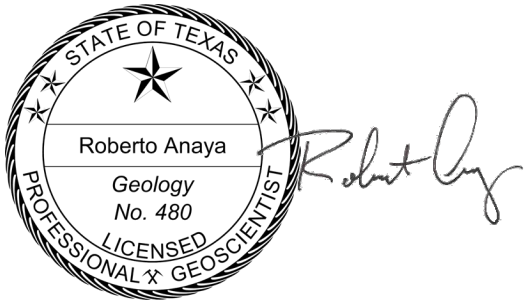
GAM RUN 23-006: CROCKETT COUNTY GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

Roberto Anaya, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-463-6115
August 23, 2023



Professional Geoscientist Seal: August 23, 2023

This page is intentionally blank.

GAM RUN 23-006: CROCKETT COUNTY GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

Roberto Anaya, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-463-6115
August 23, 2023

EXECUTIVE SUMMARY:

Texas State Water Code § 36.1071 (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.

The TWDB provides data and information to the Crockett 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, which includes:

1. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;

2. the annual volume of water that discharges from the aquifer to springs and any surface-water bodies, including lakes, streams, and rivers for each aquifer within the district; 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 Crockett County Groundwater Conservation District should be adopted by the district on or before August 16, 2023, and submitted to the executive administrator of the TWDB on or before September 15, 2023. The current management plan for the Crockett County Groundwater Conservation District expires on November 14, 2023.

We used two groundwater availability models for aquifers within Crockett County Groundwater Conservation District. Management plan information for the Dockum Aquifer is from version 1.01 of the groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015) and management plan information for the Edwards-Trinity (Plateau) and Pecos Valley aquifers is from version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Anaya and Jones, 2009).

This report replaces the results of GAM Run 17-022 (Jones, 2017). Values may differ from the previous report as a result of routine updates to the model grid file used to define county, groundwater conservation district, and aquifer boundaries, which can impact the calculated water budget values. Additionally, the approach used for analyzing model results is reviewed during each update and may have been refined to more accurately delineate groundwater flows. Tables 1, 2, and 3 summarize the groundwater availability model data required by statute. Figures 1, 3, and 5 show the area of the respective models from which the values in Table 1, 2, and 3 were extracted. Figures 2, 4, and 6 provide a generalized diagram of the groundwater flow components provided in Table 1, 2, and 3. If, after review of the figures, the Crockett County Groundwater 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 flow components presented in this report do not represent the full groundwater budget. If additional inflow and outflow information would be helpful for planning purposes, the district may submit a request in writing to the TWDB Groundwater Modeling Department for the full groundwater budget.

METHODS:

In accordance with Texas Water Code Section 36.1071(h), the groundwater availability models mentioned above were used to estimate information for the Crockett County Groundwater Conservation District management plan. Water budgets were extracted for the historical model calibration period of the Dockum aquifer (1980 through 2012), using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Water budgets were extracted for the historical model calibration period of the Pecos Valley and Edwards-Trinity (Plateau) aquifers (1981 through 2000), 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, and the flow between aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Dockum Aquifer

- We used version 1.01 of the groundwater availability model for the High Plains Aquifer System to analyze the Dockum Aquifer. See Deeds and others (2015) and Deeds and Jigmond (2015) for assumptions and limitations of the model.
- The groundwater availability model for the High Plains Aquifer System contains the following four layers:
    - Layer 1 represents the Ogallala and Pecos Valley aquifers where present
    - Layer 2 represents the Rita Blanca, Edwards-Trinity (High Plains), and Edwards-Trinity (Plateau) aquifers where present
    - Layer 3 represents the upper portion of the Dockum Aquifer and equivalent units
    - Layer 4 represents the lower portion of the Dockum Aquifer and equivalent units
- While the model for the High Plains Aquifer System includes the Pecos Valley and Edwards-Trinity (Plateau) aquifers, the focus of the High Plains Aquifer System model run was to only extract information for the Dockum Aquifer within Crockett County Groundwater Conservation District. Thus, model layers 3 and 4 combined were used for the management plan analysis.

- Water budget terms were averaged for the period 1980 through 2012 (stress periods 52 through 84).

