Texas Water Development Board

Open-File Report 98-01

Groundwater Conditions, Gaines County, Texas

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Executive Summary

The groundwater conditions of Gaines County are typical of the Southern High Plains of Texas. Areas of intensive irrigation operations usually experience overdraft of the aquifer, although exceptions do occur. The 1980s generally constituted a period of water-level rise, whereas the 1990s to date have been one of water-level decline.

Introduction

The groundwater database of the Texas Water Development Board (TWDB) contains historical and current data for the High Plains aquifer. This report relies on data from two sources: the TWDB Groundwater Data System and the Texas Department of Water Resources (TDWR) High Plains aquifer model, as documented in TDWR Report 288 (Knowles et al., 1984). This model has been utilized as a tool for estimating future groundwater availability required for state water planning, and includes Gaines County.

Setting

For this report, the High Plains aquifer model was applied to Gaines County. The High Plains aquifer was conceptualized from a regional perspective, and consists of an unconfined (or water table) aquifer comprised of heterogeneous sequences of coarse-grained sand and gravel grading upward into fine clay. As modeled, the High Plains aquifer includes the Tertiary Ogallala aquifer and underlying Cretaceous aquifers, which also represent sources of groundwater for this region. Conceptually, the model evaluates water inflows and outflows to and from the system to determine changes in storage within the aquifer (Figure 1). Changes in storage in turn influence the elevation of the water table. The bottom of the model is represented by the estimated base of the High Plains aquifer as depicted in Figure 2. Laterally, the physical limits of the model coincide with the boundary limits of Gaines County.

Availability of Data

Input data for this task included the High Plains aquifer model data sets, as well as boundary and transportation line (excluding railway) data from TWDB files. The estimated base of the aquifer was derived from the original work maps used during the High Plains aquifer modeling efforts (Knowles et al., 1984). Water-level data employed in this study were extracted from the TWDB Groundwater Data System. The wells selected for this evaluation were the current observation wells included in the water-level monitoring system of the TWDB Hydrologic Monitoring Section. Static water levels for wells in the system are measured annually during the winter months. Measuring during the winter months allows the wells sufficient time to recover from the impacts of irrigation pumpage.

Calculated Water in Storage

The saturated thickness of the High Plains aquifer in the model area was calculated using the software program SURFER7, which subtracted the estimated aquifer base surface (Figure 2) from the winter 1996 water-level surface for the High Plains aquifer (Figure 3). The saturated thickness was then multiplied by the storage coefficient (specific yield) over the model area to calculate the estimated volume of groundwater in storage in 1996. Specific yield values used for this evaluation ranged from approximately 0.12 to 0.20, and were obtained from the High Plains aquifer model (Knowles et al., 1984). The total volume of groundwater in storage calculated across the model area for 1996 equals 13,823,200 acre-feet. The corresponding spatial distribution of the volume of water in storage is shown graphically in Figure 4. The contour lines in this figure represent the volume of water (in cubic feet) available per unit area of one square foot at a given location throughout the model area.

This process was repeated using the winter 1990 and winter 1980 water levels. The winter 1990 water-level distribution and the associated estimated volume of groundwater in storage (15,166,000 acre-feet) are shown in Figures 5 and 6, respectively. The estimated winter 1980 water-level surface and the corresponding calculated volume of water in storage (13,828,000 acre-feet) are depicted in Figures 7 and 8, respectively. Changes in water storage over time were subsequently calculated for the High Plains aquifer based on the above results. Between 1980 and 1990, Gaines County experienced an overall estimated increase of 1,338,000 acre-feet of groundwater in storage. Between 1990 and 1996, the volume of water in storage decreased by approximately 1,342,800 acre-feet, resulting in a net calculated decrease of 4,800 acre-feet of water in storage for the period from 1980 to 1996. Estimated average annual rates of water-level change for the periods from 1980 to 1990, 1990 to 1996, and 1980 to 1996 are shown in Figures 9, 10 and 11, respectively.

Summary of Results

The results of this investigation indicate that Gaines County has experienced periods of groundwater level decline (outflow>inflow) as well as periods of water-level recovery (outflow<inflow) since the 1980s. During the 1980s, an increase in the amount of groundwater in storage was observed. However, water-level declines persisted within certain portions of the County, albeit subdued when compared with the decline rates observed thus far in the 1990s. Areas experiencing unabated water-level decline trends will likely incur difficulties in future production if current extraction practices are continued. Similar observations have been made for many of the surrounding counties.

Sources of Anomalous Results

This report utilized all existing data to calculate estimates of groundwater in storage. The amount of data available may vary over time. Therefore, data density can potentially impact the calculated volume of water in storage at specific locations. One possible approach for reducing the impacts of variations in data density is to limit the data employed to only those locations which have a value for every time period evaluated. Another method to reduce the impacts of data density variations would be to incorporate linear regression evaluations to describe a water-level trend for each observation well. Additional sources of uncertainty in this evaluation could stem from instances in which the water level measured in a particular well or wells for some reason is not representative of static conditions in the aquifer. Nevertheless, the approach described herein is considered to provide reasonable accuracy when comparing time periods as long as a decade, and areas as large as a county.

References

Knowles, T., Nordstrom, P., and Klempt, W. B., 1984, Evaluating the ground-water resources of the High Plains of Texas: Texas Water Development Board, Report 288.

