COMAL TRINITY
GROUNDWATER CONSERVATION DISTRICT

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Comal Trinity Groundwater Conservation District Management Plan Revision Record

Date Adopted	Effective Date	Version/Resolution
3/19/2018		Original Adoption

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TIME PERIOD FOR THIS PLAN

This plan becomes effective upon adoption by the Comal Trinity Groundwater Conservation District (CTGCD) board of directors and subsequent approval by the Texas Water Development Board (TWDB). Every five years thereafter, in accordance with Texas Water Code 36.1072 (e), the plan will be reviewed for consistency with the applicable Regional Water Plans, the State Water Plan, and Groundwater Management Areas 9 (GMA 9) and 10 (GMA 10) Desired Future Conditions (DFCs) and shall be readopted with or without amendments. The plan may be revised at any time to maintain consistency or as necessary to address any new or revised data, Groundwater Availability Models, Desired Future Conditions in GMA 9 and/or GMA 10, or district management strategies.

This plan incorporates a planning period of 50 years. Population and water demand projections cover the 50-year period from 2020 to 2070 and are consistent with those used by the TWDB for this area in statewide water planning. Upon its approval by the TWDB, this Plan will remain in effect until a revised Plan is submitted and approved, or for five years from the approval date, whichever is earlier.

DISTRICT MISSION

The Comal Trinity Groundwater Conservation District (CTGCD or district) was created under Chapter 36 of the Texas Water Code for the purpose of conserving, preserving, recharging, protecting and preventing waste of groundwater from the Trinity Aquifer and its subdivisions within Comal County. The district will conduct administrative and technical activities and programs to achieve these purposes. The district will use the authority granted under its enabling legislation, HB2407, and TWC Chapter 36 and other state laws to conduct aquifer research, monitor water well drilling and production from non-exempt wells, collect and archive well water and aquifer data, issue authorizations for well drilling, modification, equipping, and plugging, promote the capping or plugging of abandoned wells, provide information and educational material to local property owners, interact with other governmental or organizational entities, and incorporate other groundwater-related activities that may help meet the purposes of the district.

GUIDING PRINCIPLES

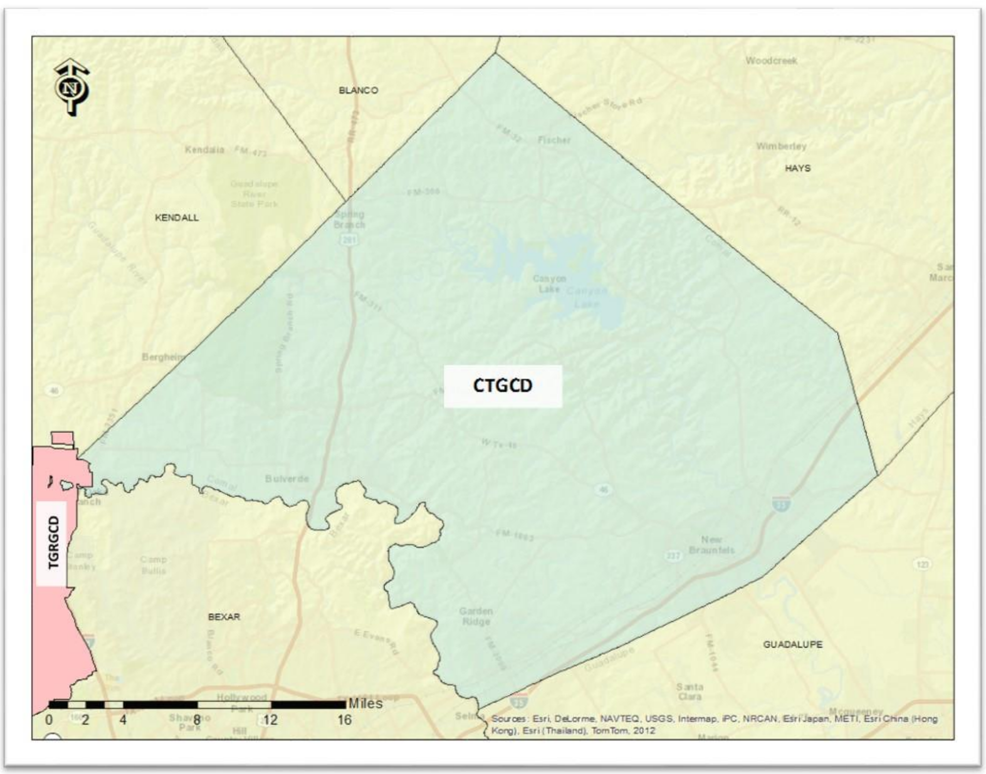
The CTGCD was created in order that appropriate groundwater management techniques and strategies could be implemented at the local level to address groundwater issues or concerns within the district. The district will incorporate the best and most current site-specific data available in the development of this plan to ensure the sustainability of the Trinity Aquifer and its subdivisions and achievement of the Desired Future Conditions (DFCs).

The district recognizes that groundwater resources throughout this region are of vital importance to all citizens and that these resources must be managed effectively. This plan serves as a guideline for the district to ensure greater understanding of local aquifer conditions, development of groundwater management concepts and strategies, and subsequent implementation of appropriate groundwater management policies.

GENERAL DESCRIPTION OF THE DISTRICT

The Comal Trinity Groundwater Conservation District comprises the majority of Comal County, excluding a small portion of territory included within the boundaries of the Trinity Glen Rose Groundwater Conservation District.

CTGCD DISTRICT BOUNDARY



Source: CTGCD

The district is overseen by a 7-member board of directors appointed by the Comal County Commissioners Court. Directors serve staggered 4 year terms. The district currently employs one part-time general manager and one part-time administrative staff. The district finalized and approved well registration rules and a fee schedule for non-exempt wells in December 2015.

