GAM Run 12-003: North Plains Groundwater Conservation District Management Plan

by William Kohlrenken
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Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-8279
July 2, 2012

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by William Kohlrenken under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on July 2, 2012.

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EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the executive administrator of the Texas Water Development Board (TWDB) 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 to North Plains Groundwater Conservation District for its groundwater management plan. The groundwater management plan for the North Plains Groundwater Conservation District is due for approval by the executive administrator of the TWDB before July 14, 2013.

This report discusses the method, assumptions, and results from model runs using the following two groundwater availability models: the northern portion of the Ogallala Aquifer, which includes the Rita Blanca Aquifer, and the Dockum Aquifer. Tables 1 and 2 summarize the groundwater availability model data required by the statute,

and Figures 1 and 2 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 07-06. GAM Run 12-003 meets current standards set after the release of GAM Run 07-06 and it is based on the most current groundwater district boundaries. If after review of the figures, the North Plains Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB immediately.

METHODS:

Groundwater availability models for the northern part of the Ogallala Aquifer, which includes the Rita Blanca Aquifer (1980 through 2008), 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

- Version 3.01 of the groundwater availability model for the northern portion of the Ogallala Aquifer was used for this analysis. This model is an update to the previously developed groundwater availability model for the northern portion of the Ogallala Aquifer described in Dutton and others (2001) and Dutton (2004). See Kelley and others (2010), Dutton (2004), and Dutton and others (2001) for assumptions and limitations of the model.

- The model for the northern portion of the Ogallala Aquifer has one layer which collectively represents the Ogallala and Rita Blanca aquifers. Water budgets for the district have been determined for the Ogallala Aquifer and Rita Blanca Aquifer and represented collectively as the "Ogallala Aquifer."

- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) for the Ogallala Aquifer is 45.7 feet for the calibration period through 2008 (Kelley and others, 2010). This represents 1.4 percent of the range of measured water levels (Kelley and others, 2010).

Dockum Aquifer

- Version 1.01 of the groundwater availability model was used for the Dockum Aquifer. See Ewing and others (2008) for assumptions and limitations of the groundwater availability model.

- The model includes three layers representing the younger geologic units overlying the Dockum Aquifer (layer 1), the upper portion of the Dockum Aquifer (layer 2), and the lower portion of the Dockum Aquifer (layer 3).

- Of the three layers, 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 aquifers represented in Layer 1 of the groundwater availability model are only included in the model for the purpose of more accurately representing flow between these units and the Dockum Aquifer. This model is not intended to explicitly simulate flow in these overlying units (Ewing and others, 2008).

- 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).

- The MODFLOW Drain package was used to simulate both evapotranspiration and springs. However, there were no model grid cells representing evapotranspiration within the district so there was no drain flow incorporated into the surface water outflow values shown in Table 2.

- 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.

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the model results 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 and 2. The components of the modified budget shown in tables 1 and 2 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 and 2. 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 and 2).

TABLE 1: SUMMARIZED INFORMATION FOR THE OGALLALA AQUIFER (INCLUDING THE RITA BLANCA AQUIFER) THAT IS NEEDED FOR NORTH PLAINS GROUNDWATER CONSERVATION DISTRICT'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	84,939
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ogallala Aquifer	31,294
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	76,841
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	72,290
Estimated net annual volume of flow between each aquifer in the district*	From Ogallala Aquifer into the Dockum Aquifer	Not Applicable

