# Cow Creek Groundwater Conservation District

## Part 2 – Data Required for Management Plan GAM Run 24-008

TEXAS WATER
DEVELOPMENT BOARD

Saheli Majumdar, Ph.D. and Grayson Dowlearn, P.G.
Texas Water Development Board
Groundwater Modeling Department
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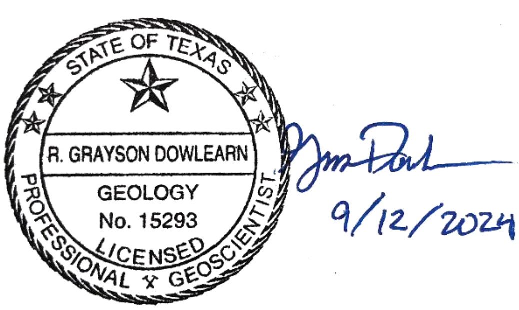


# INTRODUCTION

Texas 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 Cow Creek Groundwater Conservation District in two parts. This report constitutes part 2, 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.

This report replaces the results of GAM Run 19-011 (Jones, 2019). We used two groundwater availability models for the Cow Creek Groundwater Conservation District. Information for the Edwards-Trinity (Plateau) and Trinity aquifers is from version 2.01 of the groundwater availability model for the Hill Country portion of the Trinity Aquifer (Jones and others, 2011). Information for the Ellenburger-San Saba and Hickory aquifers is from version 1.01 of the groundwater availability model for the minor aquifers of the Llano Uplift (Shi and others, 2016).

The groundwater management plan for the Cow Creek Groundwater Conservation District should be adopted by the district on or before November 29, 2024 and submitted to the Executive Administrator of the TWDB on or before December 29, 2024. The current management plan for the Cow Creek Groundwater Conservation District expires on February 27, 2025.

# METHODS

In accordance with the provisions of the Texas Water Code § 36.1071 (h), the groundwater availability models mentioned above were used to estimate information for the Cow Creek Groundwater Conservation District management plan. 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.

Values may differ from the previous report as a result of routine updates to the spatial 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 better delineate groundwater flows. Finally, results may differ due to the use of more recent models or techniques.

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.

If the Cow Creek Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions after reviewing the figures, please notify the TWDB Groundwater Modeling Department 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.

## Models and Aquifers

***Groundwater availability model for the Hill Country portion of the Trinity Aquifer***

- Version 2.01 (Jones and others, 2011).
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Water budgets were extracted for the historical calibration period (1981 through 1997) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model was used to analyze the following aquifers:
    - Edwards-Trinity (Plateau) Aquifer
    - Trinity Aquifer

***Groundwater availability model for the minor aquifers of the Llano Uplift***

- Version 1.01 (Shi and others, 2016).
- The model was run with MODFLOW-USG (Panday and others, 2013).
- Water budgets were extracted for the historical calibration period (1981 through 2010) using ZONEBUDGET for MODFLOW USG Version 1.0 (Panday and others, 2013).
- This model was used to analyze the following aquifers:
    - Ellenburger-San Saba Aquifer
    - Hickory Aquifer

For more information on model parameters, packages used to simulate groundwater flow, other model layers, or model assumptions, please see the associated model reports linked in the References section.

# 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 Edwards-Trinity (Plateau), Trinity, Ellenburger-San Saba, and Hickory aquifers located within Cow Creek Groundwater Conservation District:

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. Figures 1, 3, 5, and 7 show the area of the model from which the values in Tables 1 through 4 were extracted. Figures 2, 4, 6, and 8 provide a generalized diagram of the groundwater flow components provided in Tables 1 through 4.

**Table 1: Summarized information for the Edwards-Trinity (Plateau) Aquifer. 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 | 6,046 |
| 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 | 3,061 |
| Estimated annual volume of flow into the district within each aquifer in the district | Edwards-Trinity (Plateau) Aquifer | 4,008 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Edwards-Trinity (Plateau) Aquifer | 257 |
| Estimated net annual volume of flow within each aquifer in the district | From Edwards-Trinity (Plateau) Aquifer to Trinity Aquifer | 6,429 |