Covering 559 square miles, Comal County resides within two Groundwater Management Areas. The western portion of the county lies within GMA 9 and as such falls within the Hill Country Priority Groundwater Management Area. This designation, originally described by the Texas Water Commission – now referred to as the Texas Commission on Environmental Quality (TCEQ)--- in 1990, is defined as an area experiencing or expected to experience quality or quantity issues within the next 50 years. Western Comal County is primarily rural in make-up; however, the southern portion of the county is experiencing considerable growth in terms of population and development around the city of Bulverde. The eastern portion of Comal County lies within GMA 10 and can be characterized as urban or rapidly urbanizing with development primarily occurring along IH-35. New Braunfels, the county seat and largest city, with a population of 57,740, lies within GMA 10. Per the U.S. Census Bureau, the 2010 population for Comal County was 108,472 (US Census Bureau, 2010).

The most recently approved regional water plan is the 2016 South Central Texas Regional Water Plan which utilizes population projections provided by TWDB in order to develop water plans to meet future water needs. These population projections for Comal County are summarized below.

Table 1. Population Projections South Central Texas Region, Comal County

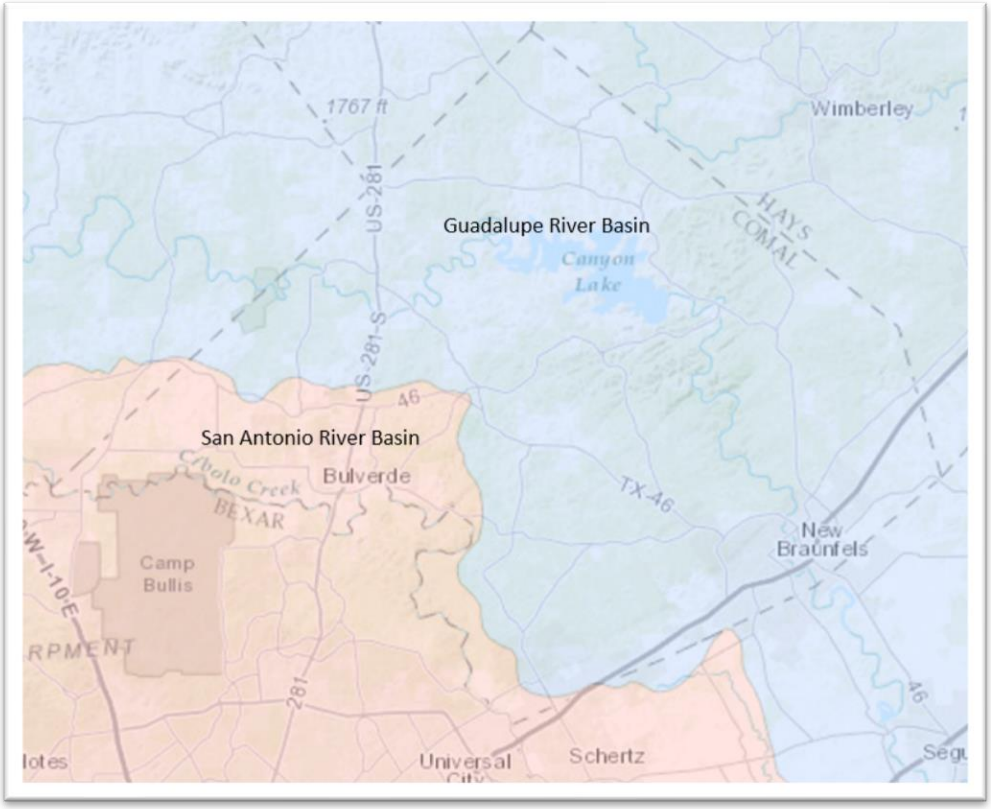
COUNTY	**YEAR**					
	2020	**2030**	**2040**	**2050**	**2060**	**2070**
Comal	140,825	178,399	216,562	255,092	293,362	330,099

Source: 2016 South Central Texas Regional Water Plan Volume I

TOPOGRAPHY AND DRAINAGE

Comal County lies within the San Antonio River and Guadalupe River basins. The Guadalupe River Basin extends across the northern three-quarters of Comal County with the remaining quarter falling within the San Antonio River Basin. Flowing into Canyon Lake, a Guadalupe-Blanco River Authority (GBRA) managed reservoir and the primary surface water provider for Comal County, the Guadalupe River continues southeast upon exiting the reservoir to New Braunfels and into Guadalupe County. The county contains numerous watersheds including Upper and Lower Blanco River, Cibolo Creek, Comal River, and Upper San Marcos. Surface drainage within the district is generally west to southeast.

DISTRICT RIVER BASINS



Source: TWDB; Groundwater Data Viewer

The primary geologic features contributing to the topography within the district are the Edwards Plateau and the Balcones Escarpment (Balcones Fault Zone). Below this escarpment the landscape transitions into the Upper Gulf Coastal Plain region.

The Edwards Plateau is characterized as a broad, topographically high area composed of Cretaceous age limestone, dolomite and marl. Deep erosion and down cutting by streams and rivers in the area have resulted in the Edwards Plateau being perceptibly higher than adjacent areas. The plateau is the southernmost extension of the Great Plains, extending westward from the Colorado River to the Pecos, and covers many Central and West Texas counties. It is bordered on the northeast by the Precambrian rocks of the Llano Uplift. Comal County lies near the southeastern edge of the Edwards Plateau.

Elevation within the district ranges from a high of approximately 1,527 feet above sea level at Devil's Hill, seven miles west of Smithson Valley to a low of 600 feet above sea level where the Guadalupe River enters Guadalupe County (George et al. 1952).

GROUNDWATER RESOURCES AND USAGE WITHIN CTGCD

The major aquifer managed by the CTGCD providing groundwater to residents is the Trinity Aquifer and its subdivisions consisting of the Upper Glen Rose Limestone, Lower Glen Rose Limestone, Cow Creek Limestone, Sligo Limestone and Hosston Sand. The Edwards Aquifer, overseen by the Edwards Aquifer Authority, overlies portions of the Trinity Aquifer and its subdivisions throughout the eastern one-third of Comal County. Wells to be completed into the Edwards Aquifer must obtain a permit through the Edwards Aquifer Authority. In areas where a well is to be completed into the Trinity Aquifer and its subdivisions, but must pass through a portion of the Edwards Aquifer, the driller must obtain a “pass through” permit from the Edwards Aquifer Authority.

