Saratoga Underground Water Conservation District Management Plan – 2014

I. Introduction

This plan becomes effective upon approval by the Texas Water Development Board (TWDB) and will remain in effect until December 1, 2019, or a period of five years whichever is later. The plan may be revised at any time, or after five years when the plan will be reviewed to insure that it is consistent with the applicable Regional Water Plans and the State Water Plan.

District Mission

The Saratoga Underground Water Conservation District (District) Management Plan strives to protect and maintain the quantity and quality of useable groundwater in Lampasas County.

Statement of Guiding Principles

The Saratoga Underground Water Conservation District is created and organized under the terms and provisions of Article XVI, Section 59, of the Constitution of Texas and Chapter 36 (formerly Chapters 50 & 52) of the Texas Water Code, Vernon's Texas Civil Statutes, and the District's actions are authorized by, and consistent with this constitutional and statutory provision, including all amendments and additions. The Act under which the Saratoga Underground Water Conservation District is created prevails over any provision of general law that is in conflict or inconsistent with this Act. The District was created for the purpose to protect and maintain the quantity of useable quality water by conserving, preserving, recharging, and protecting and preventing waste and as far as practicable to minimize the draw-down of the water table and the reduction of artesian pressure of the Trinity and other aquifers within the District boundaries. In order to carry out its constitutional and statutory purposes, the District has all the powers authorized by Article XVI, Section 59, of the Texas Constitution, and Chapter 36 of the Texas Water Code, Vernon's Texas Civil Statutes, together with all amendments and additions.

The District's purposes and powers are implemented through promulgation and enforcement of the District's regulations. These regulations are adopted and revised under the authority of Subchapter E, Chapter 36, Texas Water Code, and are incorporated herein as a part of the District's management plan.

The District is governed by a board of five directors composed of a member from each of the county's precincts and an at-large member from Lampasas County, Texas. The chairman of the board of directors is elected by the board after each general election. The District is also served with up to six ex-officio directors; one from each commissioner precinct in the County; at least one at-large member; and at least one advisory member.

History

The need for a local underground water conservation district to properly manage water from the Trinity and other aquifers in Central Texas was first identified in the late 1980's. At the request of many concerned area citizens, our local State Representative and State Senator were contacted by our County Judge, with the approval of the Lampasas County Commissioners' Court, with an approach to create and enact an Act to form a water district. During Regular Session of the 71st Legislature, H.B. No. 3122 passed unanimously both in the House and the Senate in May, 1989. Be it enacted by the Legislature of the State of Texas on June 14, 1989 with a confirmation election to be held and approved by the registered voters of Lampasas County, Texas. Such election was held in November 1989 and approved by a majority of the voters thereby officially establishing the Saratoga Underground Water Conservation District effective January 1, 1990.

The leadership of the District transferred from the Commissioners Court and the County Judge to an appointed Board of Directors in September 2005 with the passage of HB 3539 enacted on September 1, 2005. The new board members continue to represent the four precincts of Lampasas County with an at-large member making up the fifth board membership. The General election of 2006 confirmed three of the new directors with four-year terms of office. The remaining two members were elected during the 2008 general election thereby composing the Board of all elected officials.

Location and Extent

The Saratoga Underground Water Conservation District is located in Central Texas. The District comprises an area of 714 square miles or 456,960 acres, all located within the boundary of Lampasas County, Texas. Principal municipalities and communities in our District include Lampasas, Lometa, Kempner, Adamsville, Izoro, Moline, and a part of Copperas Cove, with the city of Lampasas being the County Seat. County population in 2013 was 20,222 according to the US Census Bureau.

Topography

The District is within the Brazos River Basin and the Colorado River Basin. The County/District line between San Saba and Lampasas Counties is the Colorado River. The Lampasas River, as well as numerous creeks dissects the District. Sulphur Creek is the major creek in the District and its main source of water is from springs. The District's altitude ranges from 800 to 1700 feet, and drainage is typically from west to east.

II. Groundwater Resources

The Saratoga Underground Water Conservation District lies in several aquifers, with the Trinity aquifer being the primary source of groundwater of interest in our area. Water from this aquifer is used for irrigation, public water supply, industrial, livestock, and domestic needs of the people and entities served.

Other minor aquifers and subdivisions of the Trinity include, but are not limited to, the Ellenburger-San Saba, Marble Falls, Hickory, Travis Peak (includes the Hensell, Pearsall, and Hosston subdivisions of the Trinity), Paluxy, and Glen Rose formations within the District boundaries that meet the limited needs of individuals.

Detailed information regarding the underlying geology and aquifers located within the District boundaries can be found in "The Aquifers of Texas" published by the TWDB and available for download at the following website:

http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R380_AquifersofTexas.pdf

III. Technical District Information Required By Texas Administrative Code

The following information has been provided by the TWDB and included as an Appendix which supports specific management plan requirements outlined in Title 31, Texas Administrative Code, Chapter 356 and the Texas Water Code Chapter 36.

1. Groundwater Availability Model Run 13-019 in support of the Saratoga Underground Water Conservation District Groundwater Management Plan – **Appendix A**
2. Estimate of Modeled Available Groundwater in the District based on GAM Run 10-063 MAG for the April 2011 Desired Future Conditions adopted by Groundwater Management Area 8 - **Appendix B**
3. Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 8 (GAM TASK 13-031) **- Appendix C**
4. Estimated Historical Water Use and 2012 State Water Plan Datasets - **Appendix D**

IV. Management Goals, Objectives, and Performance Standards

Goal 1.0: Providing the Most Efficient Use of Groundwater

Management Objective 1.1
Improve understanding of available and developed groundwater supplies in Lampasas County.

Performance Standard 1.1
The TWDB has an ongoing program to gather water level data from monitoring wells located within the District boundary. The current and 50-year projected groundwater pumped within the District is approximately 15% of the modeled available groundwater supply based on TWDB estimates. The District Board of Directors will coordinate with TWDB officials to assess the performance and necessity for modifications to the ongoing monitoring program on an annual basis.

Management Objective 1.2
Regulate and account for groundwater withdrawal in Lampasas County.

Performance Standard 1.2
The District has rules in place which require reporting to Lampasas County of all new wells drilled to include production volume, water use, and location. To date, the District is not aware of any new wells drilled which exceed the production volume required for a non-exemption status in the District (greater than 25,000 gallons per day). The District Board of Directors will coordinate with Lampasas County officials and local well drillers to assess the performance and necessity for modifications to the ongoing reporting program on an annual basis.

Goal 2.0: Controlling and Preventing Waste of Groundwater

Management Objective 2.1
Encourage the sustainable use of groundwater for beneficial purposes within Lampasas County.

Performance Standard 2.1
The District has adopted rules and procedures to address transportation of groundwater outside the District boundaries, well construction standards and minimum spacing requirements, and the identification of critical groundwater depletion areas, The District Board of Directors will assess the necessity for modifications or enhancements to the adopted rules on an annual basis.

Goal 3.0: Addressing Conjunctive Surface Water Management Issues

Management Objective 3.1
Assess the availability of surface water resources which may be used as an alternate to groundwater.

Performance Standard 3.1
The District Board of Directors will keep up to date and informed regarding the availability of additional surface water or groundwater resources within the District through ongoing and regular communication with TWDB representatives, local City and County officials, and regular attendance and participation in the groundwater management area 8 planning meetings. In the event that a new permit application is filed to drill a well or group of wells which will significantly increase the annual groundwater volume pumped from within the District boundary, an assessment of alternate surface water supplies available to the applicant will be an inherent part of the District's review process.

Goal 4.0: Addressing Natural Resource Issues

Management Objective 4.1
Prevent contamination and/or pollution of the aquifers from other natural resources being produced within the District.

Performance Standard 4.1:
The District has the ability to monitor new oil and gas or commercial related groundwater well drilling operations via the ongoing well reporting requirements for potential contamination issues or concerns. In the event that a potential contamination issue is identified, the District Board of Directors will assess the legal and regulatory options to minimize the concern for pollution of existing groundwater resources.

Goal 5.0: Addressing Drought Conditions

Management Objective 5.1
Monitor drought conditions.

Performance Standard 5.1
At the monthly Board meetings during drought, review available drought severity indices and implement well monitoring and/or management strategies as deemed necessary and appropriate for the existing groundwater users within the District.

Goal 6.0: Addressing Conservation, Recharge Enhancement, Brush Control, and Rainwater Harvesting

Management Objective 6.1
Provide public educational material to encourage conservation and more efficient use of groundwater, recharge enhancement practices to include brush control, and implementation of rainwater harvesting strategies.

Performance Standard 6.1
The District will distribute readily available educational material using the existing County website in order to facilitate the above mentioned objectives.

Goal 7.0: Addressing the Desired Future Conditions of the District

Management Objective 7.1
In coordination with the ongoing TWDB well monitoring program, compare annual water level measurements with previous years to determine trends, specific declines or increases in the monitor wells of the Trinity Aquifer. Water level comparisons will be used to determine if a serious decline in Trinity Aquifer water levels warrant further study or action by the District Board of Directors.

Performance Standard 7.1
The number of monitor wells sampled as well as the number of comparison analysis reports submitted to the District Board of Directors annually.

Management Objective 7.2
If deemed necessary based on a review of the monitoring well data, the District will take appropriate action such as conduct public hearings to make citizens of the SUWCD aware of severe changes in groundwater levels and/or implement additional conservation strategies.

Performance Standard 7.2
The number of public hearings conducted and/or conservation strategies implemented when severe water level changes occurred.

The District has determined that the following management goals are not applicable because they are either not cost effective or appropriate:

TWC Chapter 36.1071(a)(3): Controlling and Preventing Subsidence
TWC Chapter 36.1071(a)(7): Precipitation Enhancement

Methodology for Tracking Progress

The Chairman of the Board of Directors will give an activity report to the District Board of Directors at the annual meeting in November, or as needed, to insure management objectives and goals are being followed and achieved by the District. The Board will also elect its officers at that meeting. The Board will maintain the annual activity report on file for public inspection at the Lampasas County office upon adoption.

Management of Groundwater Supplies

The District will manage the supply of groundwater within the District in order to conserve the resource while maintaining the viability of all resource user groups, public and private. As deemed necessary, the District will identify and engage in activities and practices that, if implemented, would result in reduction of groundwater use. The District may require reduction of groundwater withdrawals to amounts that will not cause harm to the aquifers. The District may, at the Board's discretion, amend or revoke any permits after notice and hearing to achieve this purpose. The District will consider the public benefit against individual hardship in determining permit denial or limiting groundwater withdrawals after considering all appropriate testimony. The District shall treat all citizens with equality. A public or private user may appeal to the Board for discretion in enforcement of the provisions of the District's rules and regulations on grounds of adverse economic hardship or unique local conditions. The exercise of said discretion by the Board shall not be construed as limiting the power of the Board.

Actions, Procedures, Performance, and Avoidance for Plan Implementation

The District will implement and use the provisions of this plan as a guidepost for determining the direction or priority for all District activities. All operations of the District, all agreements entered into by the District, and any additional planning efforts that the District may participate in will be consistent with the provisions of this plan. The District will seek cooperation in the implementation of this plan and the management of groundwater supplies within the District. All activities of the Saratoga Underground Water Conservation District will be undertaken in cooperation and coordination with the appropriate state, regional or local water entity.

The District has adopted rules relating to the permitting of wells and production of groundwater. All rules will be adhered to and enforced. The promulgation and enforcement of the rules will be based on the best technical advice available.

The District rules may be viewed at the following website:
http://tools.cira.state.tx.us/users/0087/docs/SUWCD/SUWCD%20Rules.pdf

The District website is:
http://www.co.lampasas.tx.us/default.aspx?Lampasas_County/Saratoga

Appendix A

Groundwater Availability Model Run 13-019

GAM Run 13-019: Saratoga Underground Water Conservation District Management Plan

By Chelsea Seiter-Weatherford
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
July 3, 2013

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by Chelsea Seiter-Weatherford under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on July 3, 2013.

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GAM RUN 13-019: SARATOGA UNDERGROUND WATER CONSERVATION DISTRICT MANAGEMENT PLAN

By Chelsea Seiter-Weatherford
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
July 3, 2013

EXECUTIVE SUMMARY:

Texas Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, groundwater conservation districts 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 before being used in the plan. Information for your groundwater management plan that was derived from groundwater availability model(s) in this report includes:

- the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
- 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
- the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

This report (Part 2 of a two-part package of information from the TWDB to Saratoga Underground Water Conservation District) fulfills the requirements noted above. Part 1 of the 2-part package is the Historical Water Use/State Water Plan data report. The District will receive this data report from the TWDB Groundwater Technical Assistance Section. Questions about the data report can be directed to Mr. Stephen Allen, Stephen.Allen@twdb.texas.gov, (512) 463-7317.

The groundwater management plan for Saratoga Underground Water Conservation District should be adopted by the district on or before September 1, 2014 and submitted to the executive administrator of the TWDB on or before October 1, 2014. The current management plan for the Saratoga Underground Water Conservation District expires on November 30, 2014.

This report discusses the method, assumptions, and results from a model run using a groundwater availability model for the northern part of the Trinity Aquifer. Table 1 summarizes the groundwater availability model data required by the statute, and Figure 1 shows the areas of the model from which the values in the table were extracted. If after review of the figure, Saratoga Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the Texas Water Development Board immediately.

The Llano Uplift aquifer system, which includes the Marble Falls, Hickory, and Ellenburger-San Saba aquifers, also underlies the Kimble County Ground Water Conservation District. Groundwater availability models have not yet been completed for these minor aquifers. If the district would like information for these aquifers, they may request it from Mr. Stephen Allen, Stephen.Allen@twdb.texas.gov, (512) 463-7317.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability model for the northern part of the Trinity Aquifer was run for this analysis. Saratoga Underground Water Conservation District budgets were extracted for the historical periods 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, net inter-aquifer flow (upper), and net inter-aquifer flow (lower) for the portion of the aquifer located within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Northern part of the Trinity Aquifer

- Version 1.01 of the groundwater availability model for the northern part of the Trinity Aquifer (Bené and others, 2004) was used for these simulations.
- The model has seven layers which generally represent the Woodbine Aquifer (Layer 1), the Washita and Fredericksburg Confining Unit (Layer 2), and the Trinity Aquifer (Layer 3 through 7).

- As described in Bené and others (2004), the evapotranspiration package used in the groundwater availability model represents evaporation, transpiration, springs, seeps, and discharge to streams not modeled by the streamflow-routing package. Both the streamflow-routing package and the evapotranspiration package were used, as applicable, to extract information needed for discharges to surface water in this analysis.
- 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 model results for the aquifers located within the district and averaged over the duration of the calibration and verification portion of the model run in the district, as shown in Table 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.
- Surface water outflow—The total water discharging from the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).
- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent counties.
- Flow between aquifers—The vertical flow between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer or confining unit 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 Table 1. 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 district or county boundaries, 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 (Figure 1).

TABLE 1: SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER THAT IS NEEDED FOR SARATOGA UNDERGROUND WATER 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*	*Trinity Aquifer*
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	40,450
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	10,040
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	2,220
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	4,441
Estimated net annual volume of flow between each aquifer in the district	From the Washita Fredericksburg Confining Unit into the Trinity Aquifer	25

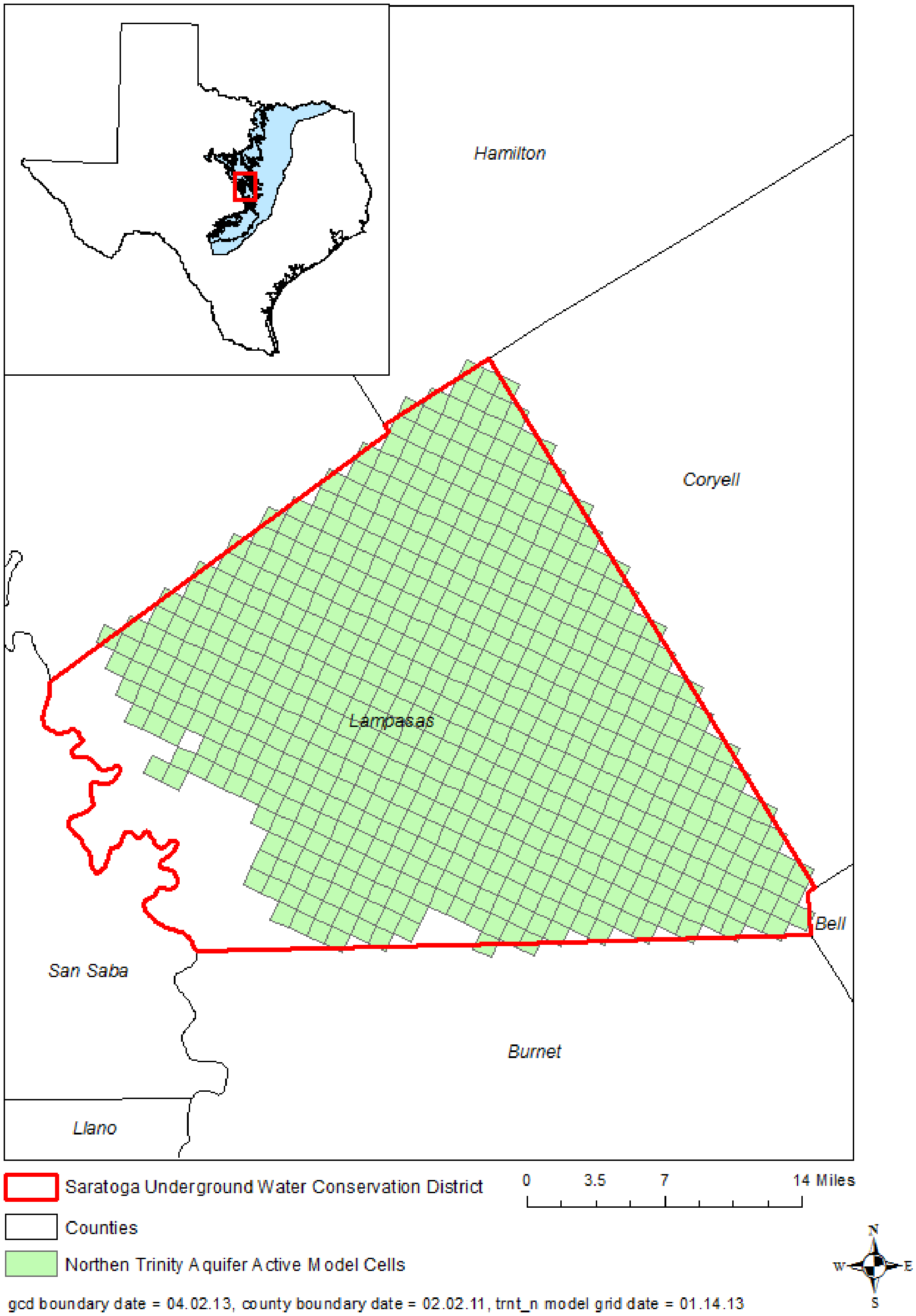


FIGURE 2: AREA OF THE GROUNDWATER MODEL FOR THE NORTHERN PART OF THE TRINITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS:

The groundwater model(s) used in completing this analysis is the best available scientific tool that can be used to meet the stated objective(s). 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 streamflow are specific to a particular historic time period.

Because the application of the groundwater was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representatives relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for the 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:

Bené, J., Harden, B., O'Rourke, D., Donnelly, A., and Yelderman, J., 2004, Northern Trinity/Woodbine Groundwater Availability Model: contract report to the Texas Water Development Board by R.W. Harden and Associates, 391 p., http://www.twdb.state.tx.us/gam/trnt_n/trnt_n.htm.

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., 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.

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.

