GAM Run 21-005: Central Texas Groundwater Conservation District Management Plan

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October 8, 2021

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EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (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 Central Texas 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 Central Texas Groundwater Conservation District should be adopted by the district on or before March 1, 2022 and submitted to the executive administrator of the TWDB on or before March 31, 2022. The current management plan for the Central Texas Groundwater Conservation District expires on May 30, 2022.

We used two groundwater availability models to estimate the management plan information for the aquifers within the Central Texas Groundwater Conservation District. Information for the Hickory, Ellenburger-San Saba, and Marble Falls aquifers is from version 1.01 of the groundwater availability model for the minor aquifers of the Llano Uplift area (Shi and others, 2016a and b). Information for the Trinity Aquifer is from version 2.01 of the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (Kelley and others, 2014). This report replaces the results of GAM Run 16-006 (Shi, 2016), as the approach used for analyzing model results has been since refined to more accurately delineate flows between hydraulically connected units and because of updates to the spatial grid file used to define county, groundwater conservation district, and aquifer boundaries. In addition, this analysis includes results from the final groundwater availability model for the minor aquifers of the Llano Uplift area, whereas only the draft model was available at the time of publication for GAM Run 16-006. Tables 1 through 4 summarize the groundwater availability model data required by statute. Figures 1, 3, 5, and 7 show the area of the models from which the values in the tables were extracted. Figures 2, 4, 6, and 8 provide generalized diagrams of the groundwater flow components provided in Tables 1 through 4. If, after review of the figures, the Central Texas 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.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability models mentioned above were used to estimate information for the Central Texas Groundwater Conservation District management plan. Water budgets were extracted for the historical model period for the Hickory, Ellenburger-San Saba, and Marble Falls aquifers (1981-2010) using ZONEBUDGET USG Version 1.00 (Panday and others, 2013). Water budgets were extracted for the historical model period for the Trinity Aquifer (1980-2012) 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:

Hickory, Ellenburger-San Saba, and Marble Falls aquifers

- We used version 1.01 of the groundwater availability model for the minor aquifers in the Llano Uplift Region to analyze the Hickory, Ellenburger-San Saba, and Marble Falls aquifers. See Shi and others (2016a and b) for assumptions and limitations of the model.
- The groundwater availability model for the minor aquifers in the Llano Uplift Region contains eight layers (from top to bottom):
  - Layer 1 — Cretaceous age and younger water-bearing units
  - Layer 2 — Permian and Pennsylvanian age confining units
  - Layer 3 — the Marble Falls Aquifer and equivalent
  - Layer 4 — Mississippian age confining units
  - Layer 5 — the Ellenburger-San Saba Aquifer and equivalent
  - Layer 6 — Cambrian age confining units
  - Layer 7 — the Hickory Aquifer and equivalent, and
  - Layer 8 — Precambrian age confining units
- Individual water budgets for the district were determined for the Marble Falls (Layer 3), Ellenburger-San Saba Aquifer (Layer 5) and the Hickory Aquifer (Layer 7).
- Water budget terms were averaged for the period 1981 to 2010 (stress periods 2 through 31)
- The model was run with MODFLOW-USG (Panday and others, 2013).

Trinity Aquifer

- We used version 2.01 of the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers. See Kelley and others (2014) for assumptions and limitations of the model.
- The groundwater availability model for the northern portion of the Trinity and Woodbine aquifers contains eight layers that generally represent the following: Layer 1 (the surficial outcrop area of the units in layers 2 through 8 and units younger than Woodbine Aquifer), Layer 2 (Woodbine Aquifer), Layer 3 (Washita and Fredericksburg Groups, and the Edwards (Balcones Fault Zone) Aquifer), and Layers 4 through 8 (Trinity Aquifer). Layers 2 through 7 also include pass-through cells. The Woodbine and Edwards (Balcones Fault Zone) aquifers are not located within the Central Texas Groundwater Conservation District.
- Perennial rivers and reservoirs were simulated using the MODFLOW River package. Ephemeral streams, flowing wells, springs, and evapotranspiration in riparian zones along perennial rivers were simulated using the MODFLOW Drain package. Groundwater discharge to surface water bodies in the district was the sum of groundwater discharge from the MODFLOW river and drain packages minus the riparian zone evapotranspiration discharge and minus flowing well discharge.
- The model was run using MODFLOW-NWT (Niswonger and others, 2011).

