Llano Estacado Underground Water Conservation District

Part 2 – Data Required for Management Plan GAM Run 25-003

TEXAS WATER DEVELOPMENT BOARD

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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 Llano Estacado Underground Water 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 19-017 (Denham and Wade, 2019). We used one groundwater availability model for the Llano Estacado Underground Water Conservation District. Information for the High Plains Aquifer System is from version 1.02 of the groundwater availability model for the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers (Cawthon and Wade, 2025; Deeds and Jigmond, 2015).

The groundwater management plan for the Llano Estacado Underground Water Conservation District should be adopted by the district on or before September 5, 2025, and submitted to the Executive Administrator of the TWDB on or before October 5, 2025. The current management plan for the Llano Estacado Underground Water Conservation District expires on December 4, 2025.

METHODS

In accordance with the provisions of the Texas Water Code § 36.1071 (h), the groundwater availability model mentioned above was used to estimate information for the Llano Estacado Underground Water 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 Llano Estacado Underground Water 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 High Plains Aquifer System for the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers

- Version 1.02 (Cawthon and Wade, 2025; Deeds and Jigmond, 2015)
- The model was run with MODFLOW-NWT (Niswonger and others, 2011).
- Water budgets were extracted for the historical calibration period (1980 through 2020) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model was used to analyze the following aquifers:
    - Ogallala Aquifer
    - Edwards Trinity (High Plains) Aquifer
    - Dockum 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 Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers located within Llano Estacado Underground Water 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 3. Figures 1, 3, and 5 show the area of the model from which the values in Tables 1 through 3 were extracted. Figures 2, 4, and 6 provide a generalized diagram of the groundwater flow components provided in Tables 1 through 3.

Table 1: Summarized information for the Dockum 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	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	4
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	8
Estimated net annual volume of flow between each aquifer in the district	From Dockum Aquifer to Edwards-Trinity (High Plains) Aquifer	1,287
	From Dockum Aquifer to Ogallala Aquifer	652
	To Dockum Aquifer from Dockum equivalent units	3
	To Dockum Aquifer from Dockum equivalent units in New Mexico	12