Appendix B

Estimate of Modeled Available Groundwater in the District based on GAM Run 10-063 MAG for the April 2011 Desired Future Conditions adopted by Groundwater Management Area 8

Texas Water Development Board
P.O. Box 13231, 1700 N. Congress Ave.
Austin, TX 78711-3231, www.twdb.texas.gov
Phone (512) 463-7847, Fax (512) 475-2053

March 20, 2012

Mr. Randy McGuire
General Manager
Saratoga Underground Water Conservation District
P.O. Box 231
Lampasas, TX 76550

Re: Modeled available groundwater estimates for the Blossom, Brazos River Alluvium, Edwards (BFZ), Ellenburger-San Saba, Hickory, Marble Falls, Nacatoch, and Trinity aquifers in Groundwater Management Area 8

Dear Mr. McGuire:

The Texas Water Code, Section 36.1084, Subsection (b), states that the Texas Water Development Board's (TWDB) Executive Administrator shall provide each groundwater conservation district and regional water planning group located wholly or partly in the groundwater management area with the modeled available groundwater in the management area based upon the desired future conditions adopted by the districts. This letter and the attached reports (GAM Run 11-011 MAG, GAM Run 10-063 MAG, GAM Run 10-065 MAG, GTA Aquifer Assessment 10-15 MAG, GTA Aquifer Assessment 10-16 MAG, GTA Aquifer Assessment 10-17 MAG, GTA Aquifer Assessment 10-18 MAG, and GTA Aquifer Assessment 10-19 MAG) are in response to this directive.

As noted in the letter received by the TWDB on September 1, 2011, from Eddy Daniel of the North Texas Groundwater Conservation District on behalf of Groundwater Management Area 8, desired future conditions were adopted for the Blossom, Brazos River Alluvium, Edwards (BFZ), Ellenburger-San Saba, Hickory, Marble Falls, Nacatoch, Trinity, and Woodbine aquifers on April 27, 2011. The desired future conditions for the Brazos River Alluvium, Nacatoch, and Woodbine aquifers were modified on June 23, 2011, as noted in the letters from Mr. Daniel received by TWDB on September 1, 2011. This mail out does not include GAM Run 10-064 MAG for the Woodbine Aquifer, which will be finalized at a later date.

Modeled available groundwater is defined in the Texas Water Code, Section 36.001, Subsection (25), as "the amount of water that the executive administrator determines may be produced on an average annual basis to achieve a desired future condition established under Section 36.108." This is different from "managed available groundwater," shown in the draft version of these reports (except GAM Run 11-011 MAG), which was a permitting value and accounted for the estimated use exempt from permitting. This change was made to reflect changes in statute by the 82nd Legislature, effective September 1, 2011. For use in the regional water planning process, modeled available groundwater estimates have been reported by aquifer, county, river basin, regional water planning area, groundwater conservation district, and any other subdivision of the aquifer designated by the management area (if applicable).

We encourage open communication and coordination between groundwater conservation districts, regional water planning groups, and the TWDB to ensure that the modeled available groundwater reported in regional water plans and groundwater management plans are not in conflict. We estimated modeled available groundwater that would have to occur to achieve the desired future condition using the best available scientific tools. However, these estimates are based on assumptions of the magnitude and distribution of projected pumping in the aquifer. It is, therefore, important for groundwater conservation districts to monitor whether their management of pumping is achieving their desired future conditions. Districts are encouraged to continue to work with the TWDB to better define available groundwater as additional information may help better assess responses of the aquifer to pumping and its distribution now and in the future.

If you have any questions, please contact Ms. Rima Petrossian of my staff at 512-936-2420 or rima.petrossian@twdb.texas.gov for further information.

Sincerely,

Melanie Callahan
Executive Administrator

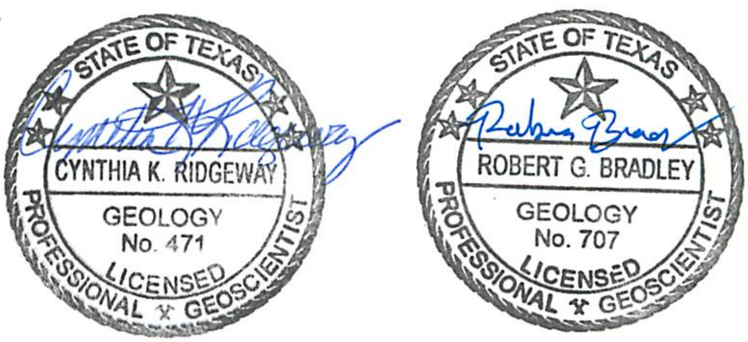
Attachments: GAM Run 11-011 MAG
GAM Run 10-063 MAG
GAM Run 10-065 MAG
GTA Aquifer Assessment 10-15 MAG
GTA Aquifer Assessment 10-16 MAG
GTA Aquifer Assessment 10-17 MAG
GTA Aquifer Assessment 10-18 MAG
GTA Aquifer Assessment 10-19 MAG

c w/atts.: L'Oreal Stepney, Deputy Director, Office of Water, Texas Commission of Environmental Quality
Kellye Rila, Texas Commission of Environmental Quality
Kelly Mills, Texas Commission of Environmental Quality
Kerry Maroney, Biggs & Mathews
Tom Gooch, Freese & Nichols, Inc.
Simone Kiel, Freese & Nichols, Inc.
David Harkins, Epsey Consultants, Inc.
David Dunn, HDR Engineering
Jaime Burke, AECOM, Inc.
Walt Sears Jr., North Texas Municipal Water District
Phil Ford, Brazos River Authority
James Kowis, Lower Colorado River Authority
Jerry Clark, Sabine River Authority
Nancy Rose, Sulphur River Basin Authority
J. Kevin Ward, Trinity River Authority
Robert E. Mace, Ph.D, P.G., Deputy Executive Administrator, Water Science and Conservation
Larry French, P.G., Groundwater Resources
Cindy Ridgeway, P.G., Groundwater Resources
Rima Petrossian, P.G., Groundwater Resources
Robert Bradley, P.G., Groundwater Resources
Dan Hardin, Water Resources Planning
Matt Nelson, Water Resources Planning
Temple McKinnon, Water Resources Planning
Lann Bookout, Water Resources Planning
Angela Kennedy, Water Resources Planning
Doug Shaw, Water Resources Planning
Wendy Barron, Water Resources Planning

GAM Run 10-063 MAG

by Mr. Wade Oliver and Mr. Robert G. Bradley, P.G.

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-3132
December 14, 2011



Cynthia K. Ridgeway, the Manager of the Groundwater Availability Modeling Section and Interim Director of the Groundwater Resources Division, is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on December 14, 2011.

Robert G. Bradley, P.G. is responsible for the water budget approach for Comanche and Erath counties within Middle Trinity Groundwater Conservation District. The seal appearing on this document was authorized by Robert G. Bradley, P.G. 707 on December 14, 2011.

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EXECUTIVE SUMMARY:

In response to receiving the adopted desired future conditions for the Trinity Aquifer in Groundwater Management Area 8, the Texas Water Development Board completed Groundwater Availability Model (GAM) Run 08-84mag, which reported the "managed available groundwater" that achieves the adopted desired future conditions. Subsequent to the release of GAM Run 08-84mag, the Middle Trinity Groundwater Conservation District requested that the Texas Water Development Board reevaluate the "managed available groundwater" for Comanche and Erath counties. This resulted in the completion of Aquifer Assessment 09-07, which addressed these counties. In April 2011, the groundwater conservation districts in Groundwater Management Area 8 readopted the desired future conditions for the Trinity Aquifer previously adopted in September 2008.

This report, an update to GAM Run 08-84mag and Aquifer Assessment 09-07, incorporates the changes above and addresses the readopted desired future conditions. In addition, the pumping estimates previously reported as "managed available groundwater" in the above reports are reported here as "modeled available groundwater" to reflect changes in statute effective September 1, 2011. The modeled available groundwater for the Trinity Aquifer as a result of the desired future conditions adopted by the members of Groundwater Management Area 8 is approximately 261,000 acre-feet per year.

REQUESTOR:

Mr. Eddy Daniel of North Texas Groundwater Conservation District on behalf of Groundwater Management Area 8

DESCRIPTION OF REQUEST:

In a letter dated August 31, 2011, Mr. Eddy Daniel provided the Texas Water Development Board (TWDB) with the desired future conditions of the Trinity Aquifer adopted in a resolution, dated April 27, 2011, by the members of Groundwater Management Area 8. This resolution referenced the desired future conditions previously adopted for the aquifer on September 17, 2008 by the groundwater conservation districts within Groundwater Management Area 8. These are summarized in Table 1.

In response to receiving the initially adopted desired future conditions from September 2008, the Texas Water Development Board completed Groundwater Availability Model (GAM) Run 08-84mag, which reported the "managed available groundwater" that achieves the above desired future conditions (Wade, 2009). On June 12, 2009, the general manager and consultants for the Middle Trinity Groundwater Conservation District met with Texas Water Development Board staff to discuss issues they had concerning GAM Run 08-84mag. After discussion, staff reevaluated pumping estimates using a water-budget approach based on the desired future conditions for Comanche and Erath counties and released this analysis as Aquifer Assessment 09-07 on November 22, 2010 (Bradley, 2010). This report, an update to GAM Run 08-84mag and Aquifer Assessment 09-07, incorporates the two changes above. In addition, the pumping estimates previously reported as "managed available groundwater" in the above reports are reported here as "modeled available groundwater" to reflect changes in statute effective September 1, 2011.

METHODS:

Groundwater Management Area 8 contains the Trinity Aquifer, a major aquifer in Texas as defined in the 2007 State Water Plan (TWDB, 2007). The location of Groundwater Management Area 8, the Trinity Aquifer, and the groundwater availability model cells that represent the aquifer are shown in Figure 1.

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. This is distinct from "managed available groundwater," shown in the draft version of this report dated December 20, 2010, which was a permitting value and accounted for the estimated use of the aquifer exempt from permitting. This change was made to reflect changes in statute by the 82nd Texas Legislature, effective September 1, 2011.

Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits. The estimated amount of pumping exempt from permitting, which the Texas Water Development Board is now required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

PARAMETERS AND ASSUMPTIONS:

The groundwater availability model for the northern portion of the Trinity Aquifer was used for the results presented in this report outside of Comanche and Erath counties. In those counties, a water budget approach was used. The parameters and assumptions for developing the modeled available groundwater are described below:

Groundwater Availability Model for the Northern Portion of the Trinity Aquifer

- The results for modeled available groundwater presented here are based on the results reported as "managed available groundwater" in GAM Run 08-84mag (Wade, 2009) for all areas except Comanche and Erath counties. See GAM Run 08-84mag for a full description of the methods and assumptions associated with the model simulation. Because GAM Run 08-84mag presented constant pumping from 2000 to 2050, it was assumed for the purposes of this analysis that pumping from 2051 to 2060 was also constant at the same level. As summarized in Table 1, desired future conditions were defined by the groundwater conservation districts in Groundwater Management Area 8 for 2050. It is expected that pumping from 2051 to 2060 would cause additional drawdown, but this analysis does not estimate drawdown in 2060. Pumping estimates for 2060 were important to include for purposes of regional water planning.

- Version 1.01 of the groundwater availability model for the northern portion of the Trinity Aquifer was used for this analysis. See Bené and others (2004) for assumptions and limitations of the model.

- The model includes seven layers which generally correspond to the Woodbine Aquifer (Layer 1), the Washita and Fredericksburg Groups (Layer 2), the Paluxy Formation (Layer 3), the Glen Rose Formation (Layer 4), the Hensell Formation (Layer 5), the Pearsall/Cow Creek/Hammett/Sligo Members (Layer 6), and the Hosston Formation (Layer 7).

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) for the four main aquifers in the model (Woodbine, Paluxy, Hensell, and Hosston) for the calibration and verification time periods (1980 to 2000) ranged from approximately 38 to 75 feet. The root mean squared error was less than ten percent of the maximum change in water levels across the model (Bené and others, 2004).

- Average annual recharge conditions based on climate data from 1980 to 1999 were assumed for the first 47 years of the simulation. The last three years of the simulation drought-of-record recharge conditions were assumed, which were defined as the years 1954 to 1956.

- Groundwater conservation district boundaries were updated since the release of GAM Run 08-84mag. The results presented here correspond to the official district boundaries as of the date of this report.

Water Budget Approach for Comanche and Erath Counties

- The modeled available groundwater presented for Comanche and Erath counties is based on Aquifer Assessment 09-07 (Bradley, 2010). See Aquifer Assessment 09-07 for a full description of the methods and assumptions associated with the water budget calculations.

- The Hensell and Hosston members were grouped as the Twin Mountains Formation in Aquifer Assessment 09-07. To be consistent with the desired future conditions, however, it was necessary to split the pumping in Aquifer Assessment 09-07 into the Hensell and Hosston members. In Comanche County, 10 percent of the pumping in the Twin Mountains Formation was assigned to the Hensell member while 90 percent was assigned to the Hosston. In Erath County, 35 percent of the pumping in Aquifer Assessment 09-07 was assigned to the Hensell with the remaining 65 percent assigned to the Hosston. These percentages were developed after a preliminary review of available pumping information and discussion with Joe Cooper of Middle Trinity Groundwater Conservation District.

RESULTS:

The modeled available groundwater for the Trinity Aquifer in Groundwater Management Area 8 as a result of the desired future conditions is approximately 261,000 acre-feet per year between 2010 and 2060. This pumping has been divided by county, regional water planning area, and river basin for each decade between 2010 and 2060 for use in the regional water planning process (Table 2). These areas are shown in Figure 2.

Since the desired future conditions are specified for individual units of the Trinity Aquifer (Paluxy, Glen Rose, Hensell, and Hosston) based on the layering used in the model, the modeled available groundwater is shown for each unit in the subsequent tables. Tables 3, 4, 5, and 6 show the modeled available groundwater summarized by county in the Paluxy, Glen Rose, Hensell, and Hosston units of the Trinity Aquifer, respectively. Tables 7, 8, 9, and 10 show the modeled available groundwater summarized by regional water planning area for the same units, respectively. Tables 11, 12, 13, and 14 show the modeled available groundwater summarized by river basin for each of the above units, respectively. The modeled available groundwater summarized by groundwater conservation district is shown for the Paluxy, Glen Rose, Hensell, and Hosston units in tables 15, 16, 17, and 18, respectively. Notice that the pumping is totaled both excluding and including areas outside of a groundwater conservation district.

LIMITATIONS:

The groundwater model used in developing estimates of modeled available groundwater is the best available scientific tool that can be used to estimate the pumping that will achieve the desired future conditions. Although the groundwater model used in this analysis is the best available scientific tool for this purpose, it, like all models, has limitations. 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 develop estimates of modeled available groundwater is the need to make assumptions about the location in the aquifer where future pumping will occur. As actual pumping changes in the future, it will be necessary to evaluate the amount of that pumping as well as its location in the context of the assumptions associated with this analysis. Evaluating the amount and location of future pumping is as important as evaluating the changes in groundwater levels, spring flows, and other metrics that describe the condition of the groundwater resources in the area that relate to the adopted desired future condition(s).

Given these limitations, users of this information are cautioned that the modeled available groundwater numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating 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 future groundwater pumping as well as whether or not they are achieving their desired future conditions. Because of the limitations of the model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine the modeled available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

REFERENCES:

Bené, J., Harden, B., O'Rourke, D., Donnelly, A., and Yelderman, J., 2004, Northern Trinity/Woodbine Groundwater Availability Model: contract report to the Texas Water Development Board by R.W. Harden and Associates, 391 p.

Bradley, R.G., 2010, GTA Aquifer Assessment 09-07: Texas Water Development Board, GTA Aquifer Assessment 09-07 Report, 19 p.

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.

Texas Water Development Board, 2007, Water for Texas – 2007—Volumes I-III; Texas Water Development Board Document No. GP-8-1, 392 p.

Wade, S., 2009, GAM Run 08-84mag, Texas Water Development Board GAM Run 08-84mag Report, 37 p.

Table 1. Desired future conditions (in feet of drawdown) for each unit of the Trinity Aquifer adopted by members of Groundwater Management Area 8.

County	Average water level decrease (feet)			
	Paluxy	Glen Rose	Hensell	Hosston
Bell	134	155	286	319
Bosque	26	33	201	220
Brown	0	0	1	1
Burnet	1	1	11	29
Callahan	n/a	n/a	0	2
Collin	298	247	224	236
Comanche	0	0	2	11
Cooke	26	42	60	78
Coryell	15	15	156	179
Dallas	240	224	263	290
Delta	175	162	162	159
Denton	98	134	180	214
Eastland	0	0	0	0
Ellis	265	283	336	362
Erath	1	1	11	27
Falls	279	354	459	480
Fannin	212	196	182	181
Grayson	175	161	160	165
Hamilton	0	2	39	51
Hill	209	253	381	406
Hood	1	2	16	56
Hunt	286	245	215	223
Johnson	37	83	208	234
Kaufman	303	286	295	312
Lamar	132	130	136	134
Lampasas	0	1	12	23
Limestone	328	392	475	492
McLennan	251	291	489	527
Milam	252	294	337	344
Mills	0	0	3	12
Montague	0	1	3	12
Navarro	344	353	399	413
Parker	5	6	16	40
Red River	82	77	78	78
Rockwall	346	272	248	265
Somervell	1	4	53	113
Tarrant	33	75	160	173
Taylor	n/a	n/a	n/a	3
Travis	124	61	98	116
Williamson	108	88	142	166
Wise	4	14	23	53

Table 2. Modeled available groundwater in acre-feet for the Trinity Aquifer in Groundwater Management Area 8 by county, regional water planning area, and river basin.

County	Regional Water Planning Area	Basin	Year					
			2010	2020	2030	2040	2050	2060
Bell	G	Brazos	7,068	7,068	7,068	7,068	7,068	7,068
Bosque	G	Brazos	5,849	5,849	5,849	5,849	5,849	5,849
Brown	F	Brazos	28	28	28	28	28	28
		Colorado	2,017	2,017	2,017	2,017	2,017	2,017
Burnet	K	Brazos	2,723	2,723	2,723	2,723	2,723	2,723
		Colorado	823	823	823	823	823	823
Callahan	G	Brazos	1,792	1,792	1,792	1,792	1,792	1,792
		Colorado	1,985	1,985	1,985	1,985	1,985	1,985
Collin	C	Sabine	0	0	0	0	0	0
		Trinity	2,104	2,104	2,104	2,104	2,104	2,104
Comanche	G	Brazos	32,115	32,115	32,115	32,115	32,115	32,115
		Colorado	120	120	120	120	120	120
Cooke	C	Red	1,284	1,284	1,284	1,284	1,284	1,284
		Trinity	5,566	5,566	5,566	5,566	5,566	5,566
Coryell	G	Brazos	3,716	3,716	3,716	3,716	3,716	3,716
Dallas	C	Trinity	5,458	5,458	5,458	5,458	5,458	5,458
Delta	D	Sulphur	362	362	362	362	362	362
Denton	C	Trinity	19,333	19,333	19,333	19,333	19,333	19,333
Eastland	G	Brazos	4,489	4,489	4,489	4,489	4,489	4,489
		Colorado	231	231	231	231	231	231
Ellis	C	Trinity	3,959	3,959	3,959	3,959	3,959	3,959
Erath	G	Brazos	32,926	32,926	32,926	32,926	32,926	32,926
Falls	G	Brazos	169	169	169	169	169	169
Fannin	C	Red	617	617	617	617	617	617
		Sulphur	0	0	0	0	0	0
		Trinity	83	83	83	83	83	83
Franklin	D	Sulphur	0	0	0	0	0	0
Grayson	C	Red	7,722	7,722	7,722	7,722	7,722	7,722
		Trinity	1,678	1,678	1,678	1,678	1,678	1,678
Hamilton	G	Brazos	2,144	2,144	2,144	2,144	2,144	2,144
Hill	G	Brazos	3,086	3,086	3,086	3,086	3,086	3,086
		Trinity	61	61	61	61	61	61
Hood	G	Brazos	11,081	11,081	11,081	11,081	11,081	11,081
		Trinity	64	64	64	64	64	64
Hunt	D	Sabine	0	0	0	0	0	0
		Sulphur	0	0	0	0	0	0
		Trinity	551	551	551	551	551	551
Johnson	G	Brazos	4,940	4,940	4,940	4,940	4,940	4,940
		Trinity	7,931	7,931	7,931	7,931	7,931	7,931
Kaufman	C	Sabine	45	45	45	45	45	45
		Trinity	1,136	1,136	1,136	1,136	1,136	1,136

Table 2. Continued.

