GAM Run 12-020: Glasscock Groundwater Conservation District Management Plan

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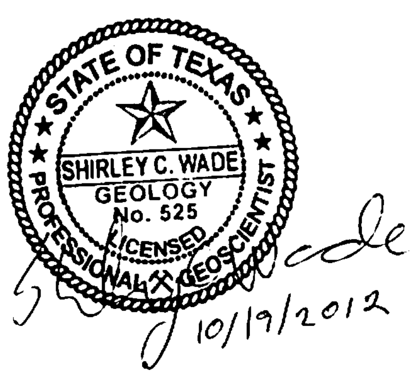
October 19, 2012



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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 to Glasscock Groundwater Conservation District for its groundwater management plan. The groundwater management plan for the Glasscock Groundwater Conservation District is due for approval by the Executive Administrator of the TWDB before December 4, 2013.

This report discusses the method, assumptions, and results from GAM run 12-020 using the groundwater availability model for the southern portion of the Ogallala aquifer, which includes the Edwards-Trinity (High Plains) Aquifer, the modified version of the groundwater model for the Dockum Aquifer, and the alternate one-layer groundwater flow model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers. Tables 1, 2, and 3 summarize the groundwater availability model data required by the statute, and Figures 1, 2, and 3 show the area of the models from which the values in the tables were extracted. This model run replaces the results of GAM Run 08-25 (Ridgeway, 2008). GAM Run 12-020 meets current standards set after the release of GAM Run 08-25 and also includes information for the Dockum Aquifer. If after review of the figures, the Glasscock 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 model for the southern portion of the Ogallala Aquifer, which includes the Edwards-Trinity (High Plains) Aquifer, the modified version of the groundwater model for the Dockum Aquifer, and the alternate one-layer groundwater flow model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers were used for this analysis. Water budgets for selected years were extracted using ZONEBUDGET Version 3.01 (Harbaugh, 2009) and the average annual water budget values for recharge, surface water outflow, lateral inflow to the district, lateral outflow from the district, and vertical flow 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 Aquifer and Edwards-Trinity (High Plains) Aquifer. 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 (Layer1). The Edwards-Trinity (High Plains) Aquifer (Layer 2 through Layer 4, collectively) is not present in Glasscock Groundwater Conservation District.

- The mean absolute error (a measure of the difference between simulated and actual water levels during the transient 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).

- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

Dockum Aquifer

- We used a modified version of the groundwater model for the Dockum Aquifer as described in Oliver and Hutchison (2010) 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. 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 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, there were no model grid cells representing drains within the district so there was no drain flow incorporated into the surface water outflow value shown in Table 2.

- The MODFLOW General-Head Boundary (GHB) package was applied to the areas in Layer 1 with a high conductance in order to properly mimic water levels in these units. Where the General-Head Boundary correlates with the Ogallala Aquifer, transient head values for the General-Head Boundary were taken from the historical portion of the groundwater availability model (Blandford and others, 2003; Dutton, 2004; Ewing and others, 2008). Outside of the footprint of the Ogallala Aquifer, General-Head Boundary values for the Dockum Aquifer model were estimated from land surface elevation (Ewing and others, 2008; discussed in Oliver and Hutchison, 2010).

- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

Edwards-Trinity (Plateau) Aquifer

- The recently modified and calibrated one-layer groundwater flow model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Hutchison and others, 2011) was used for these simulations. The modified model version was developed to more effectively simulate groundwater conditions. The model was calibrated based on groundwater elevation data from 1930 to 2005; however, water budget data was only extracted from the period 1980 to 1999 to be consistent with the analysis completed for the other aquifers.

- The model has one layer which represents the Pecos Valley Aquifer in the northwest portion of the model area, the Edwards-Trinity (Plateau) Aquifer in the middle, and the Hill Country portion of the Trinity Aquifer in the southeast portion of the model area. A lumped representation of both the Pecos Valley and Edwards-Trinity (Plateau) aquifers was used in the relatively narrow area where the Pecos Valley Aquifer overlies the Edwards-Trinity (Plateau) Aquifer.

- The standard deviation of groundwater elevation residuals (a measure of the difference between simulated and actual water levels during model calibration) for the entire model domain is 70 feet and the average residual is -1.3 feet.

- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

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 budgets for the Ogallala, Dockum, and Edwards-Trinity (Plateau) aquifers and averaged over select portions of the calibration and verification period of the model runs in the district, as shown in Tables 1, 2, and 3. The components of the modified budget include:

- Precipitation recharge—The spatially-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 and other areas.

- Flow between aquifers—The 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.

The information needed for the District's management plan is summarized in Tables 1, 2, and 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, 2, and 3).

Comparison of the alternative model for the Edwards-Trinity (Plateau) Aquifer and the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer

The alternative one-layer groundwater flow model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Hutchison and others, 2011) was developed to more effectively simulate groundwater conditions, particularly in the area of Glasscock and Reagan counties. We ran both the groundwater availability model (Anaya and Jones, 2009) and the alternative one-layer model for this analysis and compared the resulting water budgets.

The estimated annual amount of recharge from precipitation to the district from the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers is 17,570 acre-feet per year and the estimated annual amount from the alternative model is 22,976 acre-feet per year.

The estimated annual volume of water that discharges from springs and any surface water body within the district from the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers is 1,642 acre-feet per year and the estimated annual amount from the alternative model is 437 acre-feet per year. For both models this flow includes discharge represented by the MODFLOW drain package.

The estimated annual volume of flow into the district for the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers is 51,196 acre-feet per year and the estimated annual amount for the alternative model is 49,739 acre-feet per year.

The estimated annual volume of flow out of the district for the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers is 22,886 acre-feet per year and the estimated annual amount for the alternative model is 51,225 acre-feet per year. The flows into and out of the district are a sum of flows into and out of surrounding districts and counties.

The estimated net annual volume of flow from the Ogallala Aquifer into the Edwards-Trinity (Plateau) Aquifer in the district for the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers is 6,435 acre-feet per year and the estimated annual amount for the alternative model is 5,499 acre-feet per year. For both models, these are general-head boundary flows.

We used the alternative one-layer groundwater flow model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers to meet the management plan requirements (see Table 2 for a summary) because of improved model calibration in the areas of Glasscock and Reagan counties and because it was used to estimate the modeled available groundwater (MAG) in Groundwater Management Area 7.

Comparison of the modified model for the Dockum Aquifer and the groundwater availability model for the Dockum Aquifer

The modified version of the groundwater model for the Dockum Aquifer (Oliver and Hutchison, 2010) was completed to more effectively simulate the relationship between the Ogallala Aquifer and the Dockum Aquifer. We ran both the groundwater availability model (Ewing and others, 2008) and the modified version of the model for this analysis and compared the resulting water budgets.

Because the Dockum Aquifer does not crop out within the district, the estimated annual amount of recharge from precipitation to the district from both the groundwater availability model for the Dockum Aquifer and the modified model is zero acre-feet per year. The estimated annual volume of water that discharges from springs and any surface water body within the district from both the groundwater availability model for the Dockum Aquifer and the modified model is also zero acre-feet per year.

The estimated annual volume of flow into the district for the groundwater availability model for the Dockum Aquifer is zero acre-feet per year and the estimated annual amount for the modified model is 61 acre-feet per year.

The estimated annual volume of flow out of the district for the groundwater availability model for the Dockum Aquifer is 204 acre-feet per year and the estimated annual amount for the modified model is 5,606 acre-feet per year. The flows into and out of the district are a sum of flows into and out of surrounding districts and counties.

The estimated net annual volume flowing into the Dockum Aquifer from other hydrogeologic units in the district for the groundwater availability model for the Dockum Aquifer is 204 acre-feet per year and the estimated annual amount for the modified model is 5,532 acre-feet per year. For the groundwater availability model this flow is a combination of vertical leakage from the layer representing overlying younger hydrogeologic units and lateral flow from areas of the Dockum that are outside the TWDB delineation of the Dockum Aquifer. For the modified model this flow is a combination of general head boundary fluxes representing overlying younger hydrogeologic units and lateral flow from areas of the Dockum that are outside the TWDB delineation of the aquifer.

We used the modified version of the groundwater flow model for the Dockum Aquifer to meet the management plan requirements (see Table 3 for a summary) because of enhancements in the calibration and because it was used to estimate the modeled available groundwater (MAG) for Groundwater Management Area 7.