Conceptual Water Budget

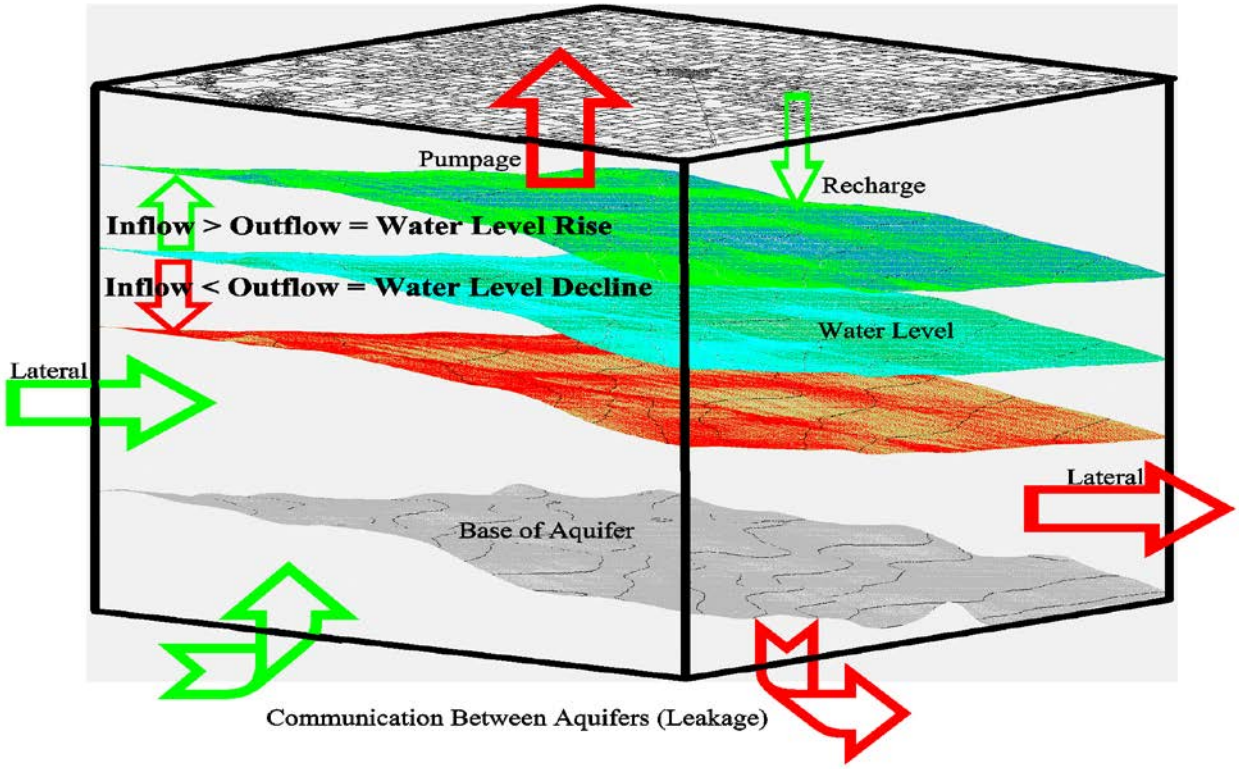
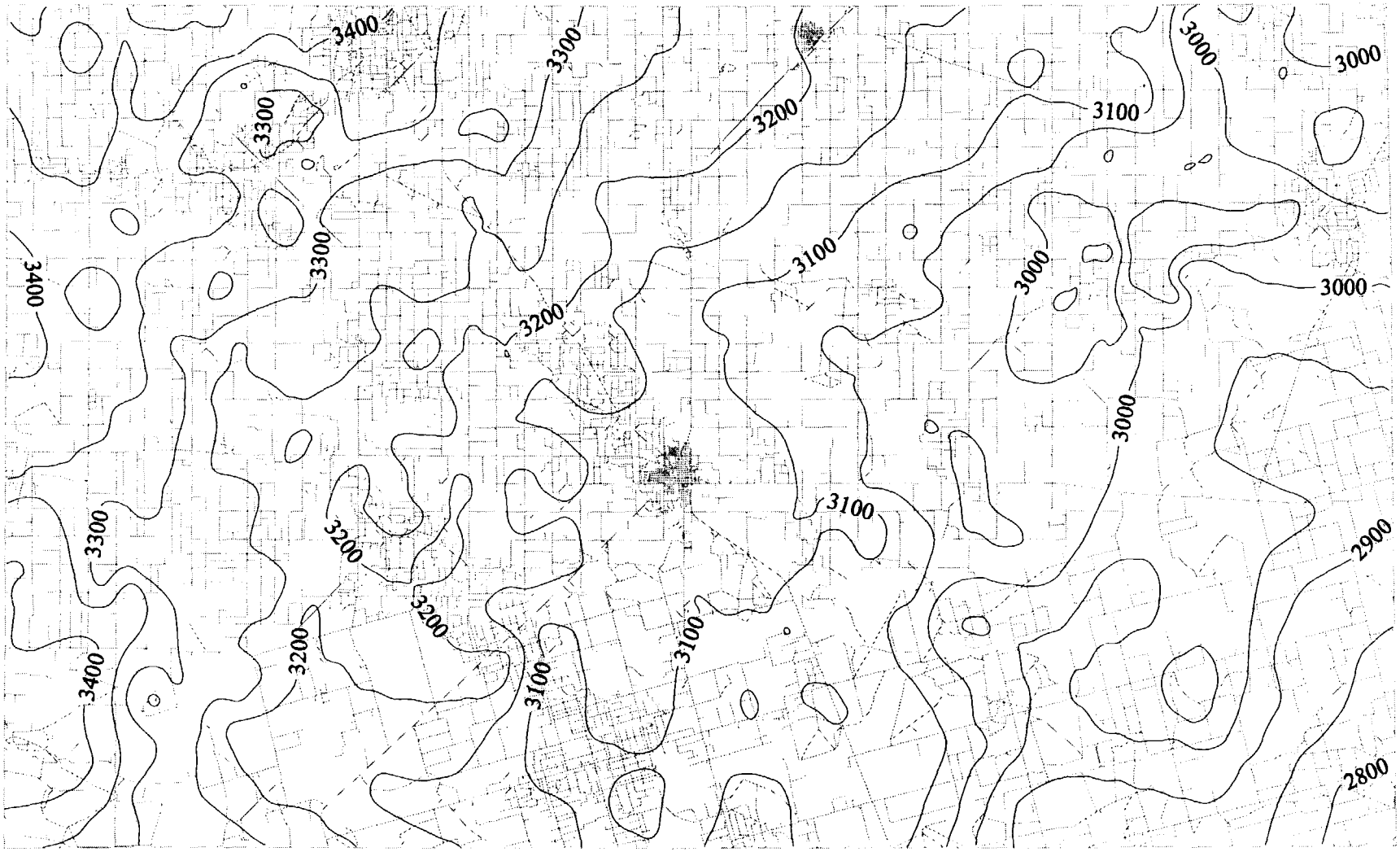


Figure 1

Contours Represent Feet Above Mean Sea Level.