County	Regional Water Planning Area	Basin	Year					
			2010	2020	2030	2040	2050	2060
Lamar	D	Red	1,320	1,320	1,320	1,320	1,320	1,320
		Sulphur	2	2	2	2	2	2
Lampasas	G	Brazos	2,925	2,925	2,925	2,925	2,925	2,925
		Colorado	192	192	192	192	192	192
Limestone	G	Brazos	69	69	69	69	69	69
		Trinity	0	0	0	0	0	0
McLennan	G	Brazos	20,690	20,690	20,690	20,690	20,690	20,690
Milam	G	Brazos	288	288	288	288	288	288
Mills	K	Brazos	1,273	1,273	1,273	1,273	1,273	1,273
		Colorado	1,128	1,128	1,128	1,128	1,128	1,128
Montague	B	Brazos	0	0	0	0	0	0
		Red	129	129	129	129	129	129
		Trinity	2,545	2,545	2,545	2,545	2,545	2,545
Navarro	C	Trinity	1,873	1,873	1,873	1,873	1,873	1,873
Parker	C	Brazos	2,799	2,799	2,799	2,799	2,799	2,799
		Trinity	12,449	12,449	12,449	12,449	12,449	12,449
Red River	D	Red	263	263	263	263	263	263
		Sulphur	267	267	267	267	267	267
Rockwall	C	Sabine	0	0	0	0	0	0
		Trinity	958	958	958	958	958	958
Somervell	G	Brazos	2,485	2,485	2,485	2,485	2,485	2,485
Tarrant	C	Trinity	18,747	18,747	18,747	18,747	18,747	18,747
Taylor	G	Brazos	153	153	153	153	153	153
		Colorado	278	278	278	278	278	278
Travis	K	Brazos	8	8	8	8	8	8
		Colorado	3,882	3,882	3,882	3,882	3,882	3,882
Williamson	G	Brazos	1,514	1,514	1,514	1,514	1,514	1,514
		Colorado	68	68	68	68	68	68
	K	Brazos	157	157	157	157	157	157
		Colorado	61	61	61	61	61	61
Wise	C	Trinity	9,282	9,282	9,282	9,282	9,282	9,282
Total			**261,061**	**261,061**	**261,061**	**261,061**	**261,061**	**261,061**

Table 3. Modeled available groundwater for the Paluxy unit of the Trinity Aquifer summarized by county in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

County	Year					
	2010	2020	2030	2040	2050	2060
Bell	96	96	96	96	96	96
Bosque	1,013	1,013	1,013	1,013	1,013	1,013
Brown	18	18	18	18	18	18
Burnet	182	182	182	182	182	182
Collin	1,762	1,762	1,762	1,762	1,762	1,762
Comanche	2,292	2,292	2,292	2,292	2,292	2,292
Cooke	3,528	3,528	3,528	3,528	3,528	3,528
Coryell	254	254	254	254	254	254
Dallas	433	433	433	433	433	433
Delta	0	0	0	0	0	0
Denton	9,822	9,822	9,822	9,822	9,822	9,822
Eastland	4	4	4	4	4	4
Ellis	400	400	400	400	400	400
Erath	13,614	13,614	13,614	13,614	13,614	13,614
Falls	0	0	0	0	0	0
Fannin	288	288	288	288	288	288
Grayson	4,708	4,708	4,708	4,708	4,708	4,708
Hamilton	291	291	291	291	291	291
Hill	1,254	1,254	1,254	1,254	1,254	1,254
Hood	942	942	942	942	942	942
Hunt	551	551	551	551	551	551
Johnson	9,493	9,493	9,493	9,493	9,493	9,493
Kaufman	102	102	102	102	102	102
Lamar	0	0	0	0	0	0
Lampasas	13	13	13	13	13	13
Limestone	0	0	0	0	0	0
McLennan	231	231	231	231	231	231
Milam	0	0	0	0	0	0
Mills	5	5	5	5	5	5
Montague	505	505	505	505	505	505
Navarro	413	413	413	413	413	413
Parker	9,800	9,800	9,800	9,800	9,800	9,800
Red River	473	473	473	473	473	473
Rockwall	958	958	958	958	958	958
Somervell	120	120	120	120	120	120
Tarrant	10,544	10,544	10,544	10,544	10,544	10,544
Travis	3	3	3	3	3	3
Williamson	11	11	11	11	11	11
Wise	2,559	2,559	2,559	2,559	2,559	2,559
Total	**76,682**	**76,682**	**76,682**	**76,682**	**76,682**	**76,682**

Table 4. Modeled available groundwater for the Glen Rose unit of the Trinity Aquifer summarized by county in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

County	Year					
	2010	2020	2030	2040	2050	2060
Bell	880	880	880	880	880	880
Bosque	258	258	258	258	258	258
Brown	0	0	0	0	0	0
Burnet	205	205	205	205	205	205
Collin	0	0	0	0	0	0
Comanche	0	0	0	0	0	0
Cooke	0	0	0	0	0	0
Coryell	784	784	784	784	784	784
Dallas	0	0	0	0	0	0
Delta	0	0	0	0	0	0
Denton	0	0	0	0	0	0
Eastland	0	0	0	0	0	0
Ellis	0	0	0	0	0	0
Erath	41	41	41	41	41	41
Falls	2	2	2	2	2	2
Fannin	0	0	0	0	0	0
Franklin	0	0	0	0	0	0
Grayson	0	0	0	0	0	0
Hamilton	46	46	46	46	46	46
Hill	10	10	10	10	10	10
Hood	4	4	4	4	4	4
Hunt	0	0	0	0	0	0
Johnson	24	24	24	24	24	24
Kaufman	0	0	0	0	0	0
Lamar	0	0	0	0	0	0
Lampasas	773	773	773	773	773	773
Limestone	4	4	4	4	4	4
McLennan	265	265	265	265	265	265
Milam	149	149	149	149	149	149
Mills	66	66	66	66	66	66
Montague	0	0	0	0	0	0
Navarro	0	0	0	0	0	0
Parker	192	192	192	192	192	192
Red River	0	0	0	0	0	0
Rockwall	0	0	0	0	0	0
Somervell	134	134	134	134	134	134
Tarrant	112	112	112	112	112	112
Travis	2,612	2,612	2,612	2,612	2,612	2,612
Williamson	760	760	760	760	760	760
Wise	5	5	5	5	5	5
Total	**7,326**	**7,326**	**7,326**	**7,326**	**7,326**	**7,326**

Table 5. Modeled available groundwater for the Hensell unit of the Trinity Aquifer summarized by county in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

County	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Bell	1,099	1,099	1,099	1,099	1,099	1,099
Bosque	1,749	1,749	1,749	1,749	1,749	1,749
Brown	79	79	79	79	79	79
Burnet	690	690	690	690	690	690
Callahan	123	123	123	123	123	123
Collin	103	103	103	103	103	103
Comanche	2,995	2,995	2,995	2,995	2,995	2,995
Cooke	1,611	1,611	1,611	1,611	1,611	1,611
Coryell	1,765	1,765	1,765	1,765	1,765	1,765
Dallas	1,121	1,121	1,121	1,121	1,121	1,121
Delta	181	181	181	181	181	181
Denton	3,112	3,112	3,112	3,112	3,112	3,112
Eastland	79	79	79	79	79	79
Ellis	1,142	1,142	1,142	1,142	1,142	1,142
Erath	6,745	6,745	6,745	6,745	6,745	6,745
Falls	22	22	22	22	22	22
Fannin	203	203	203	203	203	203
Grayson	2,345	2,345	2,345	2,345	2,345	2,345
Hamilton	1,109	1,109	1,109	1,109	1,109	1,109
Hill	933	933	933	933	933	933
Hood	3,595	3,595	3,595	3,595	3,595	3,595
Hunt	0	0	0	0	0	0
Johnson	1,065	1,065	1,065	1,065	1,065	1,065
Kaufman	240	240	240	240	240	240
Lamar	661	661	661	661	661	661
Lampasas	885	885	885	885	885	885
Limestone	15	15	15	15	15	15
McLennan	4,190	4,190	4,190	4,190	4,190	4,190
Milam	36	36	36	36	36	36
Mills	946	946	946	946	946	946
Montague	362	362	362	362	362	362
Navarro	256	256	256	256	256	256
Parker	1,441	1,441	1,441	1,441	1,441	1,441
Red River	19	19	19	19	19	19
Rockwall	0	0	0	0	0	0
Somervell	741	741	741	741	741	741
Tarrant	2,535	2,535	2,535	2,535	2,535	2,535
Travis	156	156	156	156	156	156
Williamson	415	415	415	415	415	415
Wise	1,480	1,480	1,480	1,480	1,480	1,480
Total	**46,244**	**46,244**	**46,244**	**46,244**	**46,244**	**46,244**

Table 6. Modeled available groundwater for the Hosston unit of the Trinity Aquifer summarized by county in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

County	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Bell	4,993	4,993	4,993	4,993	4,993	4,993
Bosque	2,829	2,829	2,829	2,829	2,829	2,829
Brown	1,948	1,948	1,948	1,948	1,948	1,948
Burnet	2,469	2,469	2,469	2,469	2,469	2,469
Callahan	3,654	3,654	3,654	3,654	3,654	3,654
Collin	239	239	239	239	239	239
Comanche	26,948	26,948	26,948	26,948	26,948	26,948
Cooke	1,711	1,711	1,711	1,711	1,711	1,711
Coryell	913	913	913	913	913	913
Dallas	3,904	3,904	3,904	3,904	3,904	3,904
Delta	181	181	181	181	181	181
Denton	6,399	6,399	6,399	6,399	6,399	6,399
Eastland	4,637	4,637	4,637	4,637	4,637	4,637
Ellis	2,417	2,417	2,417	2,417	2,417	2,417
Erath	12,526	12,526	12,526	12,526	12,526	12,526
Falls	145	145	145	145	145	145
Fannin	209	209	209	209	209	209
Franklin	0	0	0	0	0	0
Grayson	2,347	2,347	2,347	2,347	2,347	2,347
Hamilton	698	698	698	698	698	698
Hill	950	950	950	950	950	950
Hood	6,604	6,604	6,604	6,604	6,604	6,604
Hunt	0	0	0	0	0	0
Johnson	2,289	2,289	2,289	2,289	2,289	2,289
Kaufman	839	839	839	839	839	839
Lamar	661	661	661	661	661	661
Lampasas	1,446	1,446	1,446	1,446	1,446	1,446
Limestone	50	50	50	50	50	50
McLennan	16,004	16,004	16,004	16,004	16,004	16,004
Milam	103	103	103	103	103	103
Mills	1,384	1,384	1,384	1,384	1,384	1,384
Montague	1,807	1,807	1,807	1,807	1,807	1,807
Navarro	1,204	1,204	1,204	1,204	1,204	1,204
Parker	3,815	3,815	3,815	3,815	3,815	3,815
Red River	38	38	38	38	38	38
Rockwall	0	0	0	0	0	0
Somervell	1,490	1,490	1,490	1,490	1,490	1,490
Tarrant	5,556	5,556	5,556	5,556	5,556	5,556
Taylor	431	431	431	431	431	431
Travis	1,119	1,119	1,119	1,119	1,119	1,119
Williamson	614	614	614	614	614	614
Wise	5,238	5,238	5,238	5,238	5,238	5,238
Total	**130,809**	**130,809**	**130,809**	**130,809**	**130,809**	**130,809**

Table 7. Modeled available groundwater for the Paluxy unit of the Trinity Aquifer summarized by regional water planning area in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

Regional Water Planning Area	Year					
	2010	2020	2030	2040	2050	2060
B	505	505	505	505	505	505
C	45,317	45,317	45,317	45,317	45,317	45,317
D	1,024	1,024	1,024	1,024	1,024	1,024
F	18	18	18	18	18	18
G	29,628	29,628	29,628	29,628	29,628	29,628
K	190	190	190	190	190	190
Total	**76,682**	**76,682**	**76,682**	**76,682**	**76,682**	**76,682**

Table 8. Modeled available groundwater for the Glen Rose unit of the Trinity Aquifer summarized by regional water planning area in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

Regional Water Planning Area	Year					
	2010	2020	2030	2040	2050	2060
B	0	0	0	0	0	0
C	309	309	309	309	309	309
D	0	0	0	0	0	0
F	0	0	0	0	0	0
G	4,016	4,016	4,016	4,016	4,016	4,016
K	3,001	3,001	3,001	3,001	3,001	3,001
Total	**7,326**	**7,326**	**7,326**	**7,326**	**7,326**	**7,326**

Table 9. Modeled available groundwater for the Hensell unit of the Trinity Aquifer summarized by regional water planning area in Groundwater Management Area 12 for each decade between 2010 and 2060. Results are in acre-feet per year.

Regional Water Planning Area	Year					
	2010	2020	2030	2040	2050	2060
B	362	362	362	362	362	362
C	15,589	15,589	15,589	15,589	15,589	15,589
D	861	861	861	861	861	861
F	79	79	79	79	79	79
G	27,514	27,514	27,514	27,514	27,514	27,514
K	1,839	1,839	1,839	1,839	1,839	1,839
Total	**46,244**	**46,244**	**46,244**	**46,244**	**46,244**	**46,244**

Table 10. Modeled available groundwater for the Hosston unit of the Trinity Aquifer summarized by regional water planning area in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

Regional Water Planning Area	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
B	1,807	1,807	1,807	1,807	1,807	1,807
C	33,878	33,878	33,878	33,878	33,878	33,878
D	880	880	880	880	880	880
F	1,948	1,948	1,948	1,948	1,948	1,948
G	87,271	87,271	87,271	87,271	87,271	87,271
K	5,025	5,025	5,025	5,025	5,025	5,025
Total	**130,809**	**130,809**	**130,809**	**130,809**	**130,809**	**130,809**

Table 11. Modeled available groundwater for the Paluxy unit of the Trinity Aquifer summarized by river basin in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

River Basin	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Brazos	23,223	23,223	23,223	23,223	23,223	23,223
Colorado	193	193	193	193	193	193
Red	4,943	4,943	4,943	4,943	4,943	4,943
Sabine	4	4	4	4	4	4
Sulphur	267	267	267	267	267	267
Trinity	48,052	48,052	48,052	48,052	48,052	48,052
Total	**76,682**	**76,682**	**76,682**	**76,682**	**76,682**	**76,682**

Table 12. Modeled available groundwater for the Glen Rose unit of the Trinity Aquifer summarized by river basin in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

River Basin	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Brazos	4,263	4,263	4,263	4,263	4,263	4,263
Colorado	2,753	2,753	2,753	2,753	2,753	2,753
Red	0	0	0	0	0	0
Sabine	0	0	0	0	0	0
Sulphur	0	0	0	0	0	0
Trinity	310	310	310	310	310	310
Total	**7,326**	**7,326**	**7,326**	**7,326**	**7,326**	**7,326**

Table 13. Modeled available groundwater for the Hensell unit of the Trinity Aquifer summarized by river basin in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

River Basin	Year					
	2010	2020	2030	2040	2050	2060
Brazos	29,030	29,030	29,030	29,030	29,030	29,030
Colorado	585	585	585	585	585	585
Red	3,129	3,129	3,129	3,129	3,129	3,129
Sabine	9	9	9	9	9	9
Sulphur	182	182	182	182	182	182
Trinity	13,309	13,309	13,309	13,309	13,309	13,309
Total	**46,244**	**46,244**	**46,244**	**46,244**	**46,244**	**46,244**

Table 14. Modeled available groundwater for the Hosston unit of the Trinity Aquifer summarized by river basin in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year.

River Basin	Year					
	2010	2020	2030	2040	2050	2060
Brazos	87,971	87,971	87,971	87,971	87,971	87,971
Colorado	7,254	7,254	7,254	7,254	7,254	7,254
Red	3,263	3,263	3,263	3,263	3,263	3,263
Sabine	32	32	32	32	32	32
Sulphur	182	182	182	182	182	182
Trinity	32,107	32,107	32,107	32,107	32,107	32,107
Total	**130,809**	**130,809**	**130,809**	**130,809**	**130,809**	**130,809**

Table 15. Modeled available groundwater for the Paluxy unit of the Trinity Aquifer summarized by groundwater conservation district (GCD) in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year. UWCD refers to Underground Water Conservation District. WD refers to Water District.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Central Texas GCD	182	182	182	182	182	182
Clearwater UWCD	96	96	96	96	96	96
Fox Crossing WD	5	5	5	5	5	5
Middle Trinity GCD	17,173	17,173	17,173	17,173	17,173	17,173
North Texas GCD	15,112	15,112	15,112	15,112	15,112	15,112
Northern Trinity GCD	10,544	10,544	10,544	10,544	10,544	10,544
Post Oak Savannah GCD	0	0	0	0	0	0
Prairielands GCD	11,267	11,267	11,267	11,267	11,267	11,267
Red River GCD	4,996	4,996	4,996	4,996	4,996	4,996
Saratoga UWCD	13	13	13	13	13	13
Southern Trinity GCD	231	231	231	231	231	231
Upper Trinity GCD	13,806	13,806	13,806	13,806	13,806	13,806
Total (excluding non-district areas)	**73,425**	**73,425**	**73,425**	**73,425**	**73,425**	**73,425**
No District	3,257	3,257	3,257	3,257	3,257	3,257
Total (including non-district areas)	**76,682**	**76,682**	**76,682**	**76,682**	**76,682**	**76,682**

Table 16. Modeled available groundwater for the Glen Rose unit of the Trinity Aquifer summarized by groundwater conservation district (GCD) in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year. UWCD refers to Underground Water Conservation District. WD refers to Water District.

Groundwater Conservation District	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Central Texas GCD	205	205	205	205	205	205
Clearwater UWCD	880	880	880	880	880	880
Fox Crossing WD	66	66	66	66	66	66
Middle Trinity GCD	1,083	1,083	1,083	1,083	1,083	1,083
North Texas GCD	0	0	0	0	0	0
Northern Trinity GCD	112	112	112	112	112	112
Post Oak Savannah GCD	149	149	149	149	149	149
Prairielands GCD	168	168	168	168	168	168
Red River GCD	0	0	0	0	0	0
Saratoga UWCD	773	773	773	773	773	773
Southern Trinity GCD	265	265	265	265	265	265
Upper Trinity GCD	201	201	201	201	201	201
Total (excluding non-district areas)	**3,902**	**3,902**	**3,902**	**3,902**	**3,902**	**3,902**
No District	3,424	3,424	3,424	3,424	3,424	3,424
Total (including non-district areas)	**7,326**	**7,326**	**7,326**	**7,326**	**7,326**	**7,326**

Table 17. Modeled available groundwater for the Hensell unit of the Trinity Aquifer summarized by groundwater conservation district (GCD) in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year. UWCD refers to Underground Water Conservation District. WD refers to Water District.

Groundwater Conservation District	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Central Texas GCD	690	690	690	690	690	690
Clearwater UWCD	1,099	1,099	1,099	1,099	1,099	1,099
Fox Crossing WD	946	946	946	946	946	946
Middle Trinity GCD	13,254	13,254	13,254	13,254	13,254	13,254
North Texas GCD	4,826	4,826	4,826	4,826	4,826	4,826
Northern Trinity GCD	2,535	2,535	2,535	2,535	2,535	2,535
Post Oak Savannah GCD	36	36	36	36	36	36
Prairielands GCD	3,881	3,881	3,881	3,881	3,881	3,881
Red River GCD	2,548	2,548	2,548	2,548	2,548	2,548
Saratoga UWCD	885	885	885	885	885	885
Southern Trinity GCD	4,190	4,190	4,190	4,190	4,190	4,190
Upper Trinity GCD	6,878	6,878	6,878	6,878	6,878	6,878
Total (excluding non-district areas)	**41,768**	**41,768**	**41,768**	**41,768**	**41,768**	**41,768**
No District	4,476	4,476	4,476	4,476	4,476	4,476
Total (including non-district areas)	**46,244**	**46,244**	**46,244**	**46,244**	**46,244**	**46,244**

Table 18. Modeled available groundwater for the Hosston unit of the Trinity Aquifer summarized by groundwater conservation district (GCD) in Groundwater Management Area 8 for each decade between 2010 and 2060. Results are in acre-feet per year. UWCD refers to Underground Water Conservation District. WD refers to Water District.