- The model was run with MODFLOW-NWT (Niswonger and others, 2011).

Edwards-Trinity (Plateau) and Pecos Valley aquifers

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers to analyze the Edwards-Trinity (Plateau) and Pecos Valley aquifers. See Anaya and Jones (2009) for assumptions and limitations of the model.

- The groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers contains two layers. Within Crockett County Groundwater Conservation District:

    - Layer 1 represents the Pecos Valley Alluvium (9 model cells) or Edwards Group and equivalent limestone hydrostratigraphic units of the Edwards-Trinity (Plateau) Aquifer

    - Layer 2 represents the undifferentiated Trinity Group hydrostratigraphic units or equivalent units of the Edwards-Trinity (Plateau) Aquifer

- An individual water budget for the district was determined for the Edwards-Trinity (Plateau) Aquifer (Layers 1 and 2, combined). The Pecos Valley Aquifer is represented by nine model cells within the Crockett County Groundwater Conservation District which were modeled separately as Layer 1 to calculate the water budget values.

- Water budget terms were averaged for the period 1981 to 2000 (stress periods 2 through 21).

- 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 groundwater availability model results for the Dockum, Pecos Valley, and Edwards-Trinity (Plateau) aquifers located within the Crockett County Groundwater Conservation District and averaged over the historical calibration periods, as shown in Tables 1, 2, and 3.

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.

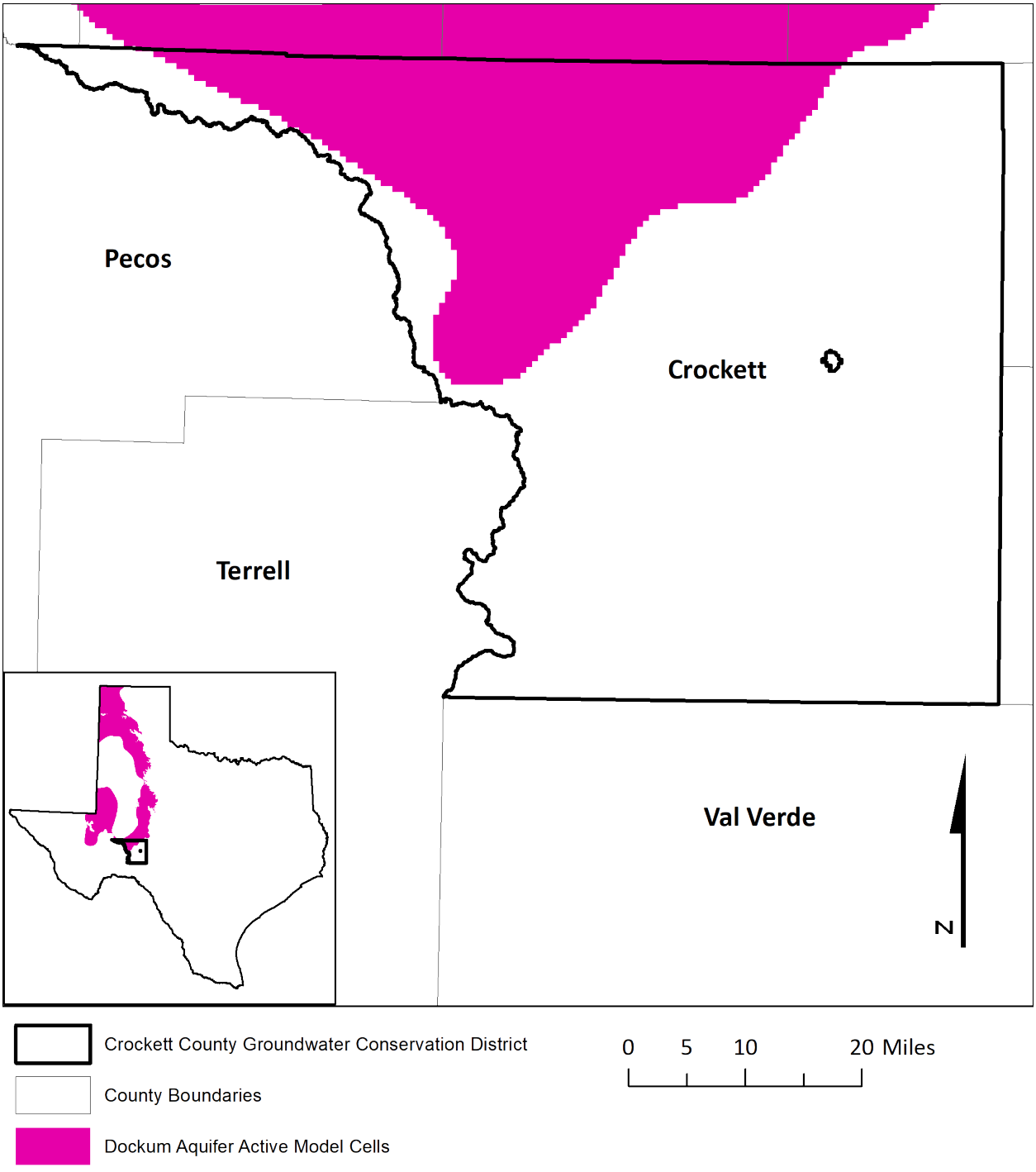
3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.