Modified from TWDB Report 288

Figure 2. Estimated base of High Plains aquifer in Gaines County, Texas

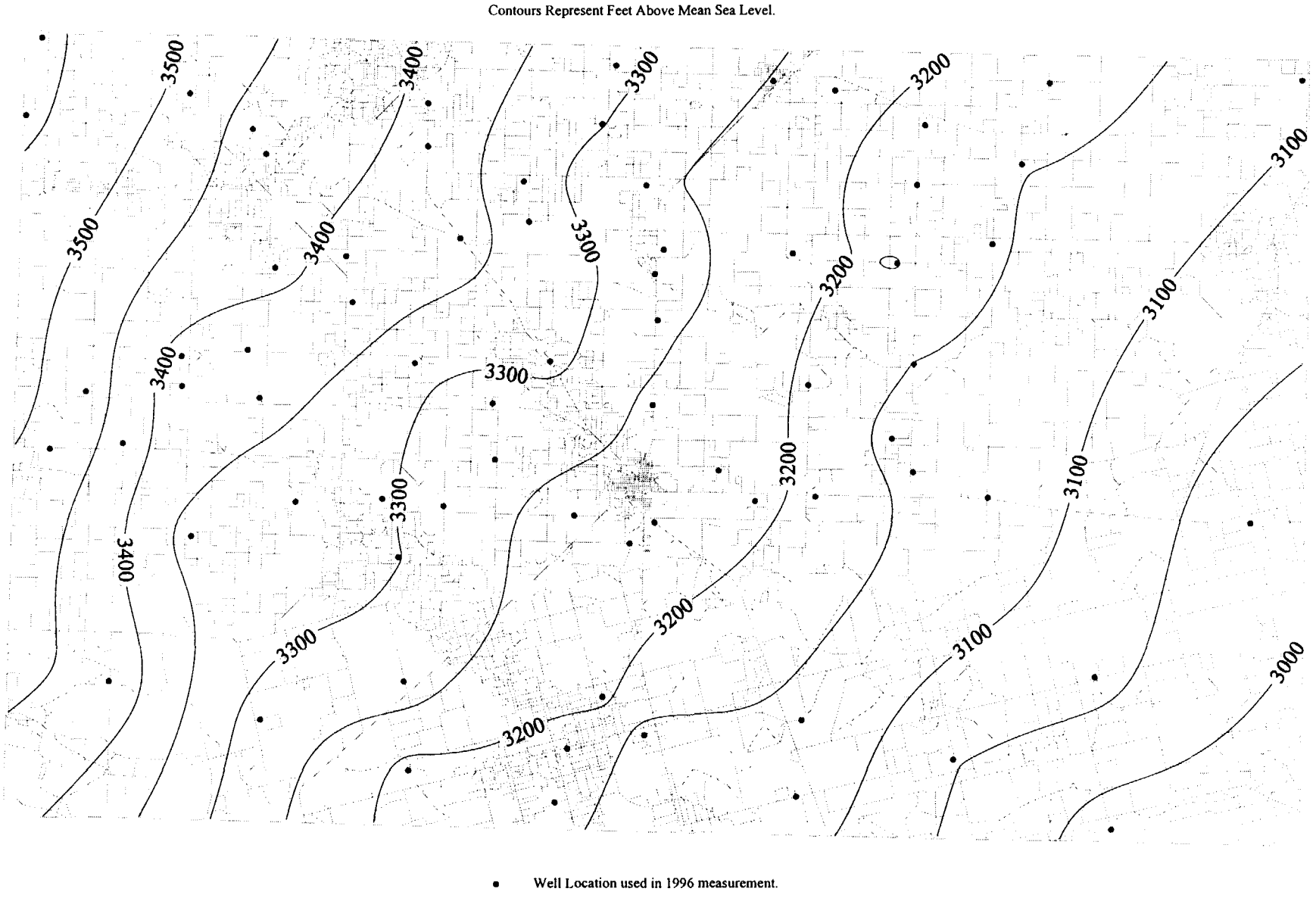
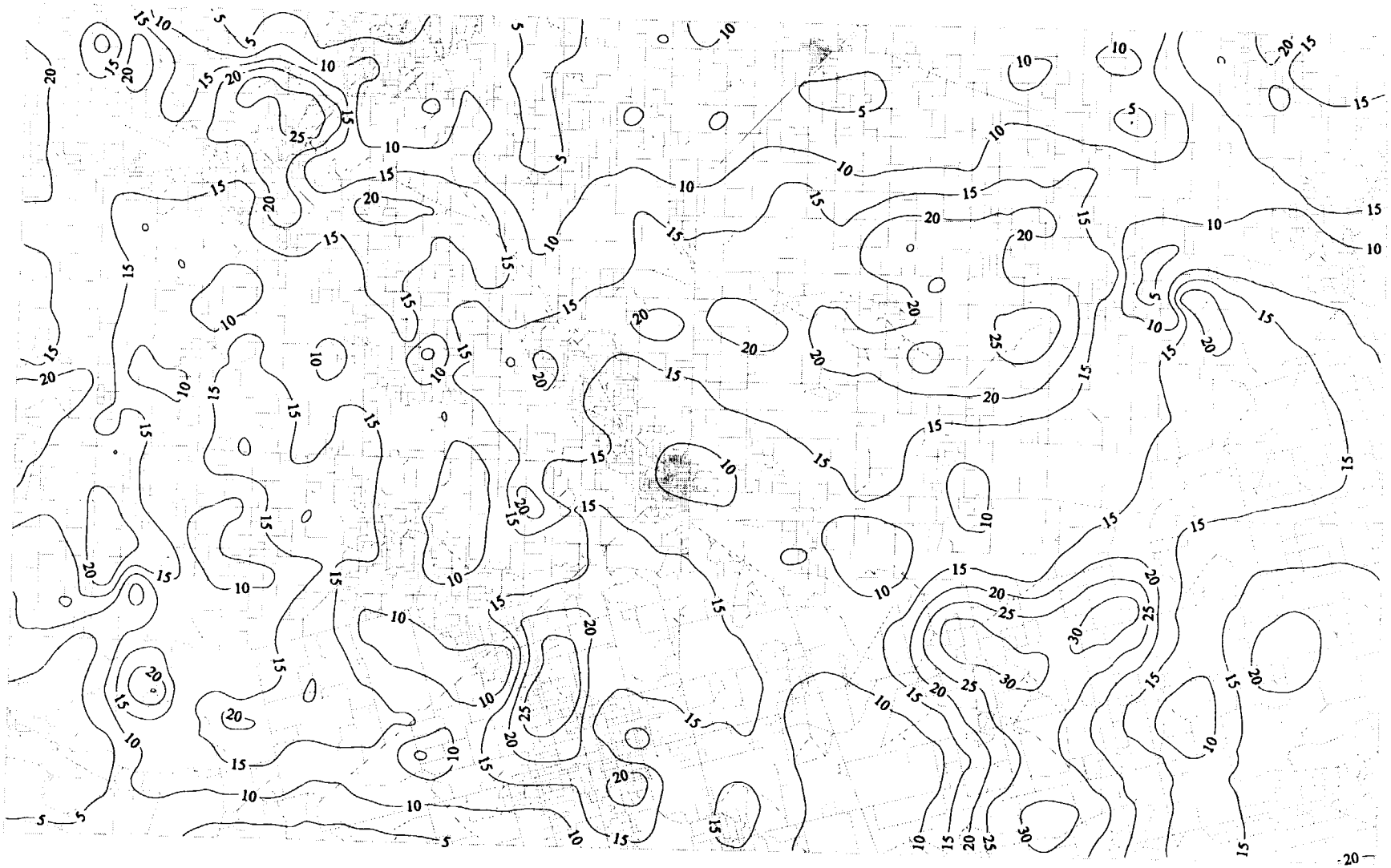