*The Groundwater Availability Model for the Dockum Aquifer estimates the flow from the Ogallala Aquifer to the Dockum Aquifer averages 6,731 acre-feet per year; however, the model report for the Dockum Aquifer indicates the model was not designed to precisely model this parameter.
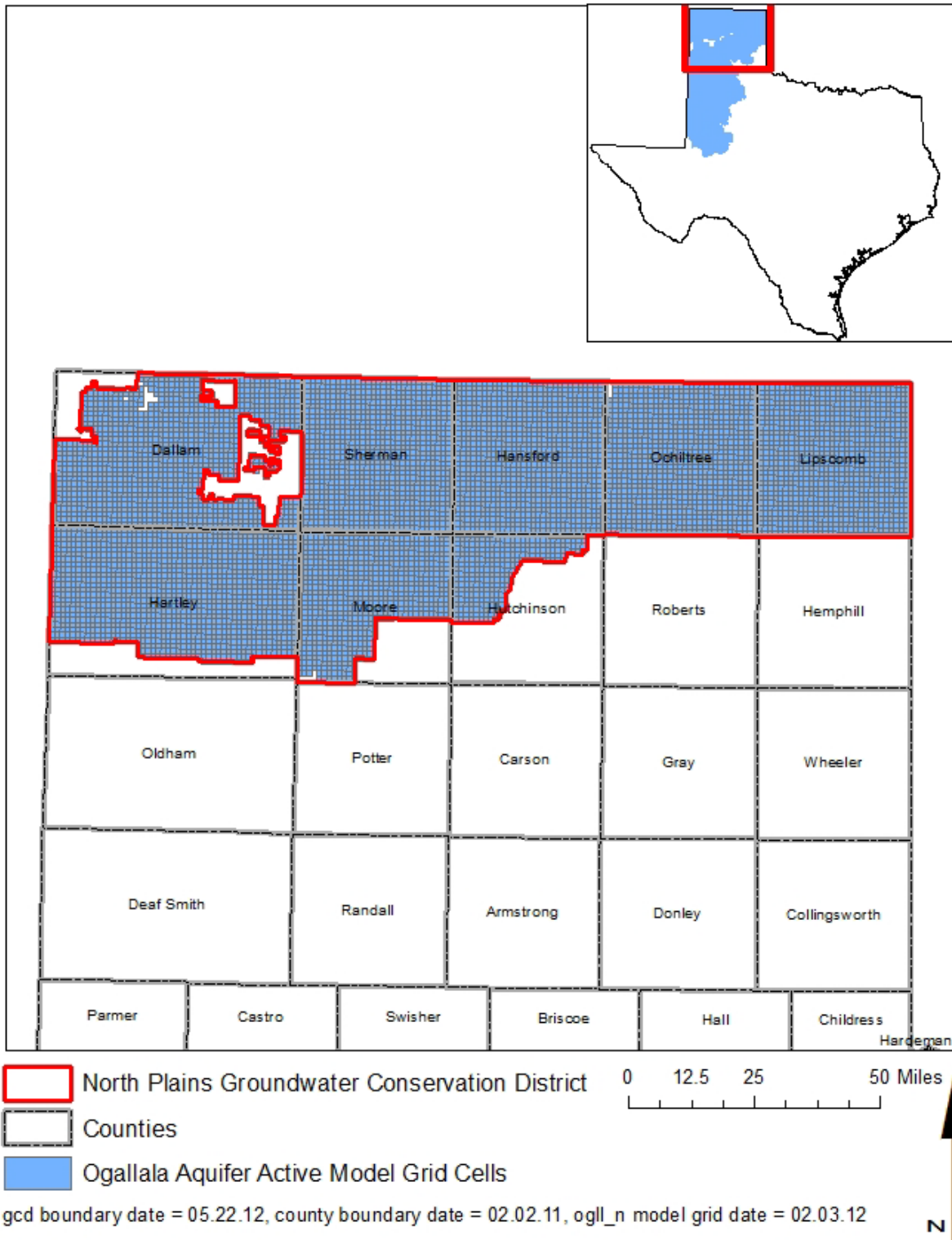
FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE OGALLALA AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE OGALLALA AND RITA BLANCA AQUIFERS EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER THAT IS NEEDED FOR NORTH PLAINS GROUNDWATER CONSERVATION DISTRICT'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	Results
Estimated annual amount of recharge from precipitation to the district	Dockum Aquifer	56
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	4,962
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	3,319
Estimated net annual volume of flow between each aquifer in the district*	From Ogallala Aquifer into the Dockum Aquifer	Not Applicable

*The Groundwater Availability Model for the Dockum Aquifer estimates the flow from the Ogallala Aquifer to the Dockum Aquifer averages 6,731 acre-feet per year; however, the model report for the Dockum Aquifer indicates the model was not designed to precisely model this parameter.

