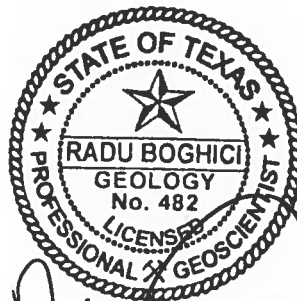

GAM RUN 19-008: BREWSTER COUNTY GROUNDWATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Radu Boghici, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-463-5808
February 28, 2019



A handwritten signature in black ink, appearing to be "Radu Boghici", written over the bottom portion of the professional seal.

2/28/2019

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EXECUTIVE SUMMARY:

Texas Water Code, Section 36.1071(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.

The TWDB provides data and information to the Brewster County Groundwater Conservation District in two parts. Part 1 is the Estimated Historical Water Use/State Water Plan dataset report, which will be provided to you separately by the TWDB Groundwater Technical Assistance Department. Please direct questions about the water data report to Mr. Stephen Allen at 512-463-7317 or stephen.allen@twdb.texas.gov. Part 2 is the required groundwater availability modeling information and this information includes:

1. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;
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 groundwater management plan for the Brewster County Groundwater Conservation District should be adopted by the district on or before October 7, 2019 and submitted to the Executive Administrator of the TWDB on or before November 6, 2019. The current

management plan for the Brewster County Groundwater Conservation District expires on January 5, 2020.

This report replaces GAM Run 13-020 (Shi, 2013). GAM Run 19-008 includes results from the following groundwater availability models: Eastern Arm of the Capitan Reef Complex Aquifer, Edwards-Trinity (Plateau) and Pecos Valley Aquifers, West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) and Igneous Aquifers, and Rustler Aquifer. Tables 1 through 4 summarize the groundwater availability model data required by statute, and Figures 1 through 4 show the area of the models from which the values in the tables were extracted. If, after review of the figures, Brewster County Groundwater Conservation District determines that the district boundaries used in this assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas Water Code, Section 36.1071(h), the groundwater availability models for the Eastern Arm of the Capitan Reef Complex Aquifer (Jones, 2016), Edwards-Trinity (Plateau) and Pecos Valley Aquifers (Anaya and Jones, 2009), West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) and Igneous Aquifers (Beach and others, 2004), and Rustler Aquifer (Ewing and others, 2012) were used to estimate information for the Brewster County Groundwater Conservation District groundwater management plan. Water budgets were extracted for the historical model periods using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The historical model periods were selected as follows: years 1980 through 2005 for the Eastern Arm of the Capitan Reef Complex Aquifer; years 1980 through 2000 for the Edwards-Trinity (Plateau), Pecos Valley Aquifers, the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) and Igneous Aquifers; and years 1980 through 2008 for the Rustler Aquifer Groundwater Availability Models. The average annual water budget values for recharge, surface-water outflow, inflow to the district, and outflow from the district for the aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Eastern Arm of the Capitan Reef Complex Aquifer

- We used version 1.01 of the groundwater availability model for the Eastern Arm of the Capitan Reef Complex Aquifer for this analysis. See Jones (2016) for assumptions and limitations of the model.

- The model has five layers which, in the area under the Brewster County Groundwater Conservation District, represent the Edwards-Trinity (Plateau) Aquifer (Layer 1), the Dewey Lake Formation (Layer 2), the Rustler Aquifer (Layers 3), the Confining Unit Above the Capitan Reef Complex Aquifer (Layer 4), and Capitan Reef Complex Aquifer (Layer 5).
- Water budgets for the district were determined for the Capitan Reef Complex Aquifer (Layer 5).
- The model was run with MODFLOW-2005 (Harbaugh, 2005).

Edwards-Trinity (Plateau) Aquifer

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers for this analysis. See Anaya and Jones (2009) for assumptions and limitations of the model.
- The model has two active layers and one inactive layer. In the area under the Brewster County Groundwater Conservation District, the two active model layers represent the Edwards (Layer 1), and the Trinity (Layer 2) hydrogeologic units.
- Water budgets were calculated for layers 1 and 2 lumped together as the Edwards-Trinity (Plateau) Aquifer for this management plan analysis.
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

Igneous Aquifer

- We used version 1.01 of the groundwater availability model for the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat, and Lobo Flat) and Igneous Aquifers for this analysis. See Beach and others (2004) for assumptions and limitations of the model.
- The model has three layers which, in the area under the Brewster County Groundwater Conservation District, represent the Salt Basin Bolson Aquifer (Layer 1), the Igneous Aquifer (Layer 2), and the underlying Cretaceous and Permian units (Layer 3). Layer 1 is not present within Brewster County Groundwater Conservation District.
- Water budgets for the district were determined for the Igneous Aquifer (Layer 2).