Figure 3. Estimated winter 1996 water levels, High Plains aquifer, Gaines County, Texas

Contours represent cubic feet of water in storage per square foot of area on the map
(saturated thickness x specific yield x unit area)



Total Estimated Water in Storage = 13,823,200 acre-feet

Figure 4. Estimated water in storage - winter 1996, High Plains aquifer, Gaines County, Texas

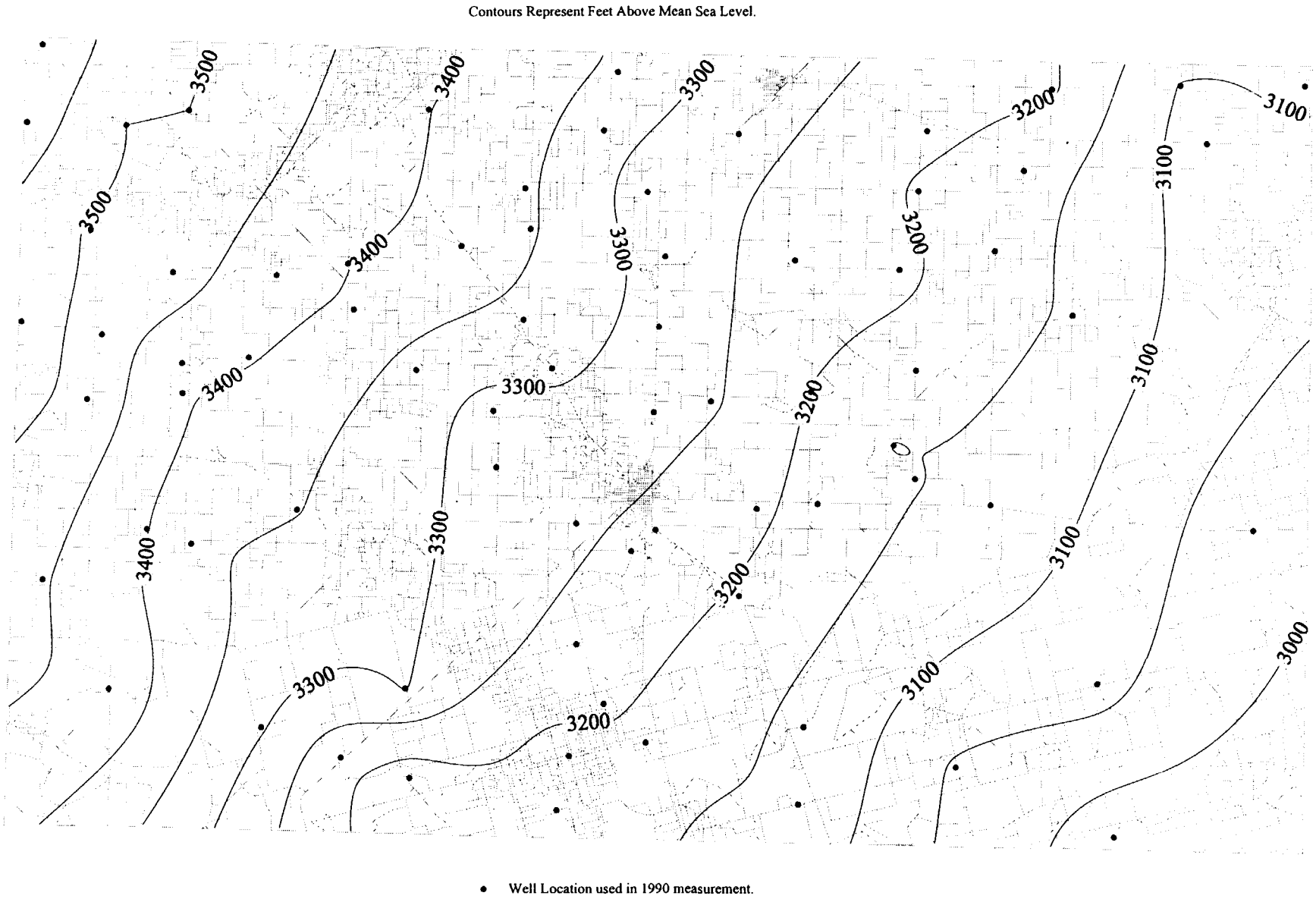
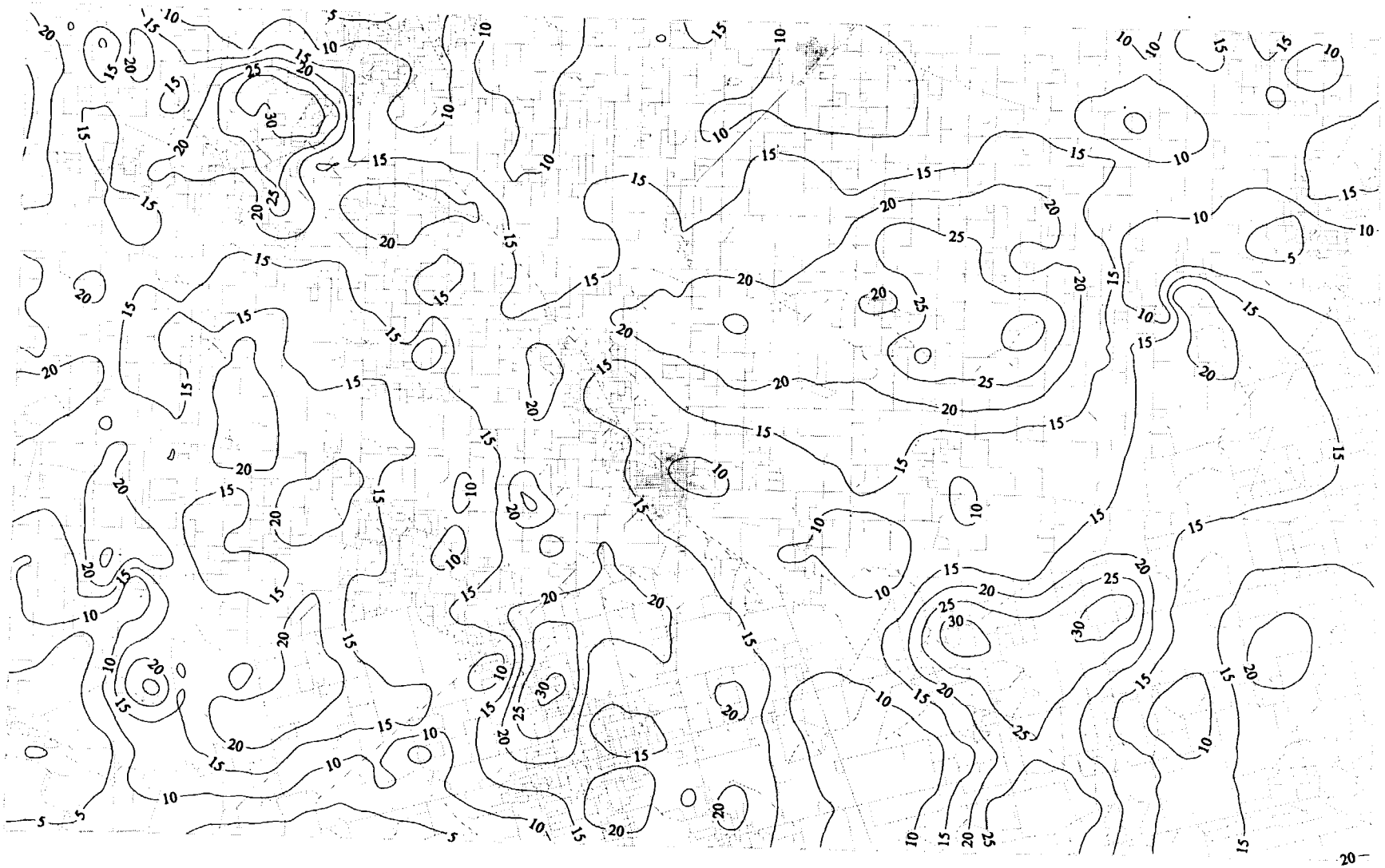