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 Hickory, Ellenburger-San Saba, Marble Falls, and Trinity aquifers located within the Central Texas 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 HICKORY AQUIFER THAT IS NEEDED FOR THE CENTRAL TEXAS 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	Hickory Aquifer	332
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Hickory Aquifer	3,301
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	7,873
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	6,337
Estimated net annual volume of flow between each aquifer in the district	From the Hickory Aquifer to equivalent units outside the official Hickory Aquifer extent	2,882
	From the Hickory Aquifer to the Cretaceous units (including the Trinity Aquifer)	1
	From the Hickory Aquifer to the Ellenburger-San Saba Aquifer	7,631
	Into the Hickory Aquifer from the Cambrian age confining unit	20,382
	From the Hickory Aquifer to the Precambrian age confining unit	5,061

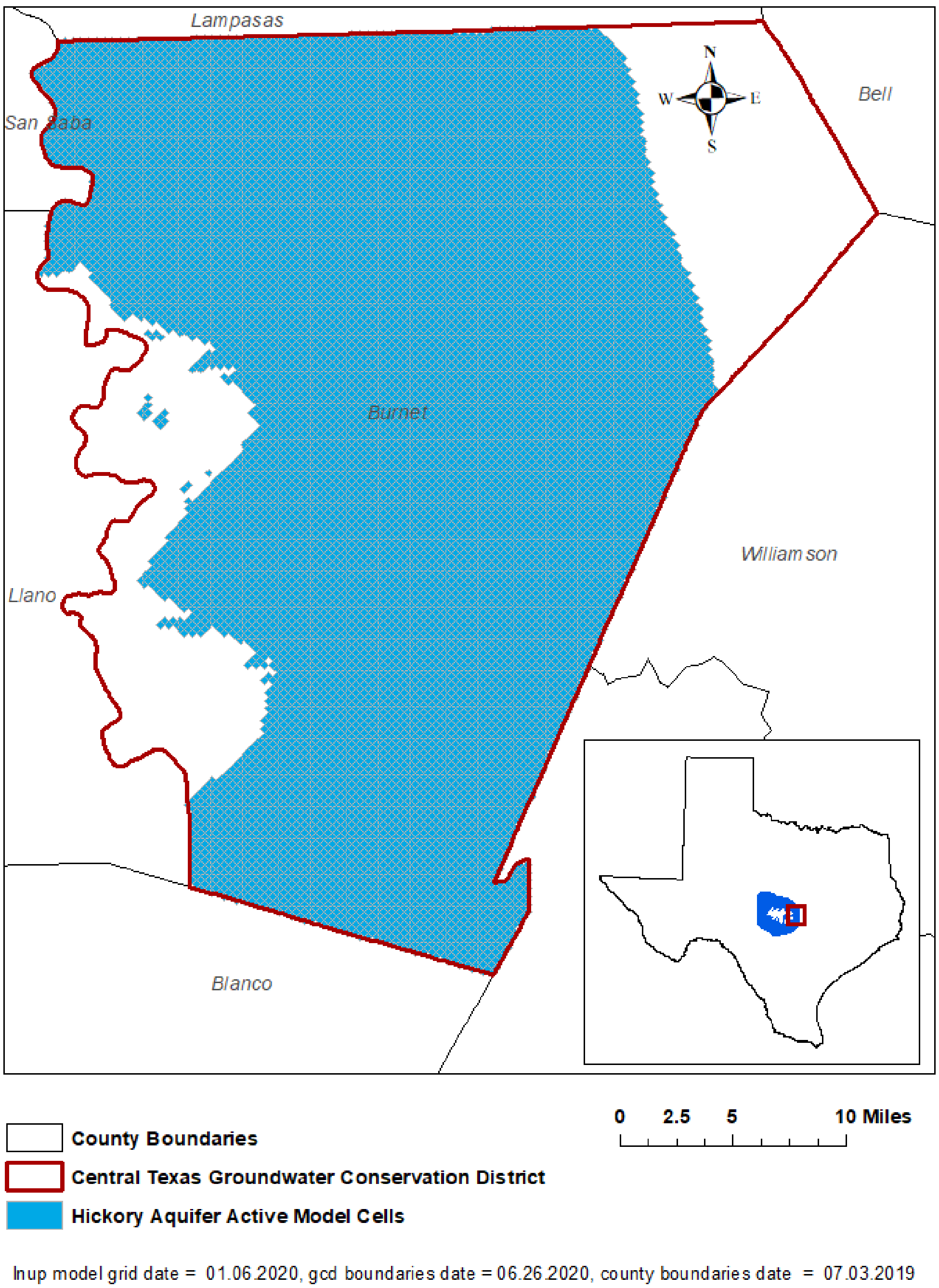
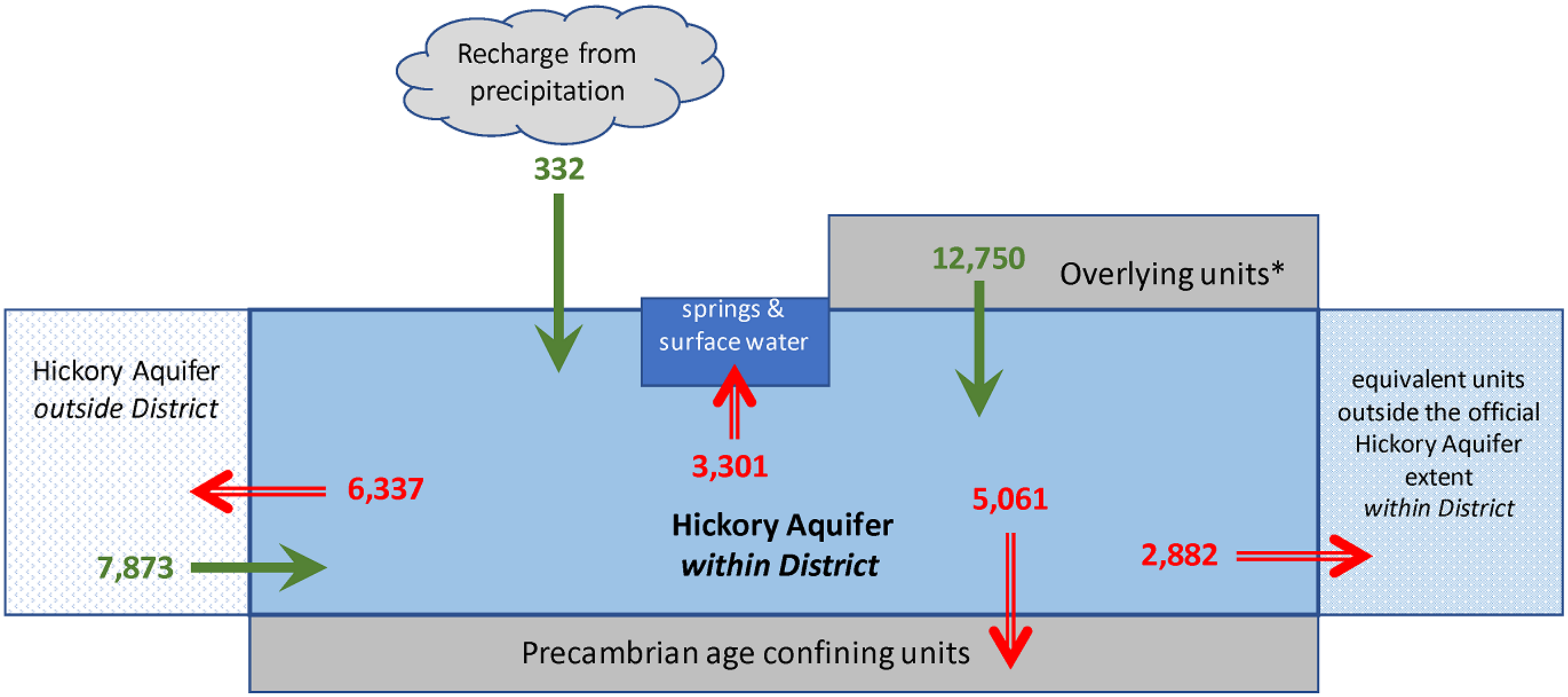


FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS IN THE LLANO UPLIFT REGION FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE HICKORY AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).



* Flow from overlying units includes net outflow of 1 acre-feet per year to Cretaceous age units, 7,631 acre-feet per year net outflow to the Ellenburger-San Saba Aquifer and 20,382 acre-feet per year net inflow from the Cambrian age confining units.

Caveat: This diagram only includes the water budget items provided in Table 1. A complete water budget would include additional inflows and outflows. If the District requires values for additional water budget items, please contact TWDB.

FIGURE 2: GENERALIZED DIAGRAM OF THE SUMMARIZED BUDGET INFORMATION FROM TABLE 1, REPRESENTING DIRECTIONS OF FLOW FOR THE HICKORY AQUIFER WITHIN CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT. FLOW VALUES EXPRESSED IN ACRE-FEET PER YEAR.

TABLE 2: SUMMARIZED INFORMATION FOR THE ELLENBURGER-SAN SABA AQUIFER THAT IS NEEDED FOR THE CENTRAL TEXAS 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	Ellenburger-San Saba Aquifer	68,867
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	68,060
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	19,920
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	8,250
Estimated net annual volume of flow between each aquifer in the district	From the Ellenburger-San Saba Aquifer to equivalent units outside the official Ellenburger-San Saba Aquifer extent	6,673
	Into the Ellenburger-San Saba Aquifer from Cretaceous units (including Trinity Aquifer)	265
	From the Ellenburger-San Saba Aquifer to the Marble Falls Aquifer	1,165
	From the Ellenburger-San Saba Aquifer to the Mississippian age confining unit	9,601
	From the Ellenburger-San Saba Aquifer to Cambrian age confining units	27,146
	Into the Ellenburger-San Saba Aquifer from the Hickory Aquifer	7,631
	Into the Ellenburger-San Saba Aquifer from the Precambrian age confining unit	670