Groundwater Conservation District	**Year**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Central Texas GCD	2,469	2,469	2,469	2,469	2,469	2,469
Clearwater UWCD	4,993	4,993	4,993	4,993	4,993	4,993
Fox Crossing WD	1,384	1,384	1,384	1,384	1,384	1,384
Middle Trinity GCD	43,216	43,216	43,216	43,216	43,216	43,216
North Texas GCD	8,349	8,349	8,349	8,349	8,349	8,349
Northern Trinity GCD	5,556	5,556	5,556	5,556	5,556	5,556
Post Oak Savannah GCD	103	103	103	103	103	103
Prairielands GCD	7,146	7,146	7,146	7,146	7,146	7,146
Red River GCD	2,556	2,556	2,556	2,556	2,556	2,556
Saratoga UWCD	1,446	1,446	1,446	1,446	1,446	1,446
Southern Trinity GCD	16,004	16,004	16,004	16,004	16,004	16,004
Upper Trinity GCD	17,464	17,464	17,464	17,464	17,464	17,464
Total (excluding non-district areas)	**110,686**	**110,686**	**110,686**	**110,686**	**110,686**	**110,686**
No District	20,123	20,123	20,123	20,123	20,123	20,123
Total (including non-district areas)	**130,809**	**130,809**	**130,809**	**130,809**	**130,809**	**130,809**

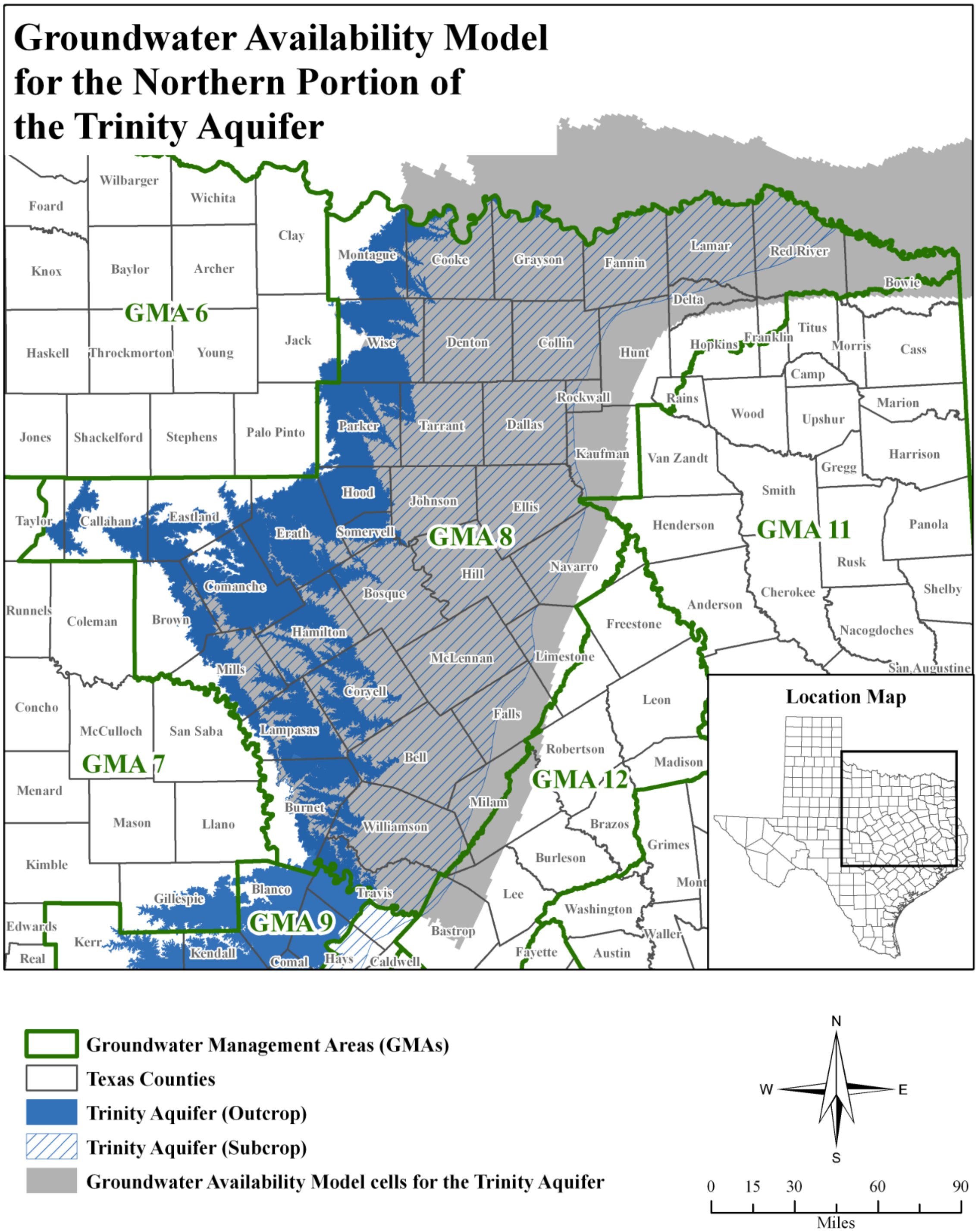

Figure 1. Map showing the areas of the groundwater availability model representing the northern portion of the Trinity Aquifer and the boundary of Groundwater Management Area 8.

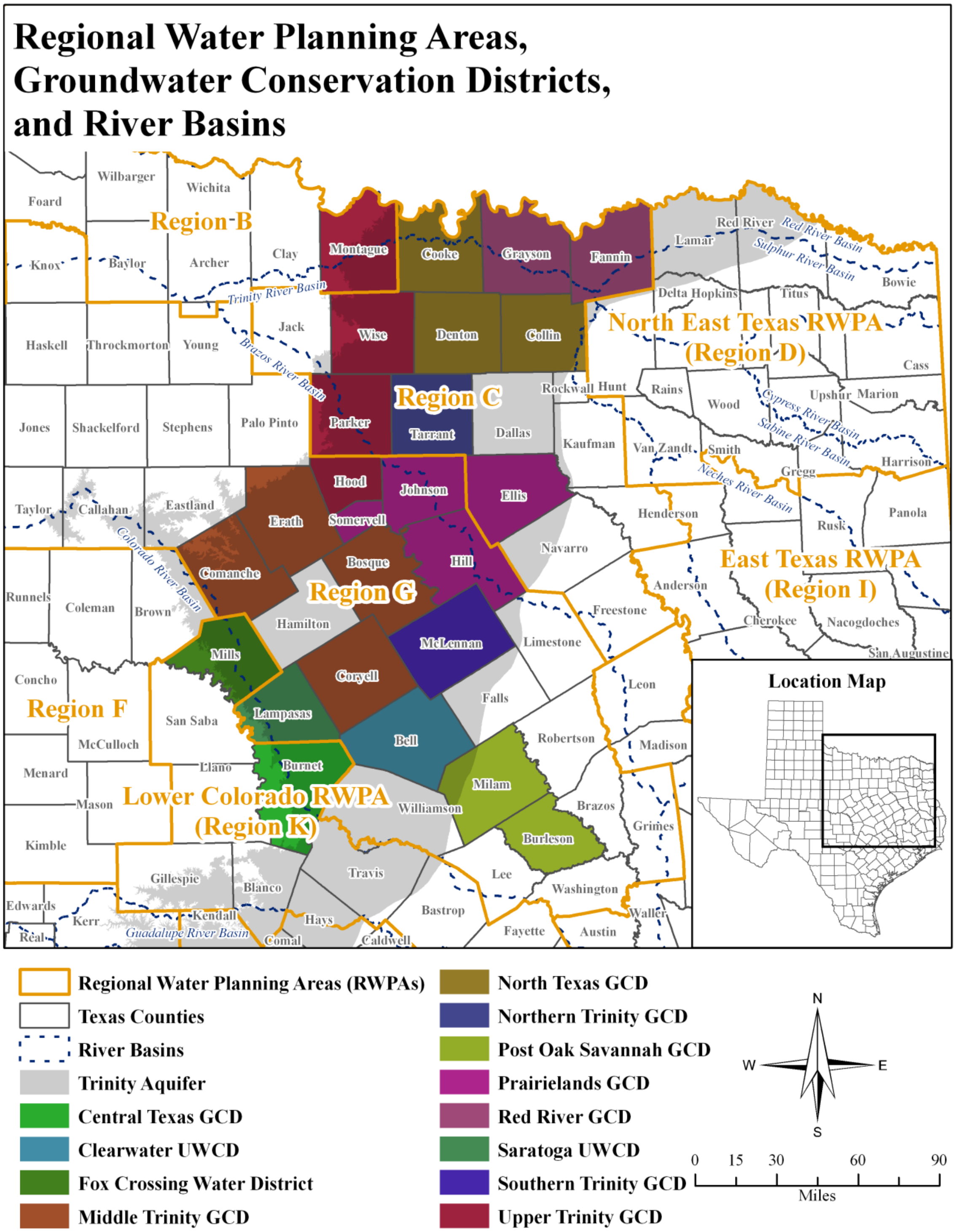

Figure 2. Map showing regional water planning areas (RWPAs), groundwater conservation districts (GCDs), counties, and river basins in and neighboring Groundwater Management Area 8.

Appendix C

Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 8 (GAM TASK 13-031)

GAM Task 13-031: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 8

by Jerry Shi, Ph.D., P.G., Robert G. Bradley, P.G., Shirley Wade, Ph.D., P.G., Ian Jones, Ph.D., P.G., Roberto Anaya, P.G., and Chelsea Seiter-Weatherford
Texas Water Development Board
Groundwater Resources Division
Jerry Shi: (512) 463-5076
January 15, 2014

The seals appearing on this document were authorized by Jianyou (Jerry) Shi, P.G. 11113, Robert G. Bradley, P.G. 707, Shirley Wade, P.G. 525, Ian Jones, P.G. 477, Roberto Anaya, P.G. 480, and Cynthia K. Ridgeway, P.G. 471 on January 15, 2014. Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by Chelsea Seiter-Weatherford under her direct supervision.

The total estimated recoverable storage in this report was calculated as follows: the Trinity and Woodbine aquifers (Jerry Shi); Hickory, Ellenburger-San Saba, and Marble Falls aquifers (Robert G. Bradley); Brazos River Alluvium Aquifer (Shirley Wade); Edwards (Balcones Fault Zone) Aquifer (Ian Jones); Blossom Aquifer (Roberto Anaya); and Nacatoch Aquifer (Chelsea Seiter-Weatherford and Jerry Shi).

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GAM TASK 13-031: TOTAL ESTIMATED RECOVERABLE STORAGE FOR AQUIFERS IN GROUNDWATER MANAGEMENT AREA 8

by Jerry Shi, Ph.D., P.G., Robert G. Bradley, P.G., Shirley Wade, Ph.D., P.G., Ian Jones, Ph.D., P.G., Roberto Anaya, P.G., and Chelsea Seiter-Weatherford
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
Jerry Shi: (512) 463-5076
January 15, 2014

INTRODUCTION:

As required by Texas Water Code § 36.108, the Texas Water Development Board (TWDB) shall provide the total estimated recoverable storage (TERS) for all of the aquifers in a groundwater management area as part of the process that groundwater conservation districts follow to develop its desired future conditions. This task report summarizes the calculation of the total estimated recoverable storage for the Hickory, Ellenburger-San Saba, Marble Falls, Trinity, Edwards (Balcones Fault Zone), Woodbine, Nacatoch, Blossom, and Brazos River Alluvium aquifers in Groundwater Management Area 8.

DEFINITION OF TOTAL ESTIMATED RECOVERABLE STORAGE:

The total estimated recoverable storage is defined as the estimated amount of groundwater in an aquifer that accounts for recovery scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume, in other words, we assume that only 25 to 75 percent of groundwater held in an aquifer can be removed by pumping.

The total recoverable storage was estimated for the portion of each aquifer in Groundwater Management Area 8 within the official lateral aquifer boundaries as published in the TWDB Report 380 (George and others, 2011). Total estimated recoverable storage values may include a mixture of water quality types, including fresh, brackish, and saline groundwater, because the available data and the existing groundwater availability models do not permit the differentiation of different water quality types. These values do not take into account the effects of land surface subsidence, degradation of water quality, or any changes to surface water-groundwater interaction that may occur due to pumping.

METHODS:

To estimate the total recoverable storage of an aquifer, the total storage of the aquifer within the official aquifer boundary was calculated first. The total storage is the volume of groundwater removed by pumping that completely drains the aquifer.

Aquifers can be either unconfined or confined (Figure 1). A well screened in an unconfined aquifer will have a water level equal to the water level outside the well. Thus, unconfined aquifers have water levels in the aquifers. A confined aquifer is bounded by low permeable geologic units at the top and bottom, and the aquifer is under hydraulic pressure above the ambient atmospheric pressure. The water level in a well screened in a confined aquifer will be above the top of the aquifer. As a result, calculation of total storage is different between unconfined and confined aquifers. For an unconfined aquifer, the total storage is equal to the volume of groundwater that makes the water level fall to the aquifer bottom. For a confined aquifer, the total storage contains two parts. The first part is the groundwater released from the aquifer when the water level falls from above the top of the aquifer to the top of the aquifer. The reduction of hydraulic pressure in the aquifer causes expansion of groundwater and deformation of aquifer solids. The aquifer is still fully saturated to this point. The second part, just like unconfined aquifer, is the groundwater released from the aquifer when the water level falls from the top to the bottom of the aquifer. Given the same aquifer area and water level drop, the amount of water released in the second part is much greater than the first part. The difference is quantified by two parameters: storativity related to confined aquifer and specific yield related to unconfined aquifer. For example, storativity values range from 10^{-5} to 10^{-3} for most confined aquifers, while the specific yield values can be 0.01 to 0.3 for most unconfined aquifers. The equations for calculating the total storage are presented below:

- for unconfined aquifers

$$\begin{aligned} Total\ Storage\ &= V_{drained} = Area \times S_y \times (Water\ Level - Bottom) \\ &= Area \times S_y \times \text{Aquifer Saturated Thickness} \end{aligned}$$

- for confined aquifers

$$Total\ Storage = V_{confined} + V_{drained}$$

- confined part

$$V_{confined} = Area \times [\, S \times (Water\ Level - Top)]$$

or

$$V_{confined} = Area \times [\, S_s \times (\mathrm{Top} - \mathrm{Bottom}) \times (Water\ Level - Top)]$$

- unconfined part

$$V_{drained} = Area \times \left[S_y \times (Top - Bottom)\right]$$

where:

- $V_{drained}$ = storage volume due to water draining from the formation (acre-feet)
- $V_{confined}$ = storage volume due to elastic properties of the aquifer and water(acre-feet)
- *Area* = area of aquifer (acre)
- *Water Level* = groundwater elevation (feet above mean sea level)
- *Top* = elevation of aquifer top (feet above mean sea level)
- *Bottom* = elevation of aquifer bottom (feet above mean sea level)
- S_y = specific yield (no units)
- S_s = specific storage (1/feet)
- S = storativity or storage coefficient (no units)

As presented in the equations, calculation of the total storage requires data such as aquifer top, aquifer bottom, aquifer storativity (for confined conditions), aquifer specific yield (for unconfined conditions), and water level. If a groundwater availability model is available, then this information is extracted from the input and output files of the model on a cell-by-cell basis. If an aquifer is simulated as confined, then the specific yield is not included in the model input file and this value is estimated using other resources and documentation. A FORTRAN-90 program was developed and used to expedite the calculation. This approach was used for the total storage calculation of the Trinity, Edwards (Balcones Fault Zone), Woodbine, and Nacatoch aquifers.

For an aquifer without a groundwater availability model, the published geologic and hydrologic data were interpreted using SURFER™ or Esri® ArcGIS™ spatial analysis tool to develop the input data for the storage calculation. This approach was used for the total storage calculation of the Hickory, Ellenburger-San Saba, Marble Falls, Blossom, and Brazos River Alluvium aquifers.

After calculating the total aquifer storage, the total recoverable storage for the aquifer was calculated as the product of the total aquifer storage and an estimated factor ranging from 25 percent to 75 percent.

PARAMETERS AND ASSUMPTIONS:

HICKORY AQUIFER

- The Hickory Aquifer within Groundwater Management Area 8 is under unconfined conditions in outcrop and confined conditions in the subcrop areas.
- The water levels from the TWDB Groundwater Database (2013) were used to create the water level grid using Surfer® software.
- For the outcrop area, the base of the Hickory Aquifer from the Source Water Assessment Project (SWAP) data (United States Geological Survey, 2002b) was used to create the grid file using Surfer® software.
- For the subcrop area, the top and bottom of the Hickory Aquifer were from Standen and others (2007).
- The aquifer top and bottom averages for each county were calculated using zonal statistics from Esri® ArcGIS™ 10.1.
- The storage coefficient of the aquifer was estimated to be 1×10^{-5} which is within the range presented in Bluntzer (1992).
- The specific yield of the aquifer was estimated to be 0.03, based on porosity measurements presented in Bluntzer (1992).

ELLENBURGER-SAN SABA AQUIFER

- The Ellenburger-San Saba Aquifer within Groundwater Management Area 8 is under unconfined conditions in outcrop and confined conditions in the subcrop areas.
- The water levels from the TWDB Groundwater Database (2013) were used to create the water level grid using Surfer® software.
- For the outcrop area, the base of the Ellenburger-San Saba Aquifer from the Source Water Assessment Project (SWAP) data (United States Geological Survey, 2002a) was used to create the grid file using Surfer® software.

- For the subcrop area, the top and bottom elevations of the Ellenburger-San Saba Aquifer were from Standen and others (2007).
- The aquifer top and bottom averages for each county were calculated using zonal statistics from Esri® ArcGIS™ 10.1.
- The storage coefficient of the aquifer was assigned the value of 0.0022 (Bluntzer, 1992).
- The specific yield of the aquifer was estimated to be 0.03, based on porosity measurements presented in Bluntzer (1992).

MARBLE FALLS AQUIFER

- The Marble Falls Aquifer within Groundwater Management Area 8 is assumed to be under unconfined conditions.
- The average saturated thickness was estimated to be 80 feet based on available data (Texas Water Development Board, 2013; Texas Department of Licensing and Regulation, 2013).
- Like other carbonate rocks in the region studied by Bluntzer (1992), the specific yield for the Marble Falls Aquifer was estimated to be 0.03.

TRINITY AQUIFER

- Version 1.01 of the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (R.W. Harden & Associates, Inc. and others, 2004) was used to estimate the total recoverable storage for the Trinity Aquifer.
- This groundwater availability model includes seven layers which represent the Woodbine Aquifer (Layer 1), the Fredericksburg/Washita groups confining unit (Layer 2), the Paluxy Formation (Layer 3), the Glen Rose Formation confining unit (Layer 4), the Hensell Formation (Layer 5), the Pearsall/Cow Creek/Hammett/Sligo formations confining unit (Layer 6), and Hosston Formation (Layer 7). In some parts of the study area various combinations of the layers represent the Antlers Formation.
- Model layers 3, 4, 5, 6, and 7 were used to calculate the total estimated recoverable storage for the Trinity Aquifer.

EDWARDS (BALCONES FAULT ZONE) AQUIFER

- Version 1.01 of the groundwater availability model for the northern segment of the Edwards (Balcones Fault Zone) Aquifer (Jones, 2003) was used to estimate the total recoverable storage for the Edwards (Balcones Fault Zone) Aquifer.
- This groundwater availability model includes one layer which represents the Edwards (Balcones Fault Zone) Aquifer.

