GAM Run 09-031

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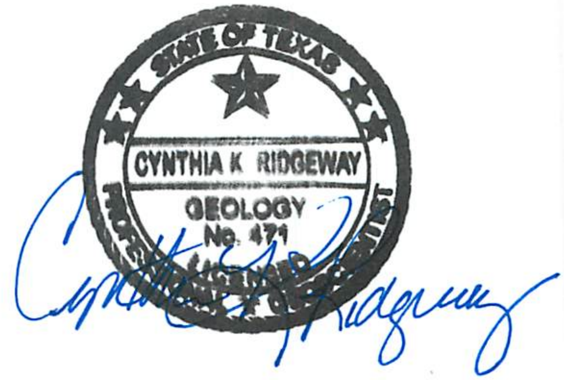

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by Eric Aschenbach under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on July 9, 2010.

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:

(1) the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
(2) 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
(3) 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 information to Medina County Groundwater Conservation District for its groundwater management plan. The groundwater management plan for Medina County Groundwater Conservation District is due for approval by the Executive Administrator of the Texas Water Development Board before September 26, 2010.

This report discusses the methods, assumptions, and results from model runs using the groundwater availability models for the Edwards-Trinity (Plateau) Aquifer; the Hill Country portion of the Trinity Aquifer; and the southern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers. 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.

METHODS:

We ran the groundwater availability models for the Edwards-Trinity (Plateau) Aquifer (1980 through 2000); the Hill Country portion of the Trinity Aquifer (1981 through 1997), which includes the portions of the Edwards-Trinity (Plateau) Aquifer in the district; and the southern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers (1980 through 1999) and (1) extracted water budgets for each year of the transient model period and (2) averaged the 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.

PARAMETERS AND ASSUMPTIONS:

Edwards-Trinity (Plateau) Aquifer

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer. 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). However, Layer 1 is not present in the district.

- 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, if the GHB is present in the district, 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 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 root mean square error (a measure of the difference between simulated and measured water levels) of the Edwards-Trinity (Plateau) groundwater availability model for the period of 1980 to 2000 is 143 feet, or six percent of the range of measured water levels (Anaya and Jones, 2009).

- We used Processing MODFLOW for Windows (PMWIN) version 5.3 (Chiang and Kinzelbach, 2001) as the interface to process model output.

Trinity Aquifer

- We used version 2.01 of the groundwater availability model for the Hill County portion of the Trinity Aquifer. See Jones and others (2009) for assumptions and limitations of the groundwater availability model.

- The groundwater availability model includes four layers, representing (from top to bottom):

  1. the Edwards Group of the Edwards-Trinity (Plateau) Aquifer,
  2. the Upper Trinity Aquifer,
  3. the Middle Trinity Aquifer, and
  4. the Lower Trinity Aquifer.

  Layer 1 is not present in the district. An individual water budget for the district was determined for the remaining layers of the Hill County portion of the Trinity Aquifer (Layer 2 to Layer 4 collectively).

- The General-Head Boundary (GHB) package of MODFLOW was used to represent flow out of the study area and across the Balcones Fault Zone (BFZ) into the Edwards (BFZ) Aquifer or the deeper Trinity Aquifer units. For simplicity, the GHB that corresponds to the uppermost layer (Layer 2) was used to represent the flow from the Edwards portion of the Edwards-Trinity (Plateau) Aquifer, across the Balcones Fault Zone 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 3 was used to represent the flow from the Trinity portion of the Edwards-Trinity (Plateau) Aquifer, across the Balcones Fault Zone and into 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 mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) for the aquifers in the model for 1990 and 1997 were 52 and 57 feet, respectively (Jones and others, 2009).

- The groundwater availability model includes some portions of the Edwards Group outside the official boundary of the Edwards-Trinity (Plateau) Aquifer. Though flow for these areas is not explicitly reported, the interaction between the Edwards Group (outside the Edwards-Trinity Plateau Aquifer) and the underlying Trinity Aquifer would be shown in the "flow between aquifers" segment of Table 1 if Layer 1 was present in the district.