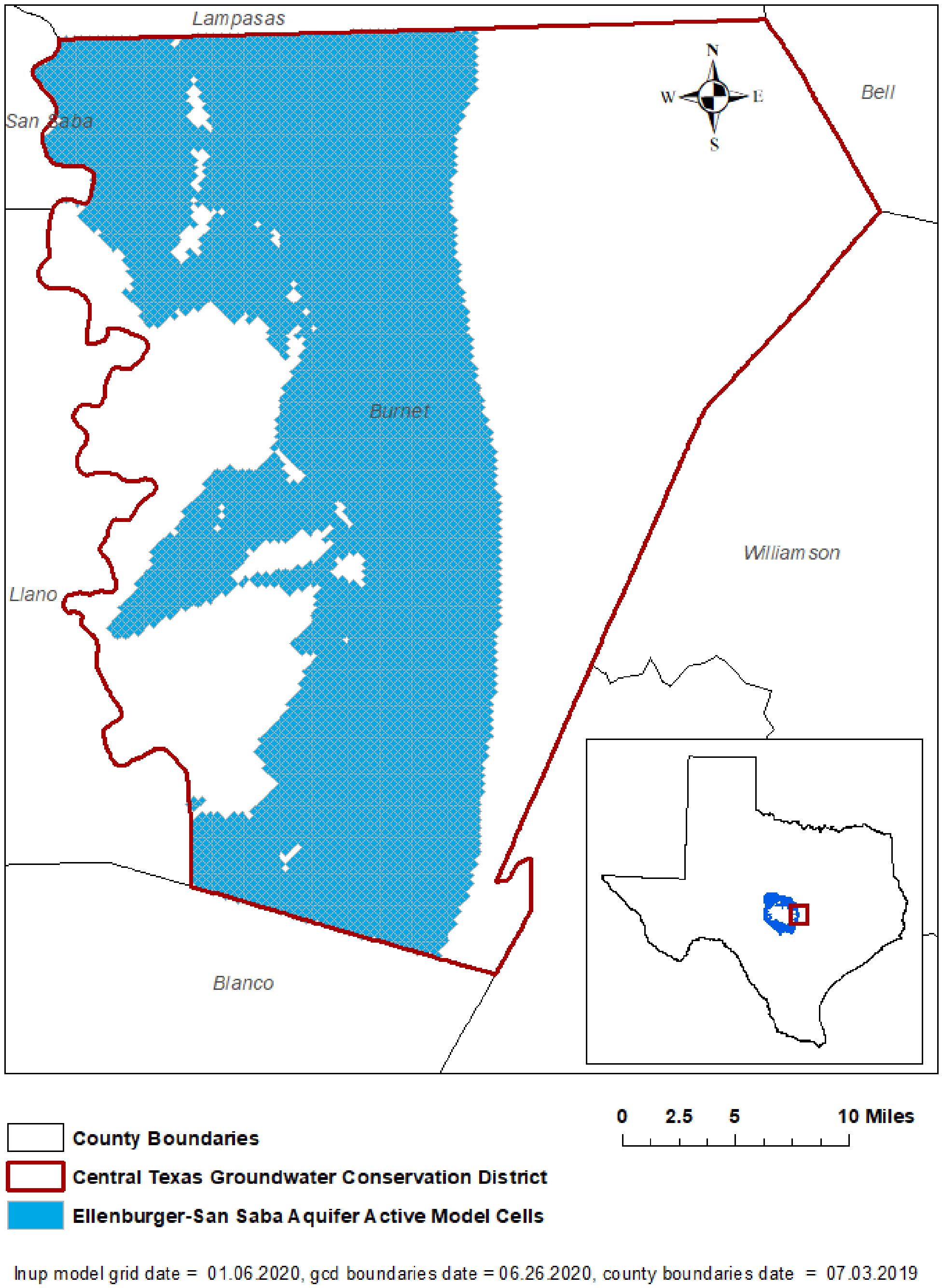
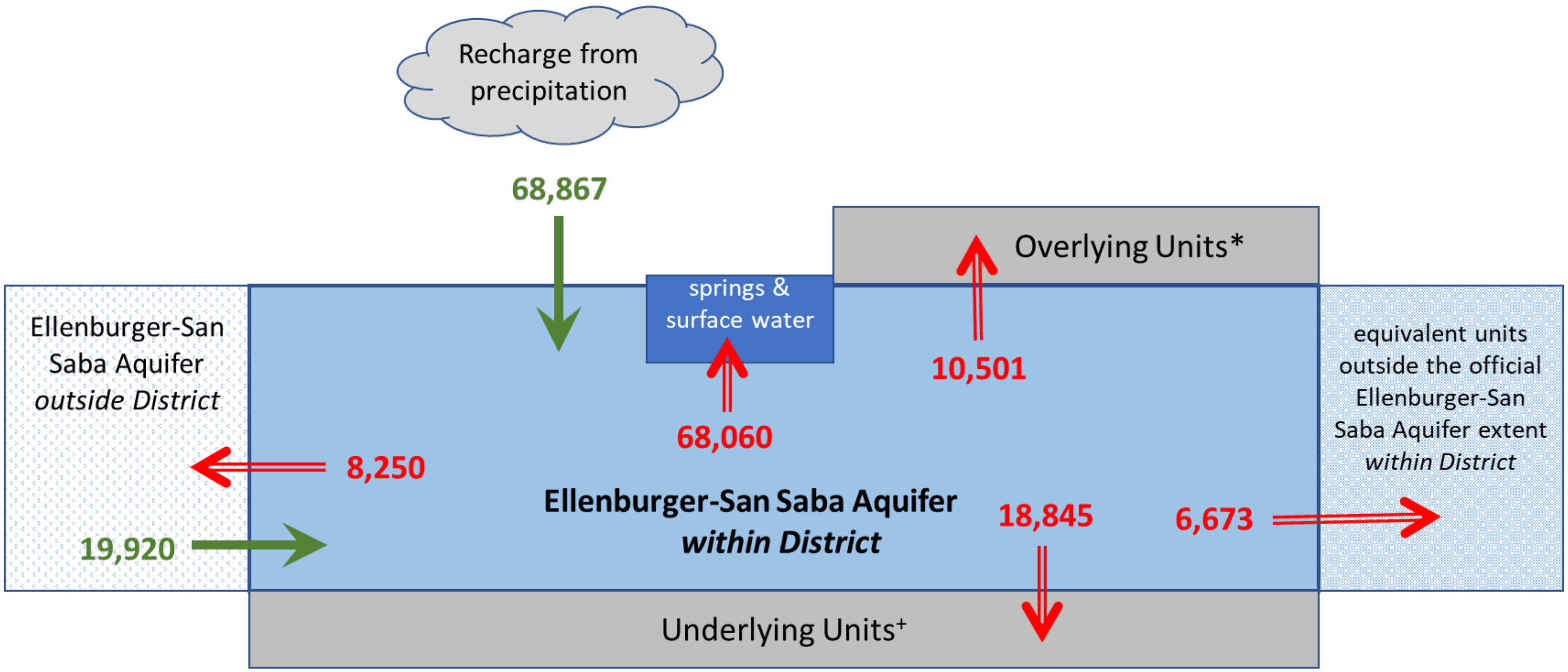


