# GAM Run 06-03

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Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-3132
March 8, 2006

## REQUESTOR:

Mr. John Jones on behalf of the Culberson County Groundwater Conservation District (GCD).

## DESCRIPTION OF REQUEST:

Mr. Jones requested a Groundwater Availability Model (GAM) run using the GAM for the Igneous and parts of the West Texas Bolsons aquifers. Mr. Jones requested that we evaluate the impact of pumpage on water levels in the West Texas Bolsons aquifer.

## METHODS:

To determine the impacts of pumping on water levels in the Culberson County GCD, we used the GAM for the Igneous and parts of the West Texas Bolsons aquifers and increased pumpage to the West Texas Bolsons aquifer incrementally, essentially providing a "sensitivity analysis" of water levels to pumpage. The portions of the West Texas Bolsons aquifer included the GAM are Wildhorse Flat, Michigan Flat, Ryan Flat, and Lobo Flat and are locally referred to as being part of the Salt Basin Bolson aquifer. To avoid confusion with other parts of the West Texas Bolsons aquifer, we refer to the West Texas Bolsons aquifer in this GAM as the Salt Basin Bolson aquifer in this report.

The baseline pumpage that we used in the predictive runs was the year 2000 estimated historic pumpage from the transient calibration/verification run. This year was the last of the historic pumpage estimates and therefore was considered to be the most accurate recent pumpage estimate for the model area. The year 2000 baseline pumpage was repeated for each year in the predictive model runs. We added an additional zero to two acre-feet per acre per year in all of Culberson County to this baseline pumpage for our predictive model runs.

It is important to note that many model cells in the Salt Basin Bolson aquifers contained significant pumpage in the 2000 historic pumpage estimate. When creating uniform pumpage rates for the predictive runs, we only changed the pumpage in a model cell if the existing pumpage was less than the desired uniform pumpage rate. For those cells with higher rates of pumping in the baseline 2000 pumpage data set than what was desired in the model run, the existing pumpage was used.

In these model runs, only the Salt Basin Bolson aquifer was evaluated. This was done for two reasons. First, most of the Igneous aquifer in Culberson County began the predictive model run dry.  Second, the 2000 estimated historic pumpage included no pumpage from the Igneous aquifer in Culberson County, and therefore we assumed that this aquifer should not be included in this evaluation.

## PARAMETERS AND ASSUMPTIONS:

- See Beach and others (2004) for assumptions and limitations of the GAM for the Igneous and West Texas Bolsons aquifers.

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the entire GAM for the period of 1990 to 2000 is 64 feet, or four percent of the range of measured water levels (Beach and others, 2004).

- The model includes three layers, representing the Salt Basin Bolson aquifer (Layer 1), the Igneous aquifer (Layer 2), and the underlying Cretaceous and Permian units (Layer 3).

- We simulated a 50-year time period for the predictive model runs.

- We used an average annual recharge based on recharge determined through the calibration of the transient model covering the years 1950 to 2000.

- We used the year 2000 historic pumpage estimate as the baseline pumpage. Pumpage is included in the model for all three layers, although pumpage in Layer 3, representing the underlying Cretaceous and Permian units, is minimal, and no pumpage is present in Culberson County from Layer 3 in the model.

- We added an additional zero to two acre-feet per acre per year to the baseline year 2000 historic estimated pumpage for the Salt Basin Bolson aquifer.

- The GAM uses drains to simulate discharge to streams. Drains are included in both the Salt Basin Bolson aquifer and Igneous aquifer layers of the model. Drain parameters were held at conditions representing the 2000 stress period for the predictive simulations.

- The GAM uses general-head boundaries (GHB) to simulate cross-formational flow into and out of layer 3, which represents the Cretaceous and Permian units underlying the Igneous aquifer. GHB parameters were held at conditions representing the 2000 stress period for the predictive simulations.

- The GAM uses the MODFLOW evapotranspiration package (ET) to simulate discharge of water to evaporation and transpiration. ET parameters were held at conditions representing the 2000 stress period for the predictive simulations.

- The GAM includes pumpage representing rural domestic, municipal, industrial, irrigation, and livestock uses.