WOODBINE AQUIFER

- Version 1.01 of the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (R.W. Harden & Associates, Inc. and others, 2004) was used to estimate the total recoverable storage for the Woodbine Aquifer.
- This groundwater availability model includes seven layers which represent Woodbine Aquifer (Layer 1), the Fredericksburg/Washita groups confining unit (Layer 2), the Paluxy Formation (Layer 3), the Glen Rose Formation confining unit (Layer 4), the Hensell Formation (Layer 5), the Pearsall/Cow Creek/Hammett/Sligo formations confining unit (Layer 6), and Hosston Formation (Layer 7). In some parts of the study area various combinations of the layers represent the Antlers Formation.
- Model layer 1 was used to calculate the total estimated recoverable storage for the Woodbine Aquifer.

NACATOCH AQUIFER

- Version 1.01 of the groundwater availability model for the Nacatoch Aquifer (Beach and others, 2009) was used to estimate the total recoverable storage for the Nacatoch Aquifer.
- This groundwater availability model includes two layers which represent the Midway, alluvium and terrace deposits (Layer 1) and the Nacatoch Aquifer (Layer 2).
- Model layer 2 was used to calculate the total estimated recoverable storage for the Nacatoch Aquifer.

Blossom Aquifer

- The aquifer top and bottom elevations were based on interpretations from McLaurin (1988) and modified using spatial analysis of data from the United States Geological Survey digital elevation model (DEM), the Geologic Atlas of Texas, and the top of the Woodbine Formation as interpreted by R.W. Harden & Associates, Inc. and others (2004).
- Water elevation data were obtained from TWDB groundwater database downloads http://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp in July 2013. To increase the number of control points used to interpret the average water level, data were selected from winter months between 2005 and 2010. Stream channel elevations were also used to further refine and add control points to the average water level interpretations.
- The spatially distributed saturated aquifer thickness and water level depth above the confined portion of the aquifer were calculated using the spatially interpreted top and bottom of the aquifer and the average 2005 to 2010 winter water level.
- The storativity values ranging from 0.000001 to 0.000112 and a specific yield value 0.2 were obtained from the Source-Water Assessment Program – Decision Support System (SWAP-DSS) database (Ulery and Others, 2011).
- The total estimated recoverable storage for each county were then calculated using spatial analysis tools within Esri® ArcGIS™ 10.2 software.

Brazos River Alluvium Aquifer

- The Brazos River Alluvium Aquifer is under water table or unconfined conditions in most places (George and others, 2011).
- The thickness of the Brazos River Alluvium Aquifer was from data presented in Shah and Houston (2007).
- Water depth data were from TWDB groundwater database downloads http://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp in July 2013. All available water depth data were used to calculate the average.
- The aquifer thickness averages for each county were then calculated using zonal statistics from Esri® ArcGIS™ 10.1.

- Average saturated aquifer thickness was then calculated using the average aquifer thickness subtracting the average water depth.
- The specific yield value of the aquifer was assigned a value of 0.15 according to Cronin and Wilson (1967).

RESULTS:

HICKORY AQUIFER

Figure 2 shows the official boundary of the Hickory Aquifer in Groundwater Management Area 8. Table 1 represents the total estimated recoverable storage for the aquifer in each county located in Groundwater Management Area 8. The total estimated recoverable storage for the Hickory Aquifer by groundwater conservation district in Groundwater Management Area 8 is presented in Table 2.

ELLENBURGER-SAN SABA AQUIFER

Figure 3 shows the official boundary of the Ellenburger-San Saba Aquifer in Groundwater Management Area 8. Table 3 represents the total estimated recoverable storage for the aquifer in each county located in Groundwater Management Area 8. The total estimated recoverable storage for the Ellenburger-San Saba Aquifer by groundwater conservation district in Groundwater Management Area 8 is presented in Table 4.

MARBLE FALLS AQUIFER

Figure 4 shows the official boundary of the Marble Falls Aquifer in Groundwater Management Area 8. Table 5 represents the total estimated recoverable storage for the aquifer in each county located in Groundwater Management Area 8. The total estimated recoverable storage for the Marble Falls Aquifer by groundwater conservation district in Groundwater Management Area 8 is presented in Table 6.

TRINITY AQUIFER

Figure 5 shows the official boundary of the Trinity Aquifer and the active MODFLOW model cells to represent the aquifer. Table 7 represents the total estimated recoverable storage for the official aquifer in each county located in Groundwater Management Area 8. Figure 6 shows the groundwater conservation districts associated with the Trinity Aquifer in Groundwater Management Area 8. The total estimated recoverable storage for the Trinity Aquifer by groundwater conservation district in Groundwater Management Area 8 is presented in Table 8.

EDWARDS (BALCONES FAULT ZONE) AQUIFER

Figure 7 shows the official boundary of the Edwards (Balcones Fault Zone) Aquifer and the active MODFLOW model cells to represent the portion of the aquifer in Groundwater Management Area 8. Table 9 represents the total estimated recoverable storage for the aquifer in each county located in Groundwater Management Area 8. Figure 8 shows the groundwater conservation district associated with the Edwards (Balcones Fault Zone) Aquifer in Groundwater Management Area 8. The total estimated recoverable storage for the aquifer by groundwater conservation district in Groundwater Management Area 8 is presented in Table 10.

WOODBINE AQUIFER

Figure 9 shows the official boundary of the Woodbine Aquifer boundary and the active MODFLOW model cells to represent the aquifer in Groundwater Management Area 8. Table 11 represents the total estimated recoverable storage for the aquifer in each county located in Groundwater Management Area 8. Figure 10 shows the groundwater conservation districts associated with the Woodbine Aquifer in Groundwater Management Area 8. The total estimated recoverable storage for the Woodbine Aquifer by groundwater conservation district in Groundwater Management Area 8 is presented in Table 12.

NACATOCH AQUIFER

Figure 11 shows the official boundary of the Nacatoch Aquifer and the active MODFLOW model cells to represent the aquifer in Groundwater Management Area 8. Table 13 represents the total estimated recoverable storage for the official aquifer in each county located in Groundwater Management Area 8. Figure 12 shows the groundwater conservation district associated with the Nacatoch Aquifer in Groundwater Management Area 8. The total estimated recoverable storage for the Nacatoch Aquifer by groundwater conservation district in Groundwater Management Area 8 is presented in Table 14.

Blossom Aquifer

Figure 13 shows the official boundary of the Blossom Aquifer located in Groundwater Management Area 8. Table 15 represents the total estimated recoverable storage for the aquifer in each county located in Groundwater Management Area 8. The total estimated recoverable storage for the aquifer by groundwater conservation district in Groundwater Management Area 8 is presented in Table 16.

Brazos River Alluvium Aquifer

Figure 14 shows the official boundary of the Brazos River Alluvium Aquifer in Groundwater Management Area 8. Table 17 represents the total estimated recoverable storage for the aquifer in each county located in Groundwater Management Area 8. The total estimated recoverable storage for the Brazos River Alluvium Aquifer by groundwater conservation district in Groundwater Management Area 8 is presented in Table 18.

LIMITATIONS

The groundwater models used in completing this analysis are the best available scientific tools that can be used to meet the stated objective(s). 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."*

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

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TABLE 1. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Brown	220,000	55,000	165,000
Burnet	6,600,000	1,650,000	4,950,000
Lampasas	2,800,000	700,000	2,100,000
Mills	630,000	157,500	472,500
Travis	33,000	8,250	24,750
Williamson	17,000	4,250	12,750
Total	**10,300,000**	**2,575,000**	**7,725,000**

TABLE 2. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No GCD	270,000	67,500	202,500
Central Texas GCD	6,600,000	1,650,000	4,950,000
Fox Crossing WD[1]	630,000	157,500	472,500
Saratoga UWCD[2]	2,800,000	700,000	2,100,000
Total	**10,300,000**	**2,575,000**	**7,725,000**

[1] WD = Water District

[2] UWCD = Underground Water Conservation District

TABLE 3. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE ELLENBURGER-SAN SABA AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Brown	420,000	105,000	315,000
Burnet	8,100,000	2,025,000	6,075,000
Lampasas	8,500,000	2,125,000	6,375,000
Mills	2,300,000	575,000	1,725,000
Total	**19,320,000**	**4,830,000**	**14,490,000**

TABLE 4. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE ELLENBURGER-SAN SABA AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No GCD	420,000	105,000	315,000
Central Texas GCD	8,100,000	2,025,000	6,075,000
Fox Crossing WD[3]	2,300,000	575,000	1,725,000
Saratoga UWCD[4]	8,500,000	2,125,000	6,375,000
Total	**19,320,000**	**4,830,000**	**14,490,000**

[3] WD = Water District
[4] UWCD = Underground Water Conservation District

TABLE 5. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE MARBLE FALLS AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Burnet	38,000	9,500	28,500
Lampasas	39,000	9,750	29,250
Total	**77,000**	**19,250**	**57,750**

TABLE 6. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE MARBLE FALLS AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Central Texas GCD	38,000	9,500	28,500
Saratoga GCD	39,000	9,750	29,250
Total	**77,000**	**19,250**	**57,750**

TABLE 7. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Bell	59,000,000	14,750,000	44,250,000
Bosque	40,000,000	10,000,000	30,000,000
Brown	2,600,000	650,000	1,950,000
Burnet	11,000,000	2,750,000	8,250,000
Callahan	1,800,000	450,000	1,350,000
Collin	88,000,000	22,000,000	66,000,000
Comanche	8,300,000	2,075,000	6,225,000
Cooke	45,000,000	11,250,000	33,750,000
Coryell	34,000,000	8,500,000	25,500,000
Dallas	77,000,000	19,250,000	57,750,000
Delta	11,000,000	2,750,000	8,250,000
Denton	64,000,000	16,000,000	48,000,000
Eastland	1,600,000	400,000	1,200,000
Ellis	78,000,000	19,500,000	58,500,000
Erath	20,000,000	5,000,000	15,000,000
Falls	36,000,000	9,000,000	27,000,000
Fannin	79,000,000	19,750,000	59,250,000
Grayson	63,000,000	15,750,000	47,250,000
Hamilton	22,000,000	5,500,000	16,500,000
Hill	52,000,000	13,000,000	39,000,000
Hood	11,000,000	2,750,000	8,250,000
Hunt	12,000,000	3,000,000	9,000,000
Johnson	35,000,000	8,750,000	26,250,000
Kaufman	9,400,000	2,350,000	7,050,000

County	***Total Storage (acre-feet)***	***25 percent of Total Storage (acre-feet)***	***75 percent of Total Storage (acre-feet)***
Lamar	77,000,000	19,250,000	57,750,000
Lampasas	12,000,000	3,000,000	9,000,000
Limestone	11,000,000	2,750,000	8,250,000
McLennan	59,000,000	14,750,000	44,250,000
Milam	22,000,000	5,500,000	16,500,000
Mills	8,500,000	2,125,000	6,375,000
Montague	7,800,000	1,950,000	5,850,000
Navarro	39,000,000	9,750,000	29,250,000
Parker	22,000,000	5,500,000	16,500,000
Red River	44,000,000	11,000,000	33,000,000
Rockwall	4,900,000	1,225,000	3,675,000
Somervell	6,000,000	1,500,000	4,500,000
Tarrant	49,000,000	12,250,000	36,750,000
Taylor	630,000	157,500	472,500
Travis	39,000,000	9,750,000	29,250,000
Williamson	77,000,000	19,250,000	57,750,000
Wise	20,000,000	5,000,000	15,000,000
Total	**1,359,530,000**	**339,882,500**	**1,019,647,500**

TABLE 8. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. THE TOTAL ESTIMATED RECOVERABLE STORAGE VALUES BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR AN AQUIFER MAY NOT BE THE SAME BECAUSE THE NUMBERS HAVE BEEN ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	***Total Storage (acre-feet)***	***25 percent of Total Storage (acre-feet)***	***75 percent of Total Storage (acre-feet)***
No GCD	470,000,000	117,500,000	352,500,000
Central Texas GCD	11,000,000	2,750,000	8,250,000
Clearwater UWCD[5]	59,000,000	14,750,000	44,250,000
Fox Crossing Water District	8,500,000	2,125,000	6,375,000
Middle Trinity GCD	100,000,000	25,000,000	75,000,000
North Texas GCD	200,000,000	50,000,000	150,000,000
Northern Trinity GCD	49,000,000	12,250,000	36,750,000
Post Oak Savannah GCD	22,000,000	5,500,000	16,500,000
Prairielands GCD	170,000,000	42,500,000	127,500,000
Red River GCD	140,000,000	35,000,000	105,000,000
Saratoga UWCD	12,000,000	3,000,000	9,000,000
Southern Trinity GCD	59,000,000	14,750,000	44,250,000
Upper Trinity GCD	61,000,000	15,250,000	45,750,000
Total	**1,361,500,000**	**340,375,000**	**1,021,125,000**

[5] UWCD = Underground Water Conservation District

TABLE 9. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE EDWARDS (BALCONES FAULT ZONE) AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Bell	11,000	2,750	8,250
Travis	5,900	1,475	4,425
Williamson	78,000	19,500	58,500
Total	**94,900**	**23,725**	**71,175**

TABLE 10. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE EDWARDS (BALCONES FAULT ZONE) AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. THE TOTAL ESTIMATED RECOVERABLE STORAGE VALUES BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR AN AQUIFER MAY NOT BE THE SAME BECAUSE THE NUMBERS HAVE BEEN ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No GCD	84,000	21,000	63,000
Clearwater UWCD[6]	11,000	2,750	8,250
Total	**95,000**	**23,750**	**71,250**

[6] UWCD = Underground Water Conservation District

TABLE 11. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE WOODBINE AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Collin	32,000,000	8,000,000	24,000,000
Cooke	1,200,000	300,000	900,000
Dallas	30,000,000	7,500,000	22,500,000
Denton	8,900,000	2,225,000	6,675,000
Ellis	25,000,000	6,250,000	18,750,000
Fannin	39,000,000	9,750,000	29,250,000
Grayson	32,000,000	8,000,000	24,000,000
Hill	6,700,000	1,675,000	5,025,000
Hunt	8,200,000	2,050,000	6,150,000
Johnson	4,500,000	1,125,000	3,375,000
Kaufman	4,700,000	1,175,000	3,525,000
Lamar	21,000,000	5,250,000	15,750,000
McLennan	900,000	225,000	675,000
Navarro	3,400,000	850,000	2,550,000
Red River	4,500,000	1,125,000	3,375,000
Rockwall	46,000	11,500	34,500
Tarrant	5,300,000	1,325,000	3,975,000
Total	**227,346,000**	**56,836,500**	**170,509,500**

TABLE 12. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE WOODBINE AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. THE TOTAL ESTIMATED RECOVERABLE STORAGE VALUES BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR AN AQUIFER MAY NOT BE THE SAME BECAUSE THE NUMBERS HAVE BEEN ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No GCD	72,000,000	18,000,000	54,000,000
North Texas GCD	42,000,000	10,500,000	31,500,000
Northern Trinity GCD	5,300,000	1,325,000	3,975,000
Prairielands GCD	36,000,000	9,000,000	27,000,000
Red River GCD	71,000,000	17,750,000	53,250,000
Southern Trinity GCD	900,000	225,000	675,000
Total	**227,200,000**	**56,800,000**	**170,400,000**

TABLE 13. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE NACATOCH AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Bowie	2,100,000	525,000	1,575,000
Delta	100,000	25,000	75,000
Ellis	66	17	50
Franklin	7,300	1,825	5,475
Hopkins	330,000	82,500	247,500
Hunt	550,000	137,500	412,500
Kaufman	120,000	30,000	90,000
Lamar	12,000	3,000	9,000
Navarro	95,000	23,750	71,250
Rains	18,000	4,500	13,500
Red River	580,000	145,000	435,000
Rockwall	280	70	210
Total	**3,912,646**	**978,162**	**2,934,485**

TABLE 14. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE NACATOCH AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. THE TOTAL ESTIMATED RECOVERABLE STORAGE VALUES BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR AN AQUIFER MAY NOT BE THE SAME BECAUSE THE NUMBERS HAVE BEEN ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No GCD	3,900,000	975,000	2,925,000
Prairielands GCD	66	17	50
Total	**3,900,066**	**975,017**	**2,925,050**

TABLE 15. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE BLOSSOM AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Bowie	910,000	227,500	682,500
Lamar	970,000	242,500	727,500
Red River	5,200,000	1,300,000	3,900,000
Total	**7,080,000**	**1,770,000**	**5,310,000**

TABLE 16. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE BLOSSOM AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No GCD	7,080,000	1,770,000	5,310,000
Total	**7,080,000**	**1,770,000**	**5,310,000**

TABLE 17. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE BRAZOS RIVER ALLUVIUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Bosque	9,600	2,400	7,200
Falls	160,000	40,000	120,000
Hill	6,600	1,650	4,950
McLennan	90,000	22,500	67,500
Milam	8,700	2,175	6,525
Total	**274,900**	**68,725**	**206,175**

TABLE 18. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE BRAZOS RIVER ALLUVIUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 8. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No GCD	160,000	40,000	120,000
Middle Trinity GCD	9,600	2,400	7,200
Post Oak Savannah GCD	8,700	2,175	6,525
Prairielands GCD	6,600	1,650	4,950
Southern Trinity GCD	90,000	22,500	67,500
Total	**274,900**	**68,725**	**206,175**

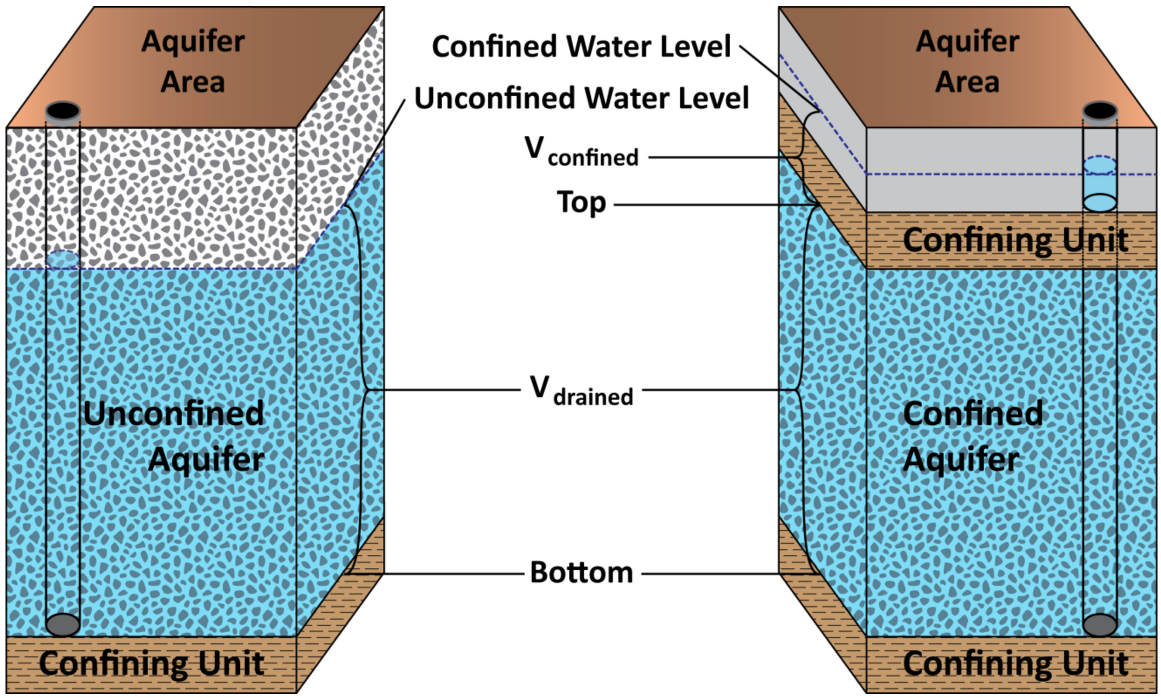

FIGURE 1. SCHEMATIC GRAPH SHOWING THE DIFFERENCE BETWEEN UNCONFINED AND CONFINED AQUIFERS.