Depths are highly variable within the Trinity Aquifer and its subdivisions and depend entirely on site-specific topography and geology, especially faulting. Water quality and water quantity also vary greatly throughout the district.

According to the Historical Water Use Survey Data (2000-2015) provided by the Texas Water Development Board in Appendix E, groundwater has supplied the majority of water needs for all water user groups, excluding livestock over the last several years, with municipal users commanding the largest share. It should be noted that the totals provided within TWDB’s Historical Water Use Survey Data include groundwater drawn from both the Edwards and Trinity Aquifers.

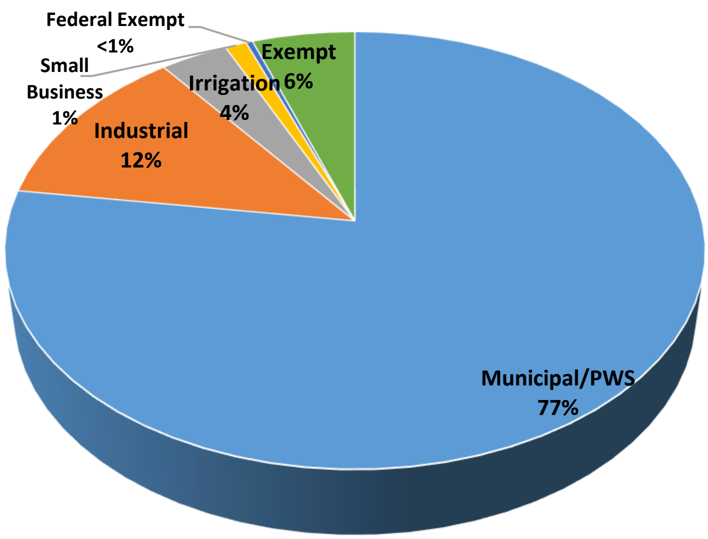
The district began collecting groundwater pumpage data from non-exempt wells January 1, 2016. Pumpage amounts categorized by Water User Group (WUG) are provided in Table 2 and reflect groundwater produced from the Trinity Aquifer and its subdivisions only. The accompanying graph depicts the percentage of total groundwater use categorized by WUG.

Table 2. Groundwater Usage (in ac-ft) by Water User Group 2016, CTGCD[1]

WUG	2016
Municipal/PWS	4684.29
Industrial	743.61
Irrigation	216.60
Small Business	68.09
Federal Exempt	21.57
Exempt	327.00

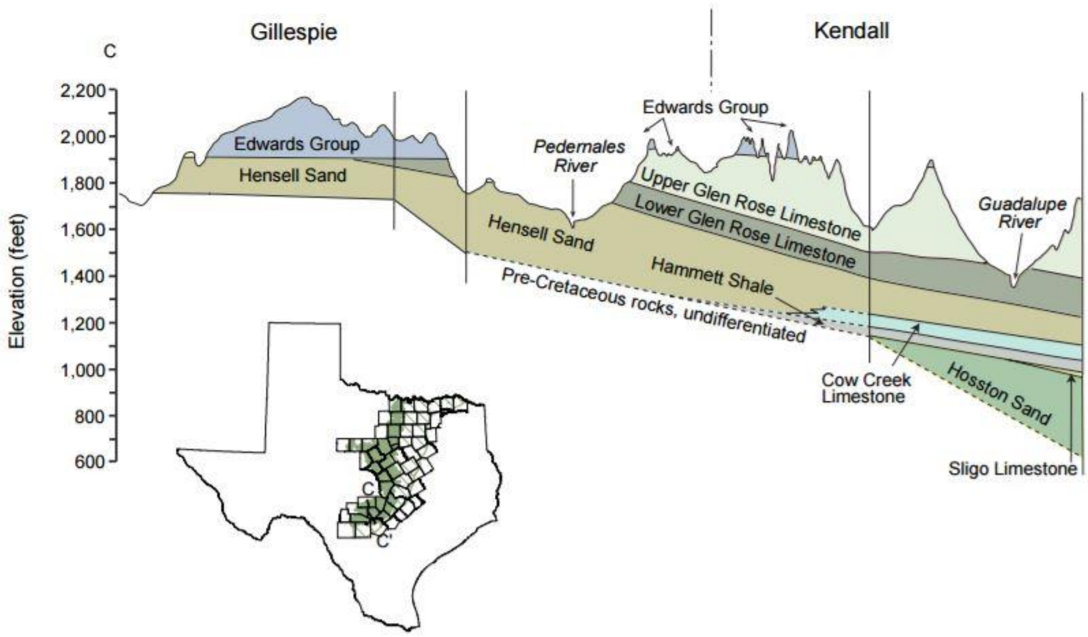
[1]Comal Trinity Groundwater Conservation District Pumpage Database. Values collected through non-exempt user pumpage reports. Exempt Number provided by TWDB, Projected Exempt Groundwater Use Estimates December 2015

CTGCD 2016 PERCENT OF TOTAL REPORTED PUMPAGE PER WUG



TRINITY AQUIFER AND ITS SUBDIVISIONS

The Trinity Aquifer extends across much of the central and northeastern part of the state. It is composed of several smaller aquifers contained within the Trinity Aquifer and its subdivisions. These aquifers consist of limestones, sands, clays, gravels, and conglomerates. Their combined freshwater saturated thickness averages about 600 feet in North Texas and about 1,900 feet in Central Texas. In general, groundwater is fresh but very hard in the outcrop of the aquifer. Total dissolved solids increase from less than 1,000 milligrams per liter in the east and southeast to between 1,000 and 5,000 milligrams per liter, or slightly to moderately saline, as the depth to the aquifer increases. Sulfate and chloride concentrations also tend to increase with depth. The Trinity Aquifer discharges to a large number of springs, with most discharging less than 10 cubic feet per second. The aquifer is one of the most extensive and highly used groundwater resources in Texas (George et al. 2011).



Structural cross section across the Trinity Aquifer in the Hill Country, including rocks from the Upper Glen Rose Formation to the Hosston Sand (modified from Ashworth, 1983; Mace and others, 2000b).

