# GAM Run 11-009: High Plains Underground Water Conservation District No. 1 Management Plan

by Eric Aschenbach
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-1708
June 24, 2011

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## EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, groundwater conservation districts shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

- the annual amount of recharge from precipitation to the groundwater resources within the district, if any;

- for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers; and

- the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

This report supersedes Groundwater Availability Model (GAM) Run 09-06. The High Plains Underground Water Conservation District No. 1 boundaries have expanded since the previous report was completed to include Swisher County, and additional areas of Lamb and Hockley counties. The purpose of this report is to provide information to High Plains Underground Water Conservation District No. 1 for its groundwater management plan based on the new district boundaries.

This report discusses the method, assumptions, and results from model runs using the groundwater availability models for the Dockum Aquifer and the southern portion of the Ogallala Aquifer, which includes the Edwards-Trinity (High Plains) Aquifer. See Groundwater Availability Model Run 08-63 (Oliver, 2008) for methods and assumptions relating to the results presented for the northern portion of the Ogallala Aquifer. Tables 1 through 3 summarize the groundwater availability model data required by the statute, and figures 1 through 3 show the area of each model from which the values in the respective tables were extracted. If after review of the figures, High Plains

Water Conservation District No. 1 determines that the district boundaries used in the assessment do not reflect current conditions, please notify the Texas Water Development Board immediately.

## METHODS:

The groundwater availability model for the southern portion of the Ogallala Aquifer and Edwards-Trinity (High Plains) Aquifer (1980 through 2000), and the Dockum Aquifer (1980 through 1997) were run for this analysis. Water budgets for each year of the transient model period were extracted and the average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow (upper), and net inter-aquifer flow (lower) for the portions of the aquifers located within the district are summarized in this report.

## PARAMETERS AND ASSUMPTIONS:

### Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer

- Version 2.01 of the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer was used for this analysis. This model is an expansion on and update to the previously developed groundwater availability model for the southern portion of the Ogallala Aquifer described in Blandford and others (2003). See Blandford and others (2008) and Blandford and others (2003) for assumptions and limitations of the model.

- The model includes four layers representing the southern portion of the Ogallala and Edwards-Trinity (High Plains) aquifers. The units comprising the Edwards-Trinity (High Plains) Aquifer (primarily Edwards, Comanche Peak, and Antlers Sand formations) are separated from the overlying Ogallala Aquifer by a layer of Cretaceous shale, where present. Water budgets for the district have been determined for the Ogallala Aquifer (Layer 1), as well as the Edwards-Trinity (High Plains) Aquifer (Layer 2 through Layer 4, collectively).

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) for the Ogallala Aquifer in 2000 is 33 feet. The mean absolute error for the Edwards-Trinity (High Plains) Aquifer in 1997 is 25 feet (Blandford and others, 2008). This represents 1.8 and 3.0 percent of the hydraulic head drop across the model area for each aquifer, respectively.

- Irrigation return flow was accounted for in the groundwater availability model by a direct reduction in agricultural pumping as described in Blandford and others (2003).

- Groundwater Vistas Version 5 (Environmental Simulations, Inc. 2007) was used as the interface to process model output.

### *Northern Portion of the Ogallala Aquifer*

- Version 2.01 of the groundwater availability model for the northern part of the Ogallala Aquifer (Dutton, 2004) was used in this analysis.

- See Dutton and others (2001) and Dutton (2004) for assumptions and limitations of the model for the northern part of the Ogallala Aquifer. Root mean squared error for this model is 53 feet. This error has more of an effect on model results where the aquifer is thin.

### *Dockum Aquifer*

- A modified version of the groundwater model for the Dockum Aquifer as described in Oliver and Hutchison (2010) was used for this analysis. This model is an update to the previously developed groundwater availability model for the Dockum Aquifer described in Ewing and others (2008). The modified model version was completed to more effectively simulate the relationship between the Ogallala Aquifer and the Dockum Aquifer and was used for this management plan data extraction analysis due to enhancements in the calibration and in order to be consistent with the Managed Available Groundwater (MAG) process. See Oliver and Hutchison (2010) and Ewing and others (2008) for assumptions and limitations of the model.