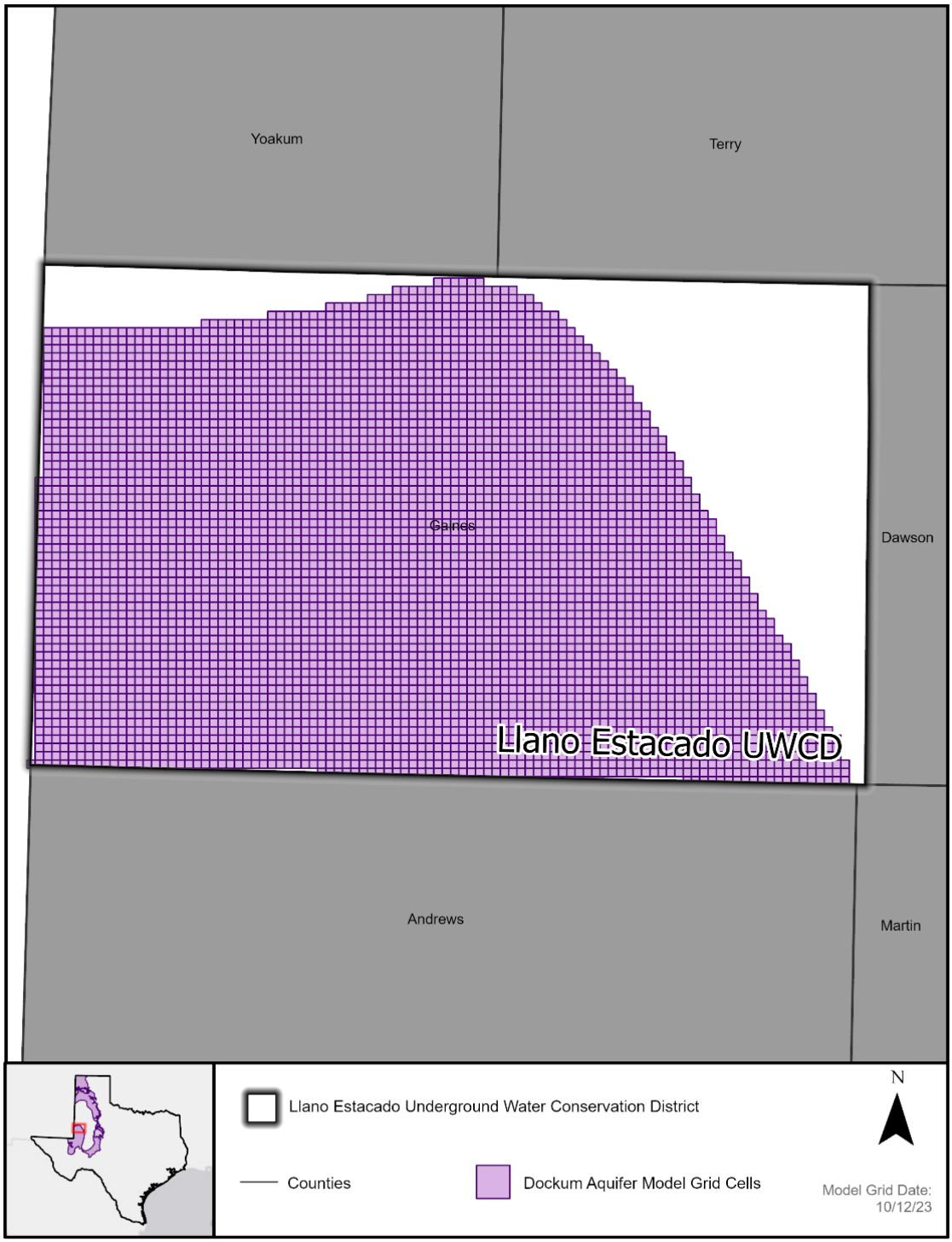
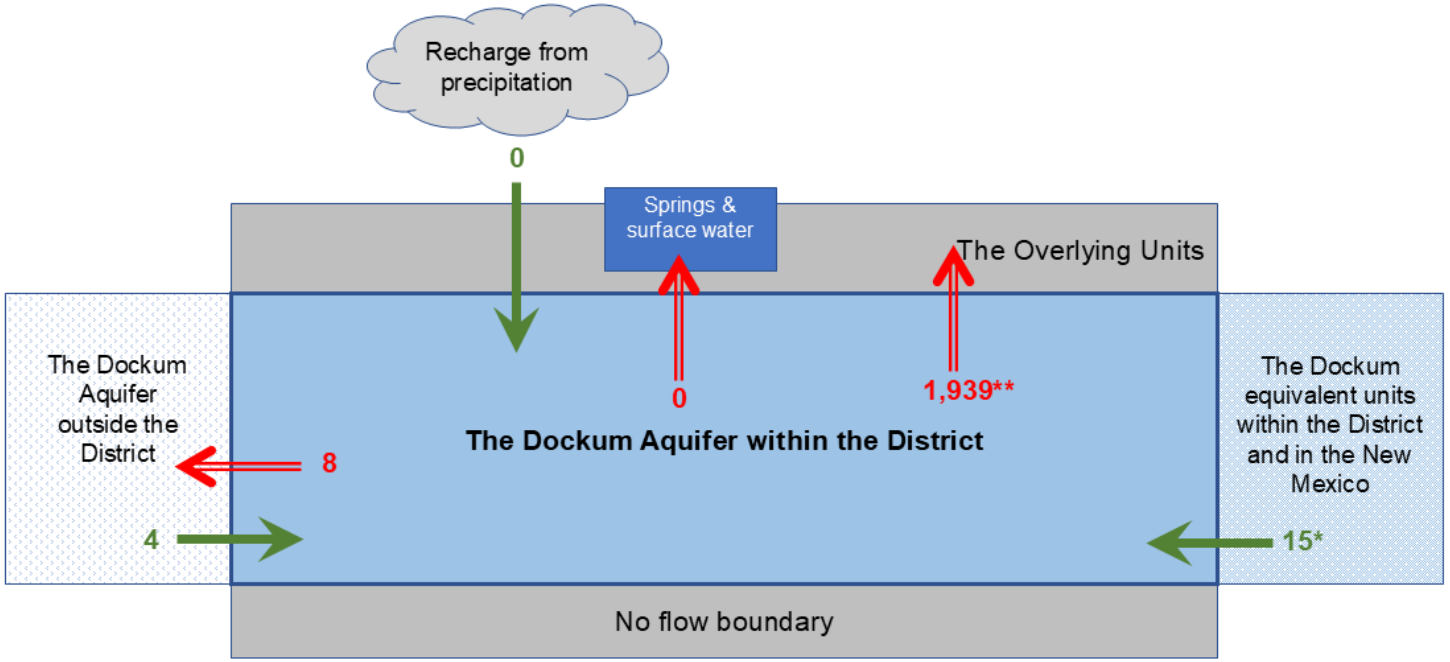


Figure 1: Area of the groundwater availability model for the Dockum Aquifer from which the information in Table 1 was extracted (the Dockum Aquifer extent within the district boundary).