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

Rustler Aquifer

- We used version 1.01 of the groundwater availability model for the Rustler Aquifer for this analysis. See Ewing and others (2012) for assumptions and limitations of the model.
- The model has two layers which, in the area under the Brewster County Groundwater Conservation District, represent the Dewey Lake Formation (Layer 1), and the Rustler Aquifer (Layer 2).
- Water budgets for the district were determined for the Rustler Aquifer (Layer 2).
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

RESULTS:

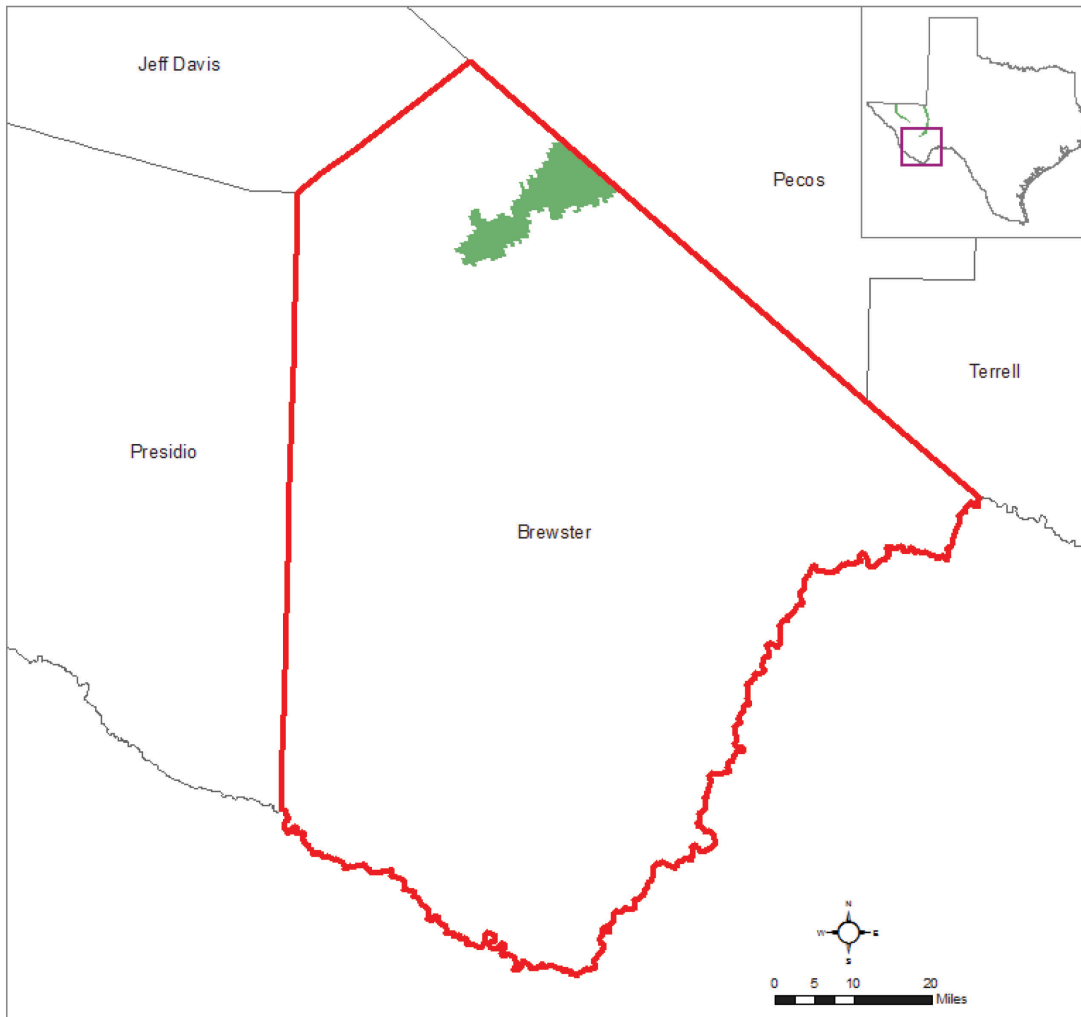
A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Capitan Reef Complex, Edwards-Trinity (Plateau), Igneous, and Rustler aquifers located within Brewster County Groundwater Conservation District and averaged over the historical calibration periods, as shown in Tables 1 through 4 .