SURFACE WATER RESOURCES AND USAGE WITHIN CTGCD

Canyon Lake is the major surface water resource within the district. Canyon Lake Water Service Company has up to 6,000 ac-ft/yr of surface water allotments from Canyon Lake managed by Guadalupe-Blanco River Authority (GBRA), 722 ac-ft/yr of surface water from the Western Canyon project for use in the Bulverde area with the remaining 130 ac-ft/yr surface water sourced from the Guadalupe River above Canyon Lake (CLWSC Water Availability Report, April 2016).

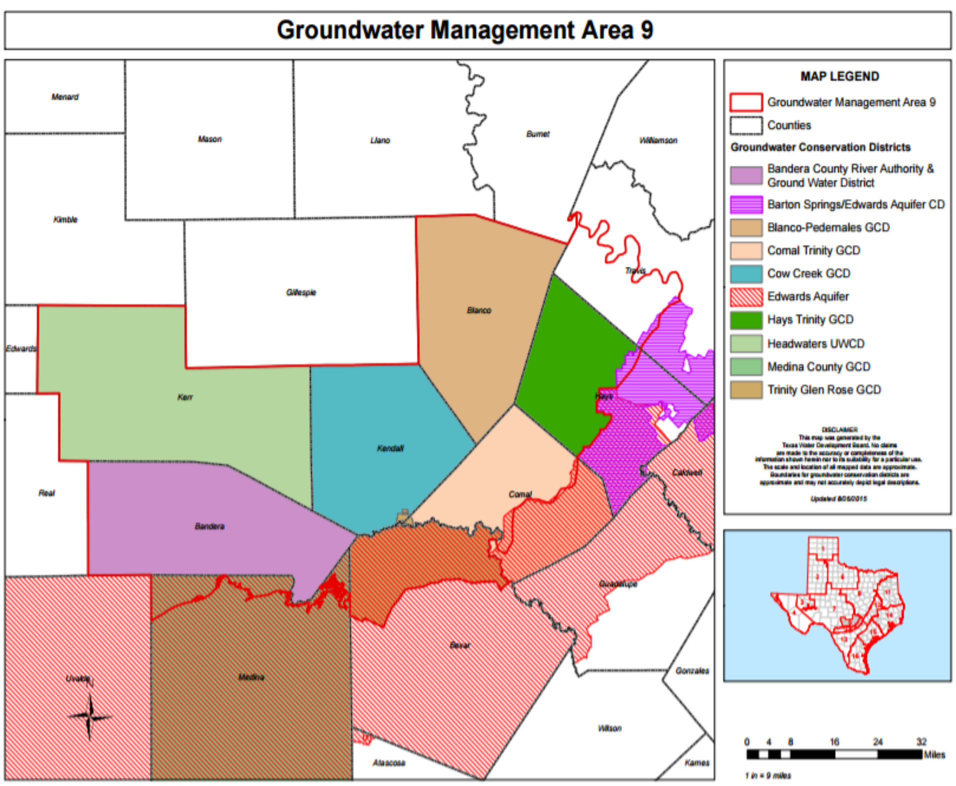
New Braunfels Utilities (NBU) is the largest water supplier for the eastern portion of the district. According to data provided in the 2016 Region L Water Plan, surface water supplies include 8,072 ac-ft/yr of purchased water from the Canyon Reservoir, 1,072 ac-ft/yr of Guadalupe Run-of-River rights, 4,590 ac-ft/yr from the Edwards Aquifer, and 536 ac-ft/yr supplied from the Trinity Aquifer (2016 South Central Texas Regional Water Plan, 2015).

JOINT PLANNING IN MANAGEMENT AREA

Every five years, the groundwater conservation districts in GMA 9 and GMA 10 shall consider groundwater availability models and other data for these management areas and shall establish desired future conditions for the relevant aquifers within the management areas. In establishing the desired future conditions of the aquifers under this section, the districts shall consider uses or conditions of an aquifer within the management area that differ substantially from one geographic area to another.

The GMAs may establish different desired future conditions for each aquifer, subdivision of an aquifer, or geologic strata located in whole or in part within the boundaries of the management area; or each geographic area overlying an aquifer in whole or in part or subdivision of an aquifer within the boundaries of these management areas. The Texas Water Development Board will calculate the Modeled Available Groundwater (MAG) from the adopted Desired Future Conditions (DFC) of these management areas.

GROUNDWATER MANAGEMENT AREA (GMA) 9:



Source: TWDB; http://www.twdb.texas.gov/groundwatermanagement_areas/maps/GMA9_GCD.pdf