- Only the outcrop area of the Hill County portion of the Trinity Aquifer was modeled, and the down-dip extent that underlies the Edwards (Balcones Fault Zone) Aquifer is not included.

- We used Processing MODFLOW for Windows (PMWIN) version 5.3 (Chiang and Kinzelbach, 2001) as the interface to process model output.

Carrizo-Wilcox, Queen City, and Sparta aquifers

- We used Version 2.01 of the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. 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, representing (from top to bottom):

  1. the Sparta Aquifer,
  2. the Weches Confining Unit,
  3. the Queen City Aquifer,
  4. the Reklaw Confining Unit,
  5. the Carrizo Aquifer,
  6. the Upper Wilcox Aquifer and top of the Middle Wilcox Aquifer where the Upper Wilcox is missing,
  7. the Middle Wilcox Aquifer, and
  8. the Lower Wilcox Aquifer.

  Layers 1, 2, and 3 are not present in the district. Out of the remaining layers listed above, an individual water budget for the district was determined for the Carrizo-Wilcox Aquifer (Layer 5 to Layer 8 collectively).

- The root mean squared error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 23 feet for the Sparta Aquifer, 18 feet for the Queen City Aquifer, and 33 feet for the Carrizo Aquifer for the calibration period (1980 to 1989) and 19, 22, and 48 feet for the same aquifers, respectively, in the verification period (1990 to 1999) (Kelley others, 2004). These root mean squared errors are between seven and ten percent of the range of measured water levels (Kelley others, 2004).

- We used Groundwater Vistas Version 5 (Environmental Simulations, Inc. 2007) 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 and 2. The components of the modified budget shown in tables 1 and 2 include:

- Precipitation recharge—This is 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—This is the total water exiting the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).

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

- Flow between aquifers—This describes the vertical flow, or leakage, 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).

Comparison of the groundwater availability models for the Edwards-Trinity (Plateau) Aquifer and the Hill Country portion of the Trinity Aquifer

Edwards-Trinity (Plateau) Aquifer and the Hill Country portion of the Trinity Aquifer overlap in the northern portion of the district. The Edwards Group and associated limestone hydrostratigraphic units (Layer 1) of the Edwards-Trinity (Plateau) Aquifer model and the Edwards Group (Layer 1) of the Hill County portion of the Trinity Aquifer model are not present in the district. Therefore, all associated flows for these layers are considered to be zero, and any comparison in flows between the two models is made on the undifferentiated Trinity Group hydrostratigraphic units (Layer 2) from the Edwards-Trinity (Plateau) Aquifer and the Trinity units (Layer 2 to Layer 4 collectively) from the Hill County portion of the Trinity Aquifer .

The estimated annual amount of recharge from precipitation to the district from the Edwards-Trinity (Plateau) Aquifer model is 8,987 acre-feet per year, and the estimated annual amount from the Hill County portion of the Trinity Aquifer model is 6,918 acre-feet per year (Layer 2 to Layer 4 collectively).

The estimated annual volume of water that discharges from springs and any surface water body to the district from the Edwards-Trinity (Plateau) Aquifer model is 841 acre-feet per year, and the estimated annual amount from the Hill County portion of the Trinity Aquifer model is 6,412 acre-feet per year (Layer 2 to Layer 4 collectively).

The estimated annual volume of flow into the district for the Edwards-Trinity (Plateau) Aquifer model is 26,688 acre-feet per year, and the estimated annual amount for the Hill County portion of the Trinity Aquifer model is 21,749 acre-feet per year (Layer 2 to Layer 4 collectively).

The estimated annual volume of flow out of the district from the Edwards-Trinity (Plateau) Aquifer model is 6,452 acre-feet per year. There is no General-Head Boundary (GHB) in Layer 1 of the Edwards-Trinity (Plateau) Aquifer model within the district: therefore, no additional flow is included. The estimated annual volume of flow out of the district from the Hill County portion of the Trinity Aquifer model is 8,526 acre-feet per year (Layer 2 to Layer 4 collectively), which also includes the estimated net flow leaving the district through the GHB in the uppermost layer (Layer 2) and going across the Balcones Fault Zone (BFZ) into the Edwards (BFZ) Aquifer within the Edwards Aquifer Authority (EAA) District.

