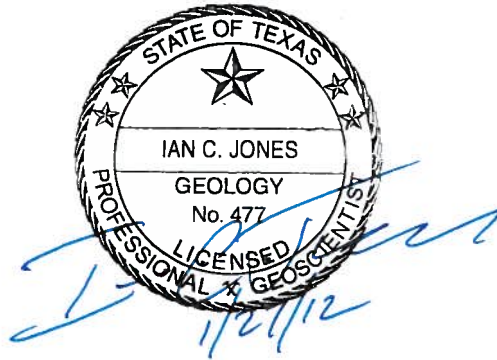

GAM RUN 11-021: PANHANDLE GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

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Groundwater Resources Division
Groundwater Availability Modeling Section
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January 27, 2012



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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.

The purpose of this report is to provide Part 2 of a two-part package of information from the Texas Water Development Board to Panhandle Groundwater Conservation District management plan to fulfill the requirements noted above. The groundwater management plan for Panhandle Groundwater Conservation District is due for approval by the Executive Administrator of the Texas Water Development Board before November 13, 2013.

This report discusses the method, assumptions, and results from model runs using the groundwater availability models for the northern part of the Ogallala, Seymour (and Blaine), and Dockum aquifers. 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. This model run replaces the results of GAM Run 08-28. GAM Run 11-021 meets current standards set after the release of GAM Run 08-28 and includes model results from additional aquifers—the Blaine and Dockum aquifers. Slight differences in the results of the two model runs for the Ogallala Aquifer are due to differences in the method of extracting data from the model. If after review of the figures, Panhandle Groundwater Conservation District 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 models for the northern part of the Ogallala, Seymour (and Blaine), and Dockum aquifers 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. The transient period is 1980 through 1997 for the Dockum Aquifer and 1980 through 1999 for the Blaine and Ogallala aquifers.

PARAMETERS AND ASSUMPTIONS:

Ogallala Aquifer

- Version 2.01 of the groundwater availability model for the northern part of the Ogallala Aquifer was used for this analysis. See Dutton and others (2001) and Dutton (2004) for assumptions and limitations of the groundwater availability model for the northern part of the Ogallala Aquifer.
- This groundwater availability model includes one layer, which generally corresponds to the Ogallala Aquifer.
- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 53 feet for the Ogallala Aquifer for the calibration period representing December 1998 (Dutton, 2004). This root mean square error is about three percent of the range of measured water levels (Dutton, 2004).

- Processing MODFLOW for Windows Version 5.1 (Chiang and Kinzelbach, 1998) was used as the interface to process model output.

Dockum Aquifer

- Version 1.01 of the groundwater availability model for the Dockum Aquifer was used for this analysis. See Ewing and others (2008) for assumptions and limitations of the groundwater availability model for the Dockum Aquifer.
- This groundwater availability model includes three layers, which generally correspond to (from top to bottom):
 1. the Ogallala and other post-Triassic formations,
 2. the Upper Dockum Aquifer, and
 3. the Lower Dockum Aquifer.
- Of the three layers listed above, individual water budgets for the district were determined for the Dockum Aquifer (Layers 2 and 3). The water budgets for Layers 2 and 3 are combined.
- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 82 feet for the Upper Dockum Aquifer, and 108 feet for the Lower Dockum Aquifer for the calibration period (1980 to 1990) and 83 and 78 feet for the same aquifers, respectively, in the verification period (1991 to 1999) (Ewing and others, 2008). These root mean square errors are between two and three percent of the range of measured water levels (Ewing and others, 2008).
- Groundwater in the Dockum Aquifer ranges from fresh to brine in composition (Ewing and others, 2008). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh, total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish, and total dissolved solids greater than 35,000 milligrams per liter are considered brines.
- Groundwater Vistas version 5 (Environmental Sciences, Inc., 2007) was used as the interface to process model output.

Seymour and Blaine aquifers

- Version 1.01 of the groundwater availability model for the Seymour and Blaine aquifers was used for this analysis. See Ewing and others (2004) for assumptions and limitations of the groundwater availability model for the Seymour and Blaine aquifers.
- This groundwater availability model includes two layers, which generally correspond to (from top to bottom):
 1. the Seymour Aquifer, and
 2. the Blaine Aquifer and parts of the underlying Permian formations.
- Of the two layers listed above, individual water budgets for the district were determined for an area zoned for the Blaine Aquifer (Layer 3). The Seymour Aquifer does not occur within the district.
- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 16 feet for the Seymour Aquifer, and 23 feet for the Blaine Aquifer for the calibration period (1980 to 1990) and 20 and 26 feet for the same aquifers, respectively, in the verification period (1991 to 1999) (Ewing and others, 2004). These root mean square errors are between one and three percent of the range of measured water levels (Ewing and others, 2004).
- Groundwater in the Seymour and Blaine aquifers ranges from fresh to brackish in composition (Ewing and others, 2004). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh and total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish.
- Processing MODFLOW for Windows Version 5.3 (Chiang and Kinzelbach, 1998) 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 net 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 a district or county boundary, 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).