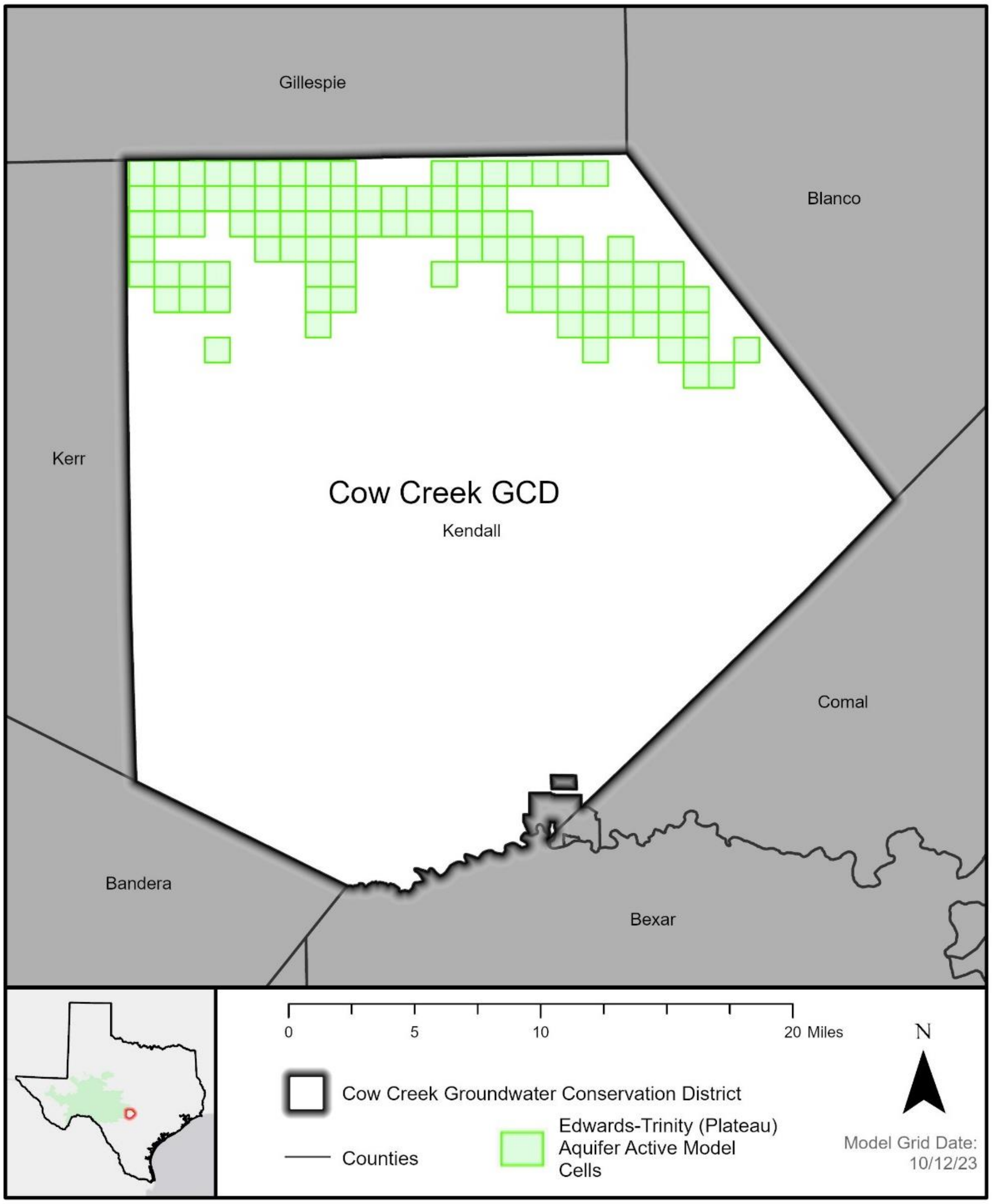
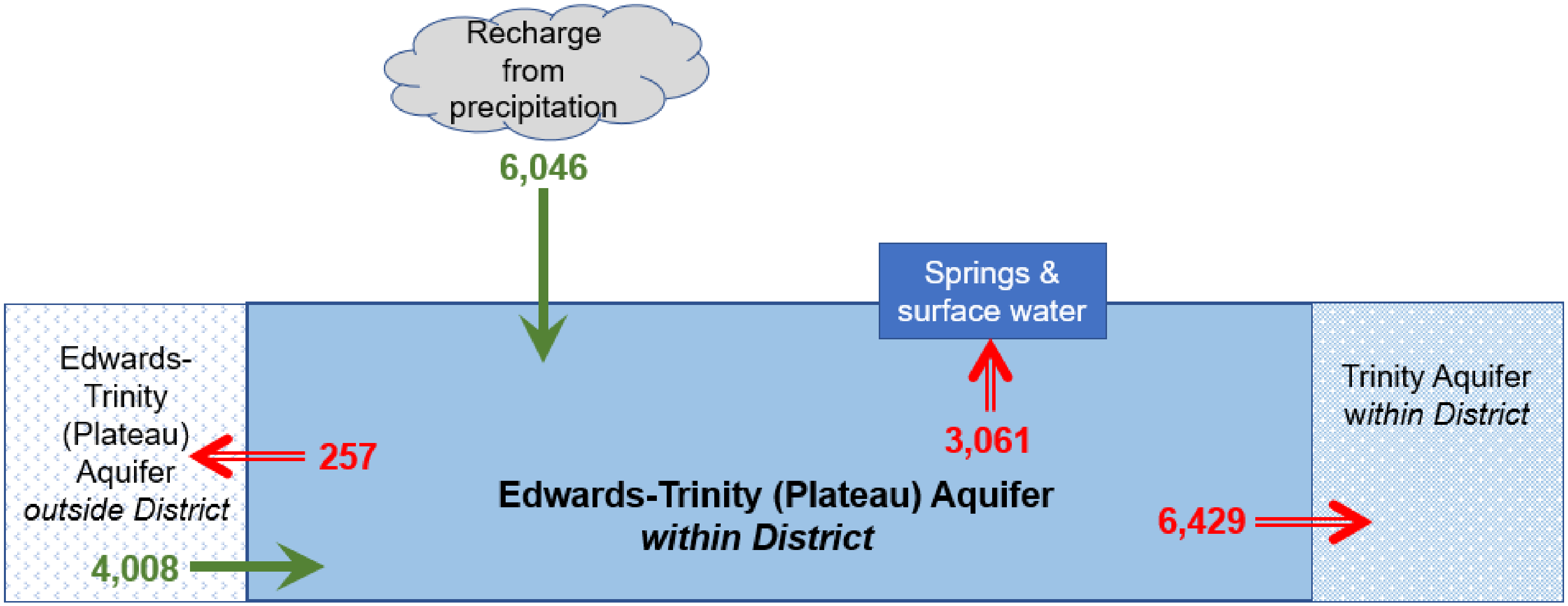