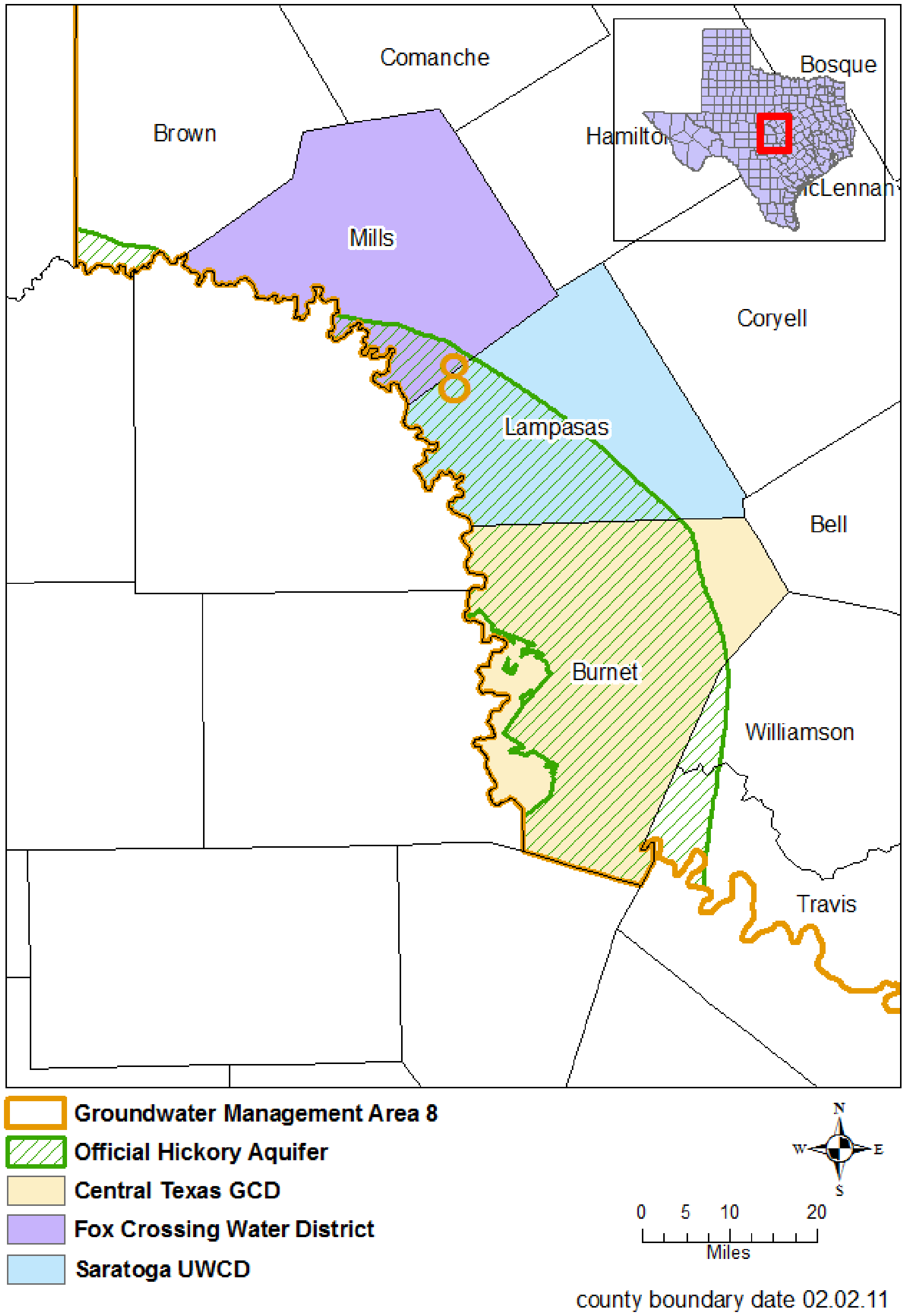

FIGURE 2. EXTENT OF THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

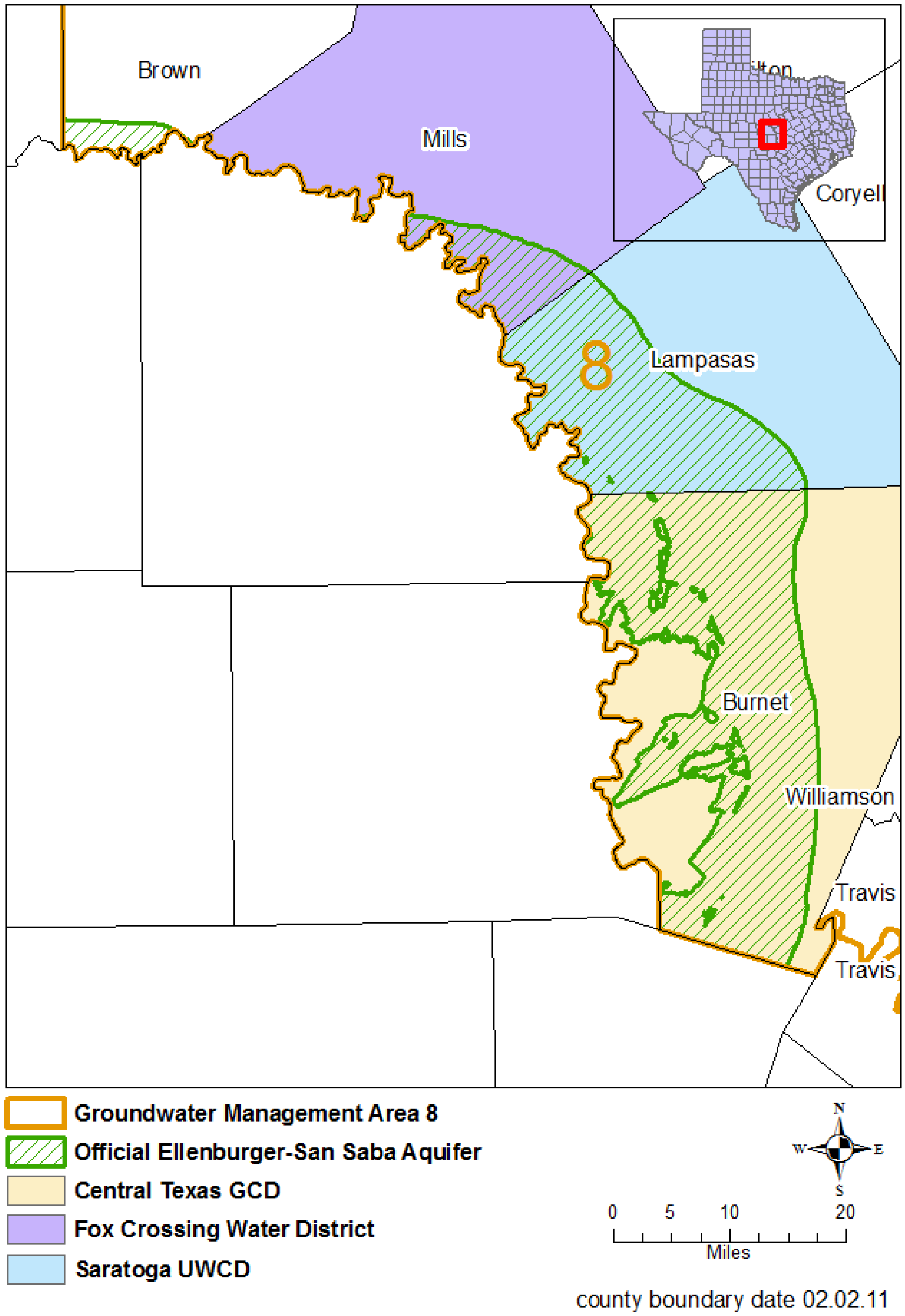

FIGURE 3. EXTENT OF THE ELLENBURGER-SAN SABA AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

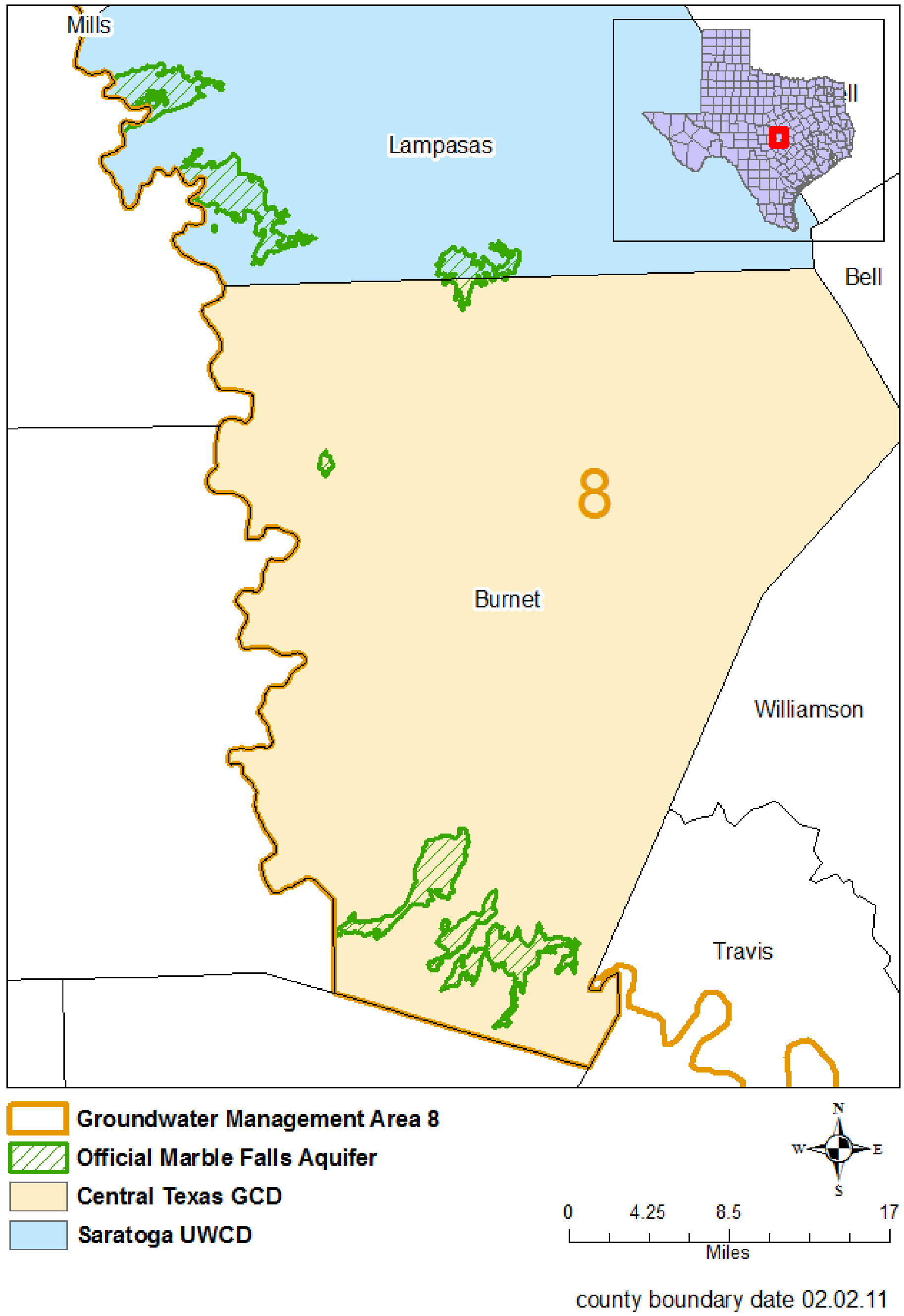

FIGURE 4. EXTENT OF THE MARBLE FALLS AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

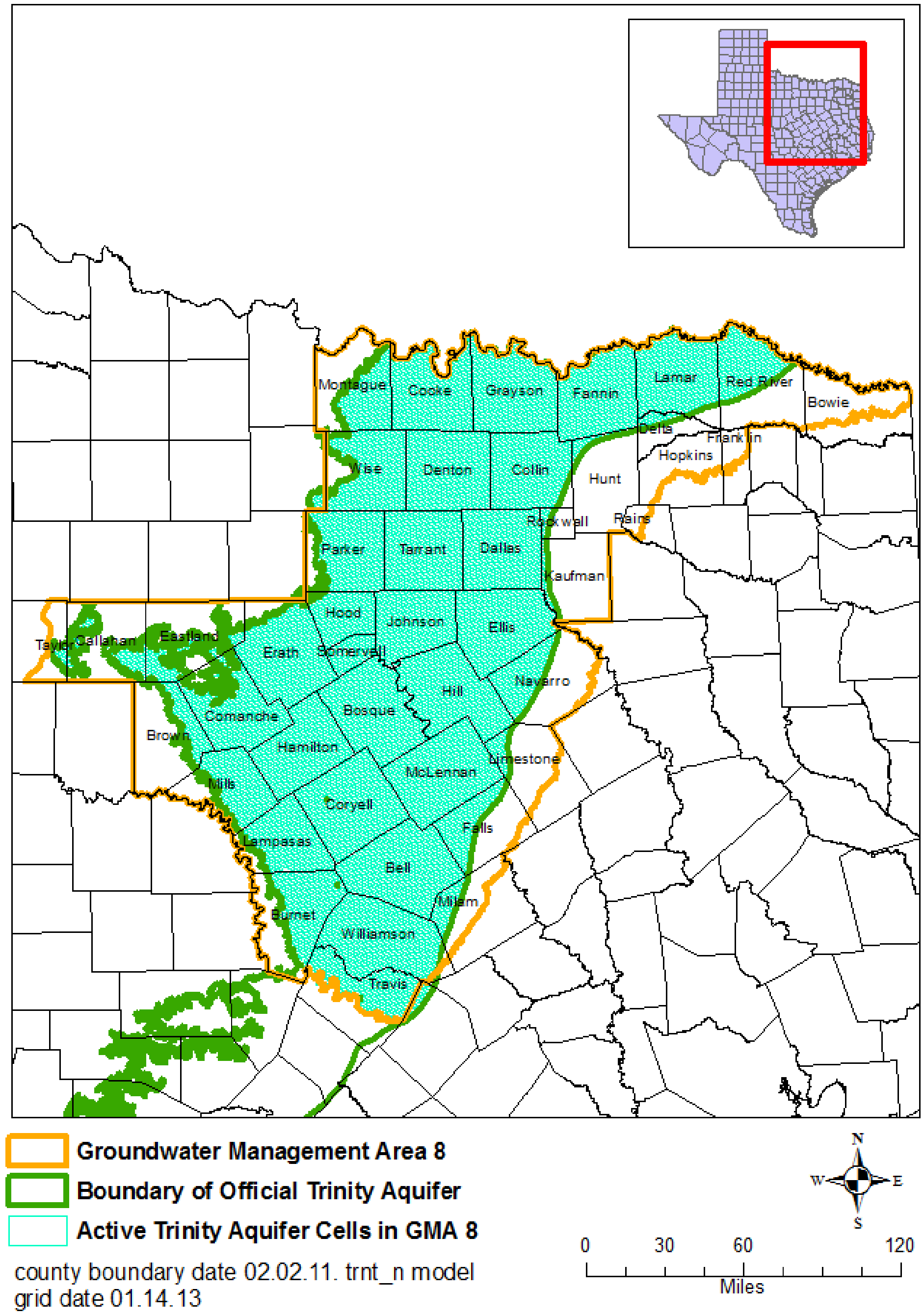

FIGURE 5. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTH TRINITY AND WOODBINE AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 8.