TABLE 1: SUMMARIZED INFORMATION FOR THE OGALLALA AQUIFER THAT IS NEEDED FOR PANHANDLE GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. THESE FLOWS INCLUDE BRACKISH WATERS.

<i>Management Plan requirement</i>	<i>Aquifer or confining unit</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the district	Ogallala Aquifer	98,167
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ogallala Aquifer	101,759
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	23,433
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	21,182
Estimated net annual volume of flow between each aquifer in the district	Ogallala Aquifer	0*

* Model assumes no flow with underlying units

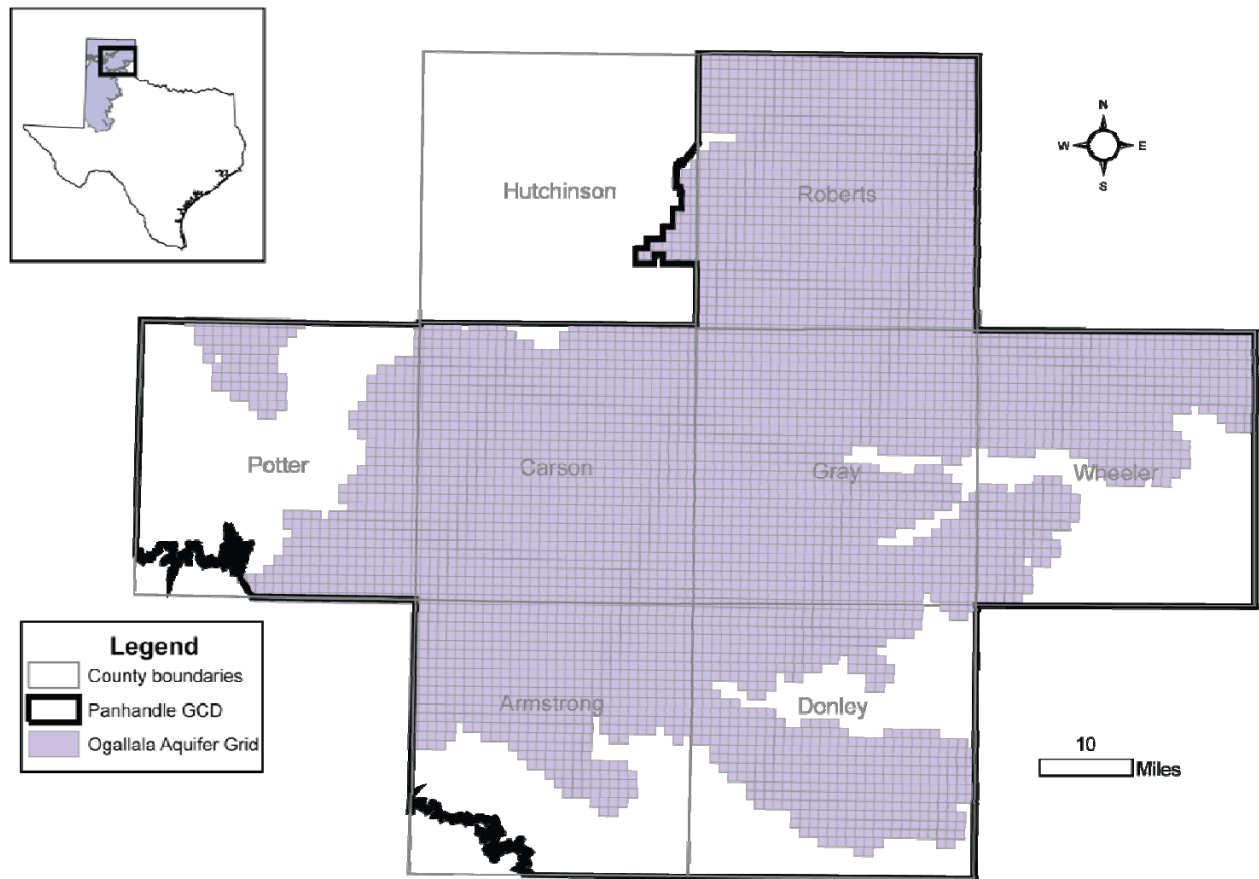


FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE OGALLALA AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER THAT IS NEEDED FOR PANHANDLE GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. THESE FLOWS MAY INCLUDE FRESH AND BRACKISH WATERS.