**Figure 1: Area of the groundwater availability model for the Hill Country portion of the Trinity Aquifer from which the information in Table 1 was extracted (the Edwards-Trinity [Plateau] Aquifer extent within the district boundary).**




*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 Edwards-Trinity [Plateau] Aquifer within the Cow Creek Groundwater Conservation District. Flow values are expressed in acre-feet per year.**

**Table 2: Summarized information for the Trinity Aquifer. 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 | 50,110 |
| Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams and rivers | Trinity Aquifer | 31,131 |
| Estimated annual volume of flow into the district within each aquifer in the district | Trinity Aquifer | 7,311 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Trinity Aquifer | 30,342 |
| Estimated net annual volume of flow within each aquifer in the district | To Trinity Aquifer from Edwards-Trinity (Plateau) Aquifer | 6,429 |

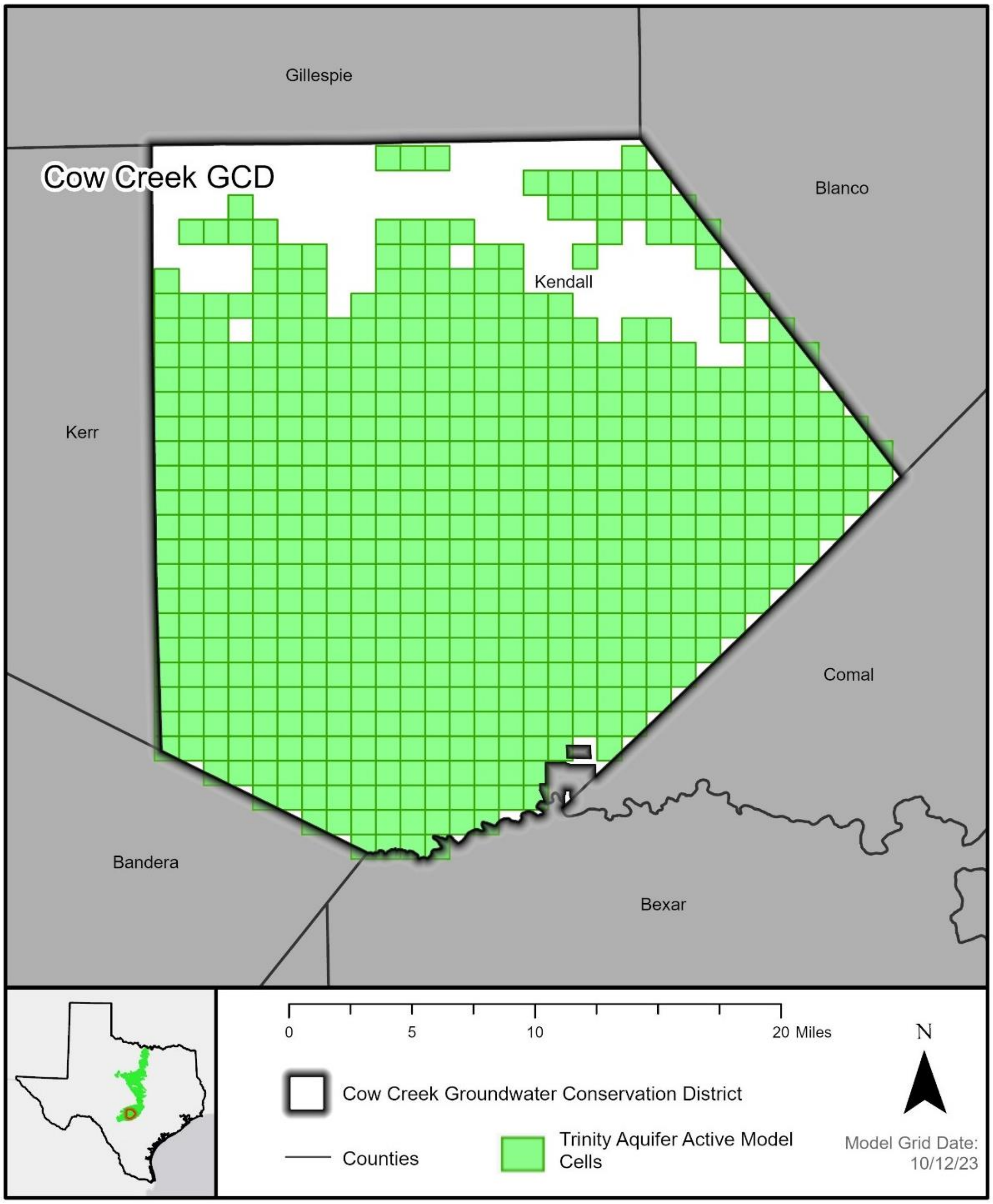
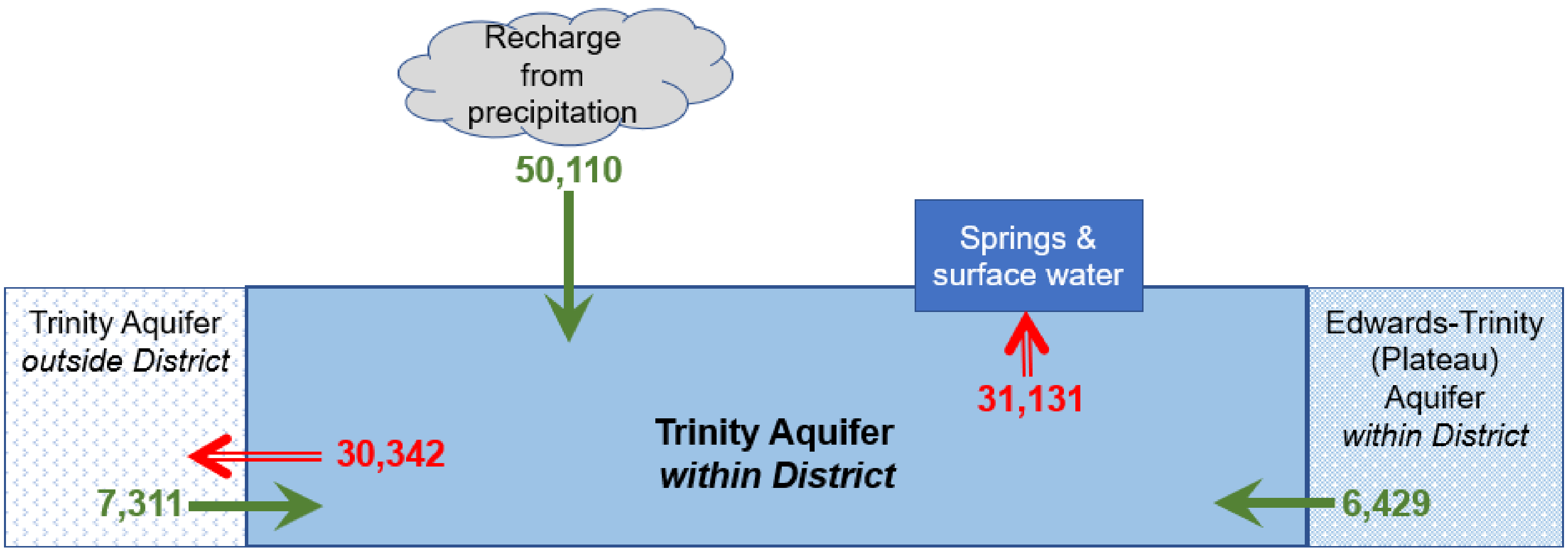