- The model includes two active layers. Layer 2 represents the upper portion of the Dockum Aquifer and Layer 3 represents the lower portion of the Dockum Aquifer. Layer 1, which is active in version 1.01 of the model documented in Ewing and others (2008), was inactivated in the modified version of the model as described in Oliver and Hutchison (2010). An individual water budget for the district was determined for the Dockum Aquifer (Layers 2 and Layer 3, collectively). It should be noted that pumping only occurs in the lower portion of the Dockum Aquifer in the groundwater availability model.

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) for the lower portion of the Dockum Aquifer between 1980 and 1997 is 53 feet. This represents 2.5 percent of the hydraulic head drop across the model area (Oliver and Hutchison 2010).

- The MODFLOW Drain package was used to simulate both evapotranspiration and springs. However, the model grid cells representing evapotranspiration within the district did not

contain a drain component for the water budget values, so all drain flow within the district will be considered as the surface water outflow value shown in Table 3.

- The MODFLOW General-Head Boundary package was used to simulate flow between the Dockum Aquifer and overlying aquifers. The water levels in the overlying aquifers were applied as described in Oliver and Hutchison (2010) using Groundwater Availability Model Run 09-001 (Smith, 2009) for the northern portion of the Ogallala Aquifer and Groundwater Availability Model Run 09-023 (Oliver, 2010b) for the southern portion of the Ogallala Aquifer.

- Groundwater Vistas Version 5 (Environmental Simulations, Inc. 2007) was used as the interface to process model output.

## RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected components were extracted from the groundwater budget for the aquifers located within the district and averaged over the duration of the calibration and verification portion of the model runs in the district, as shown in tables 1 through 3. The components of the modified budget shown in tables 1 through 3 include:

- Precipitation recharge—The areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.

- Surface water outflow—The total water discharging from the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).

- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent counties.

- Flow between aquifers—The vertical flow between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer or confining unit and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer.

The information needed for the District's management plan is summarized in tables 1 through 3. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as district or county boundaries, is assigned to

one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located (see figures 1 through 3).

## *LIMITATIONS*

The groundwater model(s) used in completing this analysis is the best available scientific tool that can be used to meet the stated objective(s). To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> "Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historic time period.

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

TABLE 1:  SUMMARIZED INFORMATION FOR THE OGALLALA AQUIFER THAT IS NEEDED FOR HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

| Management Plan requirement | Aquifer or confining unit | Results |
|---|---|---|
| Estimated annual amount of recharge from precipitation to the district | Ogallala Aquifer | 678,022 |
| Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers | Ogallala Aquifer | 10,524 |
| Estimated annual volume of flow into the district within each aquifer in the district | Ogallala Aquifer | 15,378 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Ogallala Aquifer | 20,957 |
| Estimated net annual volume of flow between each aquifer in the district | From the Ogallala Aquifer into the Edwards-Trinity (High Plains) Aquifer and adjacent underlying areas | 7,545 |
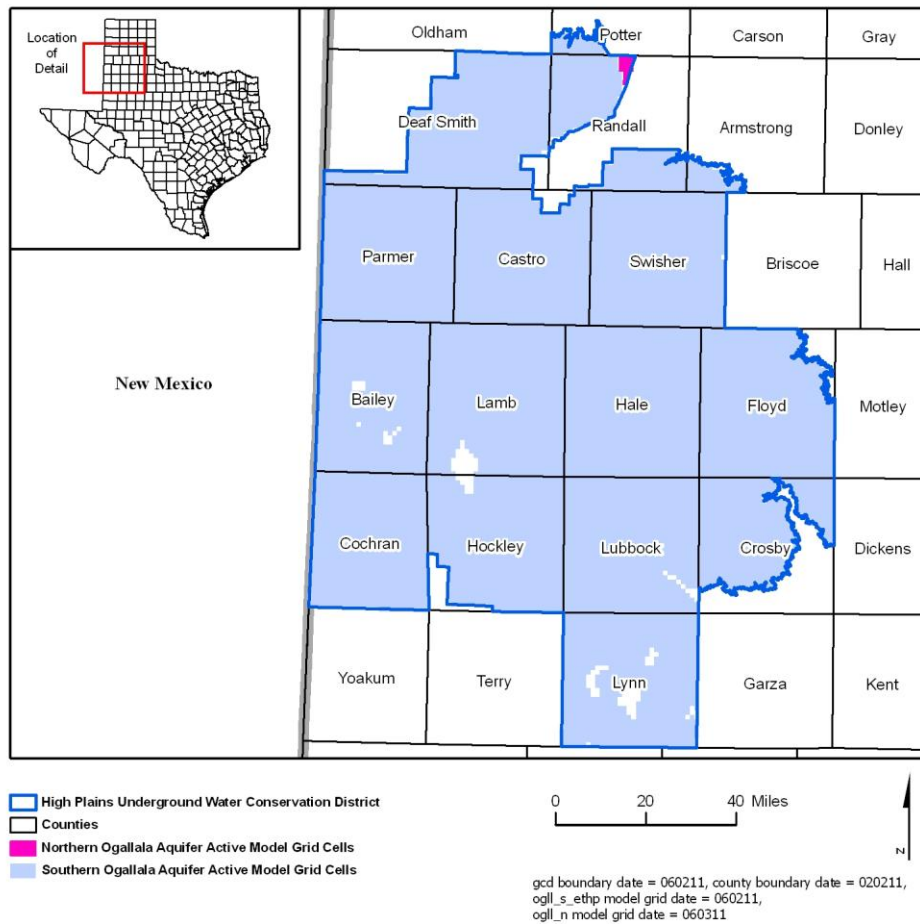
**FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODELS FOR THE OGALLALA AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).**

