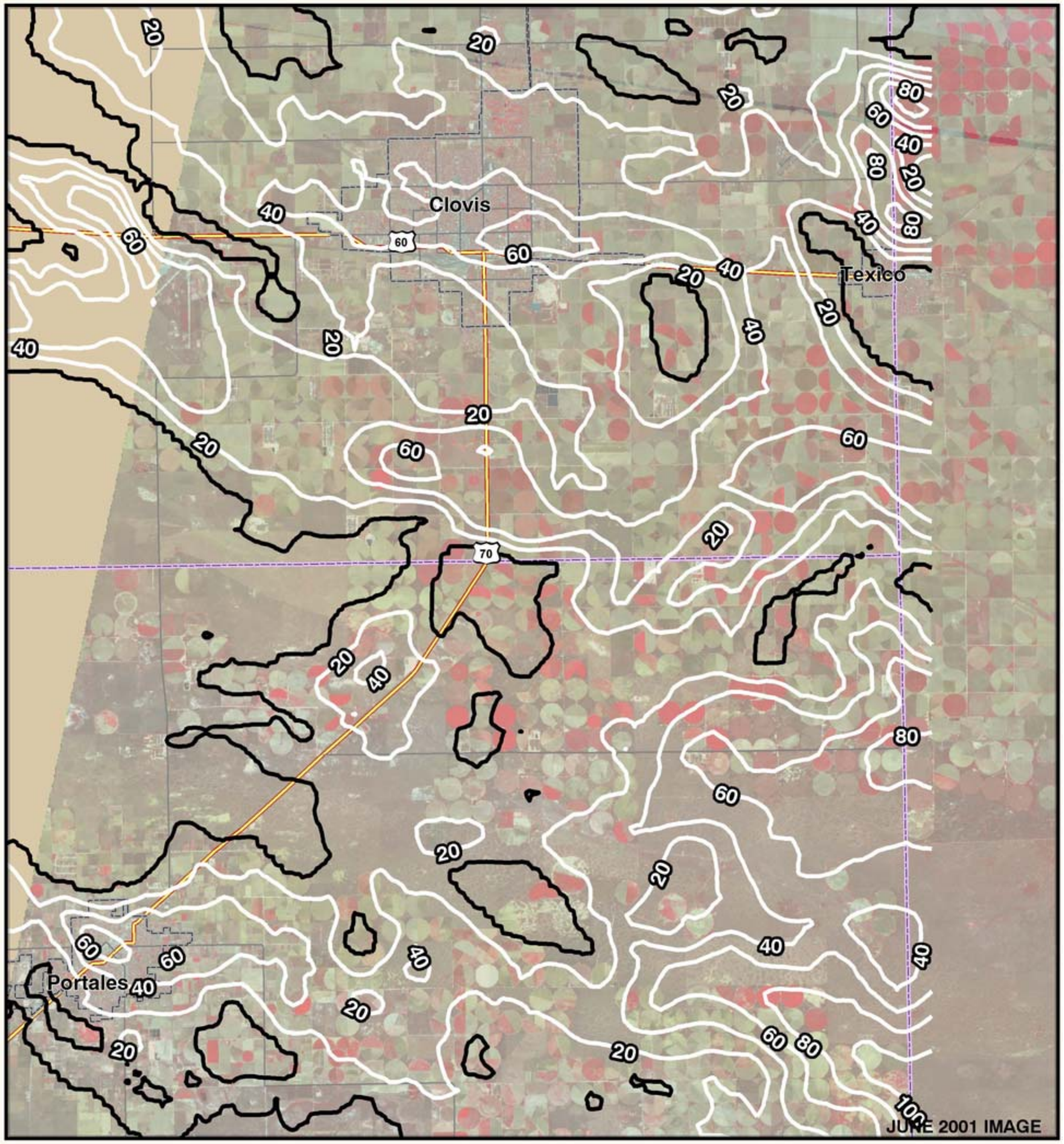
EXPLANATION

PROJECTED WINTER 2001 SATURATED THICKNESS ABOVE 35-FOOT PRACTICAL PUMPING LIMIT -- Based on Winter 1997 water level data and observed 1994-2000 decline rates and Red Bed elevations adapted from NMOSE contours. (Contour interval = 20 feet, NGVD29)

PROJECTED WINTER 2001 LINE OF ZERO SATURATED THICKNESS

Figure 9

BALLEAU GROUNDWATER, INC.



