GAM Run 15-006: Uvalde County Underground Water Conservation District Management Plan

by Bernard Bahaya, E.I.T
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 936-0883
June 26, 2015

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by Bernard Bahaya under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on June 26, 2015.

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EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2011), 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.

This report—Part 2 of a two-part package of information from the TWDB to the Uvalde County Underground Water Conservation District—fulfills the requirements noted above. Part 1 of the two-part package is the Estimated Historical Water Use/State Water Plan data report. The District will receive this data report from the TWDB Groundwater Technical Assistance Section. Questions about the data report can be directed to Mr. Stephen Allen, stephen.allen@twdb.texas.gov, (512) 463-7317.

The groundwater management plan for the Uvalde County Underground Water Conservation District should be adopted by the district on or before July 5, 2016 and submitted to the executive administrator of the TWDB on or before August 4, 2016. The current management plan for the Uvalde Underground Water Conservation District expires on October 3, 2016.

This report discusses the methods, assumptions, and results from model runs using the groundwater availability models for the Edwards-Trinity (Plateau) and the southern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Kelley and others, 2004). Please note that the Edwards (Balcones Fault Zone) Aquifer occurs within the boundaries of the Uvalde County Underground Water Conservation District but is excluded from this report because the district does not have jurisdiction over that aquifer. This model run replaces the results of GAM Run 10-022 (Aschenbach, 2010). GAM Run 15-006 meets current standards set after the release of GAM Run 10-022. Tables 1, 2, and 3 summarize the groundwater availability model data required by statute, and figures 1, 2, and 3 show the area of the models from which the values in the tables were extracted. If after review of the figures, the Uvalde County Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

The Trinity Aquifer underlies the Edwards (Balcones Fault Zone) Aquifer within the district boundaries. However, the underlying portion of the Trinity Aquifer in Uvalde County is not fully modeled or exclusively calibrated in any of our existing groundwater availability models. Information for the Trinity Aquifer underlying the Edwards (Balcones Fault Zone) Aquifer is being provided separately from the Groundwater Technical Assistance Section of the TWDB.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability models for the Edwards-Trinity (Plateau) (Anaya and Jones, 2009), and the southern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Kelley and others, 2004) were run for this analysis. Uvalde County Underground Water Conservation District water budgets were extracted for the historical model period (1981 through 2000 for the Edward-Trinity (Plateau) Aquifer and 1980 through 1999 for the southern portion of the Carrizo-Wilcox Aquifer) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). 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 portion of the aquifer located within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Edwards – Trinity (Plateau) Aquifer and Hill Country portion of the Trinity Aquifer

- Version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer was used. See Anaya and Jones (2009) for assumptions and limitations of this model.

- The Edwards-Trinity (Plateau) Aquifer model includes two layers representing the Edwards Group and associated limestone hydrostratigraphic units (Layer 1) and the undifferentiated Trinity Group hydrostratigraphic units (Layer 2). The water budget for the Hill Country portion of the Trinity Aquifer (Figure 1) was determined using Layer 2. An individual water budget for the district was determined for the Edwards-Trinity (Plateau) Aquifer (Figure 2; Layer 1 and Layer 2 collectively).

- The General-Head Boundary (GHB) package of MODFLOW was used to represent flow out of the study area and into the Edwards (Balcones Fault Zone) Aquifer or the deeper Trinity units. For simplicity, the GHB that corresponds to Layer 1 was used to represent the flow from the Edwards portion of the Edwards-Trinity (Plateau) Aquifer, across the Balcones Fault Zone (BFZ) and into the portion of the Edwards (BFZ) Aquifer within the Edwards Aquifer Authority (EAA) district. This flow is included in the management plan requirement for "estimated annual volume of flow out of the district within each aquifer in the district." The GHB in Layer 2 was used to represent the flow from the Trinity portion of the Edwards-Trinity (Plateau) Aquifer, across the Balcones Fault Zone and into an unmodeled area of the deeper Trinity Aquifer units. This flow is not specifically listed in the management plan requirement tables, but it is included in the text for reference.

- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

Carrizo-Wilcox, Queen City, and Sparta Aquifers

- Version 2.01 of the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers was used for this analysis. See Deeds and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers.

- This groundwater availability model includes eight layers, which represent the Sparta Aquifer (Layer 1), the Weches Confining Unit (Layer 2), the Queen City Aquifer (Layer 3), the Reklaw Confining Unit (Layer 4), the Carrizo Aquifer (Layer 5), the Upper Wilcox Aquifer, (Layer 6), the Middle Wilcox Aquifer (Layer 7), and the Lower Wilcox Aquifer (Layer 8).

- An overall water budget for the Uvalde Underground Water Conservation District was determined for the Carrizo-Wilcox Aquifer (Layers 5 through 8 collectively. The Sparta and Queen City aquifers are not present in Uvalde Underground Water Conservation District.

- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

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 run in the district, as shown in tables 1 and 2.

- 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 springs.

- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent counties or between the district and the Edwards (Balcones Fault Zone) Aquifer managed by the Edwards Aquifer Authority.

- Flow between aquifers—The net vertical flow between the aquifer and adjacent 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.

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.

TABLE 1 SUMMARIZED INFORMATION FOR THE HILL COUNTRY PORTION OF THE TRINITY AQUIFER THAT IS NEEDED FOR THE UVALDE COUNTY 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	Trinity Aquifer	6,404
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	4,415
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	10,629
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	10,131*
Estimated net annual volume of flow between each aquifer in the district	From Trinity Aquifer to Edwards (Balcones Fault Zone) Aquifer	Not Applicable**
	From Hill Country portion Trinity Aquifer to the Edwards-Trinity (Plateau) Aquifer	3,649

*Includes head dependent flow to Edwards (Balcones Fault Zone) Aquifer from Layer 2

**Not applicable because flow leaving the Trinity Aquifer to the Edwards (Balcones Fault Zone) Aquifer is considered flow leaving the district (from Uvalde County Underground Water Conservation District to The Edwards Aquifer Authority).

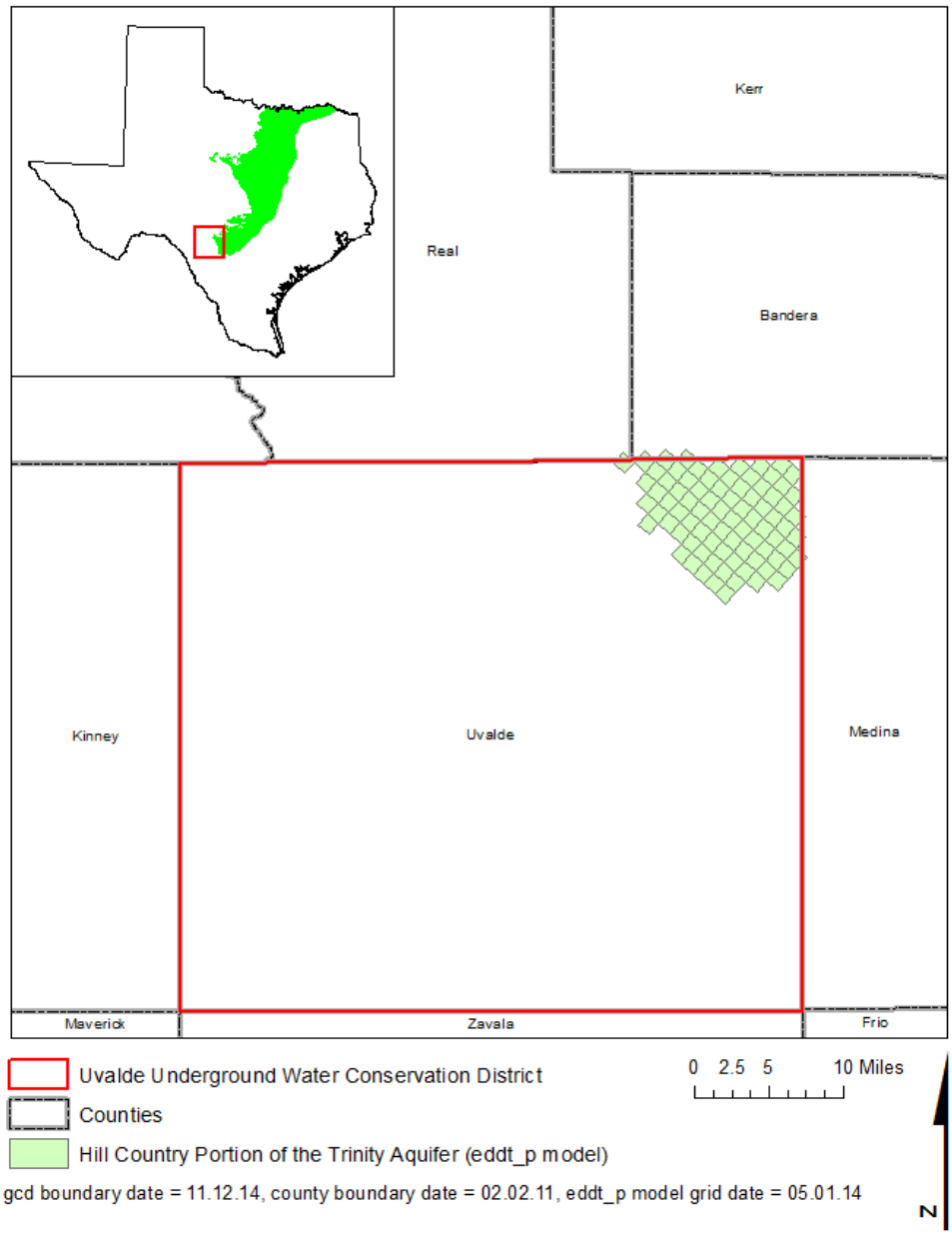