TABLE 2: SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER THAT IS NEEDED FOR HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

| *Management Plan requirement* | *Aquifer or confining unit* | *Results* |
|---|---|---|
| Estimated annual amount of recharge from precipitation to the district | Edwards-Trinity (High Plains) Aquifer | 0 |
| Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers | Edwards-Trinity (High Plains) Aquifer | 896 |
| Estimated annual volume of flow into the district within each aquifer in the district | Edwards-Trinity (High Plains) Aquifer | 14,574 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Edwards-Trinity (High Plains) Aquifer | 9,962 |
| Estimated net annual volume of flow between each aquifer in the district | From the Ogallala Aquifer and overlying units and into the Edwards-Trinity (High Plains) Aquifer | 2,577 |
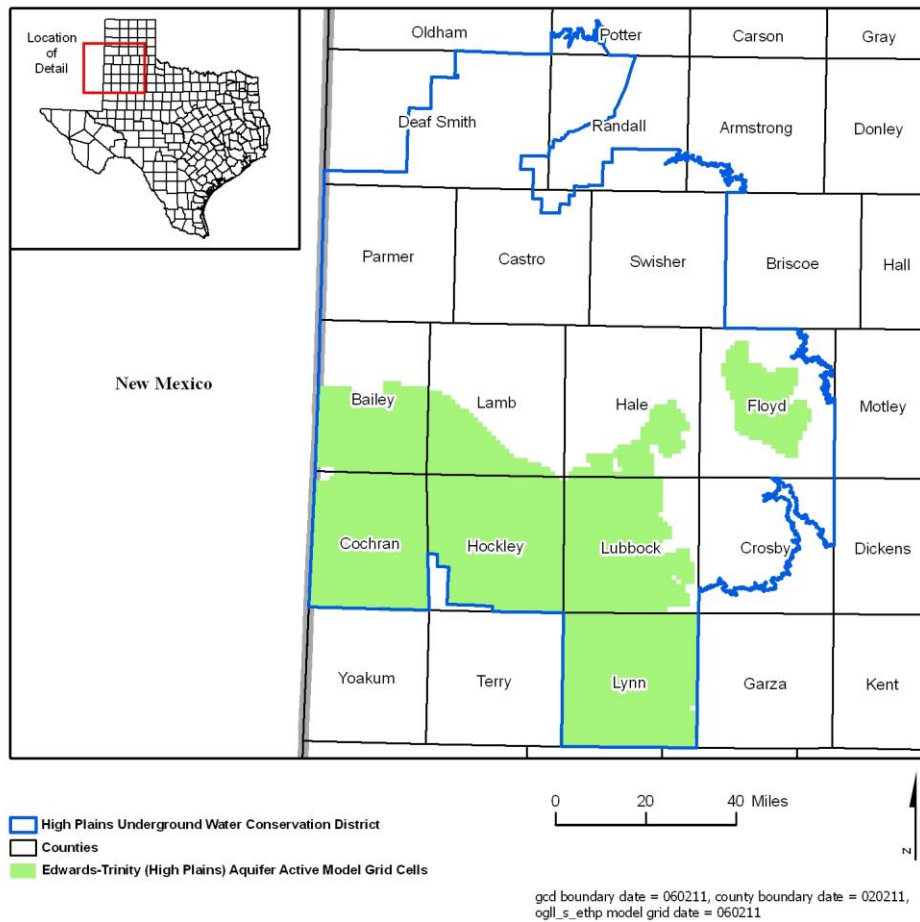
**FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).**