* Flow from the Dockum equivalent units to the Dockum Aquifer within the District includes net inflow of 13 acre-feet per year from the New Mexico and 2 acre-feet per year from the brackish portion of the Dockum group to the Dockum Aquifer within the District

** Flow from the Dockum Aquifer within the District to the Overlying Units includes 1,287 acre-feet per year to the Edwards-Trinity (High Plains) Aquifer and 652 acre-feet per year to the Ogallala Aquifer

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

Table 2: Summarized information for the Edwards-Trinity (High Plains) 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 (High Plains) Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Edwards-Trinity (High Plains) Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (High Plains) Aquifer	6,493
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (High Plains) Aquifer	404
Estimated net annual volume of flow between each aquifer in the district	To Edwards-Trinity (High Plains) Aquifer from Ogallala Aquifer	4,000
	To Edwards-Trinity (High Plains) Aquifer from Dockum Aquifer	1,287
	To Edwards-Trinity (High Plains) Aquifer from Edwards-Trinity (High Plains) equivalent units in New Mexico	13

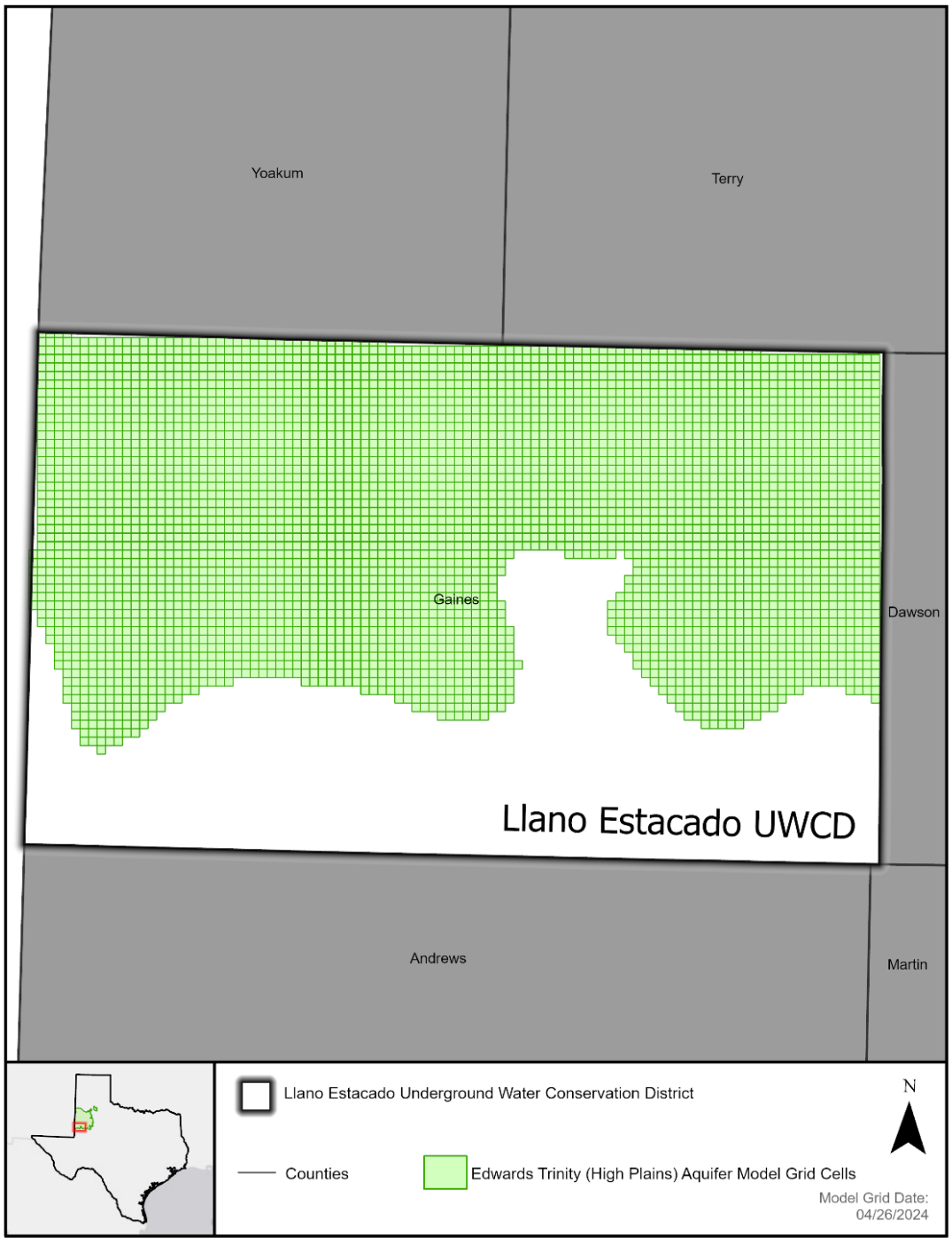
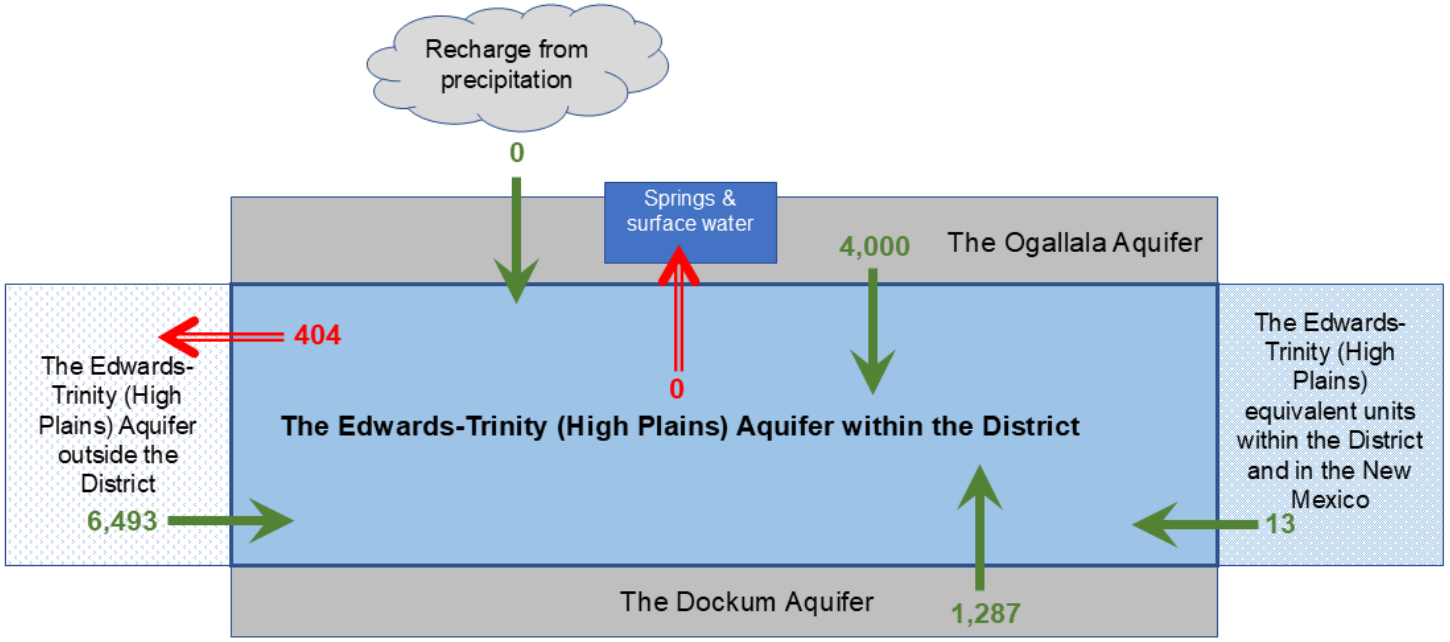


Figure 3: Area of the groundwater availability model for the Edwards-Trinity (High Plains) Aquifer from which the information in Table 2 was extracted (the Edwards-Trinity (High Plains) Aquifer extent within the district boundary).



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 (High Plains) Aquifer within the Llano Estacado Underground Water Conservation District. Flow values are expressed in acre-feet per year.