Figure 5. Estimated winter 1990 water levels, High Plains Aquifer, Gaines County, Texas

Contours represent cubic feet of water in storage per square foot of area on the map
(saturated thickness x specific yield x unit area)



Total Estimated Water in Storage = 15,166,000 acre-feet

Figure 6. Estimated water in storage - winter 1990, High Plains aquifer, Gaines County, Texas

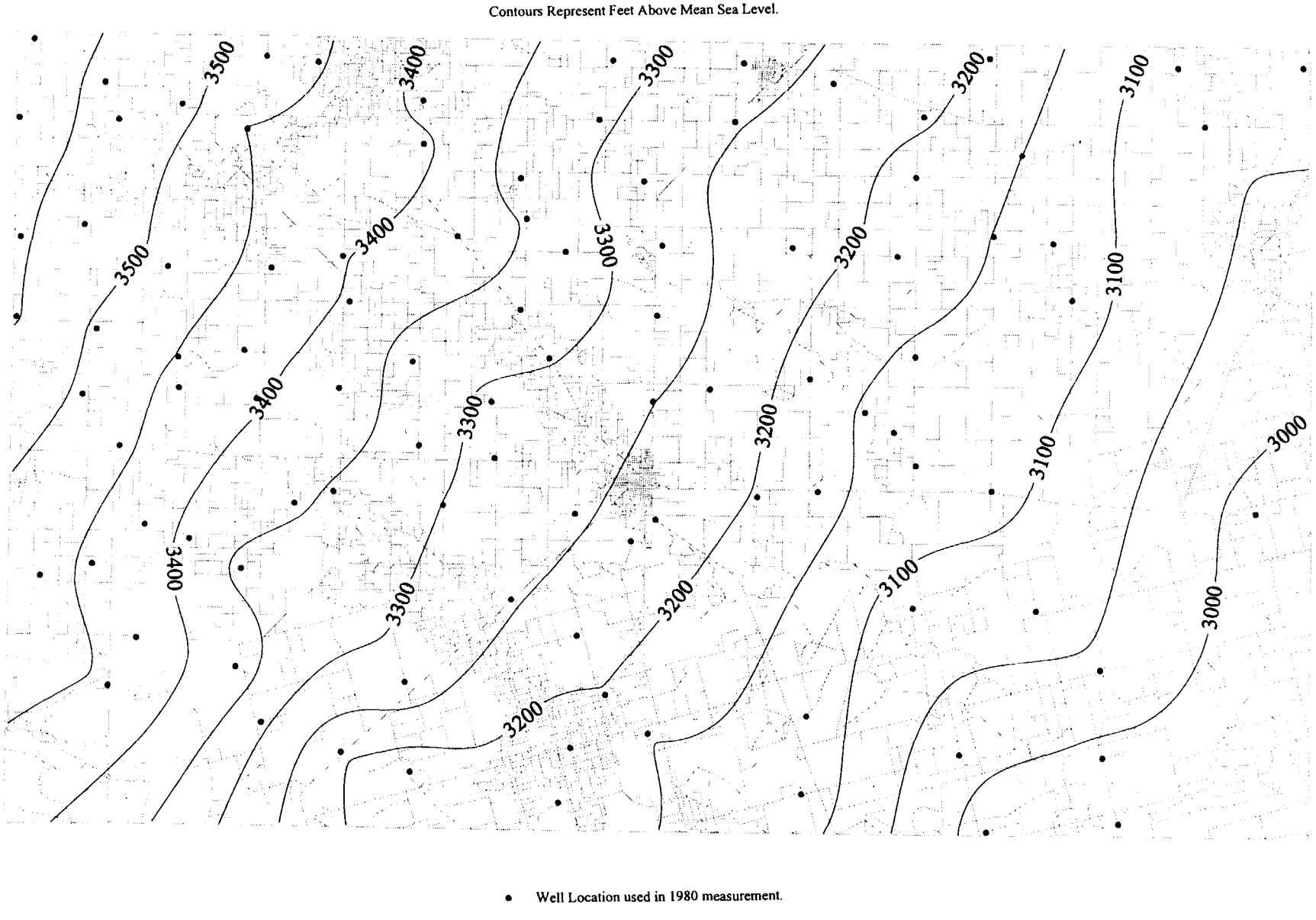
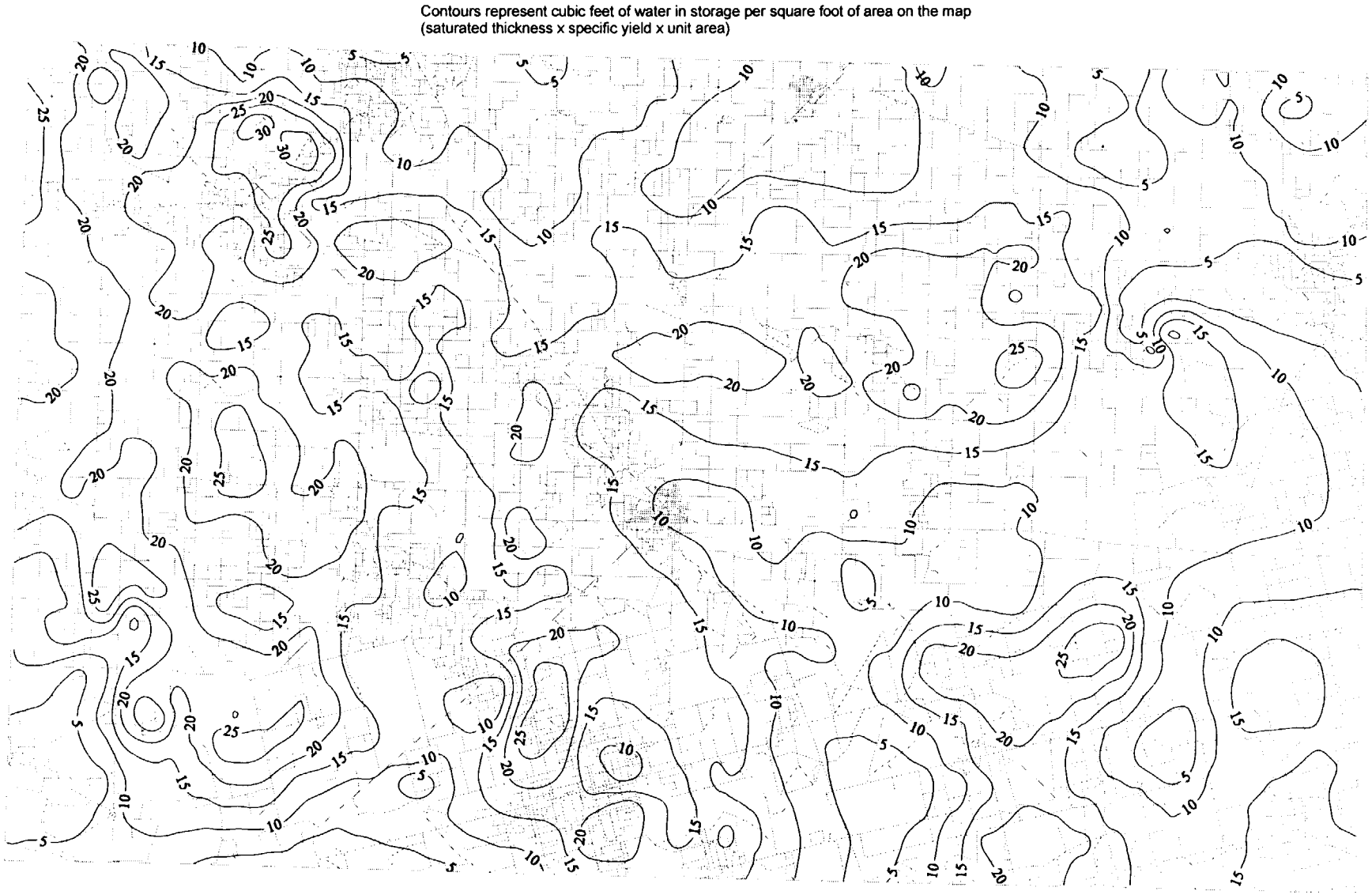