Map legend:
- North Plains Groundwater Conservation District
- Counties
- Dockum Aquifer Active Model Grid Cells

gcd boundary date = 05.22.12, county boundary date = 02.02.11, dckm model grid date = 02.03.12
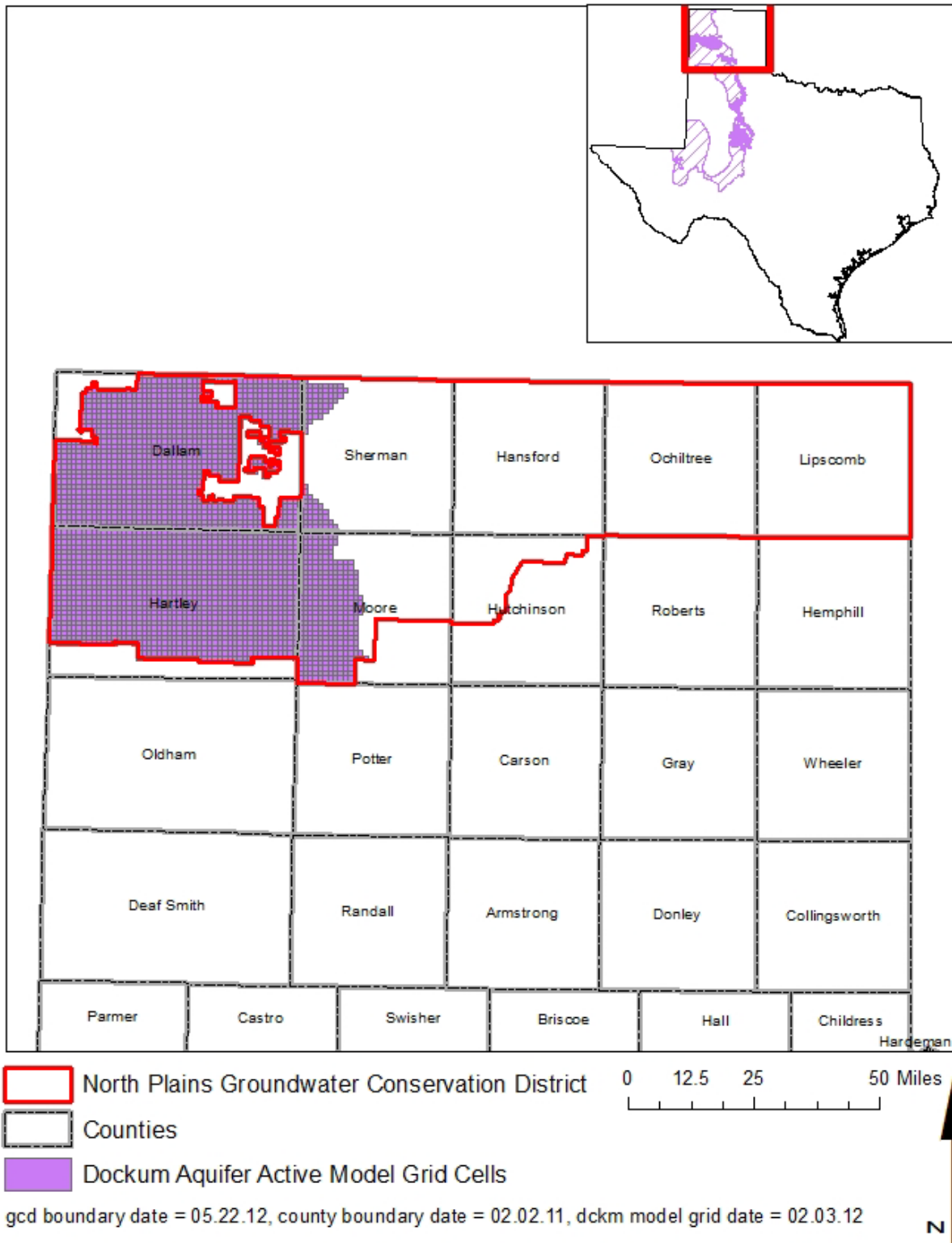
FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

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.

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