## RESULTS:

The Salt Basin Bolson aquifer is present in limited extent in Culberson County (Figure 1). Initial (2000) water levels range from approximately 3,860 feet above mean sea level where Ryan Flat crosses the Jeff Davis-Culberson county line to approximately 3,520 feet above mean sea level in the center of Wild Horse Flat (Figure 2). Initial (2000) saturated thicknesses range from zero at the bolson margins to nearly 1,000 feet in portions of the center of the bolson (Figure 3). As shown in these figures, portions of the aquifer were dry at the start of all of the predictive model runs (black cells are dry areas). Based on the model-derived specific yield of the Salt Basin Bolson aquifer of six percent, the total groundwater in storage in the aquifer at the start of the predictive model runs is approximately 4,970,000 acre-feet in the Culberson County GCD area.

Table 1 summarizes the pumping rates for the Salt Basin Bolson aquifer with these GAM runs for the Culberson County GCD area. As can be seen in this table, the annual amount of groundwater pumped from the aquifer from the district area in the model runs ranges from more than 30,000 acre-feet per year to the nearly 370,000 acre-feet per year that is currently permitted. It should be noted that 84 percent of the 2000 estimated pumpage is in the Salt Basin Bolson aquifer in Culberson County, and therefore the baseline pumpage value in Table 1 is relatively high.

**Table 1. Summary of annual pumpage from the Salt Basin Bolson aquifer in the GAM runs from the Culberson County GCD area (in acre-feet per year)**

| Pumpage Rate (acre-feet per acre per year) | Total Culberson County GCD Area Pumpage |
|---|---|
| Baseline 2000 Pumpage Rate | 30,283 |
| 0.05 | 38,598 |
| 0.10 | 47,022 |
| 0.25 | 72,293 |
| 0.50 | 114,437 |
| 1.0 | 198,932 |
| 2.0 | 368,154 |

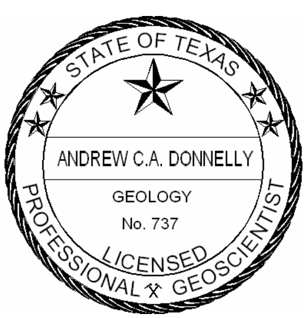
It is important to note that the volumes in Table 1 are based on the initial (2000) active area in the Salt Basin Bolson aquifer in the predictive runs. This active area decreases (and therefore annual pumpage also decreases) as parts of the aquifer dry up during the model runs. In MODFLOW, when the water level in a model cell falls below the bottom of the cell, the cell goes dry. Because the cell no longer has water in it, MODFLOW turns the cell off. When a cell goes dry, the model is indicating that there is not enough water flowing into the cell (for example, recharge) or there is too much water being removed from the cell (for example, pumping) to keep water in the cell. If pumping is the primary factor, the model is saying that the pumping may be too great for the aquifer in this area. When MODFLOW shuts a cell off, that cell is off for the rest of the simulation. In reality, the aquifer will probably not go dry because pumping will become uneconomical before the aquifer goes dry in any particular area. However, the GAM is suggesting that these areas may experience water supply problems sometime in the next 50 years.

The impact of pumping at the 2000 estimated pumpage rates over 50 years is shown in Figure 4. This figure indicates that water levels decline approximately 50 feet across the extent of the aquifer from the initial water levels (Figure 2). This is because of the relatively high pumpage included in the Salt Basin Bolson aquifer in Culberson County in the 2000 estimate pumpage, as noted above.

The impact of pumping rates of 0.05, 0.10, 0.25, 0.50, 1.0, and 2.0 acre-feet per acre per year on water levels in the Salt Basin Bolson aquifer after fifty years are shown in Figures 5, 6, 7, 8, 9, and 10, respectively. These figures show that as more water is pumped from the aquifer, water levels steadily decline and the aquifer dries up. The GAM assumes that no recharge occurs to the Salt Basin Bolson aquifer, with the exception of a small amount of recharge through alluvial fan or streambed in limited locations (Beach and others, 2004). Therefore, nearly all of the groundwater being pumped from the Salt Basin Bolson aquifer is being removed from storage. The net inflow of water from the underlying Igneous aquifer is approximately 5,000 acre-feet per year during the transient run for the entire extent of the Salt Basin Bolson aquifer, of which Culberson County comprises approximately half of the active portion in the year 2000 (Beach and others, 2004). As shown in Table 1, the amount of pumpage in most of the model runs is far greater than the amount of water entering the aquifer from the Igneous aquifer, even when taking into account that the net flux of water entering the Salt Basin Bolson aquifer from the underlying Igneous aquifer will increase as water levels decline.