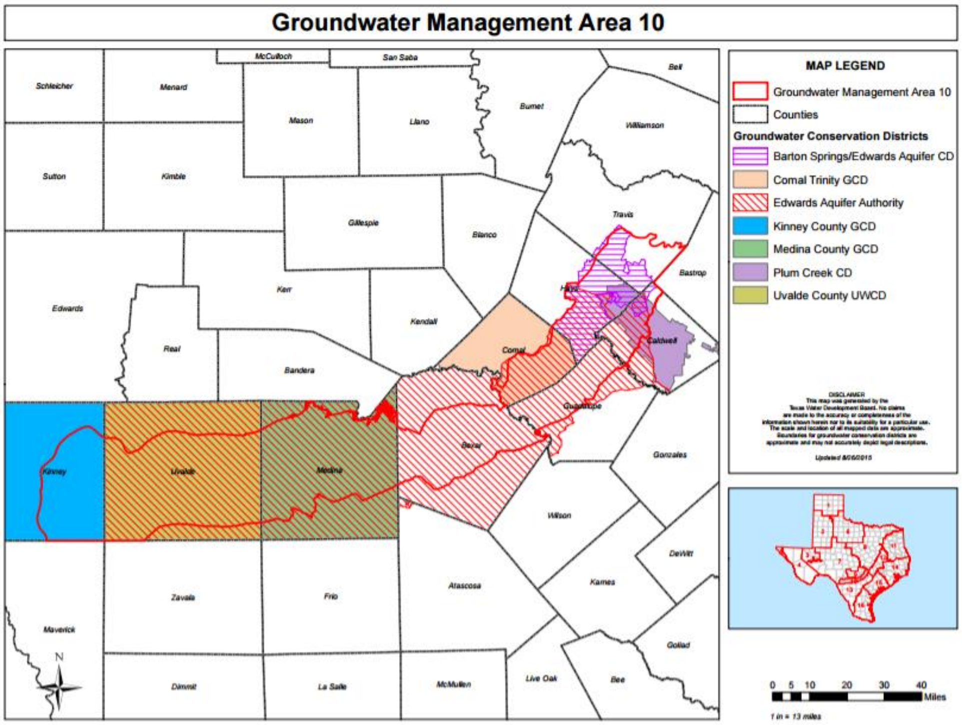
MODELED AVAILABLE GROUNDWATER BASED ON DESIRED FUTURE CONDITIONS FOR GMA 9

Modeled Available Groundwater (MAG) is defined in TWC Section 36.001 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." The Desired Future Condition (DFC) of an aquifer may only be determined through Joint Planning with other Groundwater Conservation Districts (GCDs) within the same Groundwater Management Area in accordance with TWC 36.108. The GCDs within Groundwater Management Area 9 adopted the second round of DFCs on April 28, 2016 with an amendment made on October 24, 2016 (Jones, 2017). These adopted DFCs approved by GMA 9 are found in Appendix A reflecting a Total Modeled Available Groundwater amount for the Trinity Aquifer and its subdivisions located within GMA 9 and underlying CTGCD as 10,076 ac-ft/yr (2010-2060) as reflected in Table 3 (GR16-023 MAG). The board of directors for CTGCD adopted these DFCs by resolution on February 20, 2017. This resolution can be found in Appendix C. The CTGCD was not in existence during the first round of DFC planning nor during the first half of the second round of the DFC planning process. It should be noted however, during the joint planning process to adopt DFCs for 2016, the GMA 9 committee invited a representative from Comal County to act as a non-voting member. Upon creation of the district, CTGCD became a voting member within the GMA 9 Joint Planning Committee.

Table 3. MAG for the Trinity Aquifer, GMA 9, Comal County (in ac-ft), GMA Run 16-023 MAG

COUNTY	YEAR					
	2010	2020	2030	2040	2050	2060
Comal	10,076	10,076	10,076	10,076	10,076	10,076

GROUNDWATER MANAGEMENT AREA (GMA) 10:



Source: TWDB; http://www.twdb.texas.gov/groundwater/management_areas/maps/GMA10_GCD.pdf

MODELED AVAILABLE GROUNDWATER BASED ON DESIRED FUTURE CONDITIONS FOR GMA 10

The GCDs within Groundwater Management Area 10 completed the first round of the DFC joint planning process on August 23, 2010. The adopted DFCs approved by GMA 10 are found in Appendix D reflecting a Total Modeled Available Groundwater amount for the Trinity Aquifer and its subdivisions located within GMA 10 boundaries and underlying CTGCD is 29,284 ac-ft/yr (2010-2060) as reflected in Table 4 (AA 10-29 MAG).

The CTGCD was not in existence during this first round of DFC planning. Upon creation of the district, CTGCD became a voting member within the GMA 10 Joint Planning Committee.

Table 4. MAG for the Trinity Aquifer, GMA 10, Comal County (in ac-ft), AA 10-29 MAG

COUNTY	YEAR					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Comal	29,284	29,284	29,284	29,284	29,284	29,284

PROJECTED TOTAL WATER DEMAND WITHIN CTGCD

The projected total annual water demand in Comal County is summarized in Appendix E. Taking population projections incorporated in the 2016 Region L Water Plan into consideration, it is anticipated the greatest demand on water resources will be from municipal users despite projected declines in per capita use.

ESTIMATES OF TECHNICAL INFORMATION REQUIRED BY TWC SECTION 36.1071 AND 31 TAC 356.52

Table 5 provides a groundwater flow budget and recharge variables for the district. TWDB conducted this analysis using the groundwater availability model for the Hill Country portion of the Trinity Aquifer System. Table 5 addresses some of the flow variables that affect recharge calculations and is derived from GAM Run 16-022 located in Appendix B.

Table 5. District Groundwater Flow Budget and Recharge Variable

Management Plan Requirement	Aquifer or Confining Unit	Results (ac-ft/yr)
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer System	42,457
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer System	15,601
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer System	38,106
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer System	28,422
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer System to the Edwards (Balcones Fault Zone) Aquifer and deep Trinity Aquifer	38,912*

* In the Comal Trinity Groundwater Conservation District, groundwater generally flows southeast from the Trinity Aquifer System to the Edwards (Balcones Fault Zone) Aquifer and the confined parts of the Trinity Aquifer System that underlie the Edwards (Balcones Fault Zone) Aquifer

ACTIONS, PROCEDURES, PERFORMANCE AND AVOIDANCE NECESSARY TO EFFECTUATE THE MANAGEMENT PLAN INCLUDING HOW THE DISTRICT WILL MANAGE GROUNDWATER SUPPLIES

The district will manage the supply of groundwater within the district based on the district's best available data and its assessment of water availability and groundwater storage conditions. The most current Groundwater Availability Model and Modeled Available Groundwater values developed by the TWDB for the Trinity Aquifer and its subdivisions or other groundwater models, as well as other studies performed by other entities, will also aid in the decision-making process by the district.

The District will use the management plan to guide the district in its efforts to preserve and protect the groundwater resources within Comal County. The district will ensure that rule development, regulatory activities, planning effects and daily operations are consistent with the management plan. The rules for the district will be developed in coordination with the management goals and technical information provided in the management plan. The rules shall be consistent with the provision of the management plan and Chapter 36 of the Texas Water Code.

The district has adopted rules that require the registration of non-exempt wells within the district consistent with the district's management plan, the provisions of Chapter 36.113, and other pertinent sections of Chapter 36. District rules can be found at https://www.comaltrinitygcd.com/rules-f4x40

The district is committed to working and planning with other GCDs in Groundwater Management Areas 9 and 10. The district will use the management plan as part of its cooperative efforts with the neighboring GCDs. The District will manage the supply of groundwater within the district based on Desired Future Conditions and Modeled Available Groundwater resulting from the Groundwater Management Areas 9 and 10 cooperative planning processes, production demand from exempt and non-exempt wells, and the district's best available data.