The GHB in Layer 2 of the Edwards-Trinity (Plateau) Aquifer model was used to represent flow from the undifferentiated Trinity, across the Balcones Fault Zone and into the deeper Trinity Aquifer units. This flow has been estimated to be 28,608 acre-feet per year. The GHB in Layer 3 of the Hill County portion of the Trinity Aquifer model was also used to represent flow from the Trinity across the Balcones Fault Zone within the Trinity Aquifer. This flow has been estimated to be 13,651 acre-feet per year.

While the two models cover the same general area within the district, the Edwards-Trinity (Plateau) Aquifer model calibration is not as focused on targets in the vicinity of the district since the model grid covers a larger area overall. The Hill Country portion of the Trinity Aquifer model is believed to better represent groundwater availability in the district since it is a more localized model and the calibration is more closely tied to the region. Therefore, the Hill Country portion of the Trinity Aquifer model should be used to meet the management plan requirements (see Table 1 for a summary).

Table 1: Summarized information for the Trinity Aquifer that is needed for Medina 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	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	6,918
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	6,412
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	21,749
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	8,526
Estimated net annual volume of flow between each aquifer in the district	Not applicable	Not applicable

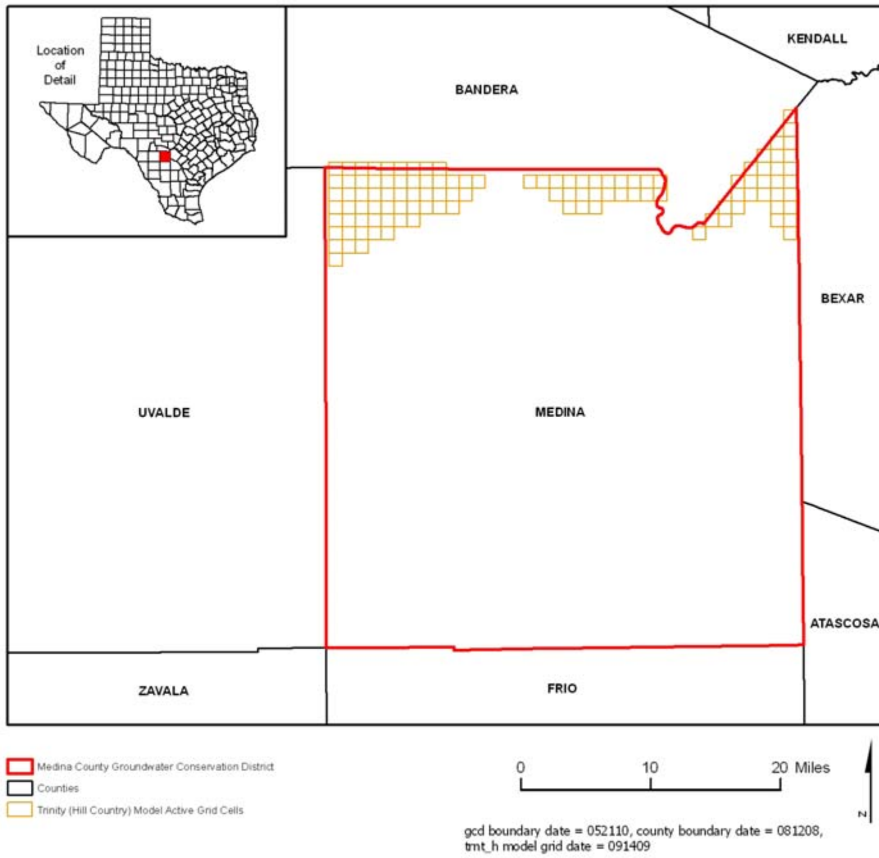

Figure 1: Area of the groundwater availability model for the Hill Country portion of the Trinity Aquifer from which the information in Table 1 was extracted (the aquifer extent within the district boundary).