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, 2, and 3. Figures 1, 3, and 5 show the geographical areas of the respective models from which the values in Table 1, 2, and 3 were extracted. Figures 2, 4 and 6 provide generalized diagrams of the groundwater flow components provided 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 models. 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 model cell overlies two counties, the cell is assigned to the county where the centroid of the cell is located.

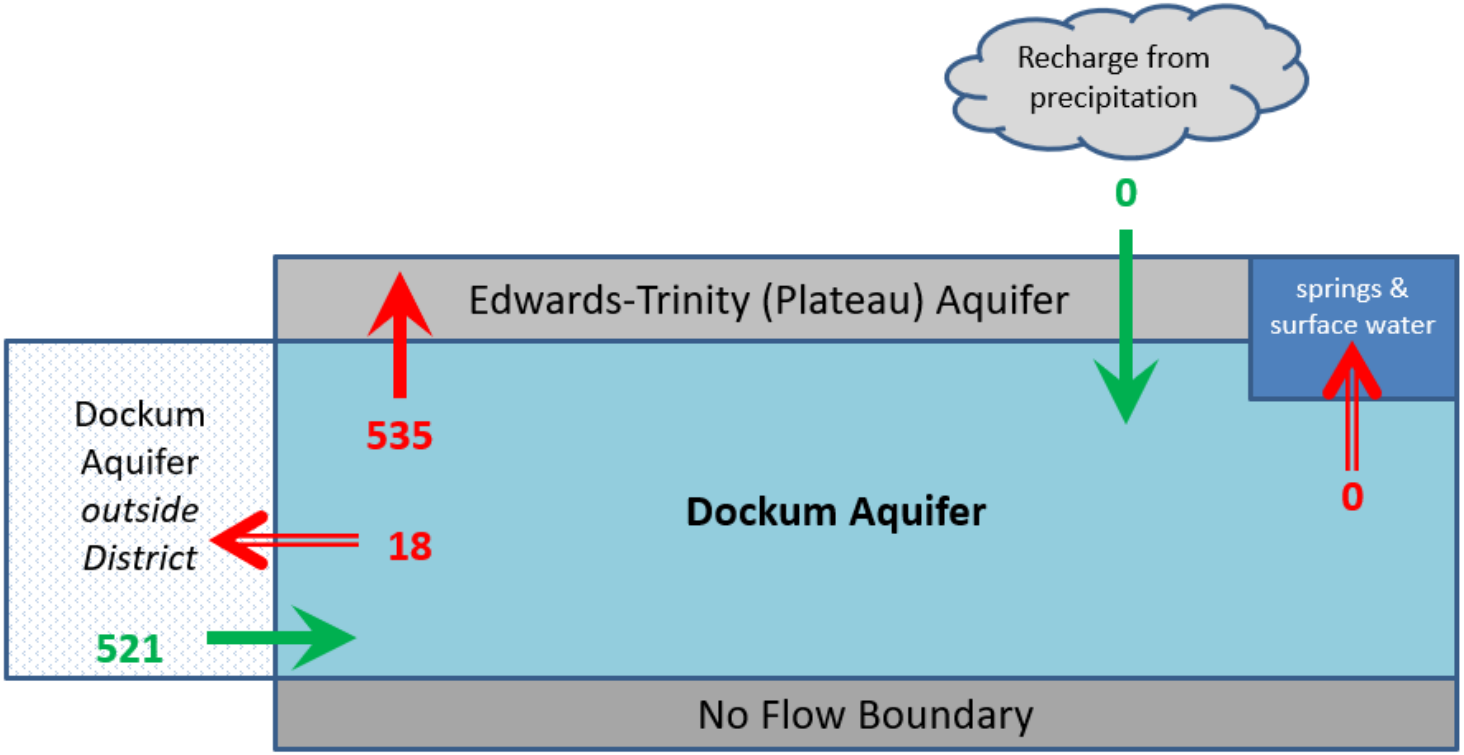
Table 1: Summarized information for the Dockum Aquifer for the Crockett County Groundwater Conservation District groundwater management plan. All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