REMAINING SATURATED THICKNESS ABOVE 35-FOOT PRACTICAL LIMIT

(Volume = 722,000 AF)

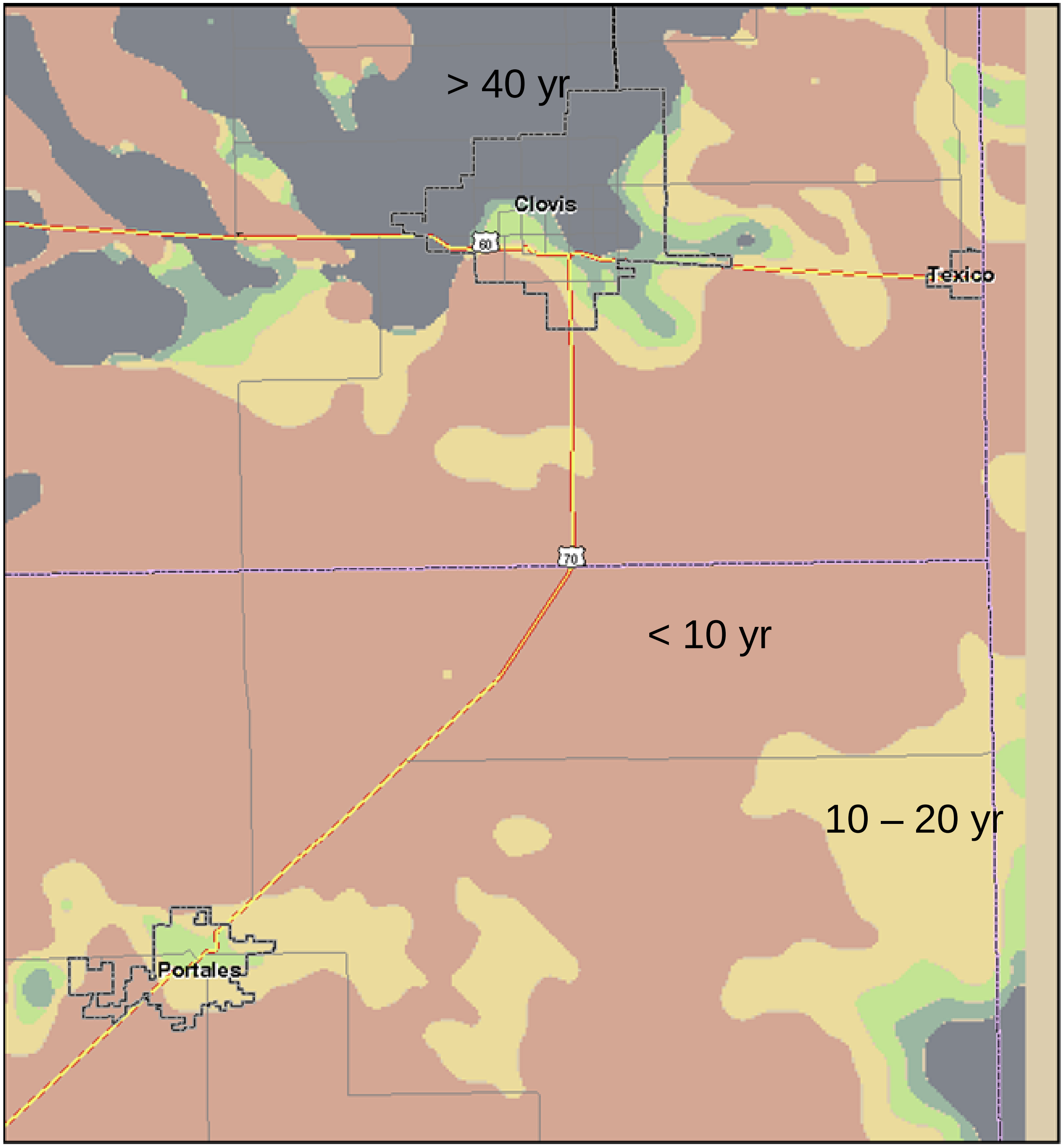
EXPLANATION

PROJECTED WINTER 2001 SATURATED THICKNESS ABOVE 35-FOOT PRACTICAL PUMPING LIMIT -- Based on Winter 1997 water level data and observed 1994-2000 decline rates and Red Bed elevations adapted from NMOSE contours. (Contour interval = 20 feet, NGVD29)

PROJECTED WINTER 2001 LINE OF ZERO SATURATED THICKNESS

Figure 10

BALLEAU GROUNDWATER, INC.