**TABLE 3: SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER THAT IS NEEDED FOR HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT NO. 1'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.**

| Management Plan requirement | Aquifer or confining unit | Results |
|---|---|---|
| Estimated annual amount of recharge from precipitation to the district | Dockum Aquifer | 425 |
| Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers | Dockum Aquifer | 649 |
| Estimated annual volume of flow into the district within each aquifer in the district | Dockum Aquifer | 6,637 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Dockum Aquifer | 10,142 |
| Estimated net annual volume of flow between each aquifer in the district | From the Edwards-Trinity (High Plains) Aquifer and overlying younger units and into the Dockum Aquifer | 5,014 |
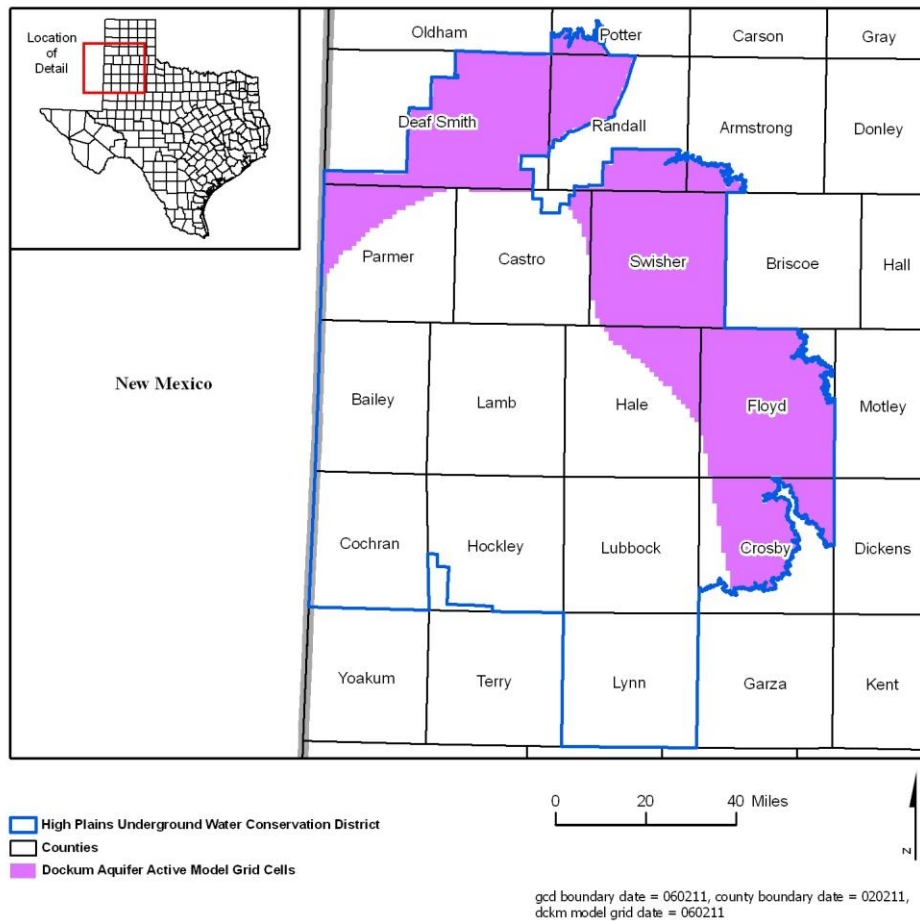
**FIGURE 3: AREA OF THE GROUNDWATER MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).**

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