## REFERENCES:

Beach, J. A., Ashworth, J. B., Finch, Jr., S. T., Chastain-Howley, A., Calhoun, K., Urbanczyk, K. M., Sharp, J. M., and Olson, J., 2004, Groundwater availability model for the Igneous and parts of the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) aquifers: contract report to the Texas Water Development Board, 208 p.

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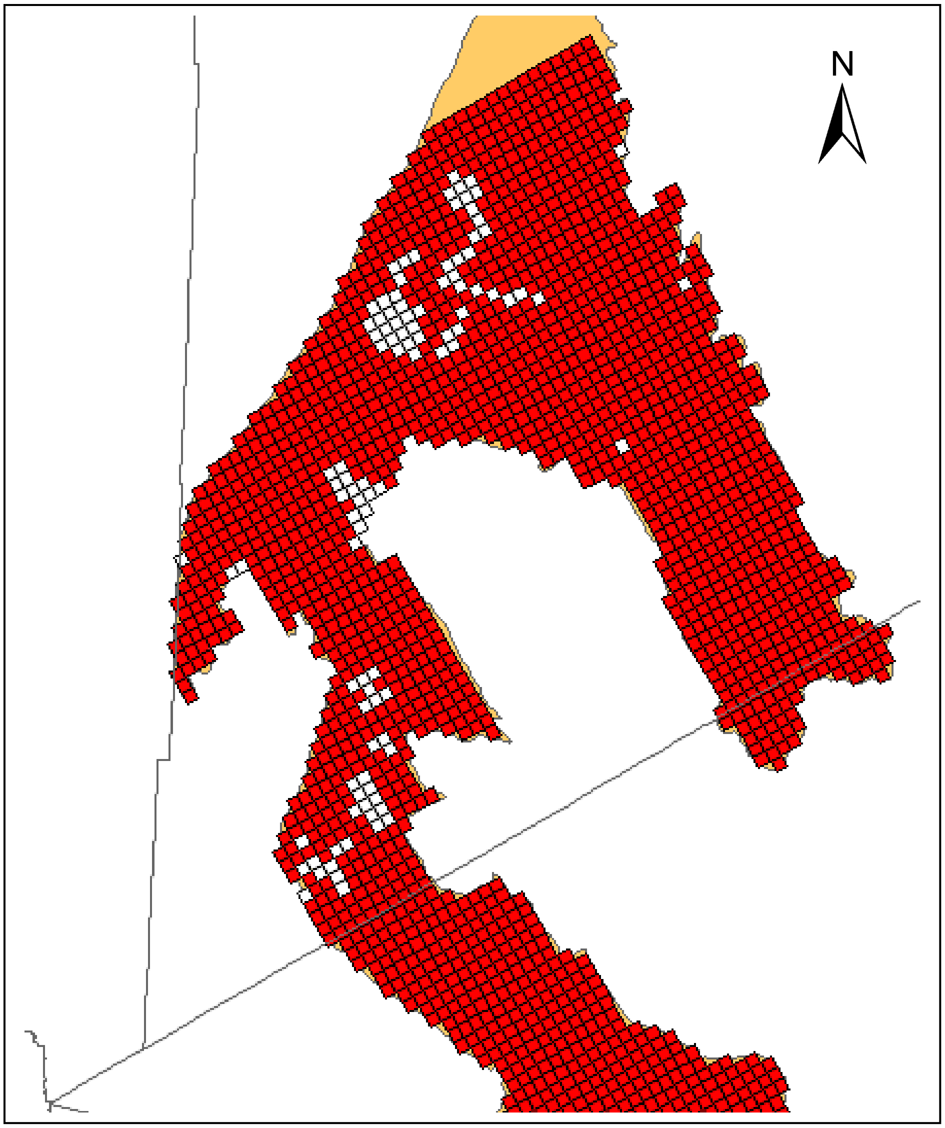


Figure 1. Extent of the Salt Basin Bolson aquifer in the GAM. Model cells in red are active cells that contain pumpage in 2000. Model cells in white are active cells without pumpage. The actual extent of the Salt Basin Bolson aquifer is shown in tan.