1. 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.
2. Surface-water outflow—the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.
3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.
4. 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 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 through 4. 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 EASTERN ARM OF THE CAPITAN REEF COMPLEX AQUIFER FOR BREWSTER 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	Capitan Reef Complex Aquifer	16,171
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Capitan Reef Complex Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Capitan Reef Complex Aquifer	0
Estimated annual volume of flow out of the district within each aquifer in the district	Capitan Reef Complex Aquifer	29,390
Estimated net annual volume of flow between each aquifer in the district	Net flow from adjacent units into Capitan Reef Complex Aquifer	16,940



-  Brewster County Groundwater Conservation District boundary
-  County boundaries
-  Active model grid cells, Capitan Reef Complex Aquifer

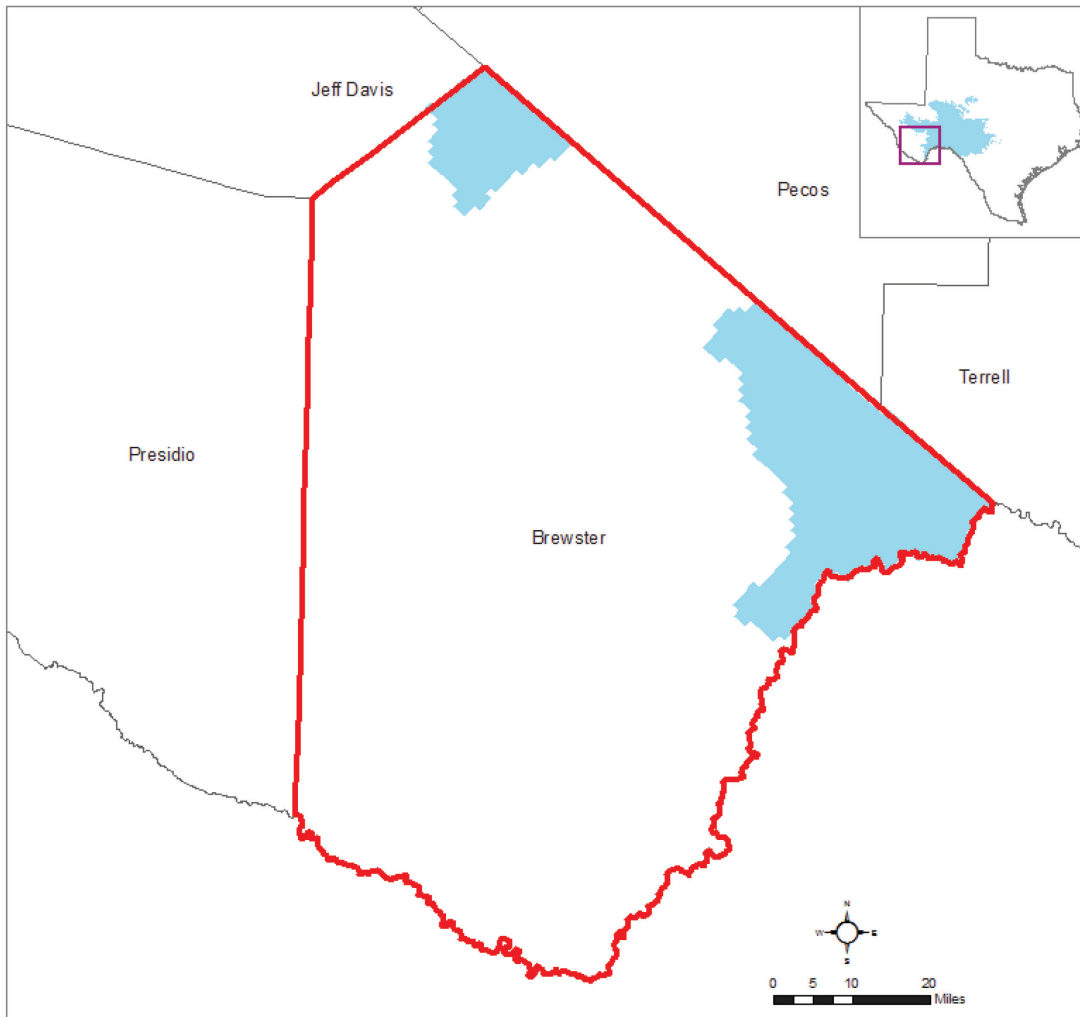
Data vintages:
County boundaries 02.20.2011
GCD boundary 01.22.2018
crx 12.20.2016




FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CAPITAN REEF COMPLEX AQUIFER FOR WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE CAPITAN REEF COMPLEX AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FOR BREWSTER 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	29,759
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	31,261
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	15,172
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	15,739
Estimated net annual volume of flow between each aquifer in the district	Not applicable	Not applicable

Due to changes to the model grid since the previous management plan report (2013), the groundwater flow volumes have also changed.



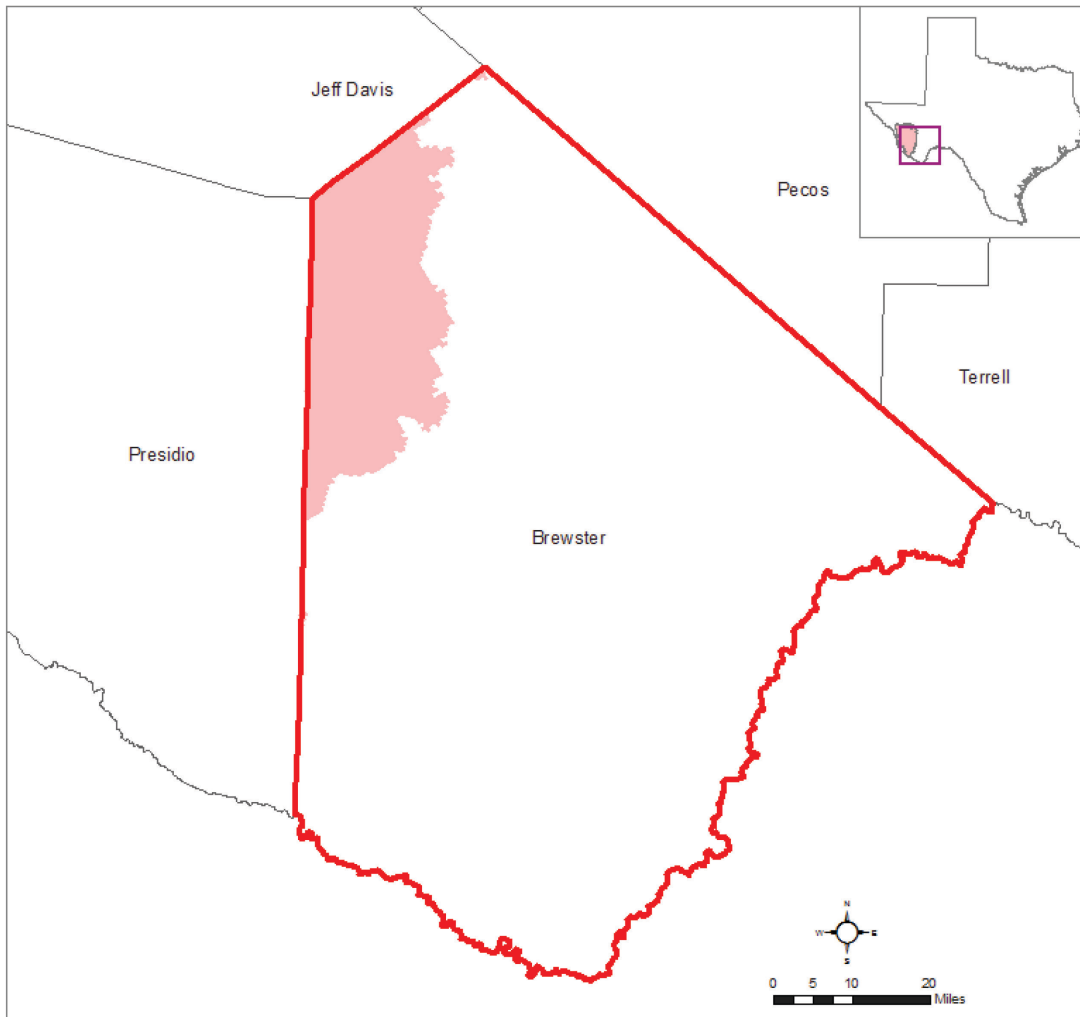
-  Brewster County Groundwater Conservation District boundary
-  County boundaries
-  Active model grid cells, Edwards-Trinity (Plateau) GAM