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	521
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	18
Estimated net annual volume of flow between each aquifer in the district	From Dockum Aquifer to Edwards-Trinity (Plateau) Aquifer	535



GCD boundary date: 06.26.2020, County boundary date: 07.03.2019. hpas date: 06.26.2020

Figure 1: Area of the High Plains Aquifer System groundwater availability model from which the information in Table 1 was extracted (the Dockum Aquifer extent within the district boundary).



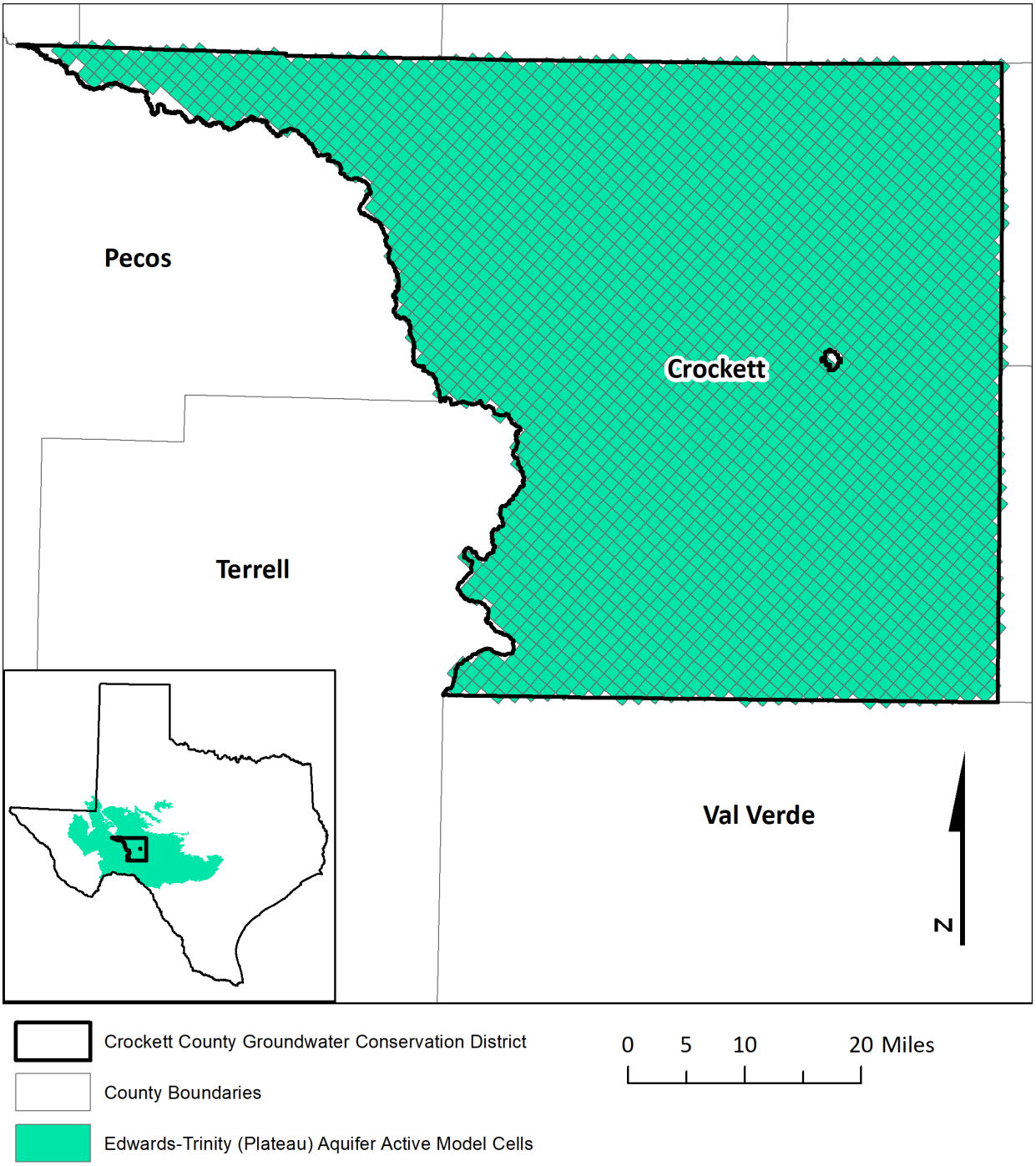
Caveat: This diagram only includes the water budget items provided in Table 1. A complete water budget would include additional inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department.