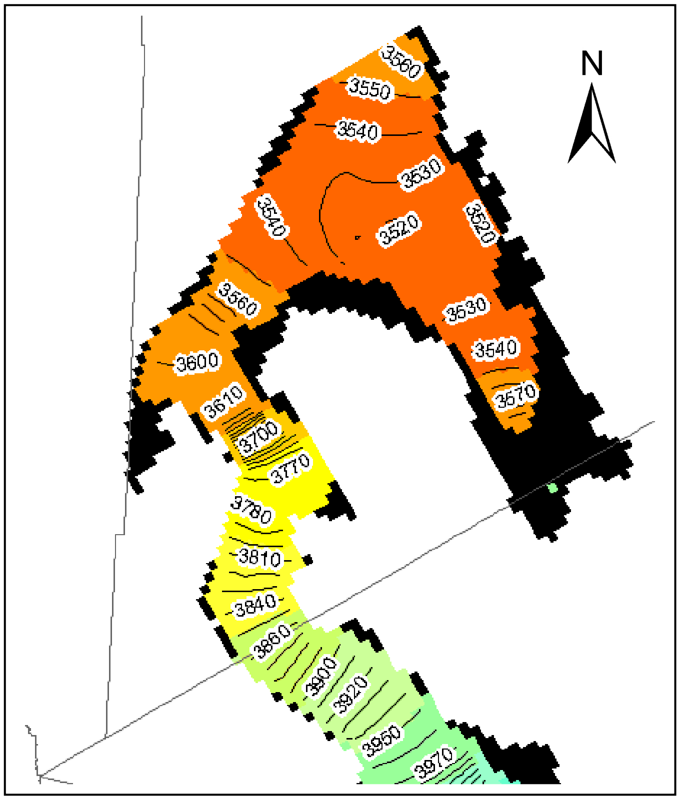


Figure 2. Initial water levels in the Salt Basin Bolson aquifer in the year 2000. Contour interval is 10 feet. Black areas are where the aquifer is dry.

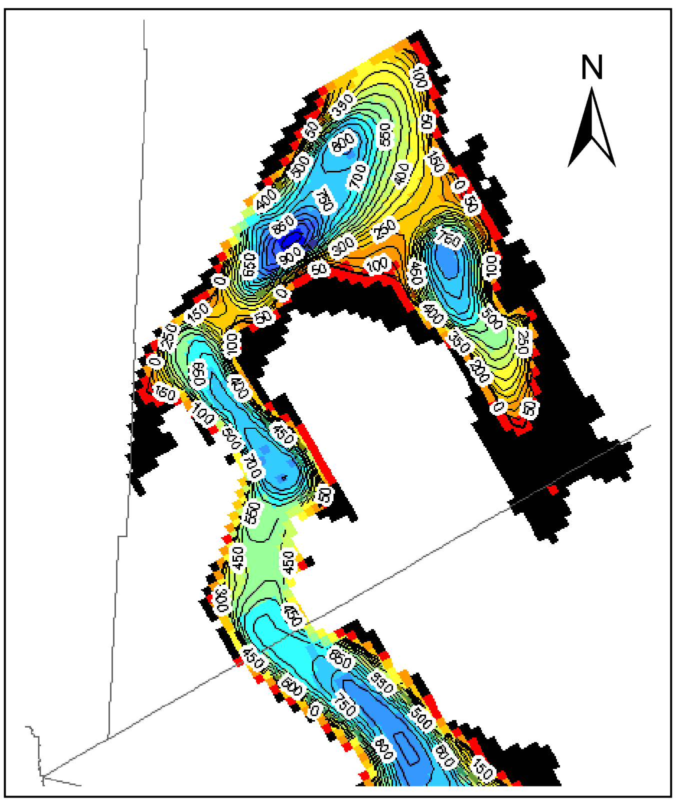


Figure 3. Initial saturated thicknesses in the Salt Basin Bolson aquifer in the year 2000. Contour interval is 50 feet. Black areas are where the aquifer is dry.