<i>Management Plan requirement</i>	<i>Aquifer</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the district	Dockum Aquifer	2,643
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	3,105
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	1,471
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	1,047
Estimated net annual volume of flow between each aquifer in the district	From overlying units into Dockum Aquifer	424



FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3: SUMMARIZED INFORMATION FOR THE BLAINE AQUIFER THAT IS NEEDED FOR PANHANDLE GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. THESE FLOWS MAY INCLUDE FRESH AND BRACKISH WATERS.

<i>Management Plan requirement</i>	<i>Aquifer</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the district	Blaine Aquifer	4,132
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Blaine Aquifer	5,911
Estimated annual volume of flow into the district within each aquifer in the district	Blaine Aquifer	8,636
Estimated annual volume of flow out of the district within each aquifer in the district	Blaine Aquifer	7,505
Estimated net annual volume of flow between each aquifer in the district	Blaine Aquifer	0*

* The model reports net annual flow into the Blaine Aquifer of 367 acre-feet per year from nonexistent overlying units. This numerical modeling issue is currently under investigation.

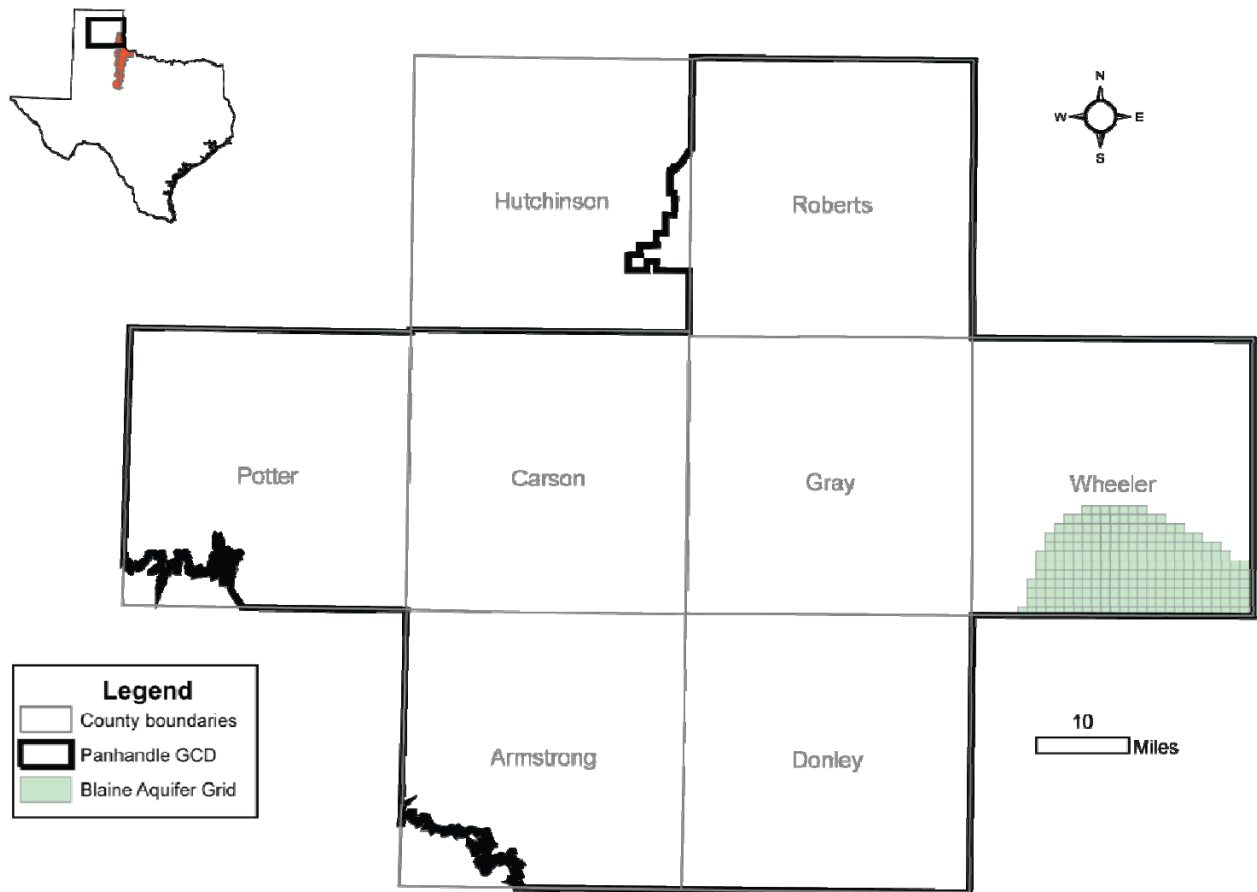


FIGURE 3: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE BLAINE AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

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 interaction with streams are specific to particular historic time periods.

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 related 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.

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