The district will seek cooperation and coordination in the development and implementation of this plan with the appropriate state, regional or local water management or planning entities.

The district shall review and re-adopt this plan, with or without revisions, at least once every five years in accordance with Chapter 36.1072(e). Any amendment to this plan shall be in accordance with Chapter 36.1073.

The district will encourage cooperative and voluntary rule compliance, but if rule enforcement becomes necessary, the enforcement will be legal, fair, and impartial.

METHODOLOGY FOR TRACKING PROGRESS IN ACHIEVING MANAGEMENT GOALS

District staff will present an annual report to the board of directors on district performance and progress in achieving management goals and objectives for the preceding fiscal year.

GROUNDWATER MANAGEMENT GOALS

1.0 Implement management strategies that will provide for the most efficient use of groundwater.

1.A Management Objective

Within five years of the adoption of this management plan, the district will implement and maintain a program of issuing well operating permits for non-exempt wells within the district

Performance Standard

Upon implementation of operating permit issuance system, the number of well operating permit applications and the number of permits issued will be presented and discussed in the annual report to the district board of directors

1.B Management Objective

Ongoing program of quarterly collection and record-keeping of actual meter readings from non-exempt wells to quantify Trinity groundwater withdrawal from non-exempt water wells within the district

Performance Standard

Annual report submitted to the board of directors will record acre-ft of Trinity groundwater pumped by non-exempt wells during the preceding fiscal year

2.0 Implement strategies that will control and prevent waste of groundwater.

2.A Management Objective

Each year the district will provide information on the importance of controlling and preventing waste of groundwater through one or more of the following methods:

- Article provided to local media and/or community news
- Distribution of water conservation literature at public meetings or events
- Information on the district website
- Maintain water conservation literature at the district office

Performance Standard

Number of articles provided to local news media and/or newsletters, and number of water conservation literature handed out to the public will be provided in the annual report to the district board of directors.

3.0 Implement strategies that will control and prevent subsidence.

The rigid geologic framework of the region precludes subsidence from occurring. Therefore, this goal is not applicable to the operations of this district.

4.0 Implement management strategies that will address conjunctive surface water management issues.

4.A Management Objective

The General Manager or one designated board member of the CTGCD will at least once per year attend and participate in GMA 9 and 10 activities. The district will participate in the regional water planning process by attending at least one meeting annually of the Region L planning group to encourage development of alternative water supplies.

Performance Standard

Attendance of these meetings will be reported to the board of directors during regular board meetings

4.B Management Objective

Within five years of the adoption of this management plan, 2 wells completed to the Middle Trinity will be designated and monitored by the District on at least a quarterly basis.

Performance Standard

Upon designation of monitor wells, water levels will be provided to the board of directors on a quarterly basis.

5.0 Implement strategies that will address natural resource issues which impact the use and availability of groundwater, or which are impacted by the use of groundwater.

The district is not currently aware of any natural resource issues impacted by the Trinity Aquifer. Therefore this goal is not applicable.

6.0 Implement strategies that will address drought conditions.

6.A Management Objective

The district will collect drought condition information on a, at minimum, quarterly basis related to Comal County and the surrounding region utilizing the Palmer Drought Severity Index.

Performance Standard

Drought condition information will be summarized and discussed at least quarterly during district board meetings.

6.B Management Objective

Collect and provide information on precipitation patterns across Comal County as recorded by the National Weather Service on a quarterly basis.

Performance Standard
Report precipitation conditions to the district board of directors during regular board meetings on an, at minimum, quarterly basis.

7.0 Implement strategies that will address:

Conservation

7.A Management Objective
Within one year of the adoption of this management plan, the district will maintain on the district's website information regarding the importance of groundwater conservation and water conservation methods.

Performance Standard
Maintain a record of "hits" to conservation information on the website; include in annual report to the district board of directors.

7.B Management Objective
Within one year of the adoption of this management plan, the district will make available handouts containing water conservation information at public information events or other locations, such as district office.

Performance Standard
Report the number of handouts provided and a list of events or other locations where provided in annual report to the district board of directors.

7.C Management Objective
Within one year of the adoption of this management plan, the district will prepare a presentation describing the purpose of CTGCD and including information about water conservation for meetings of local organizations.

Performance Standard
Report the number of presentations offered to local organizations in annual report to the district board of directors.

Recharge Enhancement

7.D Management Objective
The district will investigate potential recharge enhancement sites either natural or artificial

Performance Standard
Annually, the General Manager will include a report to the board of directors on the district's findings related to recharge enhancement

Rainwater Harvesting

7.E. Management Objective
Within one year of the adoption of this management plan, the district will maintain on the district's website information on rainwater harvesting and links to resources.

Performance Standard
Maintain a tally of "hits" to rainwater harvesting information on the website; provide this information in annual report to the district board of directors.

Precipitation Enhancement

The precipitation enhancement goal is not applicable to the district as this objective is not currently effective at this time.

Brush Control

7.F Management Objective
Within one year of the adoption of this management plan, the district will acquire and provide handouts containing brush control information to promote recharge and protect water quality, to include best practices regarding management of ashe juniper, and provide the handouts at public information events or other locations.

Performance Standard
Report the number of handouts provided and a list of events or other locations where provided in an annual report to the district board of directors.

8.0 Addressing Desired Future Conditions

8.A Management Objective
Within five years of the adoption of this management plan, the district will begin to monitor the water level in the Trinity Aquifer on a quarterly basis to ensure the achievement of the DFC adopted GMA 9 and GMA 10.

Performance Standard
The district will monitor the water level in at least one district-designated monitor well and compare with the average drawdown and allowable drawdown resulting from the DFC process. The data will be presented to the district board of directors in an annual report, reviewed by the district at least once every five years, and presented to GMA 9 and GMA 10 as required under TWC 36.108.

REFERENCES

2016 South Central Texas Regional Water Plan, Volume I — Executive Summary and Regional Water Plan, December 2015.

Allen, S. 2016, Estimated Historical Use and 2017 State Water Plan Datasets: Comal Trinity Groundwater Conservation District. Texas Water Development Board, September 20, 2017.