**Figure 3: Area of the groundwater availability model for the Hill Country portion of the Trinity Aquifer from which the information in Table 2 was extracted (the Trinity Aquifer extent within the district boundary).**




*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 Trinity Aquifer within the Cow Creek Groundwater Conservation District. Flow values are expressed in acre-feet per year.**

**Table 3: Summarized information for the Ellenburger-San Saba Aquifer. 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 | Ellenburger-San Saba Aquifer | 0 |
| Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams and rivers | Ellenburger-San Saba Aquifer | 0 |
| Estimated annual volume of flow into the district within each aquifer in the district | Ellenburger-San Saba Aquifer | 5,059 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Ellenburger-San Saba Aquifer | 4,814 |
| Estimated net annual volume of flow within each aquifer in the district | To Ellenburger-San Saba Aquifer from overlying units* | 4,319 |
| | From Ellenburger-San Saba Aquifer to Ellenburger-San Saba equivalent units | 3,516 |
| | From Ellenburger-San Saba Aquifer to underlying units* | 1,050 |

***** Please see Figure 6 for a breakdown of flows between individual overlying and underlying units.

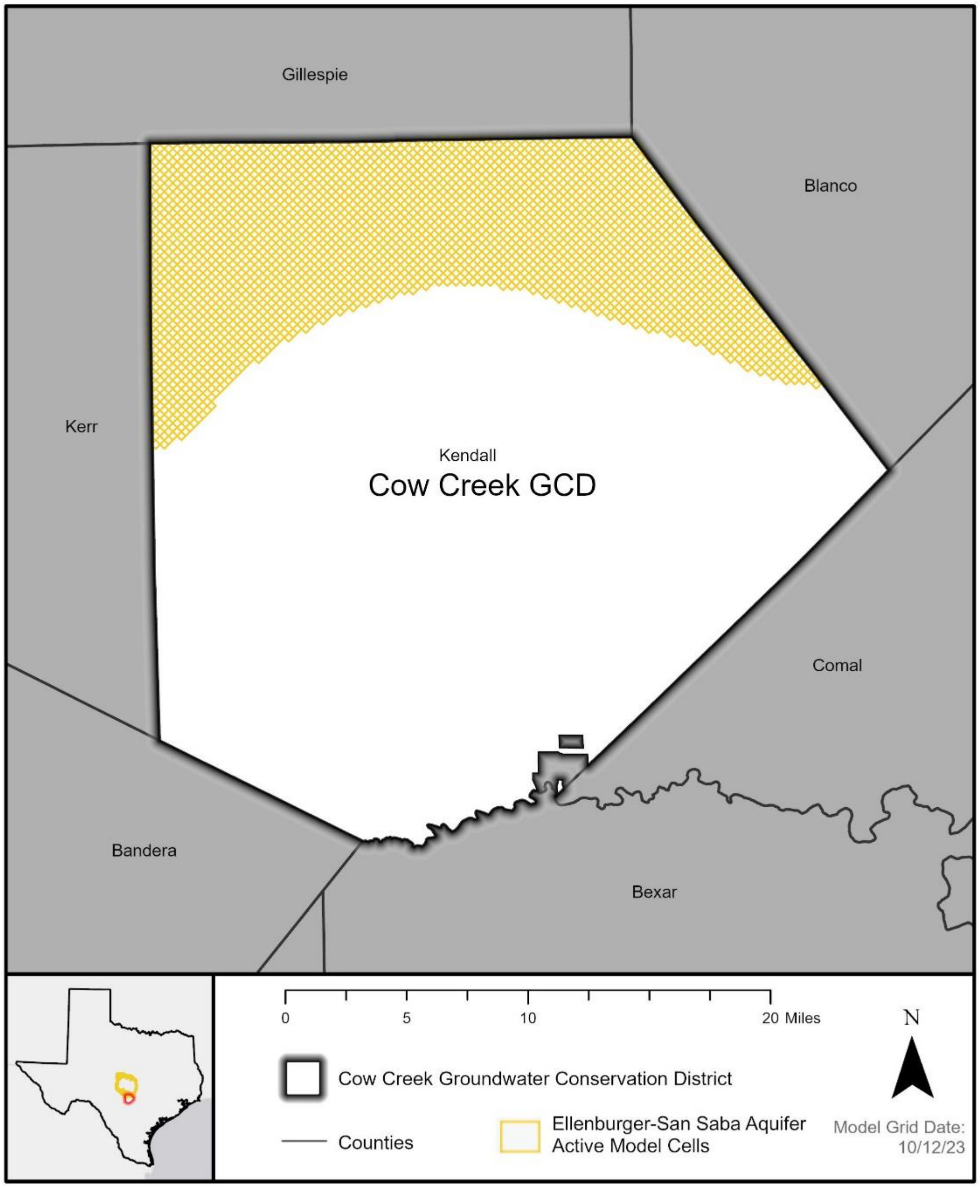
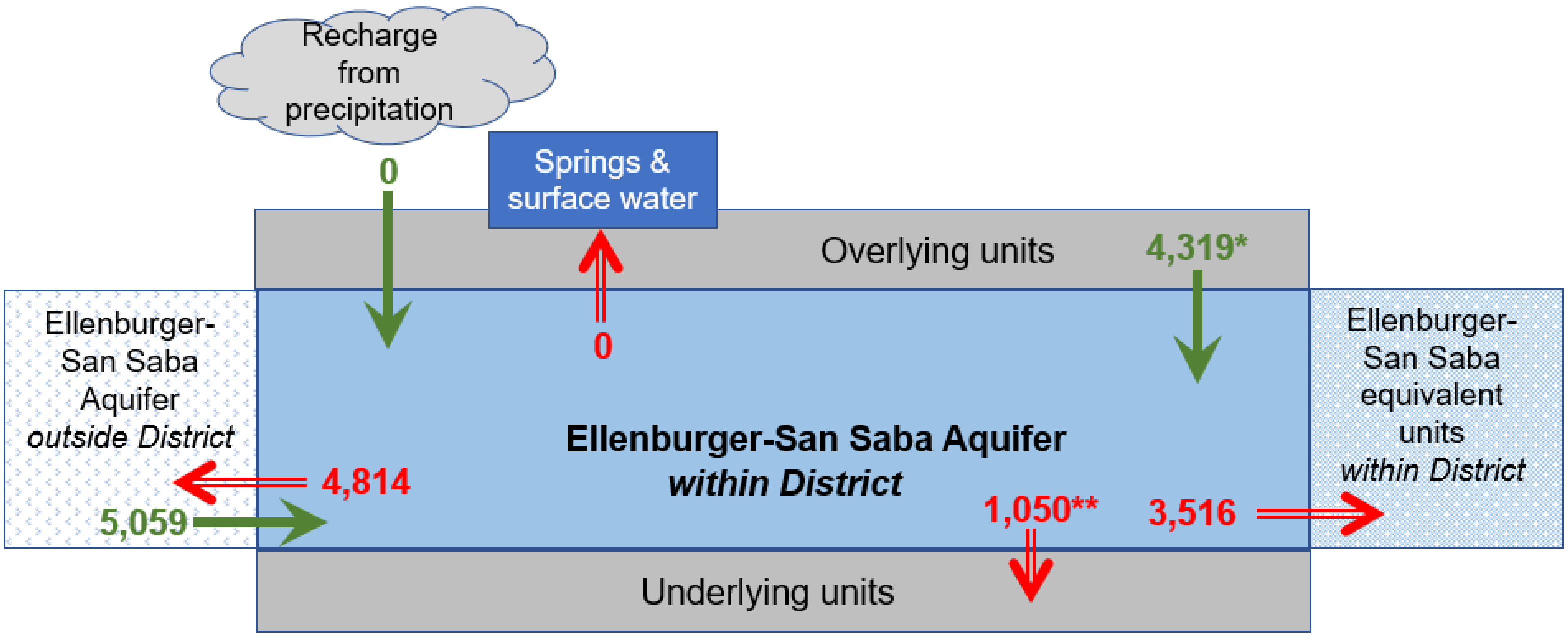



**Figure 5: Area of the groundwater availability model for the minor aquifers of the Llano Uplift from which the information in Table 3 was extracted (the Ellenburger-San Saba Aquifer extent within the district boundary).**




*Flow from overlying units includes net inflow of 4,742 acre-ft per year to the Ellenburger-San Saba Aquifer from Mississippian confining units, and net outflow of 17 acre-ft per year and 406 acre-ft per year to the Permian and Pennsylvanian confining units and Marble Falls Aquifer respectively from the Ellenburger-San Saba Aquifer.
**Flow to underlying units includes net outflow of 2,749 acre-ft per year to the Cambrian confining units from the Ellenburger-San Saba Aquifer and net inflow of 1,624 acre-ft per year and 75 acre-ft per year to the Ellenburger-San Saba Aquifer from the Hickory Aquifer and Precambrian confining units respectively.