FIGURE 3: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS IN THE LLANO UPLIFT REGION FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE ELLENBURGER-SAN SABA AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).



+ Flow into underlying units includes net outflow of 27,146 acre-feet per year to Cambrian age confining units, 7,631 acre-feet per year net inflow from the Hickory Aquifer, and 670 acre-feet per year net inflow from the Precambrian age confining units.

* Flow into overlying units includes net inflow of 265 acre-feet per year from Cretaceous age unit, 1,165 acre-feet per year net outflow to the Marble Falls Aquifer, and 9,601 acre-feet per year net outflow to the Mississippian age confining units.

Caveat: This diagram only includes the water budget items provided in Table 2. A complete water budget would include additional inflows and outflows. If the District requires values for additional water budget items, please contact TWDB.

FIGURE 4: GENERALIZED DIAGRAM OF THE SUMMARIZED BUDGET INFORMATION FROM TABLE 2, REPRESENTING DIRECTIONS OF FLOW FOR THE ELLENBURGER-SAN SABA AQUIFER WITHIN CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT. FLOW VALUES EXPRESSED IN ACRE-FEET PER YEAR.

TABLE 3: SUMMARIZED INFORMATION FOR THE MARBLE FALLS AQUIFER THAT IS NEEDED FOR THE CENTRAL TEXAS 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	Marble Falls Aquifer	2,181
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Marble Falls Aquifer	10,772
Estimated annual volume of flow into the district within each aquifer in the district	Marble Falls Aquifer	10
Estimated annual volume of flow out of the district within each aquifer in the district	Marble Falls Aquifer	60
Estimated net annual volume of flow between each aquifer in the district	Into the Marble Falls Aquifer from equivalent units outside the official Marble Falls Aquifer extent	2,153
	Into the Marble Falls Aquifer from the Cretaceous units (including Trinity Aquifer)	16
	From the Marbles Falls Aquifer to the Pennsylvanian and Permian age confining units	284
	From the Marble Falls Aquifer to the Mississippian Age confining units	1,941
	Into the Marble Falls Aquifer from the Ellenburger-San Saba Aquifer	1,165