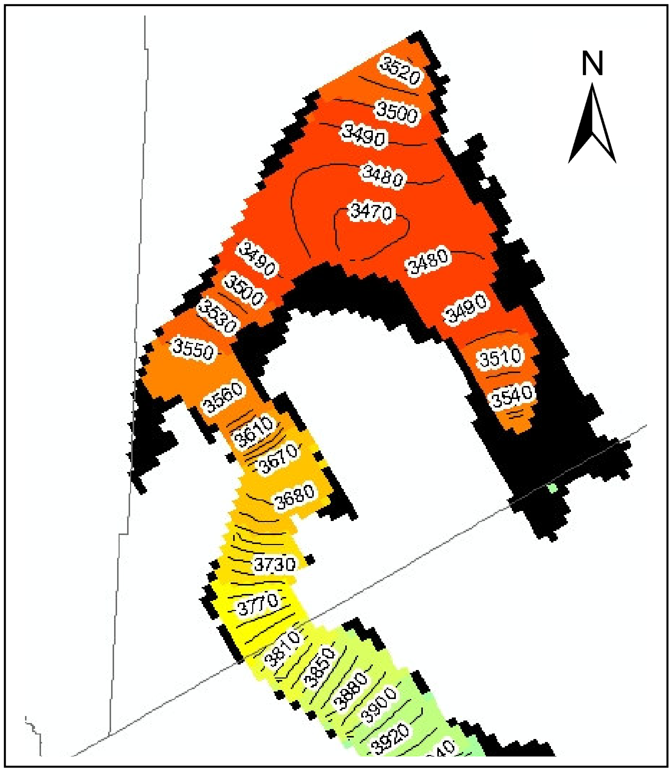


Figure 4. Water levels in the Salt Basin Bolson aquifer after 50 years with the 2000 estimated historic pumpage rate. Contour interval is 10 feet.

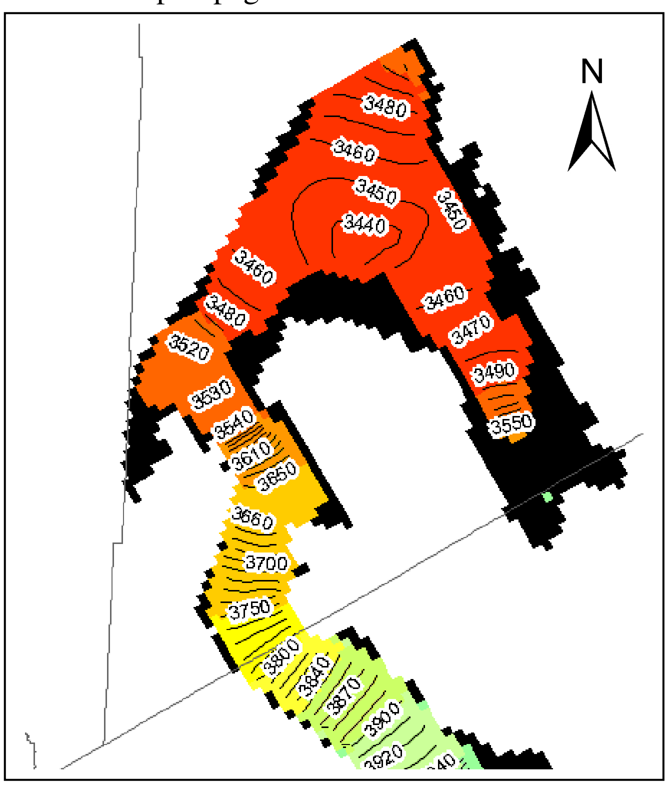


Figure 5. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 0.05 acre-feet per acre per year. Contour interval is 10 feet.