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(s) 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 THE GLASSCOCK 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	1,298
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ogallala Aquifer	610
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	1,430
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	893
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer into the Edwards-Trinity (Plateau) Aquifer	5,499

TABLE 2: SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER THAT IS NEEDED FOR THE GLASSCOCK 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	Edwards-Trinity (Plateau) Aquifer	22,976
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	437
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	49,739
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	51,225
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer into the Edwards-Trinity (Plateau) Aquifer	5,499

TABLE 3: SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER THAT IS NEEDED FOR THE GLASSCOCK 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	Dockum Aquifer	0
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	61
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	5,606
Estimated net annual volume of flow between each aquifer in the district	From overlying younger units and from areas of the Dockum that are outside the TWDB delineation of the Dockum Aquifer	5,532*

*4,636 acre-feet per year is contributed by the portion of the Dockum that is outside the TWDB delineation of the Dockum Aquifer.

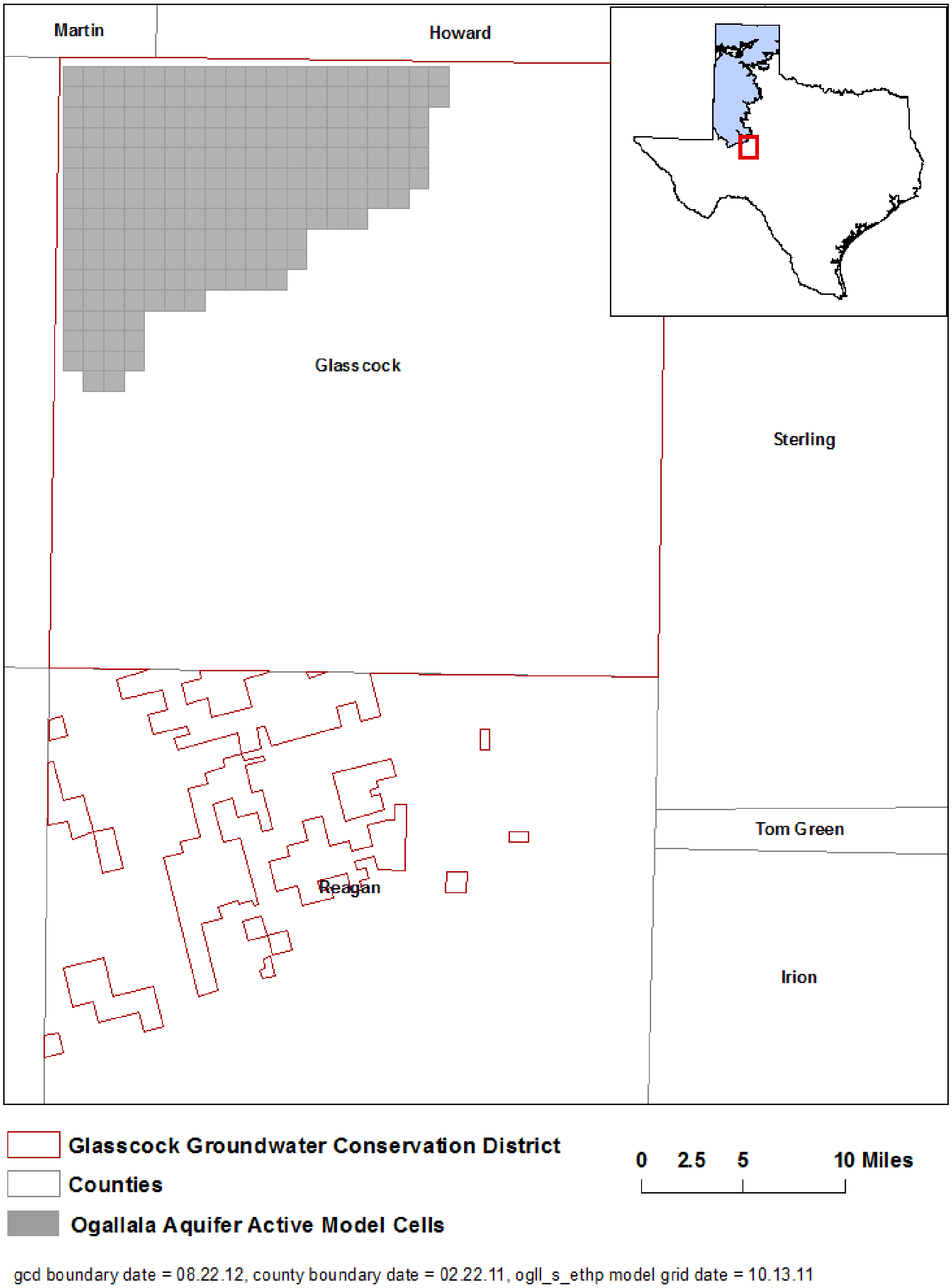

FIGURE 1: AREA OF THE GROUNDWATER MODEL FOR THE SOUTHERN PORTION OF THE OGALLALA AQUIFER AND THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