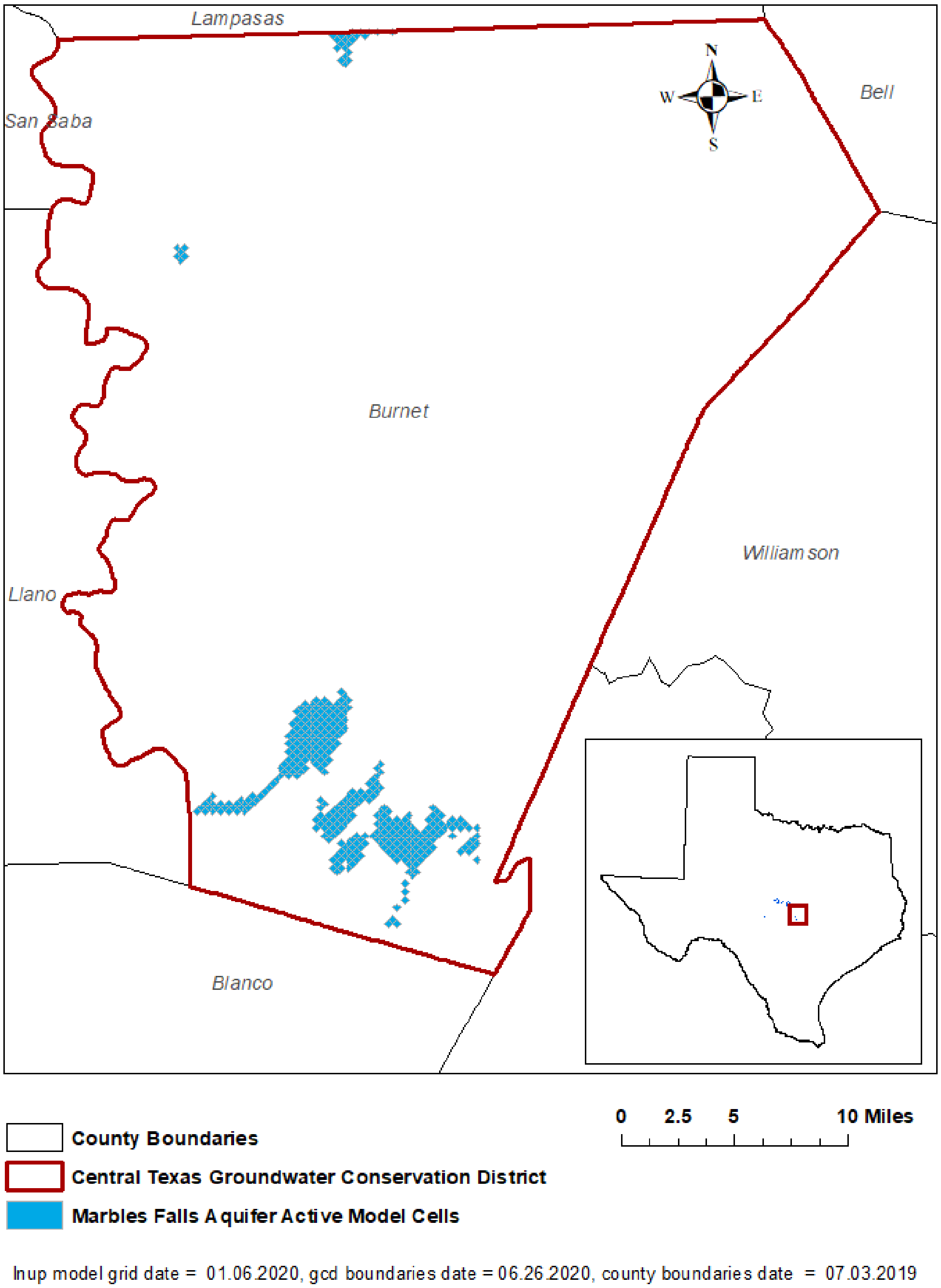
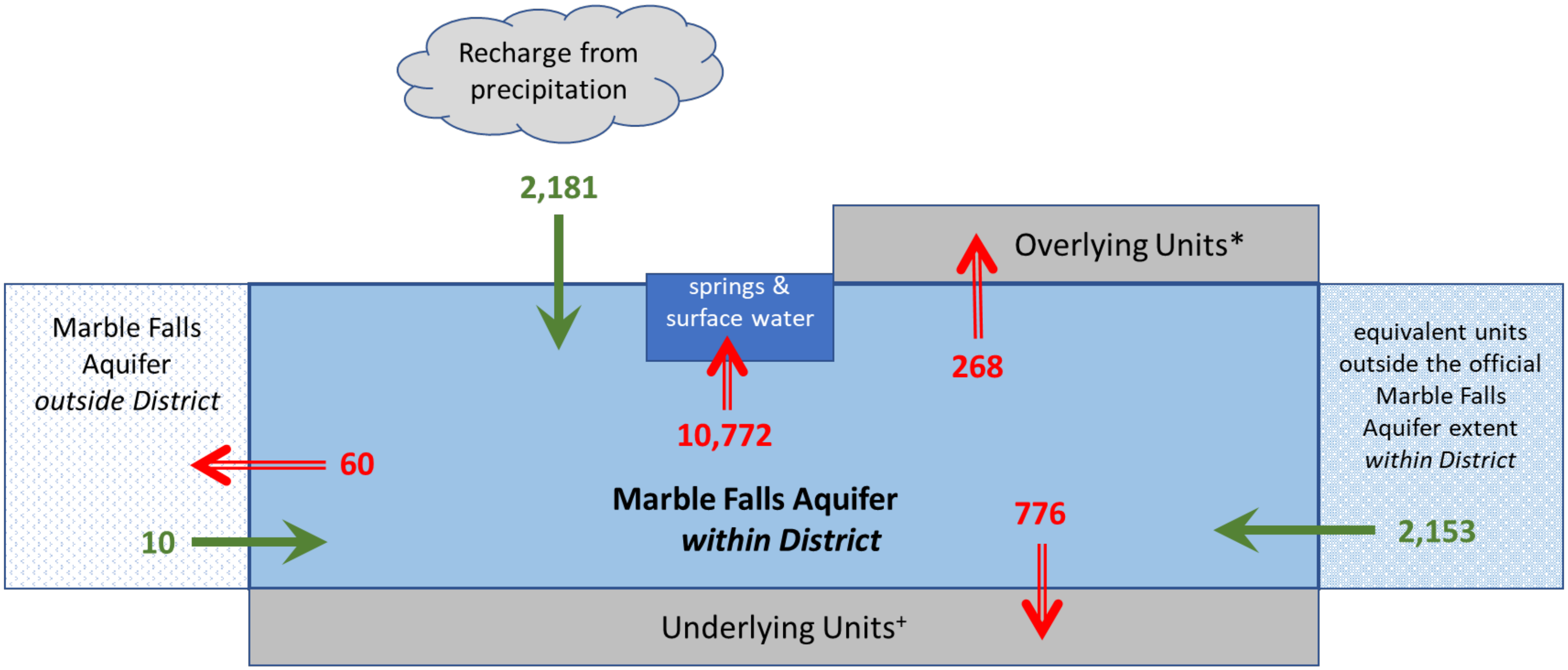


FIGURE 5: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS IN THE LLANO UPLIFT REGION FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE MARBLE FALLS AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).