*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 the Ellenburger-San Saba Aquifer within the Cow Creek Groundwater Conservation District. Flow values are expressed in acre-feet per year.**

**Table 4: Summarized information for the Hickory Aquifer. 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 | Hickory Aquifer | 0 |
| Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams and rivers | Hickory Aquifer | 0 |
| Estimated annual volume of flow into the district within each aquifer in the district | Hickory Aquifer | 2,699 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Hickory Aquifer | 2,066 |
| Estimated net annual volume of flow within each aquifer in the district | From Hickory Aquifer to overlying units* | 165 |
| | From Hickory Aquifer to Hickory equivalent units | 280 |
| | From Hickory Aquifer to Precambrian confining units | 208 |

*Please see Figure 8 for a breakdown of flows between individual overlying units.

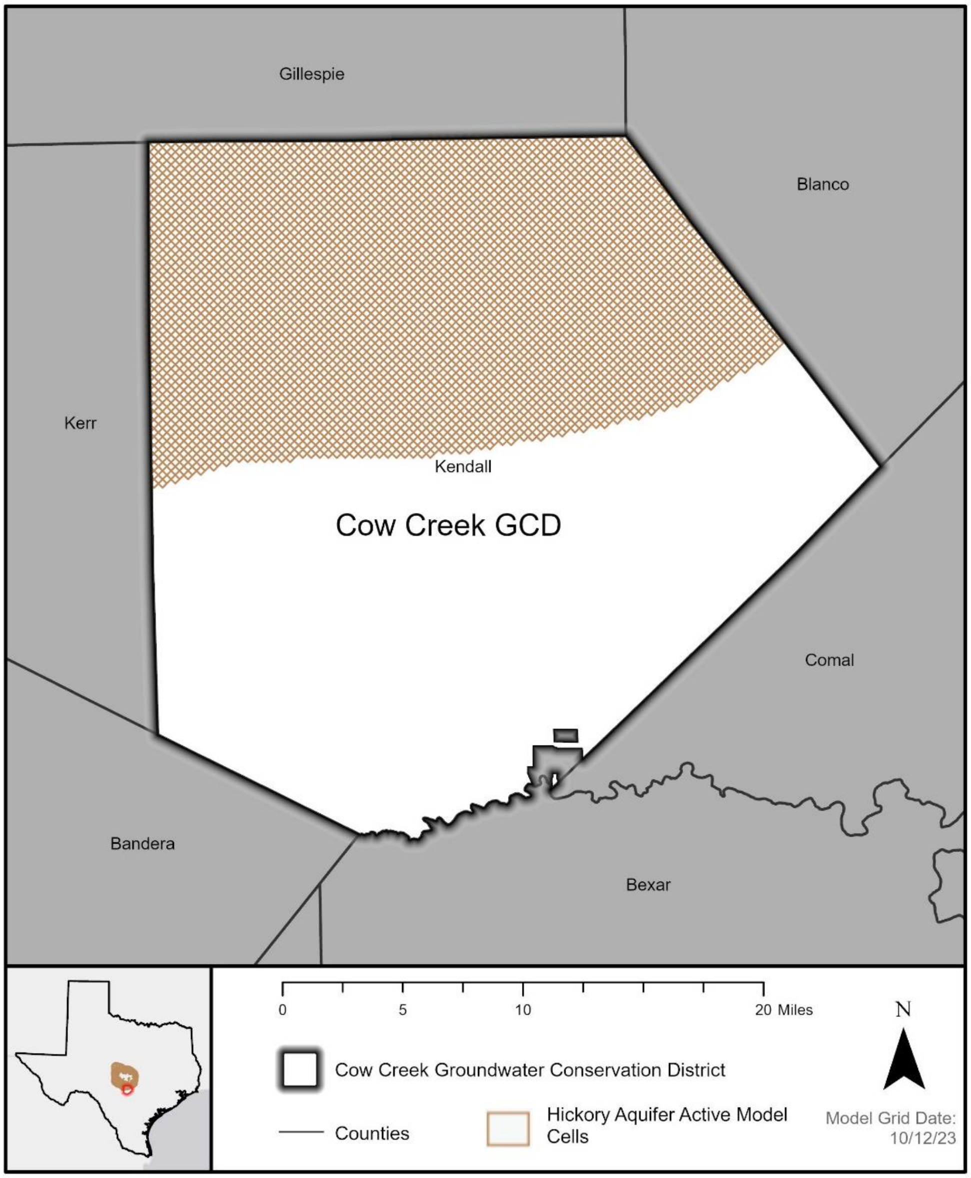
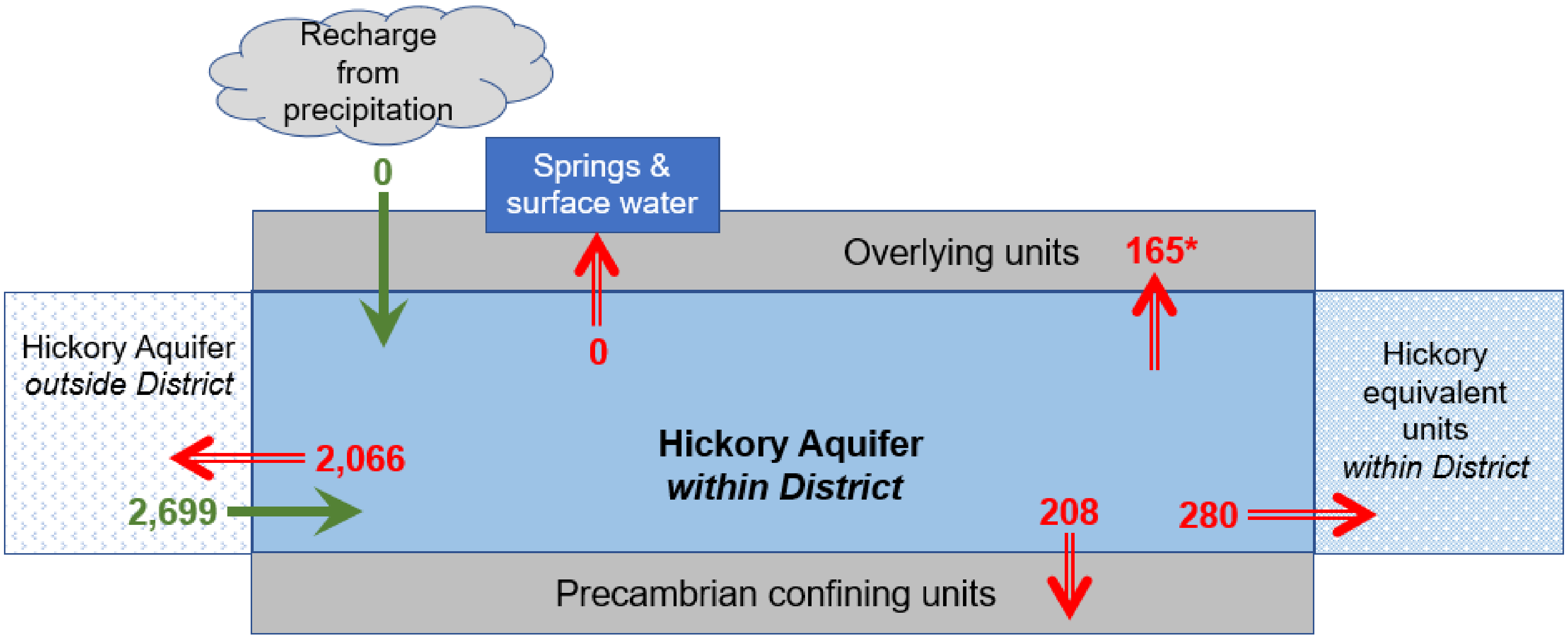