Figure 2: Generalized diagram of the summarized budget information from Table 1, representing directions of flow for the Dockum Aquifer within Crockett County Groundwater Conservation District. Flow values are expressed in acre-feet per year.

Table 2: Summarized information for the Edwards-Trinity (Plateau) Aquifer for the Crockett County Groundwater Conservation District groundwater management plan. All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

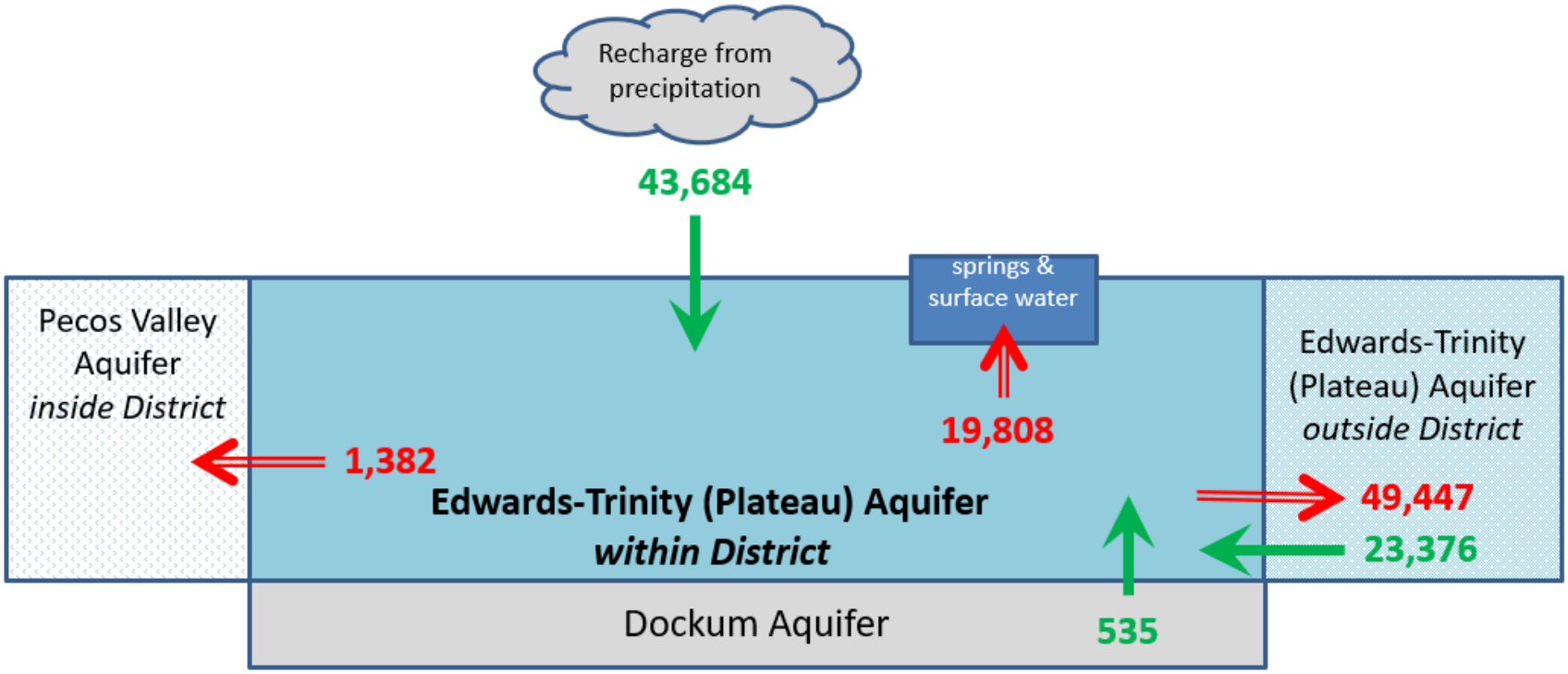
Management plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	43,684
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	19,808
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	23,376
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	49,447
Estimated net annual volume of flow between each aquifer in the district	From Edwards-Trinity (Plateau) Aquifer to Pecos Valley Aquifer	1,382
	To Edwards-Trinity (Plateau) Aquifer from Dockum Aquifer	535*