+ Flow into underlying units includes net outflow of 1,941 acre-feet per year to Mississippian age confining units and 1,165 acre-feet per year net inflow from Ellenburger-San Saba Aquifer.

* Flow into overlying units includes net inflow of 16 acre-feet per year from Cretaceous units and 284 acre-feet per year net outflow to Pennsylvanian and Permian age confining units.

Caveat: This diagram only includes the water budget items provided in Table 3. A complete water budget would include additional inflows and outflows. If the District requires values for additional water budget items, please contact TWDB.

FIGURE 6: GENERALIZED DIAGRAM OF THE SUMMARIZED BUDGET INFORMATION FROM TABLE 3, REPRESENTING DIRECTIONS OF FLOW FOR THE MARBLE FALLS AQUIFER WITHIN CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT. FLOW VALUES EXPRESSED IN ACRE-FEET PER YEAR.

TABLE 4: SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER THAT IS NEEDED FOR THE CENTRAL TEXAS 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	Trinity Aquifer	13,831
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers.	Trinity Aquifer	13,729
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	2,947
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	12,339
Estimated net annual volume of flow between each aquifer in the district	Into the Trinity Aquifer from younger overlying Washita and Fredericksburg Confining Units	8,034
	From the Trinity Aquifer into underlying Paleozoic Aquifers[1]	263
	From the Trinity Aquifer to underlying Pennsylvanian and Permian age confining units[1]	20,443

[1] Flow from the Trinity Aquifer to underlying units is based on the Groundwater Availability Model for the Minor Aquifers of the Llano Uplift Region of Texas.