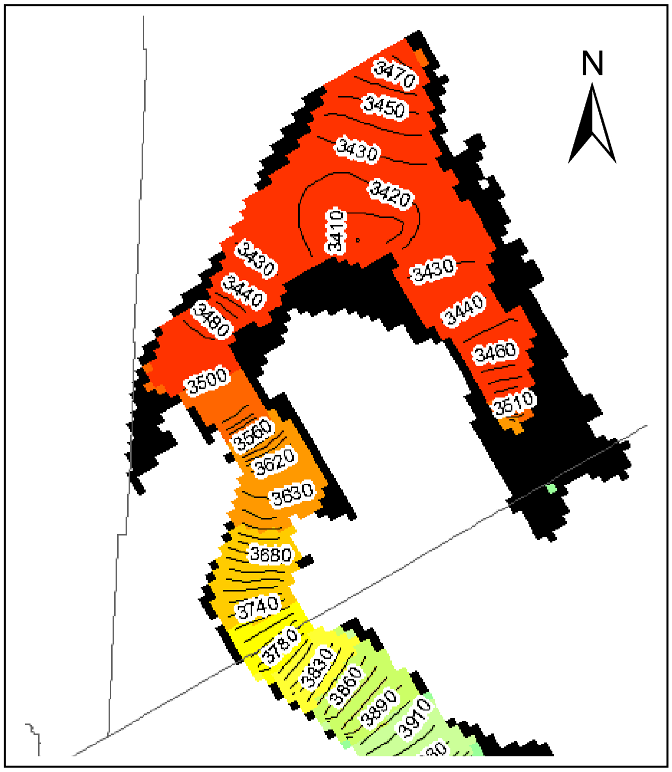


Figure 6.  Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 0.10 acre-feet per acre per year. Contour interval is 10 feet.

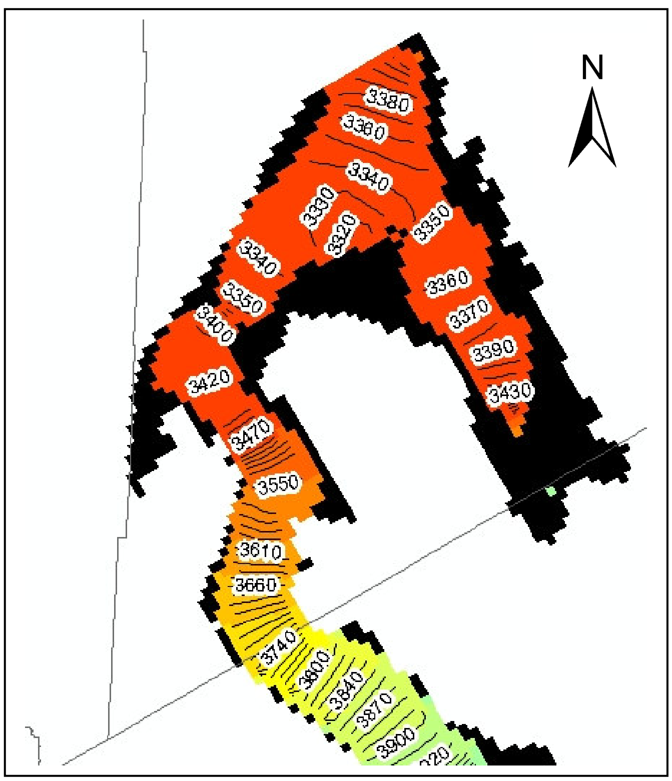


Figure 7.  Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 0.25 acre-feet per acre per year. Contour interval is 10 feet.

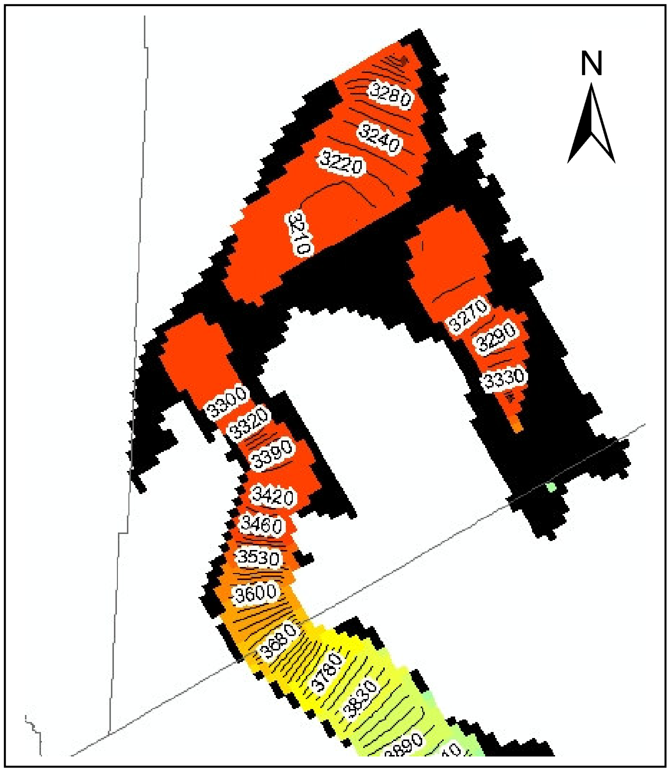


Figure 8. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 0.50 acre-feet per acre per year. Contour interval is 10 feet.