Table 3: Summarized information for the Ogallala 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	Ogallala Aquifer	68,754
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ogallala Aquifer	2,164
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	8,292
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	2,138
Estimated net annual volume of flow between each aquifer in the district	From Ogallala Aquifer to Edwards-Trinity (High Plains) Aquifer and other underlying formations	2,306*
	To Ogallala Aquifer from Ogallala equivalent units in New Mexico	948

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

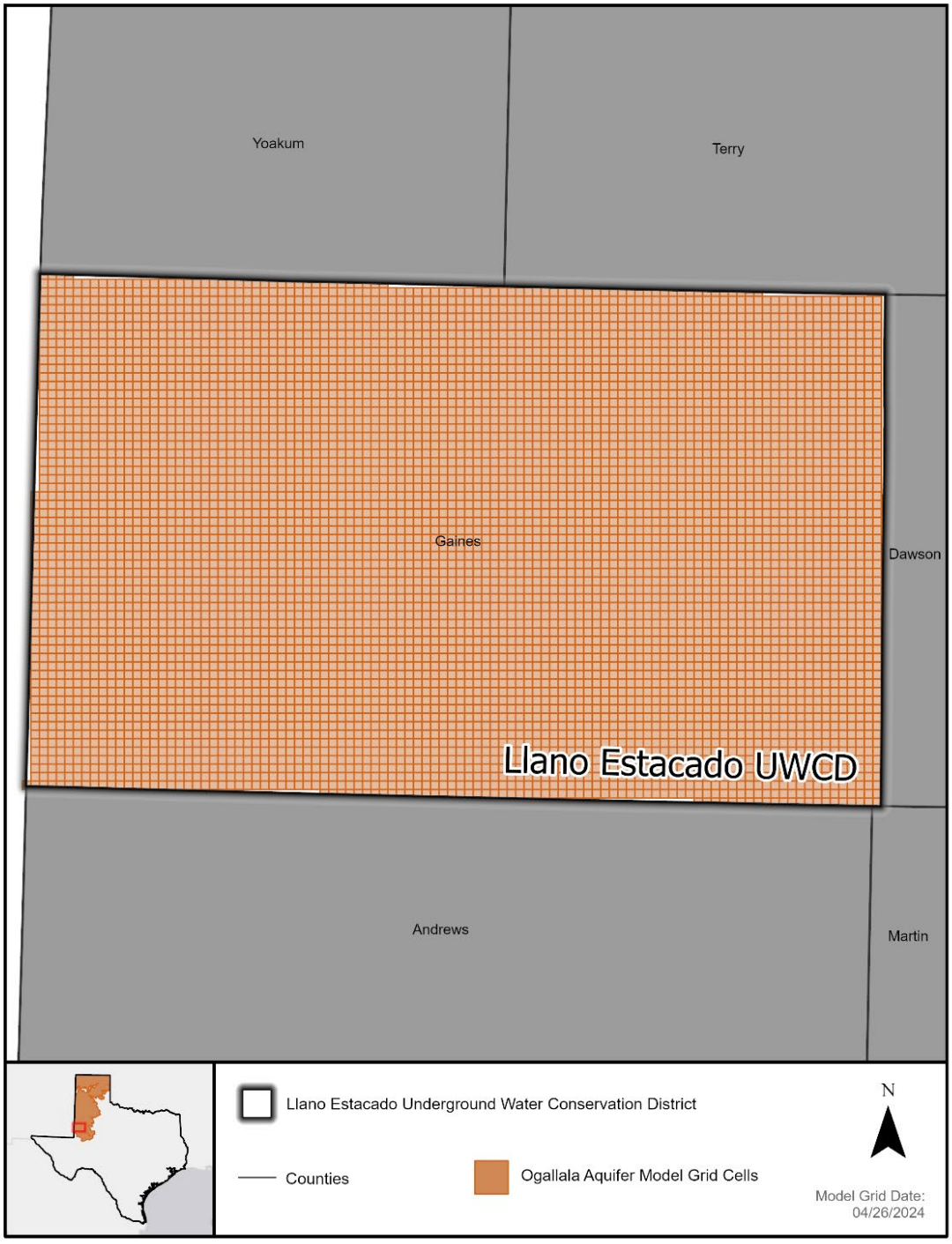
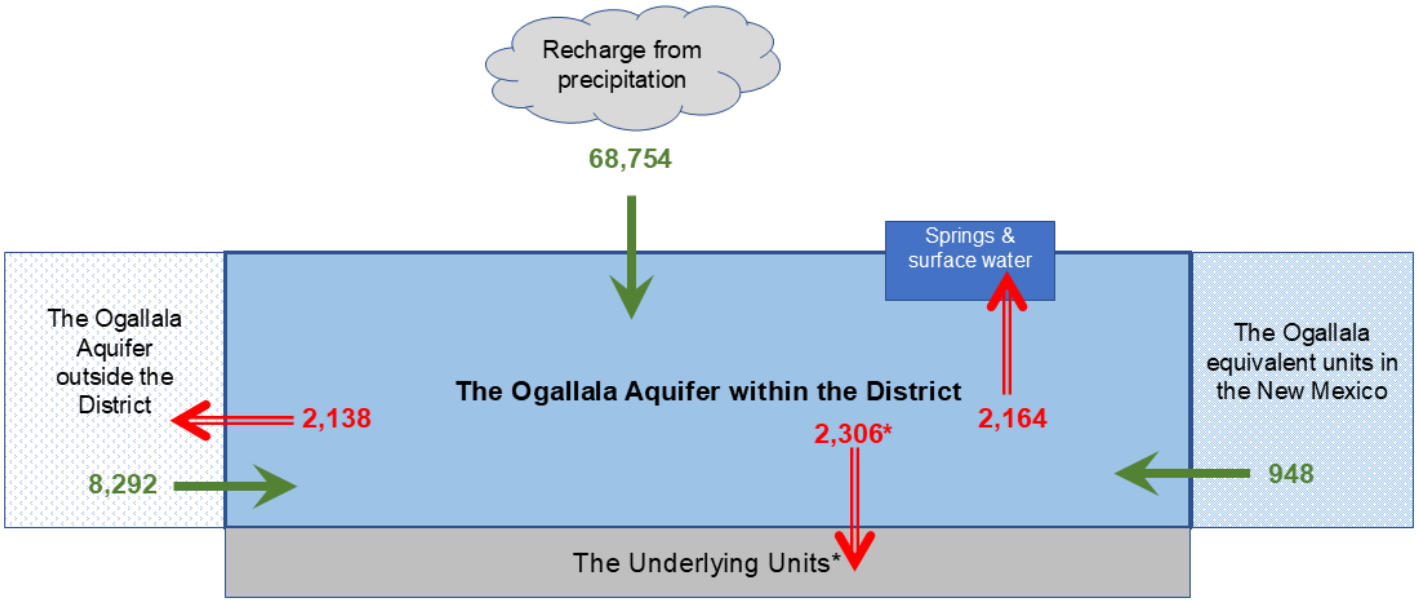