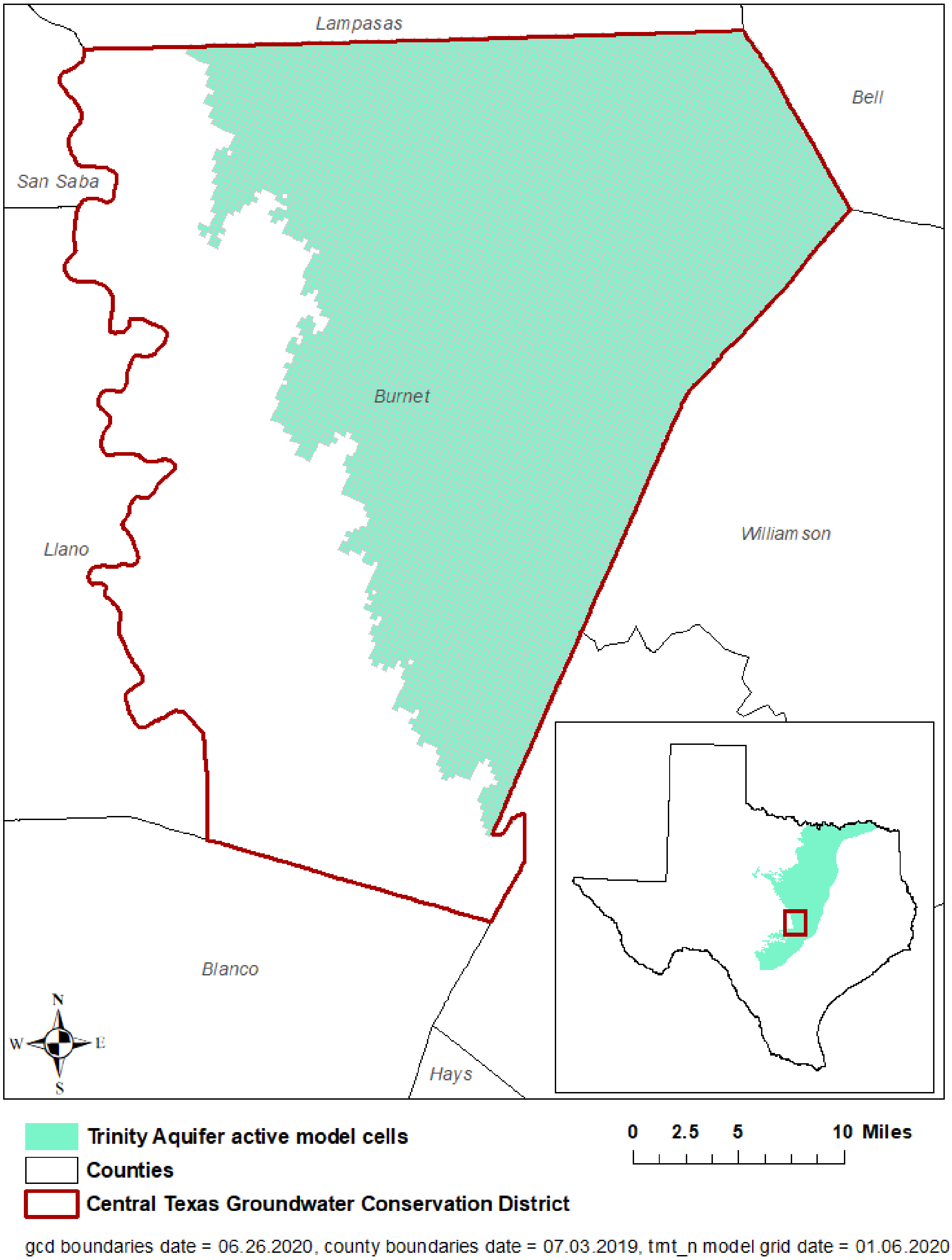
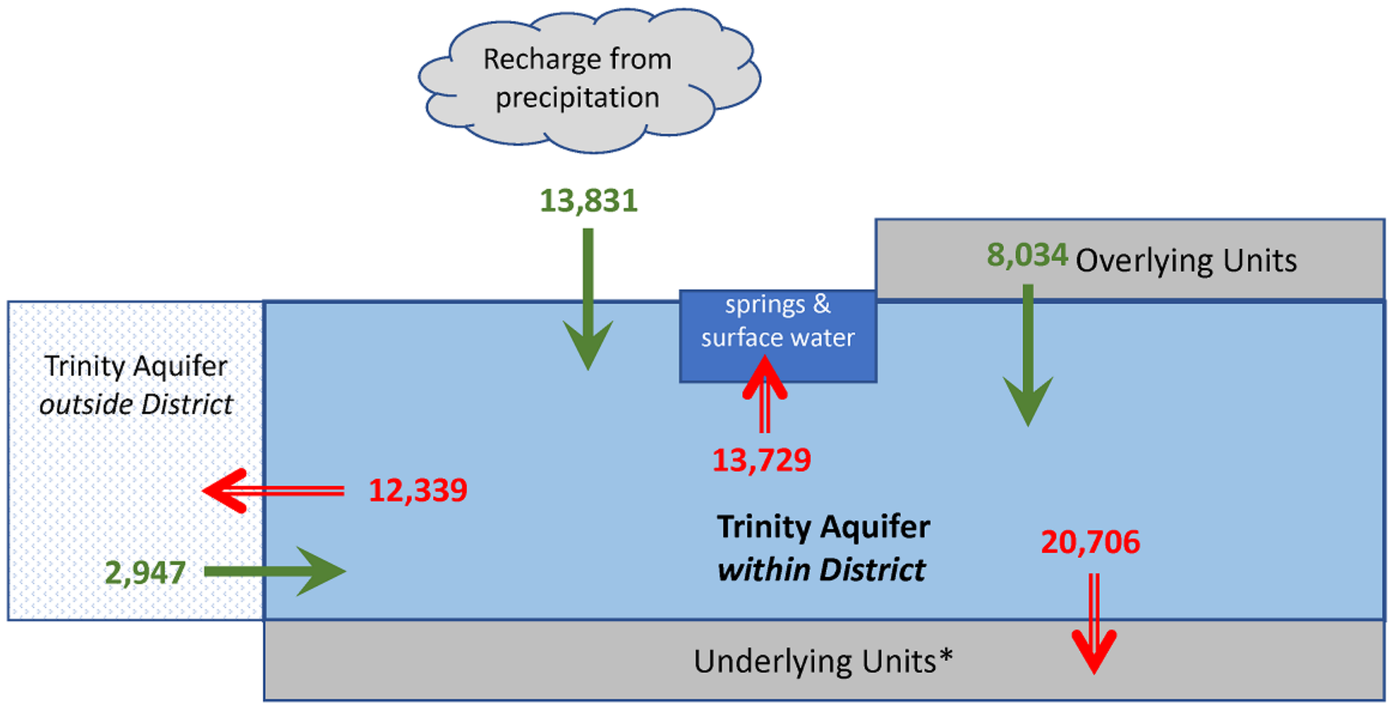


FIGURE 7: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE TRINITY AND WOODBINE AQUIFERS FROM WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED (THE TRINITY AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).



* Flow from the Trinity Aquifer to underlying units based on the Groundwater Availability Model for the Minor Aquifers of the Llano Uplift Region of Texas. This term includes 263 acre-feet per year net outflow from the Trinity Aquifer into the underlying Paleozoic Aquifers and 20,443 acre-feet per year net outflow from the Trinity Aquifer to Pennsylvanian and Permian age 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. If the District requires values for additional water budget items, please contact TWDB.

FIGURE 8: GENERALIZED DIAGRAM OF THE SUMMARIZED BUDGET INFORMATION FROM TABLE 4, REPRESENTING DIRECTIONS OF FLOW FOR THE TRINITY AQUIFER WITHIN CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT. FLOW VALUES 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.

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