* *Value calculated from the High Plains Aquifer System groundwater availability model from which the information in Table 1 was extracted (the Dockum Aquifer extent within the district boundary).*



GCD boundary date: 06.26.2020, County boundary date: 07.03.2019. eddt_p date: 06.26.2020

Figure 3: Area of the Edwards-Trinity (Plateau) and Pecos Valley aquifers groundwater availability model from which the information in Table 2 was extracted (the Edwards-Trinity [Plateau] Aquifer extent within the district boundary).

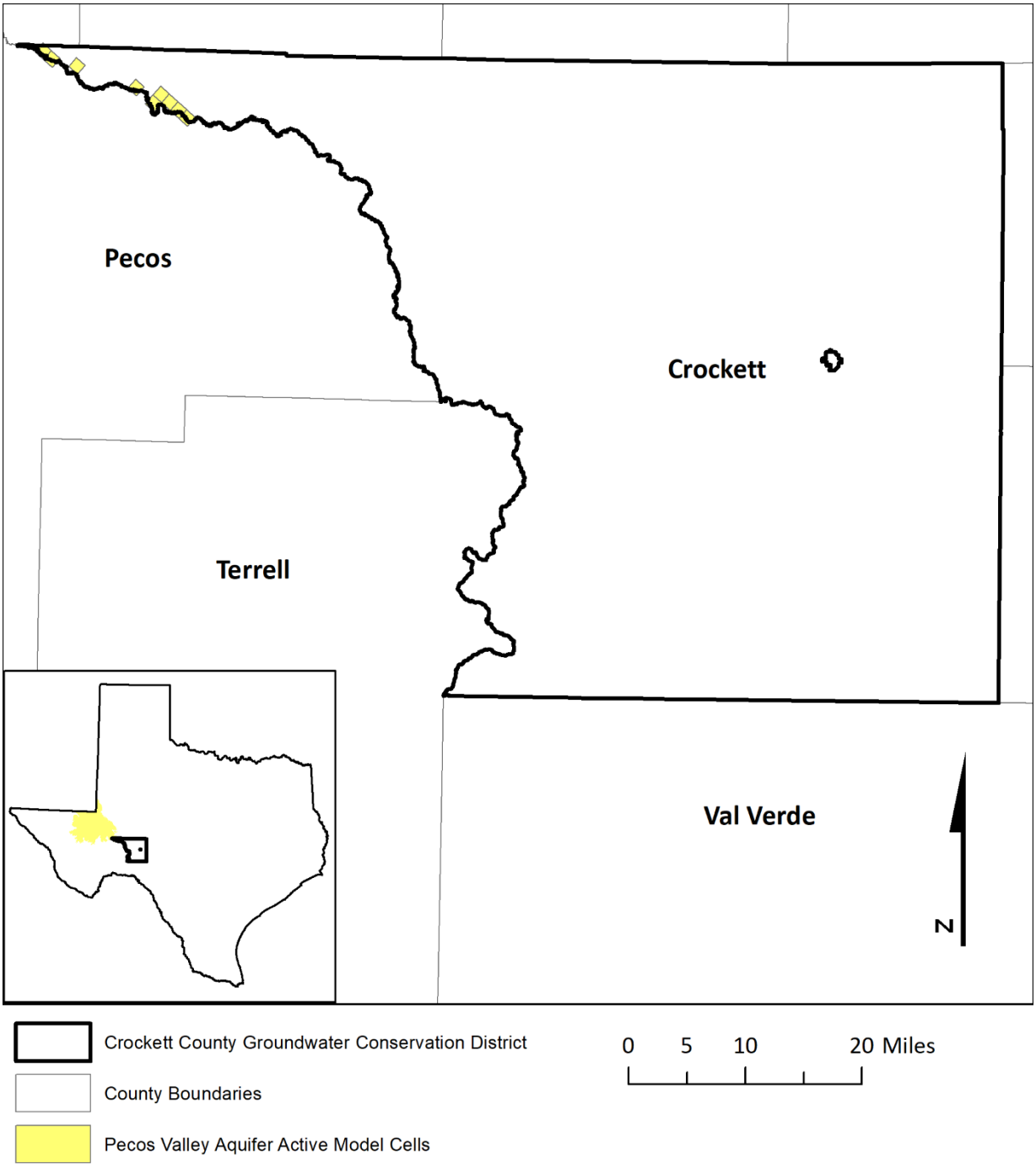


Caveat: This diagram only includes the water budget items provided in Table 2. A complete water budget would include additional inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department.

Figure 4: **Generalized diagram of the summarized budget information from Table 2, representing directions of flow for the Edwards-Trinity (Plateau) Aquifer within Crockett County Groundwater Conservation District. Flow values are expressed in acre-feet per year.**