Figure 5: Area of the groundwater availability model for the Ogallala Aquifer from which the information in Table 3 was extracted (the Ogallala Aquifer extent within the district boundary).



* Flow from the underlying units includes net outflow of 18,573 acre-feet per year from the Ogallala Aquifer to the Edwards-Trinity (High Plains) Aquifer and net inflow of 16,267 acre-feet per year to the Ogallala Aquifer from the underlying units.

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 6: Generalized diagram of the summarized budget information from Table 3, representing directions of flow for the Ogallala Aquifer within the Llano Estacado Underground Water Conservation District. Flow values are expressed in acre-feet per year.

LIMITATIONS

The groundwater model 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 a 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 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 groundwater models 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

Cawthon, T., and Wade, S., 2025, Extension of the Groundwater Availability Model for the High Plains Aquifer System through 2020 (version 1.02),1187 p., https://gw-models.s3.amazonaws.com/Download_GAMs/hpas/hpas_report_final_June2025.pdf?d=18959.299999952316

Deeds, N.E., and Jigmond, M., 2015, Numerical model report for the High Plains Aquifer System groundwater availability model, 640 p., www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf

Denham, A., and Wade, S. 2019, GAM Run 19-017: Texas Water Development Board, GAM Run 19-017 Report, 14 p., www.twdb.texas.gov/groundwater/docs/GAMruns/GR19-017.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., water.usgs.gov/nrp/gwsoftware/zonebud3/zonebudget3.html

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.

Niswonger, R. G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, A Newtonian formulation for MODFLOW-2005: U.S. Geological Survey Survey Techniques and Methods 6-A37, 44 p.

Texas Water Code § 36.1071