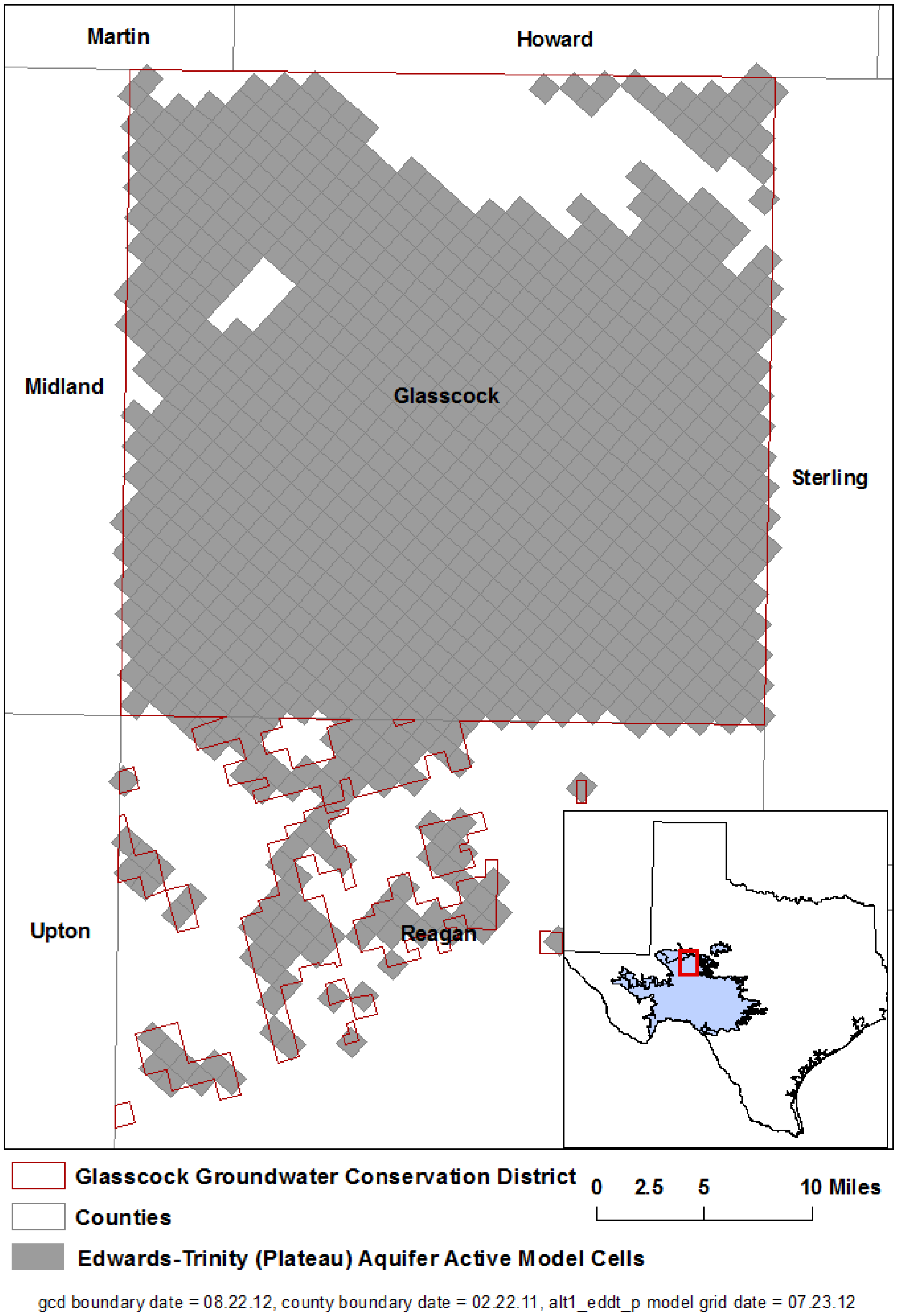

FIGURE 2: AREA OF THE ALTERNATE MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