FIGURE 1 AREA OF THE GROUNDWATER AVAILABILITY MODEL THAT INCLUDES THE HILL COUNTRY PORTION OF THE TRINITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE TRINITY AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2 SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER THAT IS NEEDED FOR THE UVALDE COUNTY 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	8,436
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	10,346
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	20,903
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	24,570*
Estimated net annual volume of flow between each aquifer in the district	From the Hill Country portion of the Trinity Aquifer to the Edwards-Trinity (Plateau) Aquifer	3,649

*Includes flow to or from the Edwards (Balcones Fault Zone) Aquifer

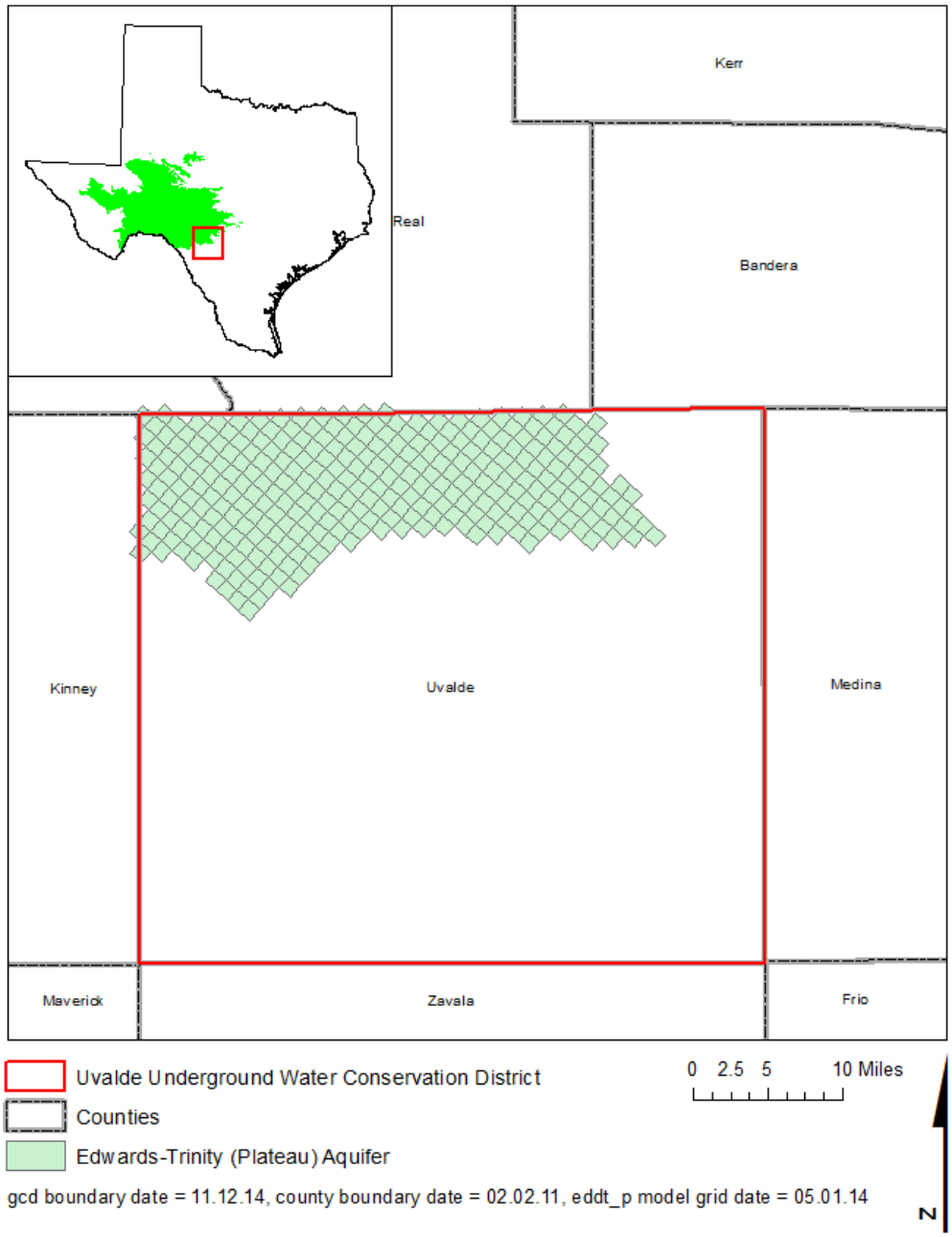

FIGURE 2 AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS- TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE EDWARDS-TRINITY (PLATEAU) AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3 SUMMARIZED INFORMATION FOR THE CARRIZO-WILCOX AQUIFER THAT IS NEEDED FOR THE UVALDE COUNTY 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	Carrizo-Wilcox Aquifer	3,003
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Carrizo-Wilcox Aquifer	29
Estimated annual volume of flow into the district within each aquifer in the district	Carrizo-Wilcox Aquifer	251*
Estimated annual volume of flow out of the district within each aquifer in the district	Carrizo-Wilcox Aquifer	9,074*
Estimated net annual volume of flow between each aquifer in the district	From Carrizo-Wilcox Aquifer to Underlying Units	not applicable **