Data vintages:
County boundaries 02.20.2011
GCD boundary 01.22.2018
eddt_p model grid 02.03.2014

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

TABLE 3. SUMMARIZED INFORMATION FOR THE IGNEOUS AQUIFER FOR BREWSTER 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	Igneous Aquifer	6,584
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Igneous Aquifer	136
Estimated annual volume of flow into the district within each aquifer in the district	Igneous Aquifer	1,118
Estimated annual volume of flow out of the district within each aquifer in the district	Igneous Aquifer	1,364
Estimated net annual volume of flow between each aquifer in the district	Net flow from Igneous Aquifer to underlying Cretaceous and Permian Units	3,472



-  Brewster County Groundwater Conservation District boundary
-  County boundaries
-  Active model grid cells, Igneous Aquifer GAM

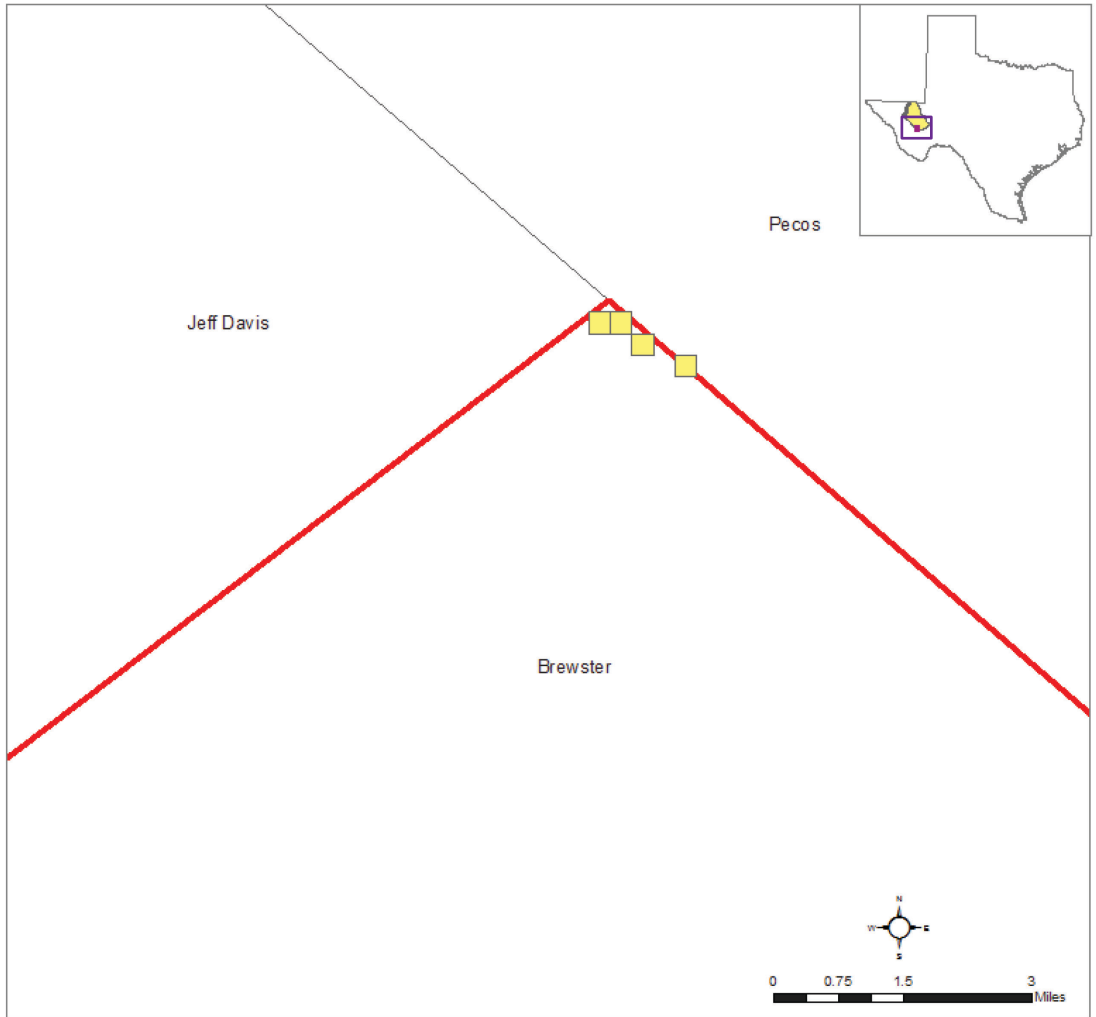
Data vintages:
County boundaries 02.20.2011
GCD boundary 01.22.2018
igbl model grid 11.19.2015