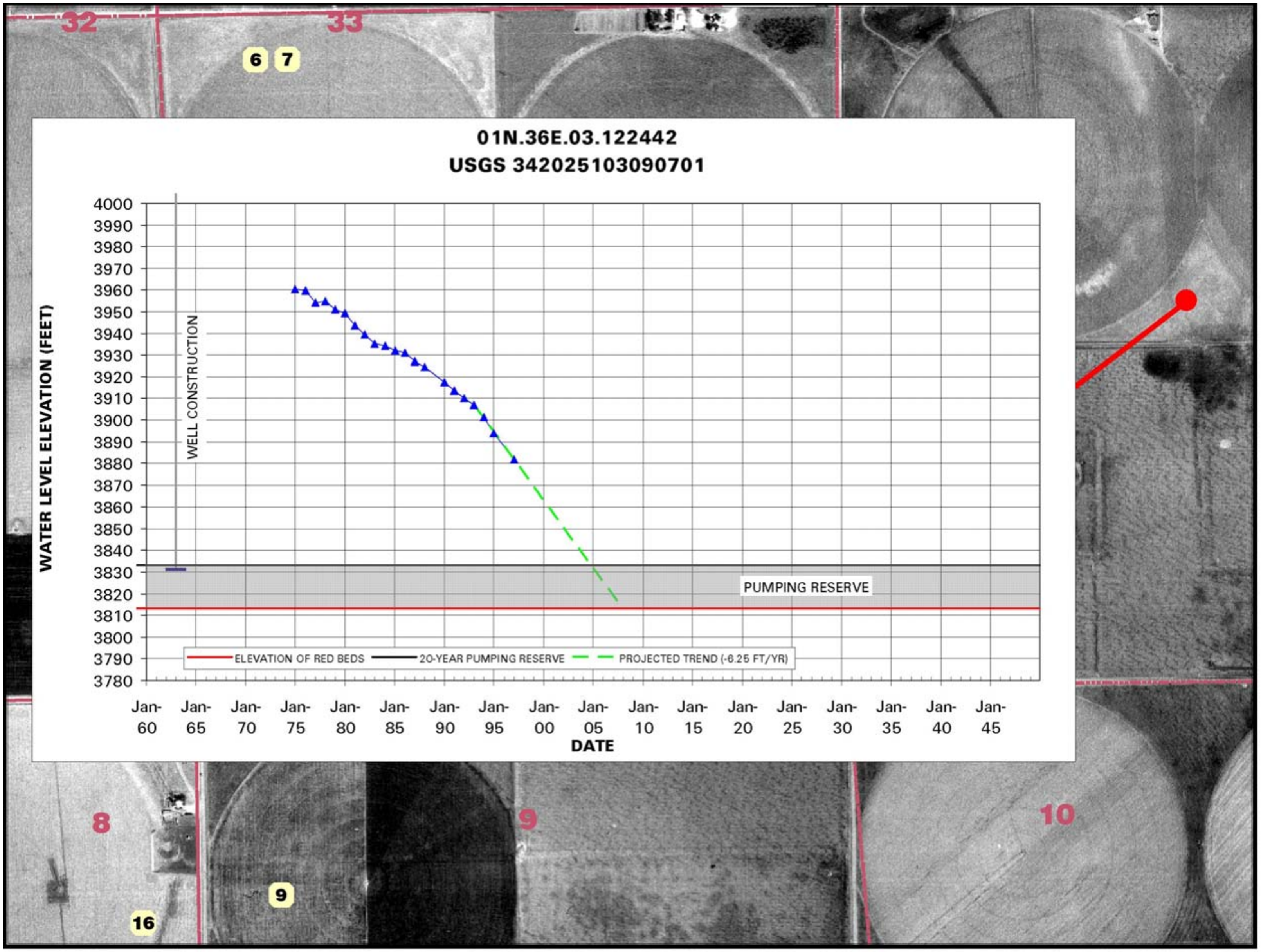
REMAINING AQUIFER LIFE

PROJECTED AQUIFER LIFE (ABOVE 35 FOOT PPL)

- LESS THAN 10 YEARS
- 10 TO 20 YEARS
- 20 TO 30 YEARS
- 30 TO 40 YEARS
- >40 YEARS AND AREAS OF RISING WATER LEVELS

Figure 11

BALLEAU GROUNDWATER, INC.