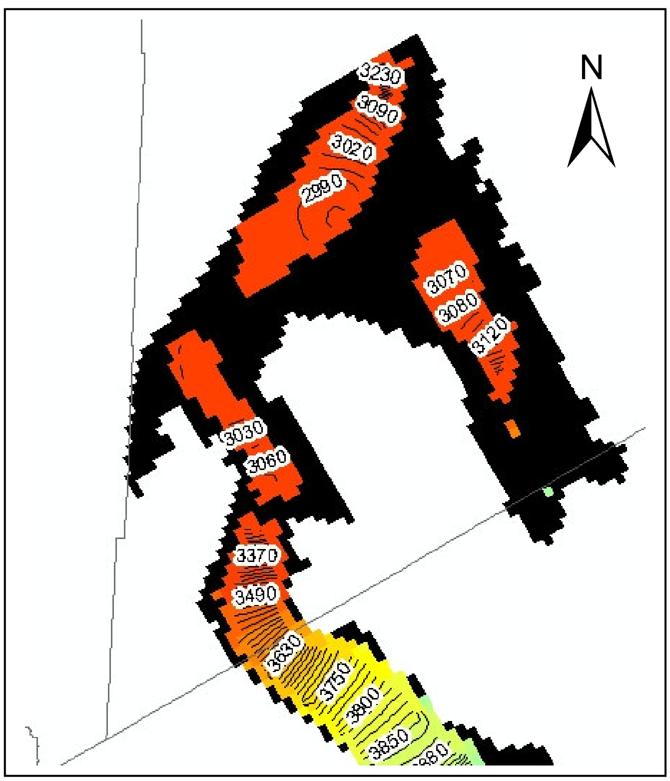


Figure 9. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 1.0 acre-feet per acre per year. Contour interval is 10 feet.

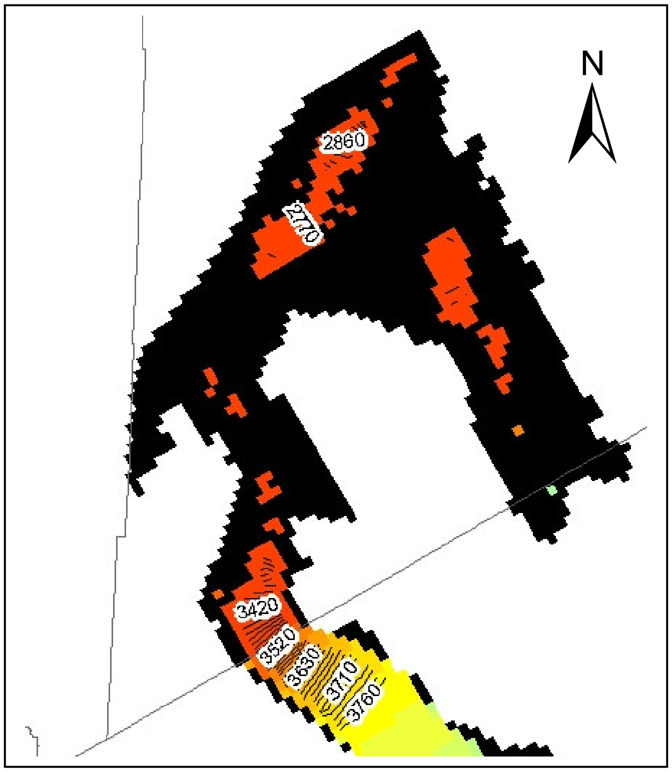


Figure 10. Water levels in the Salt Basin Bolson aquifer after 50 years with a uniform pumping rate of 2.0 acre-feet per acre per year. Contour interval is 10 feet.