*Due to resolution of delineation of outcrop boundary an additional 1,029 acre-feet of net flow may be contributed to these categories.

** Model assumes no-flow condition at the base of the Carriz0-Wilcox Aquifer.

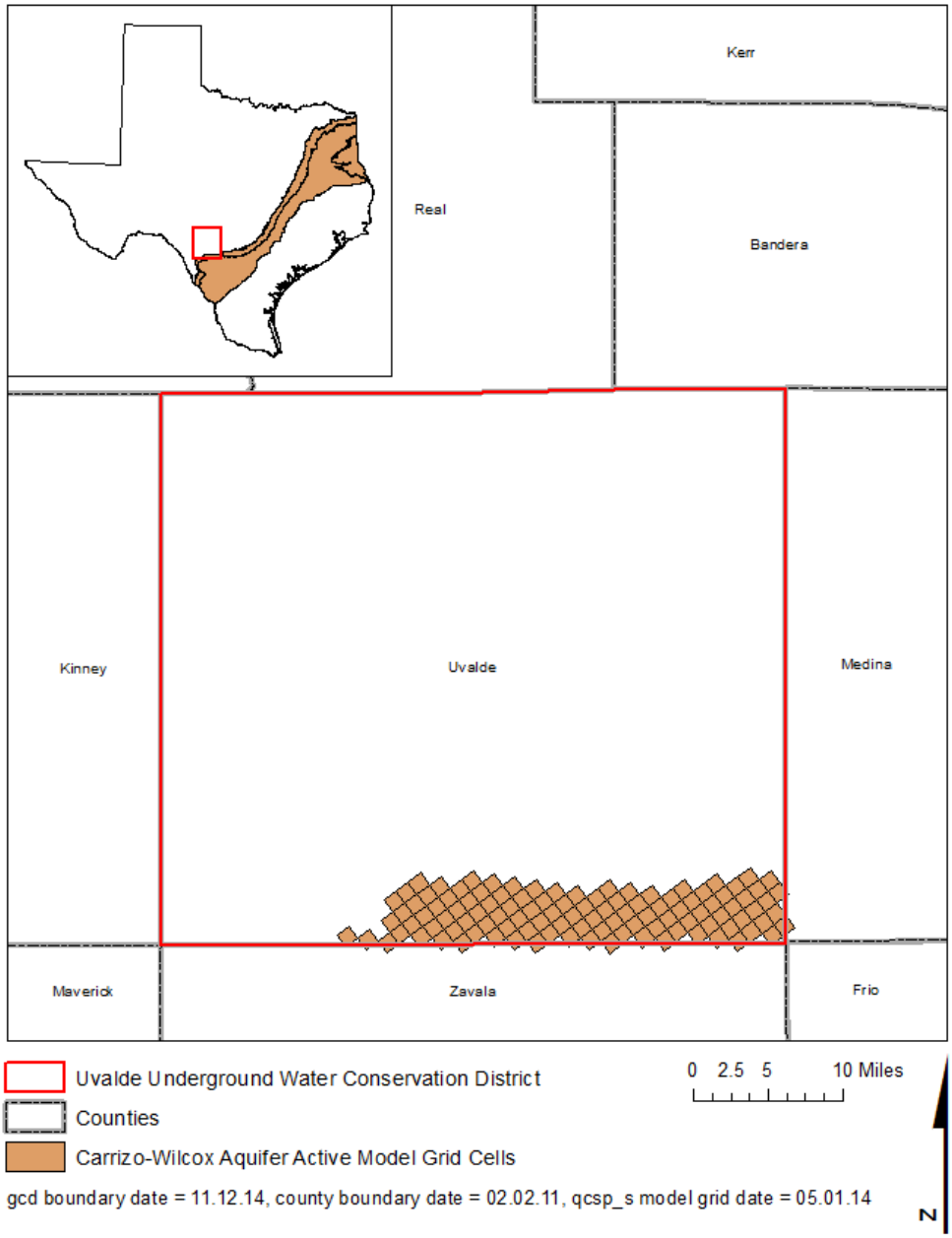

FIGURE 3 AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE SOUTHERN PART OF THE CARRIZO-WILCOX AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE CARRIZO-WILCOX AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

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 models 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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