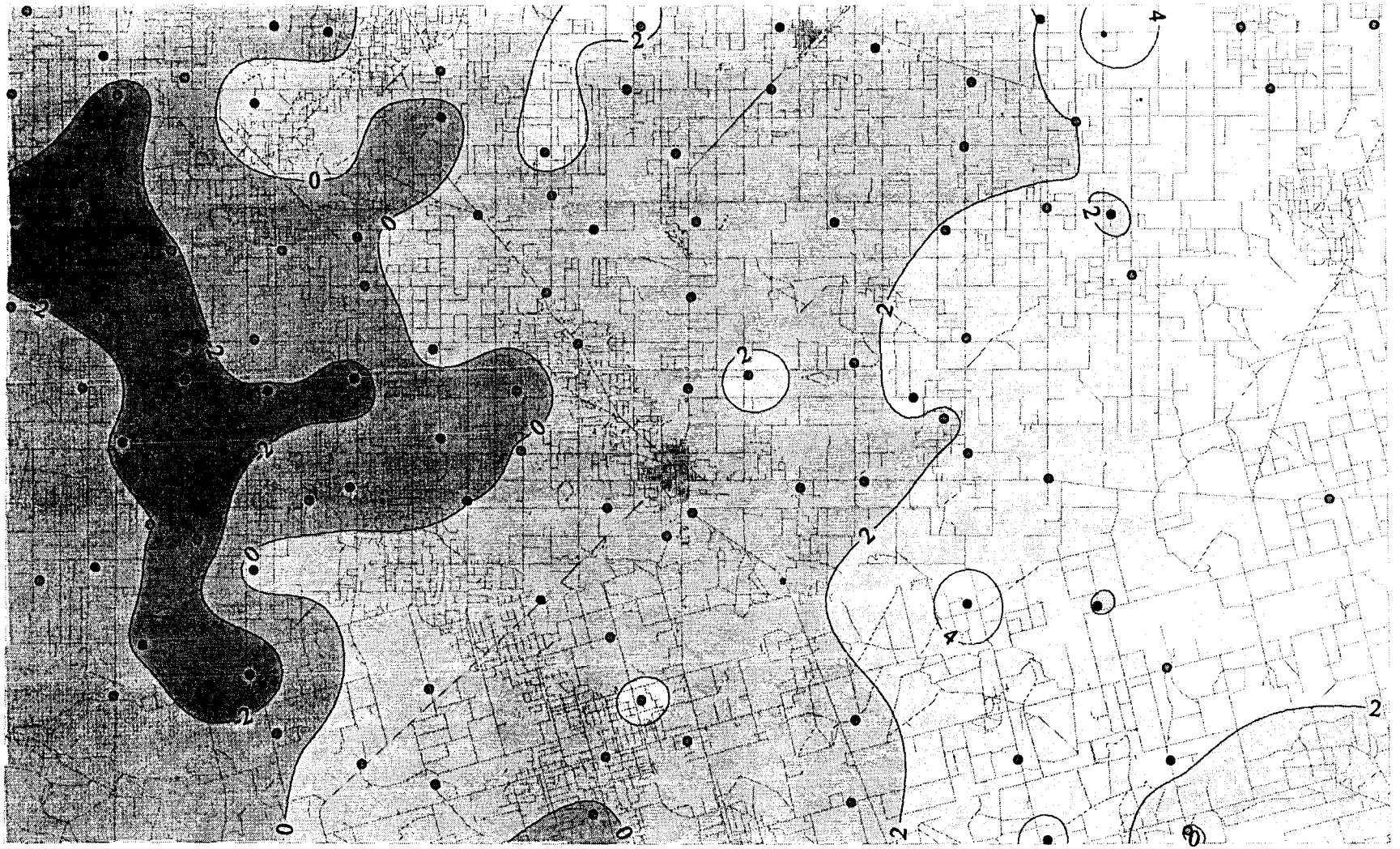
Figure 7. Estimated winter 1980 water levels, High Plains aquifer, Gaines County, Texas



Total Estimated Water in Storage = 13,828,000 acre-feet

Figure 8. Estimated water in storage - winter 1980, High Plains aquifer, Gaines County, Texas

Contours Represent Feet per Year.