Table 2: Summarized information for the Carrizo-Wilcox Aquifer that is needed for Medina 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. Flows may include fresh and brackish waters.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Carrizo-Wilcox Aquifer	14,102
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	588
Estimated annual volume of flow into the district within each aquifer in the district	Carrizo-Wilcox Aquifer	1,395
Estimated annual volume of flow out of the district within each aquifer in the district	Carrizo-Wilcox Aquifer	29,792
Estimated net annual volume of flow between each aquifer in the district	Reklaw Confining Unit into the Carrizo-Wilcox Aquifer	14

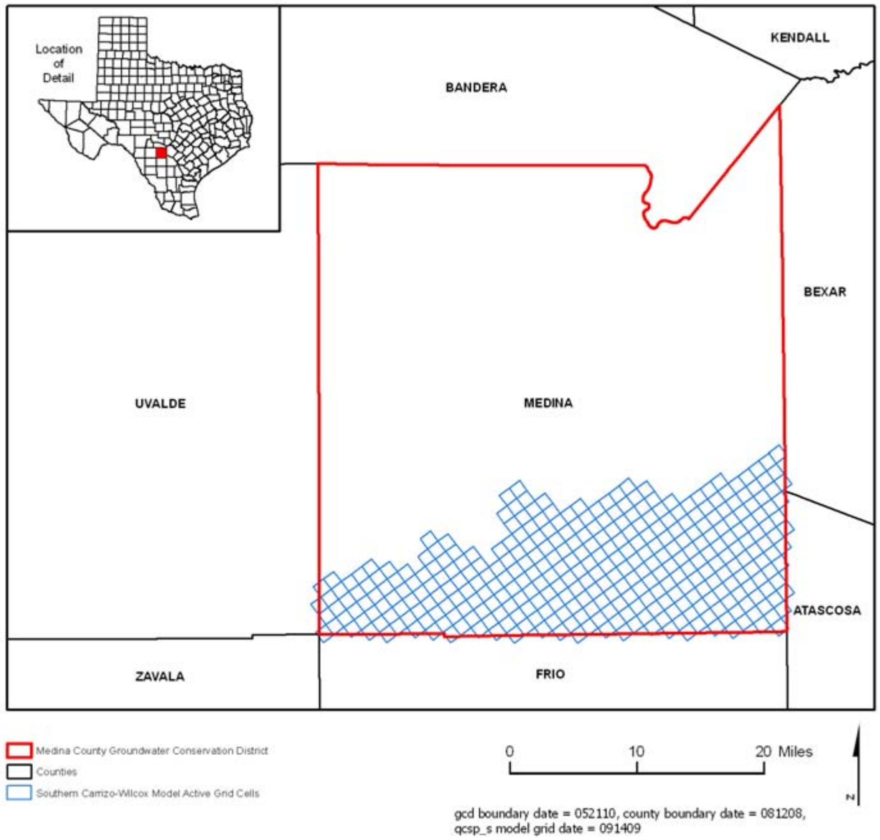

Figure 2: Area of the groundwater availability model for the southern portion of the Carrizo-Wilcox Aquifer from which the information in Table 2 was extracted (the aquifer extent within the district boundary).

REFERENCES:

Anaya, R., and Jones, I., 2009, Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas: Texas Water Development Board Report 373, 103 p., http://www.twdb.state.tx.us/gam/eddt_p/eddt_p.htm.

Chiang, W., and Kinzelbach, W., 2001, Groundwater Modeling with PMWIN, 346 p.

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Kelley, V.A., Deeds, N.E., Fryar, D.G., and Nicot, J.P., 2004, Groundwater availability models for the Queen City and Sparta aquifers: Contract report to the Texas Water Development Board, 867 p., http://www.twdb.state.tx.us/gam/qc_sp/qc_sp.htm.