HYDROGRAPH EXAMINATION

Figure 12

BALLEAU GROUNDWATER, INC.

WELL DATA EXAMINATION

Well ID	Depth to Water (ft)	Pumping Depth to Water [2] (ft)	Pumping Drawdown (ft)	Total Depth (ft)	Water Column (ft)	Pumping Water Column (ft)
1						
2						
3						
4	261.87	278.5	16.63	310	48.13	31.5
5	245.8			299.5	53.7	
6	237.06			285	47.94	
7	283			320	37	
8	>297.8					
9	297.7			360	62.3	
10						
11	294.59					
12	301.85	312.2	10.35	351	49.15	38.8
13						
14	232.45					
15						
16	282.25			323	40.75	
17	>297.8					
18	284.56			340	55.44	
19						
Average	272.11	295.35	13.49	323.56	49.30	35.15

Table 1

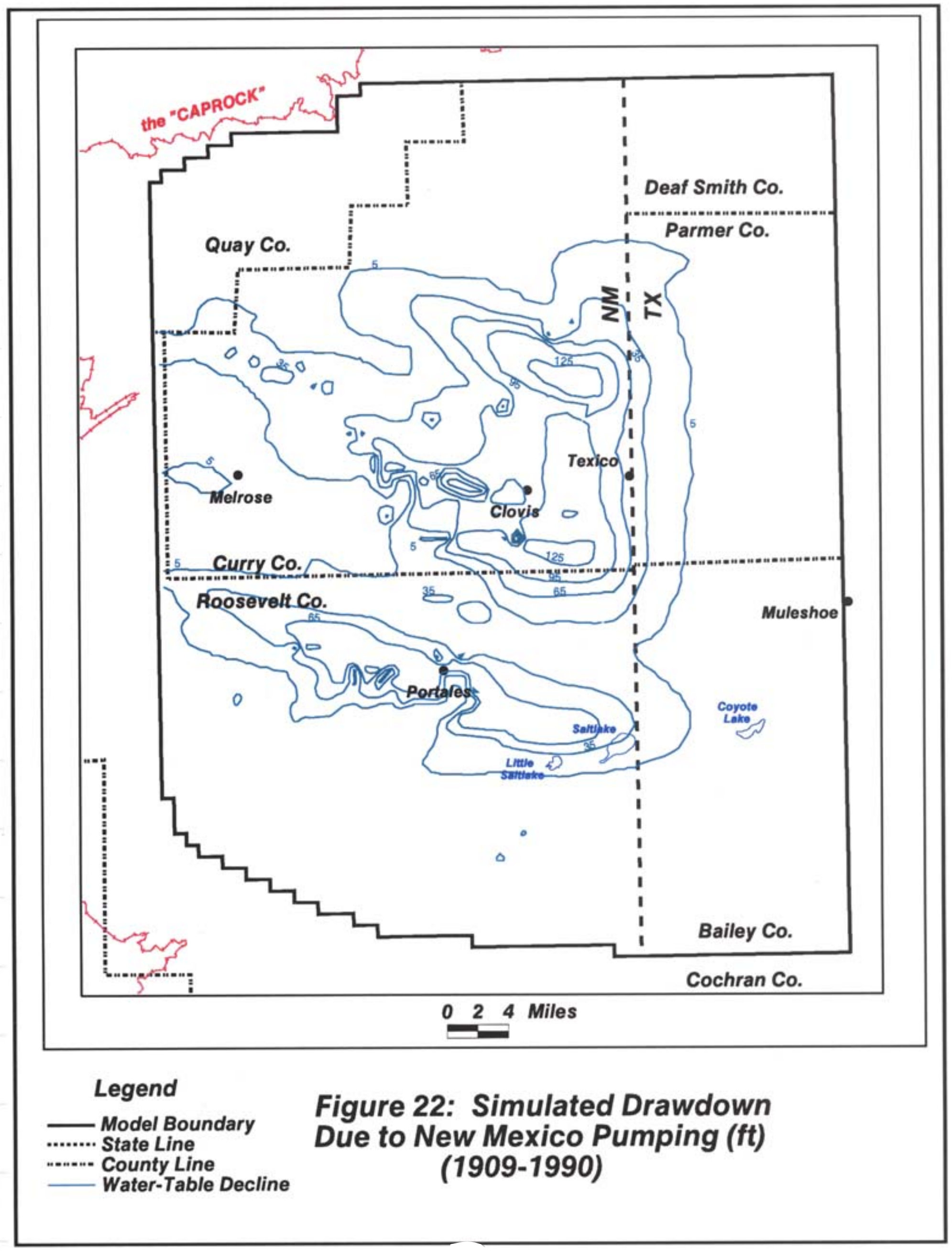


Figure 22: Simulated Drawdown Due to New Mexico Pumping (ft) (1909-1990)