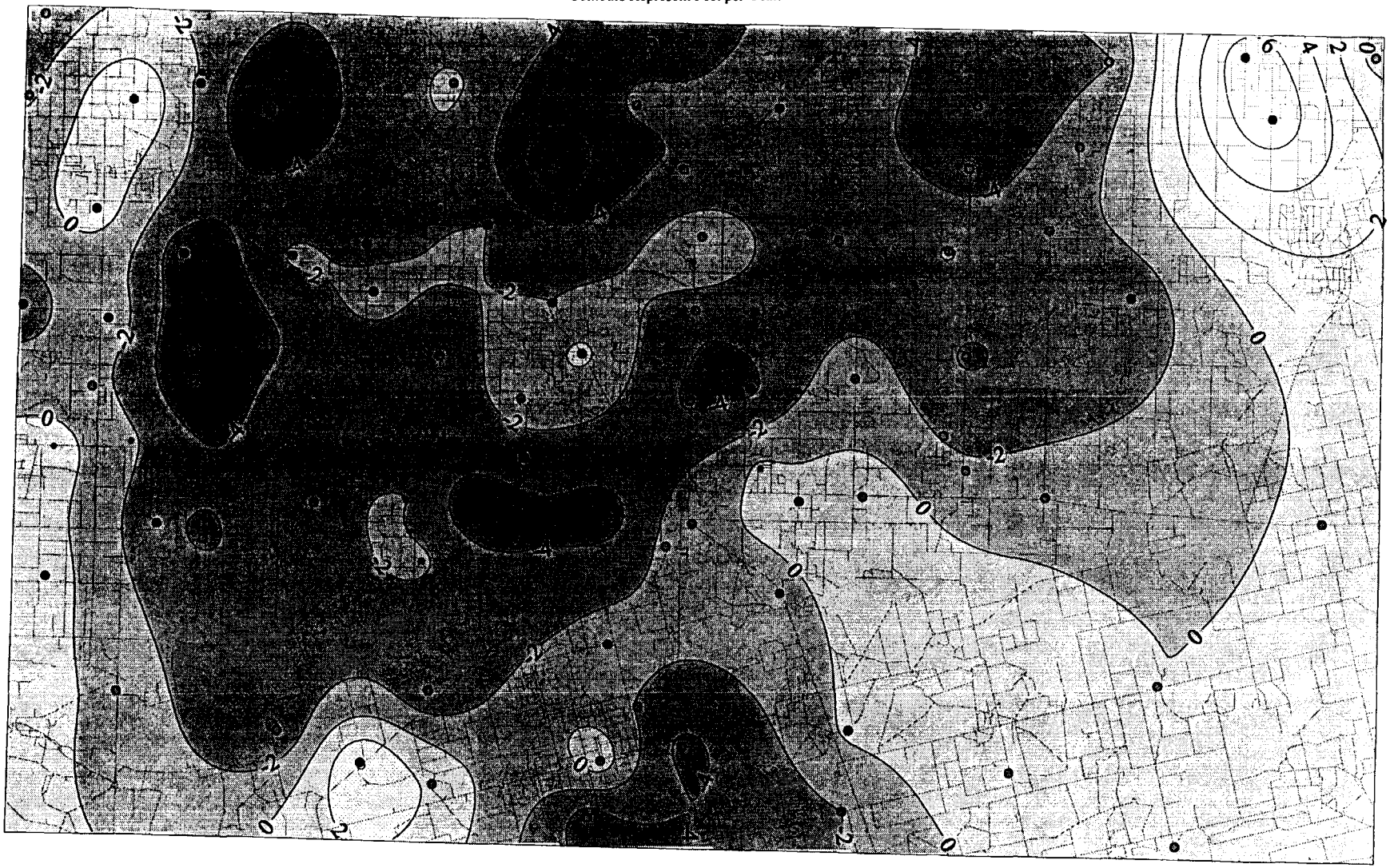


Estimated Total Volumetric Change in Storage 1980 - 1990 = +1,338,000 acre-feet

- Well Location used in 1990 measurement.
- Well Location used in 1980 measurement.

Figure 9. High Plains aquifer estimated average water-level change rates between 1980 and 1990, Gaines County, Texas

Contours Represent Feet per Year.

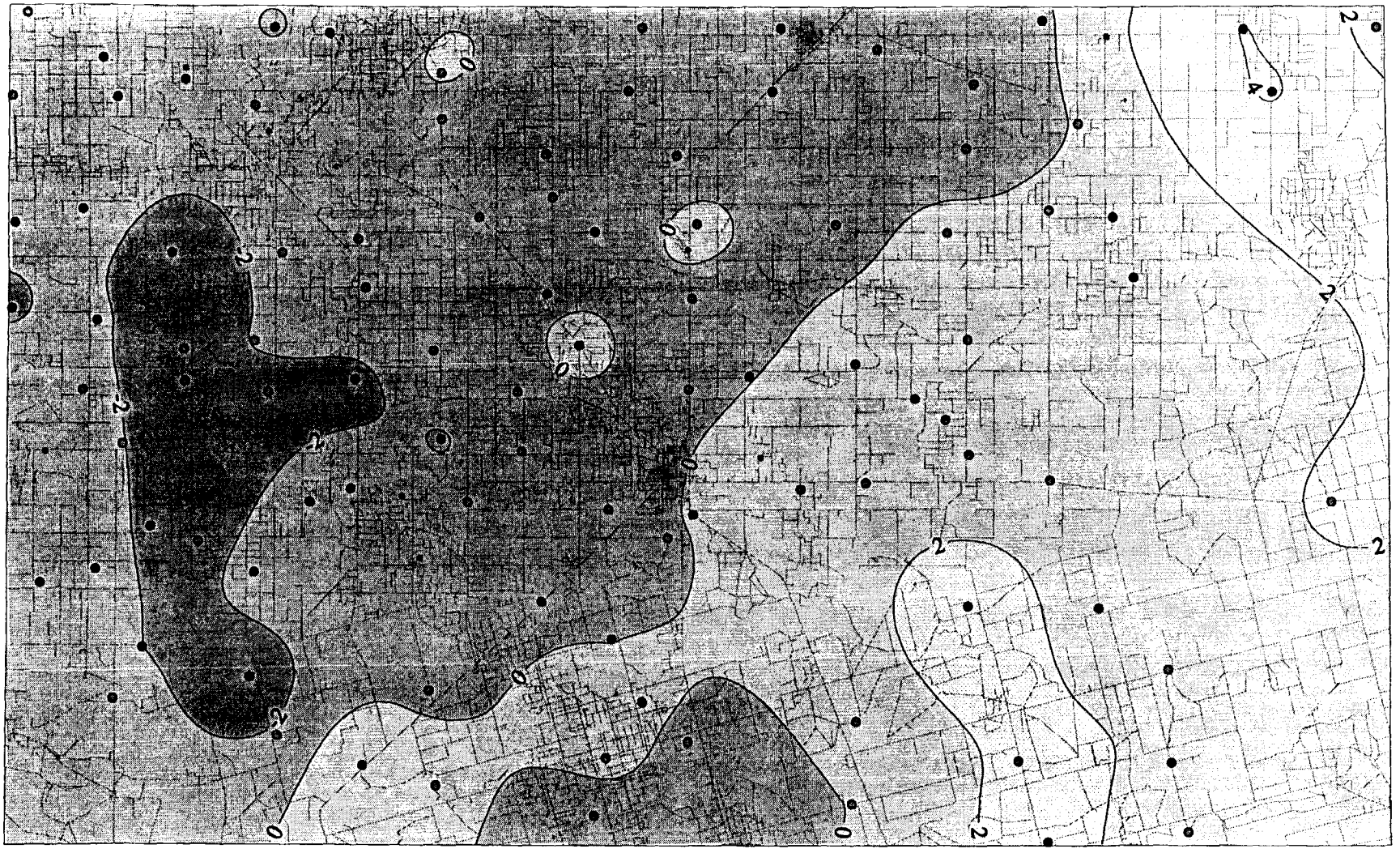


Estimated Total Volumetric Change in Storage 1990 - 1996 = -1,342,800 acre-feet

- Well Location used in 1996 measurement.
- Well Location used in 1990 measurement.

Figure 10. High Plains aquifer estimated average water-level change rates between 1990 and 1996, Gaines County, Texas

Contours Represent Feet per Year.



Estimated Total Volumetric Change in Storage 1980 - 1996 = -4,800 acre-feet

- Well Location used in 1996 measurement.
- Well Location used in 1980 measurement.

Figure 11. High Plains aquifer estimated average water-level change rates between 1980 and 1996, Gaines County, Texas