Canyon Lake Water Service Company, Water Availability Report, April 2016.

Comal Trinity Groundwater Conservation District, Pumpage Database.

George, P.G., Mace, R E., and Petrossian, R., 2011, Aquifers of Texas, Report 380, Texas Water Development Board, Austin, TX.

George, W.O., S. D. Breeding, and W. W. Hastings, 1952, Geology and ground-water resources of Comal County, Texas. USGS Water Supply Paper 1138.

Jones, I., 2017, GAM Run 16-023 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 9: Texas Water Development Board.

Thorkildsen D. and Backhouse S., 2010, GTA Aquifer Assessment 10-29: Texas Water Development Board, GTA Aquifer Assessment 10-29 Report, 11 p.

Texas Water Development Board, Groundwater Availability Model (GAM) 15-001

U.S. Census Bureau, United States Census (2010)

APPENDIX A - TWDB GAM 16-023 MAG, GMA 9 Resolution and GMA 10, Resolution

GAM RUN 16-023 MAG: MODELED AVAILABLE GROUNDWATER FOR THE AQUIFERS IN GROUNDWATER MANAGEMENT AREA 9

Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 463-6641
February 28, 2017

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GAM RUN 16-023 MAG: MODELED AVAILABLE GROUNDWATER FOR THE AQUIFERS IN GROUNDWATER MANAGEMENT AREA 9

Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 463-6641
February 28, 2017

EXECUTIVE SUMMARY:

We have prepared estimates of the modeled available groundwater for the relevant aquifers of Groundwater Management Area 9—the Trinity, Edwards Group of the Edwards-Trinity (Plateau), Ellenburger-San Saba, and Hickory aquifers. The estimates are based on the desired future conditions for these aquifers adopted by the groundwater conservation districts in Groundwater Management Area 9 on April 28, 2016. The explanatory report and other materials submitted to the Texas Water Development Board (TWDB) were determined to be administratively complete on November 23, 2016.

The modeled available groundwater values are summarized by decade for the groundwater conservation districts (Tables 1, 3, 5, and 7) and for use in the regional water planning process (Tables 2, 4, 6, and 8). The modeled available groundwater estimates are 2,208 acre-feet per year in the Edwards Group of the Edwards-Trinity (Plateau) Aquifer, up to 75 acre-feet per year in the Ellenburger-San Saba Aquifer, 140 acre-feet per year in the Hickory Aquifer, and range from approximately 93,000 acre-feet per year in 2010 to about 90,500 acre-feet per year in 2060 in the Trinity Aquifer. Please note that the Trinity Aquifer includes both the Trinity Aquifer as defined by the TWDB and the Trinity Group of the Edwards-Trinity (Plateau) Aquifer. The modeled available groundwater estimates were extracted from results of model runs using the groundwater availability models for the Hill Country portion of the Trinity Aquifer version 2.01 (Jones and others, 2011), and the minor aquifers of the Llano Uplift Area (Shi and others, 2016).

REQUESTOR:

Mr. Ronald Fieseler, chair of Groundwater Management Area 9 districts.

DESCRIPTION OF REQUEST:

In a letter dated April 25, 2016, Mr. Ronald Fieseler provided the TWDB with the desired future conditions of the Trinity, Edwards Group of the Edwards-Trinity (Plateau), Ellenburger-San Saba, and Hickory aquifers in Groundwater Management Area 9. Mr.

Fieseler provided additional clarifications for baseline years for each desired future condition, areas not covered by the models, assumed climatic conditions, and spatial pumping distributions through emails to the TWDB on June 8, 2016, August 15, 2016 and September 9, 2016. Mr. Fieseler also clarified the water level drawdown for the Ellenburger-San Saba Aquifer in Kendall County in a letter dated October 19, 2016.

The final adopted desired future conditions for the aquifers in Groundwater Management Area 9 are:

- Trinity Aquifer *[Upper, Middle, and Lower undifferentiated]* - Allow for an increase in average drawdown of approximately 30 feet through 2060 (throughout GMA-9) consistent with "Scenario 6" in TWDB GAM Task 10-005.
- Edwards Group of Edwards-Trinity (Plateau) *[Aquifer]* in Kendall and Bandera counties - Allow for no net increase in average drawdown in Bandera and Kendall counties through 2070.
- Ellenburger-San Saba Aquifer in Kendall County - Allow for an increase in average drawdown of no less than 7 feet in Kendall County through 2070.
- Hickory Aquifer in Kendall County - Allow for an increase in average drawdown of no more than 7 Feet in Kendall County through 2070.

The Trinity Aquifer includes both the Trinity Aquifer as defined by the TWDB and the Trinity Group of the Edwards-Trinity (Plateau) Aquifer.

Additionally, districts in Groundwater Management Area 9 voted to declare that the following aquifers or parts of aquifers be classified as non-relevant for the purposes of joint planning:

- Edwards Group of the Edwards-Trinity (Plateau) Aquifer in Kerr and Blanco counties.
- Ellenburger-San Saba Aquifer in Blanco and Kerr counties.
- Hickory Aquifer in Blanco, Hays, Kerr, and Travis counties.
- Marble Falls Aquifer in Blanco County.
- Edwards (Balcones Fault Zone) Aquifer in Bexar, Comal, Hays, and Travis counties.

METHODS:

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. 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 desired future condition for the Trinity Aquifer is identical to the one adopted in 2010 and the associated modeled available groundwater is based on a specific model run and scenario—Scenario 6 in GAM Task 10-005 (Hutchison, 2010) and GAM Task 10-050 (Hassan, 2012). Trinity Aquifer water-level drawdown is based on 2008 water levels.