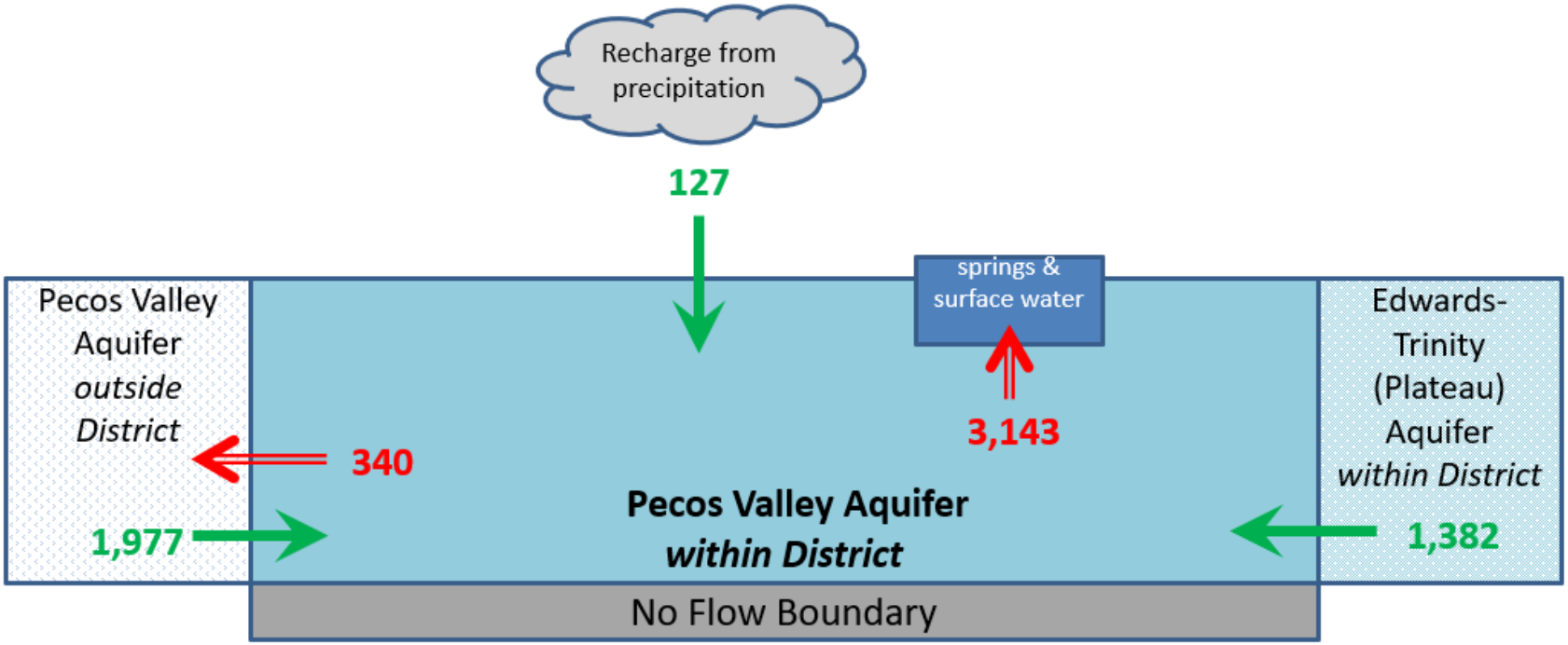
Table 3: Summarized information for the Pecos Valley Aquifer for the Crockett County Groundwater Conservation District groundwater management plan. All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Pecos Valley Aquifer	127
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Pecos Valley Aquifer	3,143
Estimated annual volume of flow into the district within each aquifer in the district	Pecos Valley Aquifer	1,977
Estimated annual volume of flow out of the district within each aquifer in the district	Pecos Valley Aquifer	340
Estimated net annual volume of flow between each aquifer in the district	To Pecos Valley Aquifer from Edwards-Trinity (Plateau) Aquifer	1,382



GCD boundary date: 06.26.2020, County boundary date: 07.03.2019. eddt_p date: 06.26.2020

Figure 5: Area of Edwards-Trinity (Plateau) and Pecos Valley aquifers groundwater availability model from which the information in Table 3 was extracted (the Pecos Valley Aquifer extent within the district boundary).



Caveat: This diagram only includes the water budget items provided in Table 3. A complete water budget would include additional inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department.

Figure 6: Generalized diagram of the summarized budget information from Table 3, representing directions of flow for Pecos Valley Aquifer within Crockett County Groundwater Conservation District. Flow values are expressed in acre-feet per year.

LIMITATIONS:

The groundwater models used in completing this analysis are the best available scientific tools 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 historical 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 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. www.twdb.texas.gov/groundwater/models/gam/eddt_p/ET-Plateau_Full.pdf

Deeds, N. E. and Jigmond, M., 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model, Prepared for the Texas Water Development Board by Intera Inc., 640 p. www.twdb.texas.gov/groundwater/models/gam/hpas/hpas.asp

Deeds, N. E., Harding, J. J., Jones, T. L., Singh, A., Hamlin, S. and Reedy, R. C., 2015, Final Conceptual Model Report for the High Plains Aquifer System Groundwater Availability Model, 590 p., www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Conceptual_Report.pdf

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, pubs.usgs.gov/of/1990/0392/report.pdf.

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 groundwater-water flow model: U.S. Geological Survey Open-File Report 96-485, 56 p, pubs.usgs.gov/of/1996/0485/report.pdf.

Jones, I., 2017, GAM Run 17-022: Texas Water Development Board, GAM Run 17-022 Report, 20 p., www.twdb.texas.gov/groundwater/docs/GAMruns/GR17-022.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., nap.nationalacademies.org/catalog/11972/models-in-environmental-regulatory-decision-making.

Niswonger, R.G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, a Newton formulation for MODFLOW-2005: USGS, Techniques and Methods 6-A37, 44 p, pubs.usgs.gov/tm/tm6a37/pdf/tm6a37.pdf.

Texas Water Code § 36.1071