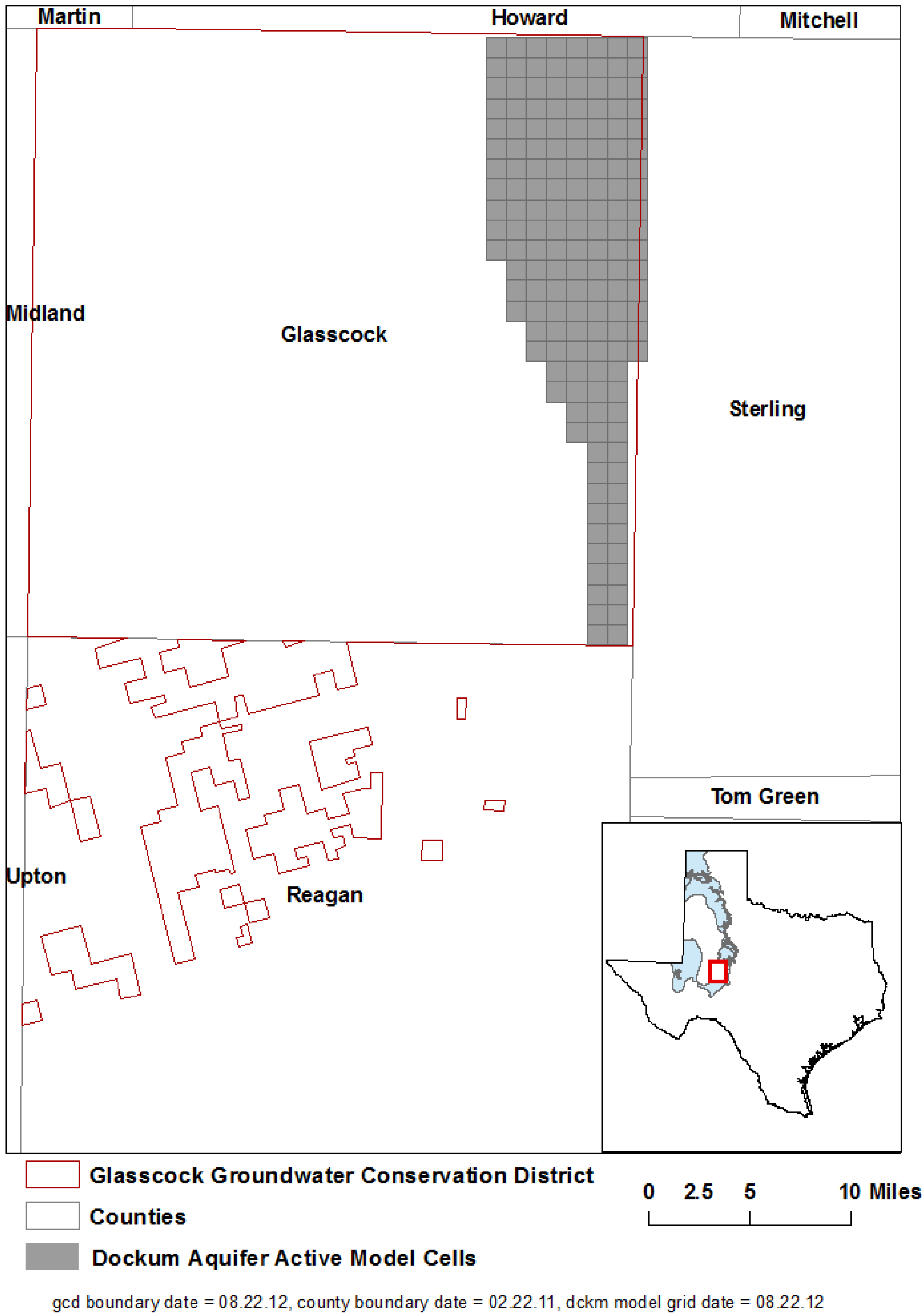

FIGURE 3: AREA OF THE GROUNDWATER MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

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