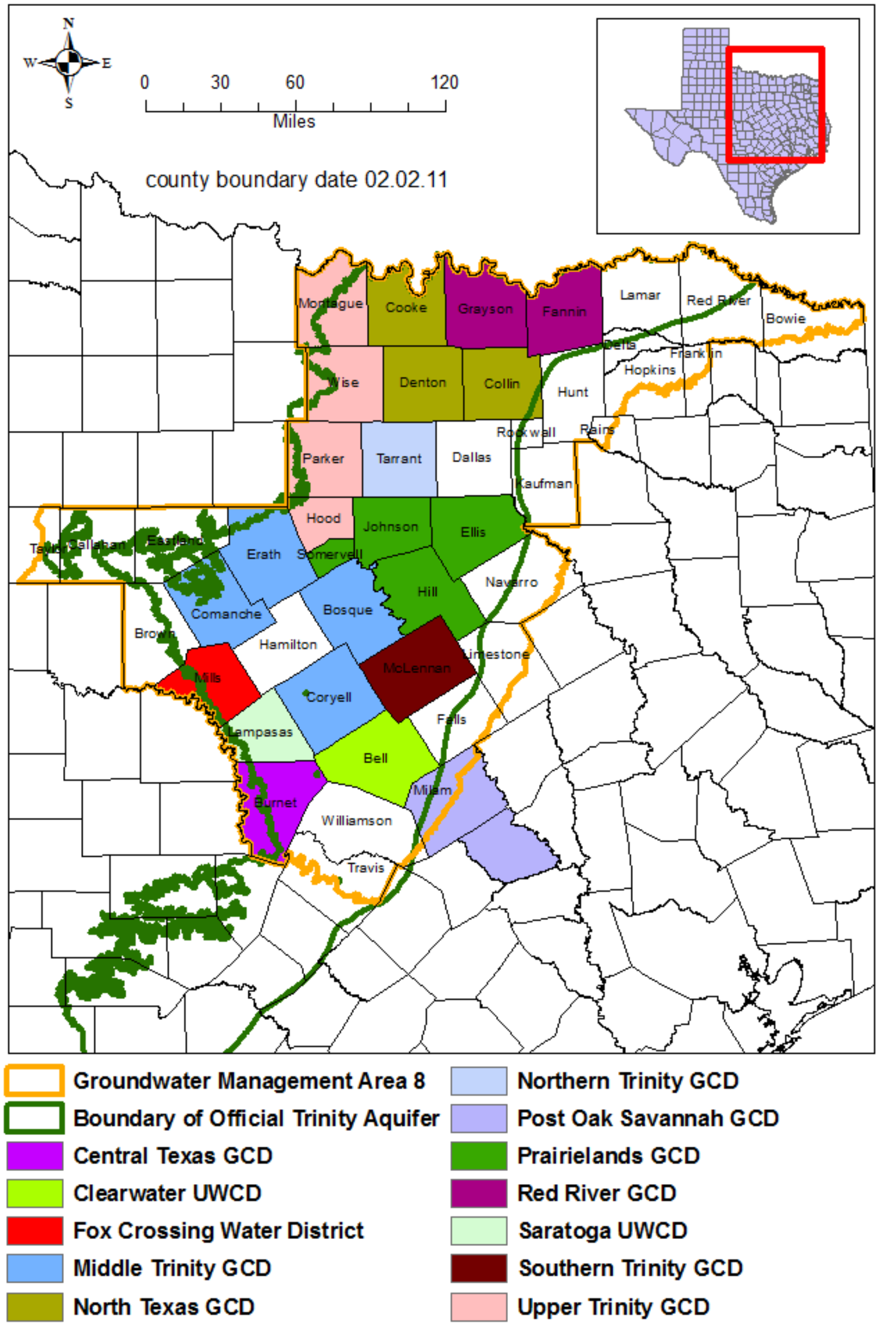

FIGURE 6. GROUNDWATER DISTRICTS ASSOCIATED WITH THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

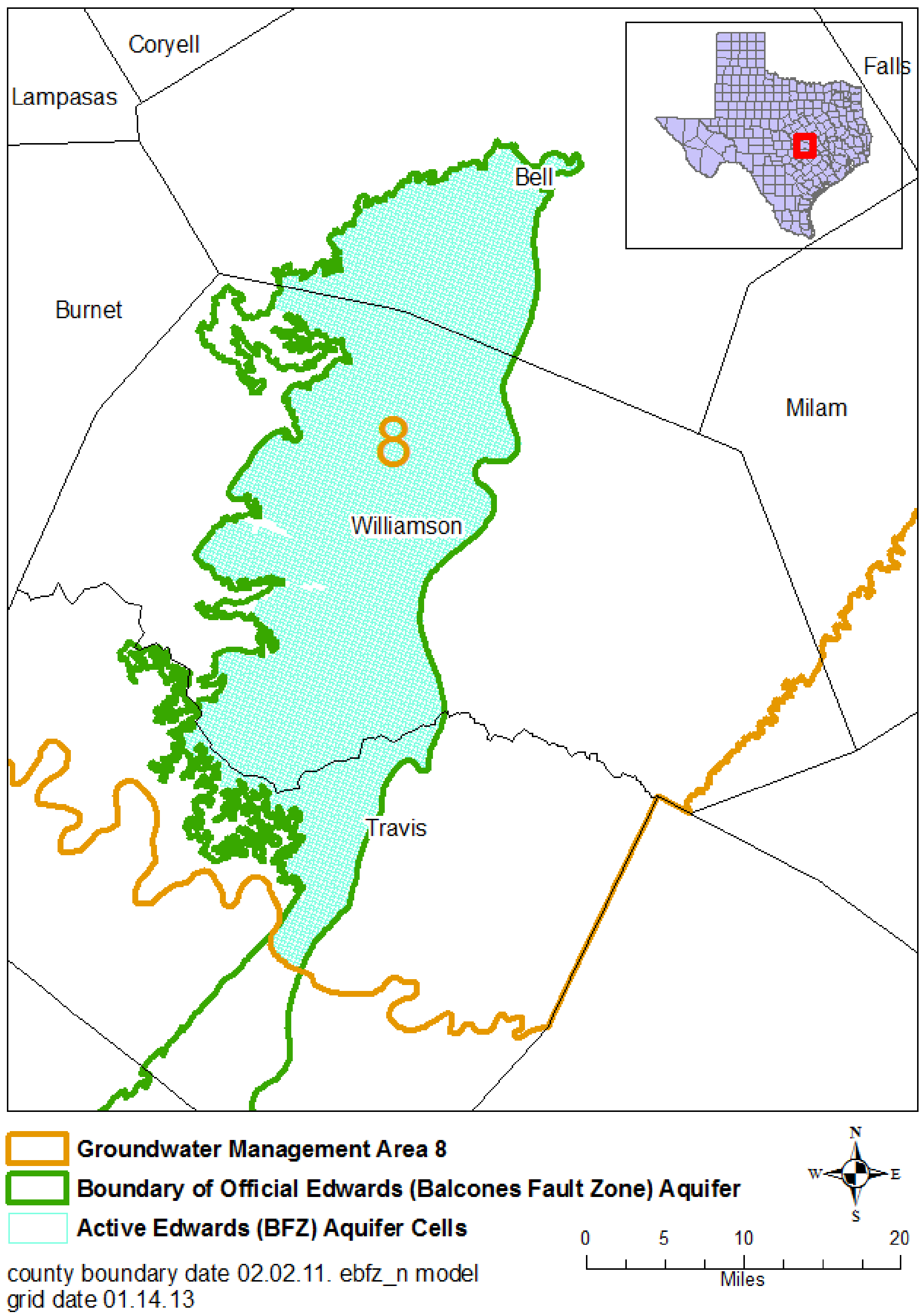

FIGURE 7. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN SEGMENT OF EDWARDS (BALCONES FAULT ZONE) AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE EDWARDS (BALCONES FAULT ZONE) AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

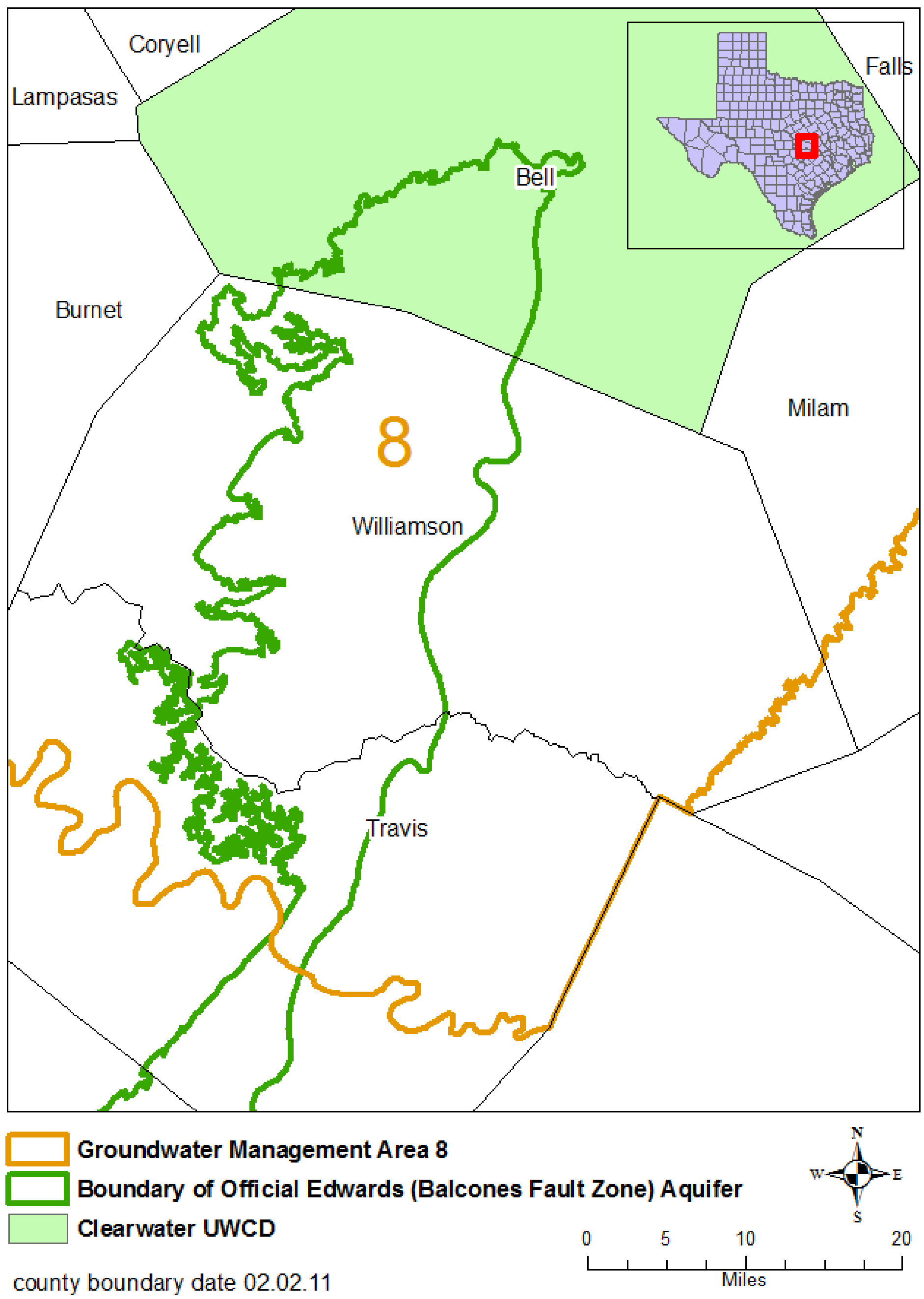

FIGURE 8. GROUNDWATER DISTRICT ASSOCIATED WITH THE EDWARDS (BALCONES FAULT ZONE) AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

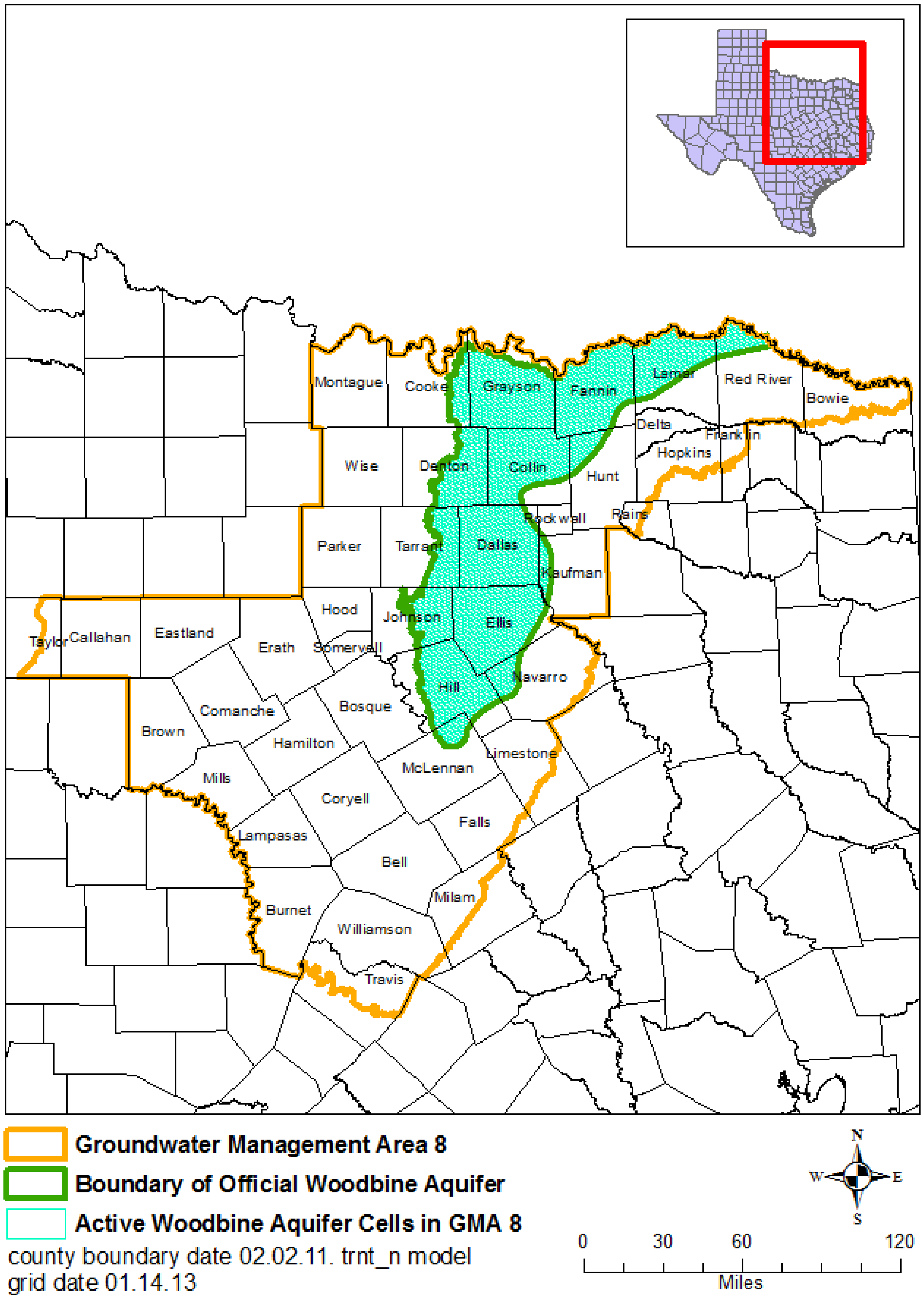

FIGURE 9. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE THE NORTHERN PORTION OF THE TRINITY AND WOODBINE AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE WOODBINE AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

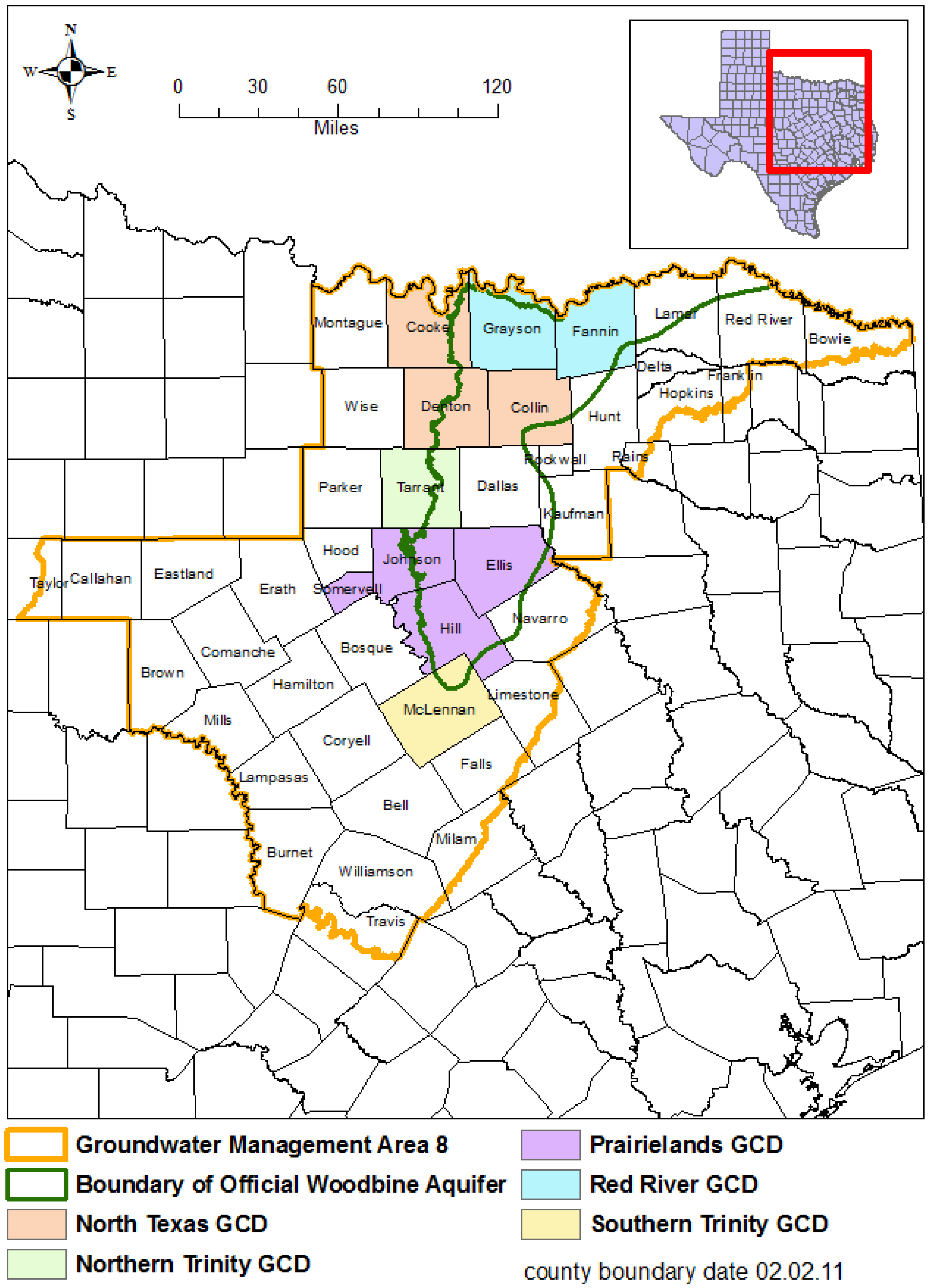

FIGURE 10. GROUNDWATER DISTRICT ASSOCIATED WITH THE WOODBINE AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

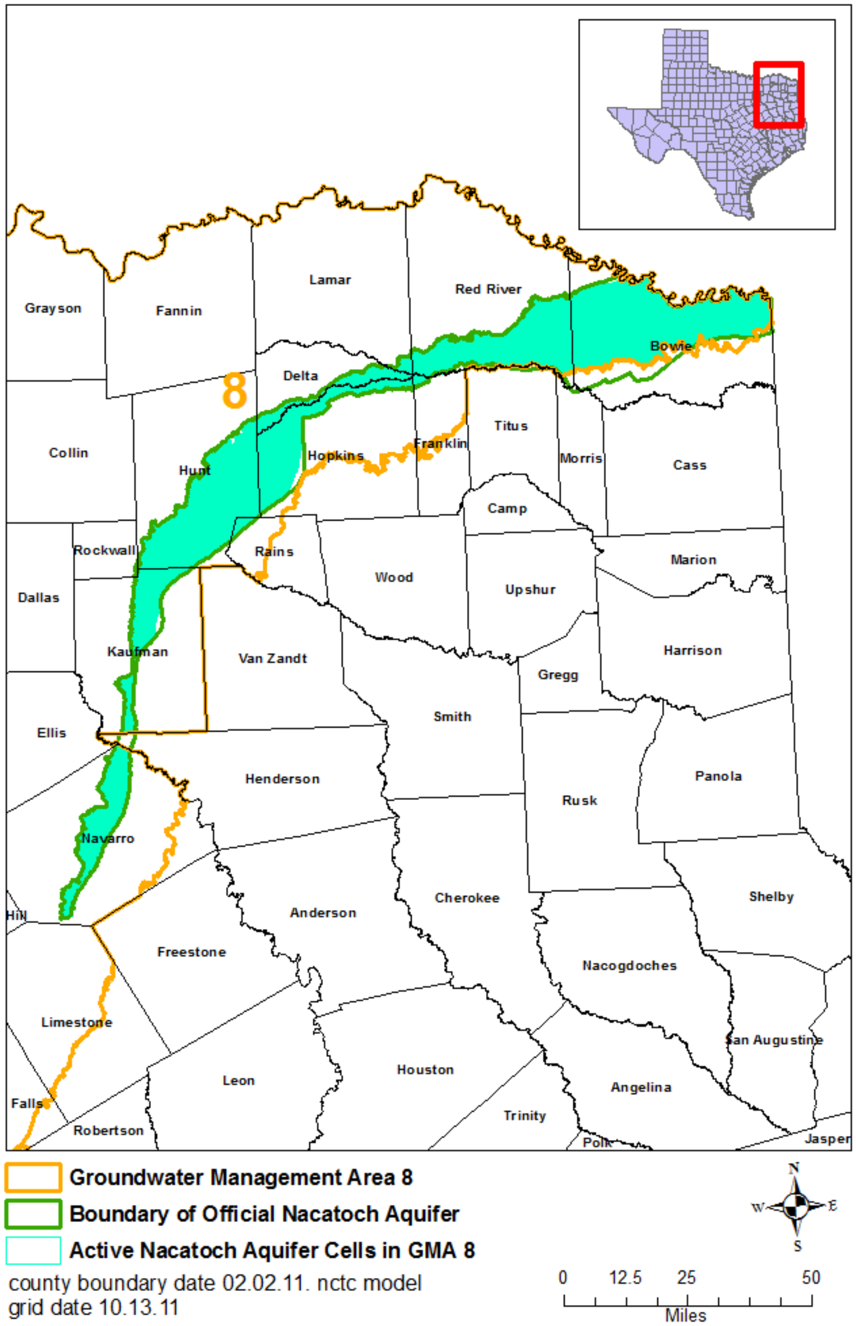

FIGURE 11. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NACATOCH AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE NACATOCH AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