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

TABLE 4. SUMMARIZED INFORMATION FOR THE RUSTLER AQUIFER FOR BREWSTER 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	Rustler Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Rustler Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Rustler Aquifer	15*
Estimated annual volume of flow out of the district within each aquifer in the district	Rustler Aquifer	15
Estimated net annual volume of flow between each aquifer in the district	Flow between Rustler Aquifer and overlying units	0

*Includes flows from Jeff Davis County to the west and Davis Mountains to the south.



-  Brewster County Groundwater Conservation District boundary
-  County boundaries
-  Active model grid cells, Rustler Aquifer GAM

Data vintages:
County boundaries 02.20.2011
GCD boundary 01.22.2018
rslr model grid 02.03.2014

FIGURE 4. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE RUSTLER AQUIFER FOR WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED (THE RUSTLER AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS:

The groundwater models used in completing this analysis are the best available scientific tools that can be used to meet the stated objectives. 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.

REFERENCES:

- Anaya, R. and Jones, I. C., 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.texas.gov/groundwater/models/gam/eddt_p/ET-Plateau_Full.pdf.
- Beach, A.B., Ashworth, J.B., Finch, Jr., S.T., Chastain-Howley, A., Calhoun, K., Urbanczyk, K.M., Sharp, J.M., Olson, J., 2004, Groundwater Availability Model for the Igneous and parts of the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) Aquifers, Texas Water Development Board, 407 p.
- Ewing, J.E., Kelley, V.A., Jones, T.L., Yan, T., Singh, A., Powers, D.W., Holt, R.M., Sharp, J.M., 2012, Final Groundwater Availability Model Report for the Rustler Aquifer, Texas Water Development Board, 460 p.
- Harbaugh, A. W., 2005, MODFLOW-2005, the U.S. Geological Survey modular ground-water model -- the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16.
- Harbaugh, A. W., 2009, Zonebudget Version 3.01, a computer program for computing subregional water budgets for MODFLOW ground-water flow models, U.S. Geological Survey Groundwater Software.
- Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model-user guide to modularization concepts and the ground-water flow process: U.S. Geological Survey Open-File Report 00-92, 121 p.
- Harbaugh, A. W., and McDonald, M.G., 1996, User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 96-485, 56 p.
- Jones, I. C., 2016, Groundwater Availability Model: Eastern Arm of the Capitan Reef Complex Aquifer of Texas, Texas Water Development Board, 503 p.,
http://www.twdb.texas.gov/groundwater/models/gam/crcx/CapitanModelReport_Final.pdf.

National Research Council, 2007, Models in Environmental Regulatory Decision Making
Committee on Models in the Regulatory Decision Process, National Academies Press,
Washington D.C., 287 p., http://www.nap.edu/catalog.php?record_id=11972.

Shi, J., 2013, GAM Run 13-020: Brewster County Groundwater Conservation District
Management Plan,
<http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR13-020.pdf>.

Texas Water Code, 2011, <http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf>.