Adapted from Musharrafieh and Logan, 1999

Figure 13

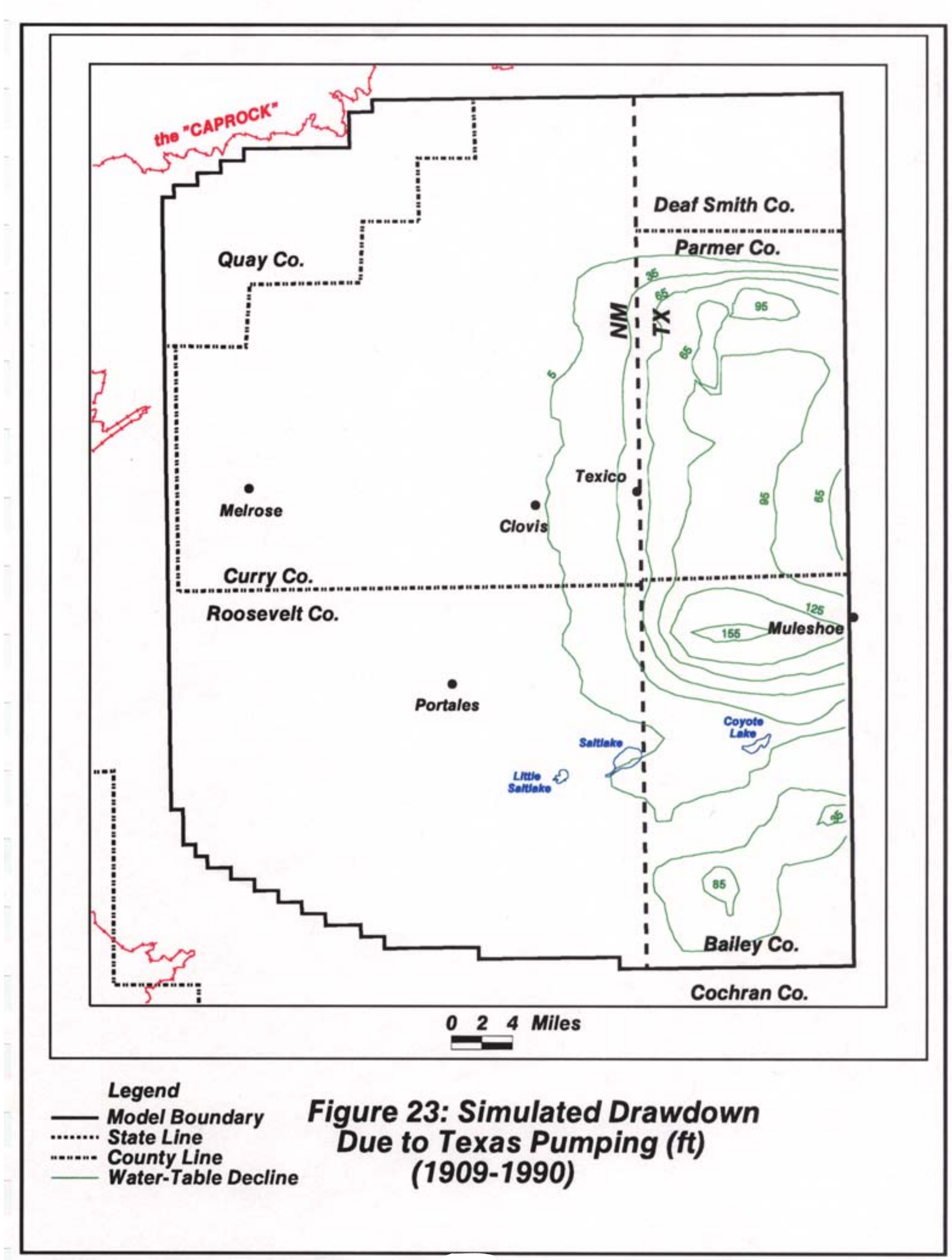
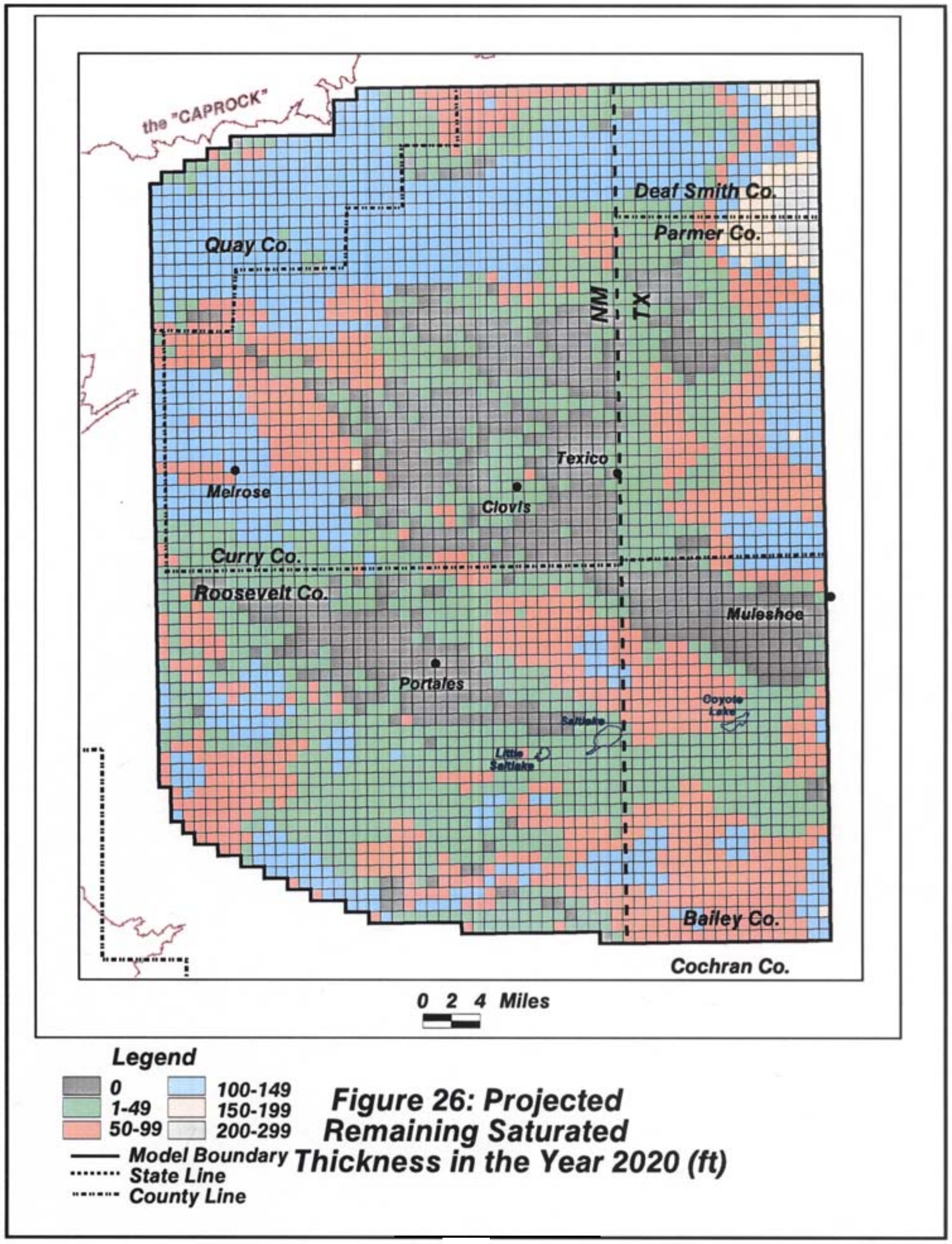


Figure 23: Simulated Drawdown Due to Texas Pumping (ft) (1909-1990)

Adapted from Musharrafieh and Logan, 1999

Figure 14



Adapted from Musharrafieh and Logan, 1999

Figure 15