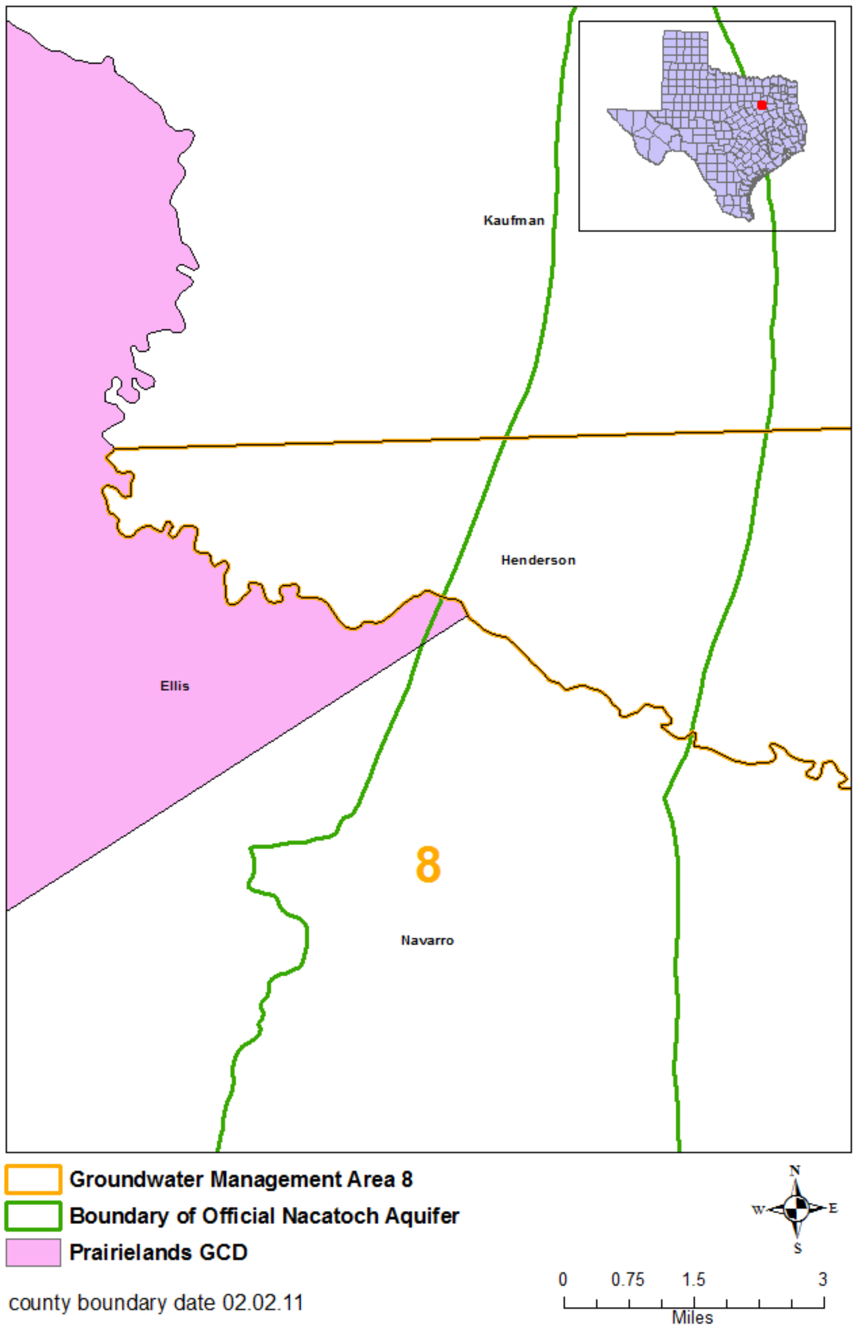

FIGURE 12. GROUNDWATER DISTRICT ASSOCIATED WITH THE NACATOCH AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

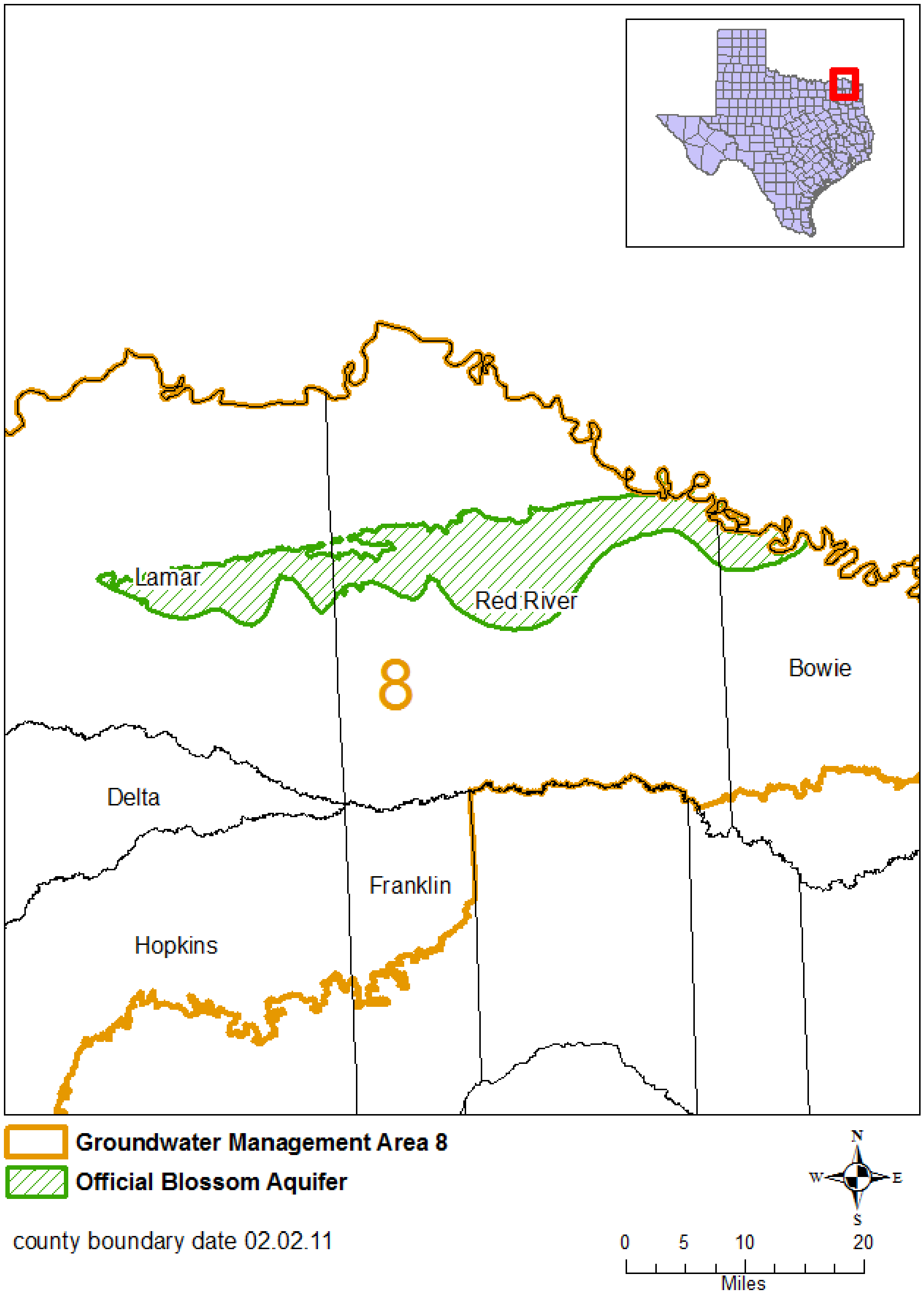

FIGURE 13. EXTENT OF THE BLOSSOM AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

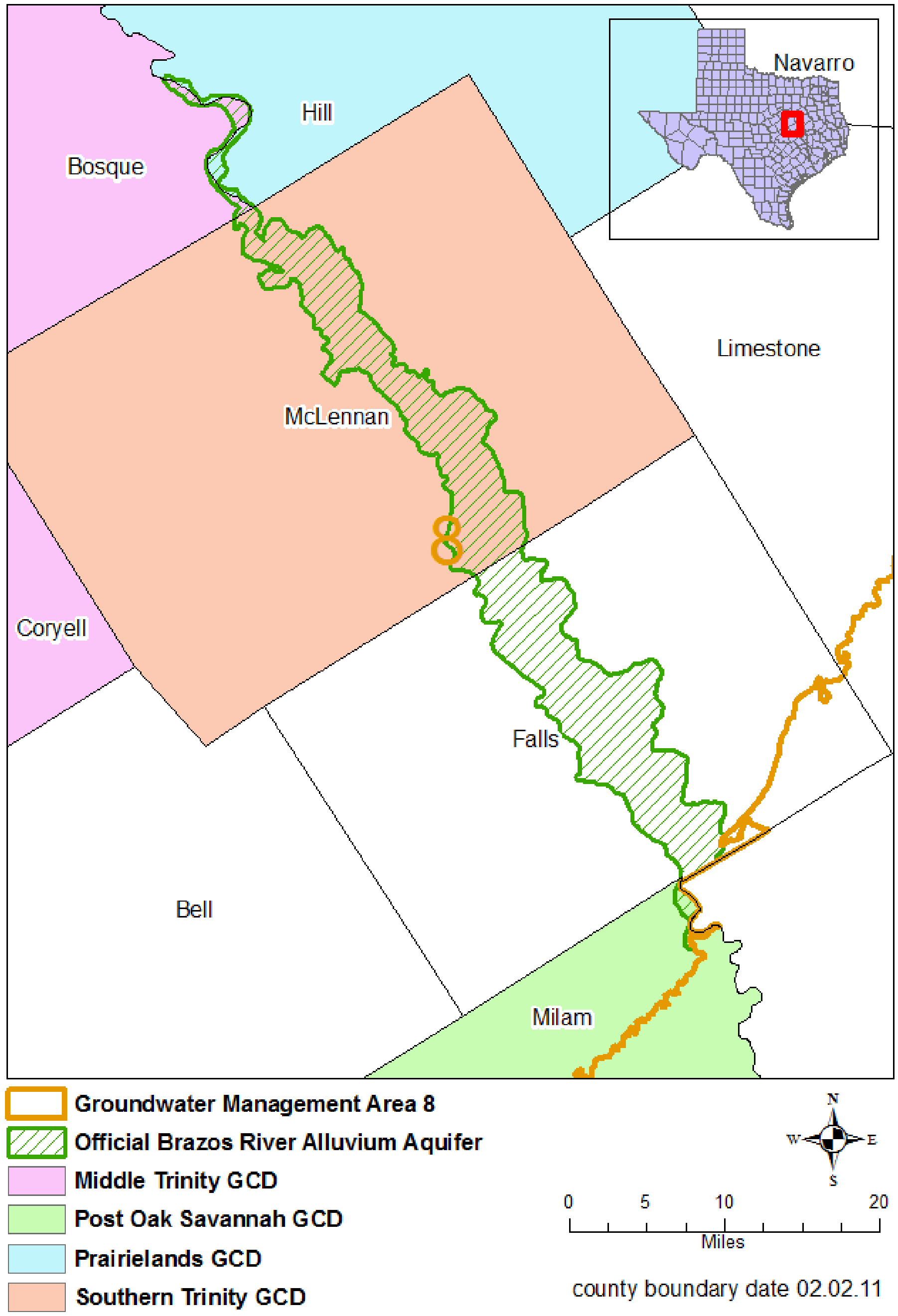

FIGURE 14. EXTENT OF THE BRAZOS RIVER ALLUVIUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 8.

Appendix D

Estimated Historical Water Use and 2012 State Water Plan Datasets

Estimated Historical Water Use And 2012 State Water Plan Datasets:

Saratoga Underground Water Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Resources Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
February 12, 2014

GROUNDWATER MANAGEMENT PLAN DATA:

This package of water data reports (part 1 of a 2-part package of information) is being provided to groundwater conservation districts to help them meet the requirements for approval of their five-year groundwater management plan. Each report in the package addresses a specific numbered requirement in the Texas Water Development Board's groundwater management plan checklist. The checklist can be viewed and downloaded from this web address:

http://www.twdb.texas.gov/groundwater/docs/GCD/GMPChecklist0113.pdf

The five reports included in part 1 are:

1. Estimated Historical Water Use (checklist Item 2)

   from the TWDB Historical Water Use Survey (WUS)

2. Projected Surface Water Supplies (checklist Item 6)
3. Projected Water Demands (checklist Item 7)
4. Projected Water Supply Needs (checklist Item 8)
5. Projected Water Management Strategies (checklist Item 9)

   reports 2-5 are from the 2012 Texas State Water Plan (SWP)

Part 2 of the 2-part package is the groundwater availability model (GAM) report. The District should have received, or will receive, this report from the Groundwater Availability Modeling Section. Questions about the GAM can be directed to Dr. Shirley Wade, shirley.wade@twdb.texas.gov, (512) 936-0883.

DISCLAIMER:

The data presented in this report represents the most up-to-date WUS and 2012 SWP data available as of 2/12/2014. Although it does not happen frequently, neither of these datasets are static so they are subject to change pending the availability of more accurate WUS data or an amendment to the 2012 SWP. District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The WUS dataset can be verified at this web address:

http://www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/

The 2012 SWP dataset can be verified by contacting Sabrina Anderson (sabrina.anderson@twdb.texas.gov or 512-936-0886).

For additional questions regarding this data, please contact Stephen Allen (stephen.allen@twdb.texas.gov or 512-463-7317) or Rima Petrossian (rima.petrossian@twdb.texas.gov or 512-936-2420).

Estimated Historical Water Use
TWDB Historical Water Use Survey (WUS) Data

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2012. TWDB staff anticipates the calculation and posting of these estimates at a later date.

LAMPASAS COUNTY

All values are in acre-fee/year

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2011	GW	116	0	117	0	81	305	619
	SW	3,487	58	156	0	450	567	4,718
2010	GW	107	0	79	0	76	296	558
	SW	2,014	159	97	0	474	551	3,295
2009	GW	256	0	76	0	150	252	734
	SW	2,495	120	85	0	375	466	3,541
2008	GW	414	0	73	0	51	214	752
	SW	2,560	120	102	0	358	397	3,537
2007	GW	320	0	0	0	0	184	504
	SW	2,412	106	0	0	348	342	3,208
2006	GW	436	0	0	0	0	226	662
	SW	2,598	106	0	0	337	420	3,461
2005	GW	396	0	0	0	0	249	645
	SW	1,522	106	0	0	342	462	2,432
2004	GW	379	0	0	0	0	245	624
	SW	2,564	106	0	0	333	496	3,499
2003	GW	377	0	0	0	0	236	613
	SW	955	91	0	0	599	476	2,121
2002	GW	374	0	0	0	0	264	638
	SW	3,565	105	0	0	306	532	4,508
2001	GW	343	0	0	0	0	240	583
	SW	3,661	105	0	0	135	484	4,385
2000	GW	341	0	0	0	1	1,048	1,390
	SW	3,718	108	0	0	169	1,048	5,043

Projected Surface Water Supplies
TWDB 2012 State Water Plan Data

LAMPASAS COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	Source Name	2010	2020	2030	2040	2050	2060
G	COPPERAS COVE	BRAZOS	BRAZOS RIVER AUTHORITY LITTLE RIVER LAKE/RESERVOIR SYSTEM	22	30	34	38	40	41
G	IRRIGATION	BRAZOS	BRAZOS RIVER COMBINED RUN-OF-RIVER IRRIGATION	1,132	1,133	1,133	1,133	1,134	1,134
G	IRRIGATION	COLORADO	BRAZOS RIVER COMBINED RUN-OF-RIVER IRRIGATION	150	150	150	150	150	150
G	KEMPNER	BRAZOS	BRAZOS RIVER AUTHORITY LITTLE RIVER LAKE/RESERVOIR SYSTEM	300	366	411	446	467	482
G	KEMPNER WSC	BRAZOS	BRAZOS RIVER AUTHORITY LITTLE RIVER LAKE/RESERVOIR SYSTEM	2,166	2,138	2,108	2,080	2,050	2,015
G	LAMPASAS	BRAZOS	BRAZOS RIVER AUTHORITY LITTLE RIVER LAKE/RESERVOIR SYSTEM	5,652	5,641	5,635	5,630	5,627	5,623
G	LIVESTOCK	BRAZOS	LIVESTOCK LOCAL SUPPLY	537	537	537	537	537	537
G	LIVESTOCK	COLORADO	LIVESTOCK LOCAL SUPPLY	151	151	151	151	151	151
G	LOMETA	BRAZOS	HIGHLAND LAKES LAKE/RESERVOIR SYSTEM	52	57	59	61	62	64
G	LOMETA	COLORADO	HIGHLAND LAKES LAKE/RESERVOIR SYSTEM	78	84	88	91	93	95
G	MANUFACTURING	BRAZOS	BRAZOS RIVER COMBINED RUN-OF-RIVER MANUFACTURING	18	18	18	18	18	18
	Sum of Projected Surface Water Supplies (acre-feet/year)			**10,258**	**10,305**	**10,324**	**10,335**	**10,329**	**10,310**

Projected Water Demands
TWDB 2012 State Water Plan Data

Please note that the demand numbers presented here include the plumbing code savings found in the Regional and State Water Plans.

LAMPASAS COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
G	COPPERAS COVE	BRAZOS	22	30	34	38	40	41
G	LOMETA	BRAZOS	52	57	59	61	62	64
G	KEMPNER	BRAZOS	300	366	411	446	467	482
G	KEMPNER WSC	BRAZOS	1,293	1,547	1,734	1,870	1,956	2,015
G	MANUFACTURING	BRAZOS	129	142	153	164	174	187
G	MINING	BRAZOS	90	85	82	80	77	76
G	COUNTY-OTHER	BRAZOS	889	904	914	919	923	1,040
G	IRRIGATION	BRAZOS	34	33	33	32	32	32
G	LIVESTOCK	BRAZOS	537	537	537	537	537	537
G	LAMPASAS	BRAZOS	1,842	2,016	2,119	2,174	2,223	2,082
G	LOMETA	COLORADO	78	84	88	91	93	95
G	LIVESTOCK	COLORADO	151	151	151	151	151	151
G	IRRIGATION	COLORADO	134	133	131	130	128	127
G	MINING	COLORADO	62	59	57	55	54	52
G	COUNTY-OTHER	COLORADO	61	62	63	63	63	72
		Sum of Projected Water Demands (acre-feet/year)	**5,674**	**6,206**	**6,566**	**6,811**	**6,980**	**7,053**

Projected Water Supply Needs
TWDB 2012 State Water Plan Data

Negative values (in red) reflect a projected water supply need, positive values a surplus.

LAMPASAS COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
G	COPPERAS COVE	BRAZOS	0	0	0	0	0	0
G	COUNTY-OTHER	BRAZOS	127	112	102	97	93	0
G	COUNTY-OTHER	COLORADO	37	36	35	35	35	2
G	IRRIGATION	BRAZOS	1,098	1,100	1,100	1,101	1,102	1,102
G	IRRIGATION	COLORADO	17	18	20	21	23	24
G	KEMPNER	BRAZOS	0	0	0	0	0	0
G	KEMPNER WSC	BRAZOS	873	591	374	210	94	0
G	LAMPASAS	BRAZOS	3,810	3,625	3,516	3,456	3,404	3,541
G	LIVESTOCK	BRAZOS	0	0	0	0	0	0
G	LIVESTOCK	COLORADO	0	0	0	0	0	0
G	LOMETA	BRAZOS	0	0	0	0	0	0
G	LOMETA	COLORADO	0	0	0	0	0	0
G	MANUFACTURING	BRAZOS	-111	-124	-135	-146	-156	-169
G	MINING	BRAZOS	44	49	52	54	57	58
G	MINING	COLORADO	37	40	42	44	45	47
	Sum of Projected Water Supply Needs (acre-feet/year)		**-111**	**-124**	**-135**	**-146**	**-156**	**-169**

Projected Water Management Strategies
TWDB 2012 State Water Plan Data

LAMPASAS COUNTY

WUG, Basin (RWPG)

All values are in acre-feet/year

Water Management Strategy	Source Name [Origin]	2010	2020	2030	2040	2050	2060
KEMPNER WSC, BRAZOS (G)							
VOLUNTARY REDISTRIBUTION	BRAZOS RIVER AUTHORITY LITTLE RIVER LAKE/RESERVOIR SYSTEM [RESERVOIR]	0	0	0	0	10	10
MANUFACTURING, BRAZOS (G)							
MANUFACTURING WATER CONSERVATION	CONSERVATION [LAMPASAS]	4	7	11	11	12	13
VOLUNTARY REDISTRIBUTION	BRAZOS RIVER AUTHORITY LITTLE RIVER LAKE/RESERVOIR SYSTEM [RESERVOIR]	165	165	165	165	165	165
Sum of Projected Water Management Strategies (acre-feet/year)		**169**	**172**	**176**	**176**	**187**	**188**