**Figure 7: Area of the groundwater availability model for the minor aquifers of the Llano Uplift from which the information in Table 4 was extracted (the Hickory Aquifer extent within the district boundary).**




*Flow from overlying units includes net outflow of 1,624 acre-ft per year and 1,289 acre-ft per year to the Ellenburger-San Saba Aquifer and Ellenburger-San Saba equivalent units respectively from the Hickory Aquifer, and net inflow of 2,748 acre-ft per year to the Hickory Aquifer from the Cambrian confining units.

*Caveat: This diagram only includes the water budget items provided in Table 4. 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 8: Generalized diagram of the summarized budget information from Table 4, representing directions of flow for the Hickory Aquifer within the Cow Creek 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 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 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 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

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., water.usgs.gov/software/MODFLOW-96/.

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., water.usgs.gov/nrp/gwsoftware/zonebud3/zonebudget3.html.

Jones, I.C., Anaya, R., and Wade, S.C., 2011, Groundwater Availability Model: Hill Country Portion of the Trinity Aquifer of Texas. Texas Water Development Board Report, 175 p., www.twdb.texas.gov/groundwater/models/gam/trnt_h/R377_HillCountryGAM.pdf

Jones, I., 2019, GAM Run 19-011: Texas Water Development Board, GAM Run 19-011 Report, 17 p., www.twdb.texas.gov/groundwater/docs/GAMruns/GR19-011.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., www.nap.edu/catalog/11972/models-in-environmental-regulatory-decision-making.

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Texas Water Code § 36.1071