For other relevant aquifers—the Edwards Group of the Edwards-Trinity (Plateau), Ellenburger-San Saba, and Hickory aquifers—the groundwater availability models for the Hill Country portion of the Trinity Aquifer version 2.01 (Jones and others, 2011), and the minor aquifers of the Llano Uplift Area (Shi and others, 2016) were used to simulate the desired future conditions outlined in the explanatory report (GMA 9 and others, 2016) and further clarified as noted in the previous section. Water level drawdown calculations were based on the water levels simulated in final years of the historical versions of the respective models. These final years are 1997 in the groundwater availability model for the Hill Country portion of the Trinity Aquifer and 2010 in the groundwater availability model for the minor aquifers of the Llano Uplift Area. The predictive model runs retain pumping rates from the historic period—1980 through 1997—except in the aquifer or area of interest. In those areas, pumping rates are varied such that they produce the desired future average water level drawdown conditions. Pumping rates were reported on 10-year intervals from 2010 through 2060 (for the Trinity Aquifer) and 2010 through 2070 (for all other relevant aquifers). The groundwater availability estimates for 2070 for the Trinity Aquifer will be determined by the regional water planning groups.

Water level drawdown averages were calculated for the relevant portions of each aquifer. Drawdown for model cells which became dry during the simulation (water level dropped below the base of the cell) were excluded from the averaging. Estimates of modeled available groundwater therefore decrease over time as continued simulated pumping predicts the development of dry model cells in areas of Hays, Kerr, and Travis counties. The calculated water-level drawdown averages were compared with the desired future conditions to verify that the pumping scenario achieved the desired future conditions.

Modeled available groundwater values for the Trinity Aquifer and the Edwards Group of the Edwards-Trinity (Plateau) Aquifer were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). For the Ellenburger-San Saba and Hickory aquifers, modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONBUDUSG Version 1.01 (Panday and others, 2013).

PARAMETERS AND ASSUMPTIONS:

Trinity and Edwards-Trinity (Plateau) Aquifers

We used the groundwater availability model (version 2.01) for the Hill Country portion of the Trinity Aquifer developed by Jones and others (2009) to determine modeled available groundwater in the Trinity Aquifer and the Edwards Group of the Edwards-Trinity (Plateau) Aquifer. See Jones and others (2009) for details on model construction, recharge, discharge, assumptions, and limitations. The parameters and assumptions for the groundwater availability model for the Hill Country portion of the Trinity Aquifer are described below:

- The model has four layers:
  - Layer 1 represents mostly the Edwards Group of the Edwards-Trinity (Plateau) Aquifer and larger portions of the Edwards Group not classified as an aquifer,
  - Layer 2 represents the Upper Trinity Aquifer,
  - Layer 3 represents the Middle Trinity Aquifer, and
  - Layer 4 represents the Lower Trinity Aquifer.
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Parts of Bandera, Blanco, and Kerr counties are not included in the model and consequently are not included in the modeled available groundwater calculations.
- Drawdown for cells with water levels below the base elevation of the cell ("dry" cells) were excluded from calculation of average drawdown and the modeled available groundwater values.
- In separate model runs, modeled available groundwater was calculated for the Trinity Aquifer and the Edwards Group of the Edwards-Trinity (Plateau) Aquifer. The Trinity Aquifer is defined as the Trinity Group occurring within Groundwater Management Area 9, irrespective of whether it forms part of the Trinity Aquifer or Edwards-Trinity (Plateau) Aquifer.
- The results for the Trinity Aquifer presented in this report are based on Scenario 6 of GAM Task 10-005 (Hutchison, 2010). See Hutchison (2010) for a full description of the methods, assumptions, and results of the model simulations. Each scenario in GAM Task 10-005 consisted of a series of 387 separate 50-year

model simulations, each with a different recharge configuration. Though the pumping input to the model was the same for each of the 387 simulations, the pumping output differed depending on the occurrence of inactive (or dry) cells. Because the analysis was statistical any baseline year may be assumed, therefore average drawdown is based on 2008 conditions as noted in the Groundwater Management Area 9 explanatory report.

- The results for the Edwards Group of the Edwards-Trinity (Plateau) Aquifer are based on a single model run using historic pumping rates in all parts of the model area except the Edwards Group of Kendall and Bandera counties and average recharge from GAM Task 10-005. Recharge used in this model run represents the average recharge taken from the 387 simulations (Run 169) used in Trinity Aquifer model runs. Average drawdown was calculated based on the last historic stress period (1997).

Minor aquifers of the Llano Uplift Area

We used version 1.01 of the groundwater availability model for the minor aquifers in the Llano Uplift Area. See Shi and others (2016) for assumptions and limitations of the model. The parameters and assumptions for the groundwater availability model for the minor aquifers of the Llano Uplift Area are described below:

- The model contains eight layers:
    - Layer 1 (the Trinity Aquifer, Edwards-Trinity (Plateau) Aquifer, and younger alluvium deposits),
    - Layer 2 (confining units),
    - Layer 3 (the Marble Falls Aquifer and equivalent units),
    - Layer 4 (confining units),
    - Layer 5 (Ellenburger-San Saba Aquifer and equivalent units),
    - Layer 6 (confining units),
    - Layer 7 (the Hickory Aquifer and equivalent units), and
    - Layer 8 (Precambrian units).
- The model was run with MODFLOW-USG beta (development) version (Panday and others, 2013).

- Perennial rivers and reservoirs were simulated using the MODFLOW-USG river package. Springs were simulated using the MODFLOW-USG drain package.
- There is no historic pumping information available for the Ellenburger-San Saba and Hickory aquifers of Kendall County. Consequently, we used uniformly distributed pumping to simulate the desired future condition and determine the modeled available groundwater.

RESULTS:

The modeled available groundwater for the Trinity Aquifer that achieves the desired future conditions adopted by districts in Groundwater Management Area 9 decreases from 93,052 to 90,503 acre-feet per year between 2010 and 2060 (Tables 1 and 2). This decline is attributable to the occurrence of increasing numbers of dry model cells over time in parts of Hays, Kerr, and Travis counties. The modeled available groundwater for the Edwards Group of the Edwards-Trinity (Plateau), Ellenburger-San Saba, and Hickory aquifers are 2,208, 75, and 140 acre-feet per year, respectively (Tables 3 through 8). The modeled available groundwater for the respective aquifers has been summarized by aquifer, county, and groundwater conservation district (Tables 1, 3, 5, and 7). The modeled available groundwater is also summarized by county, regional water planning area, river basin, and aquifer for use in the regional water planning process (Tables 2, 4, 6, and 8).

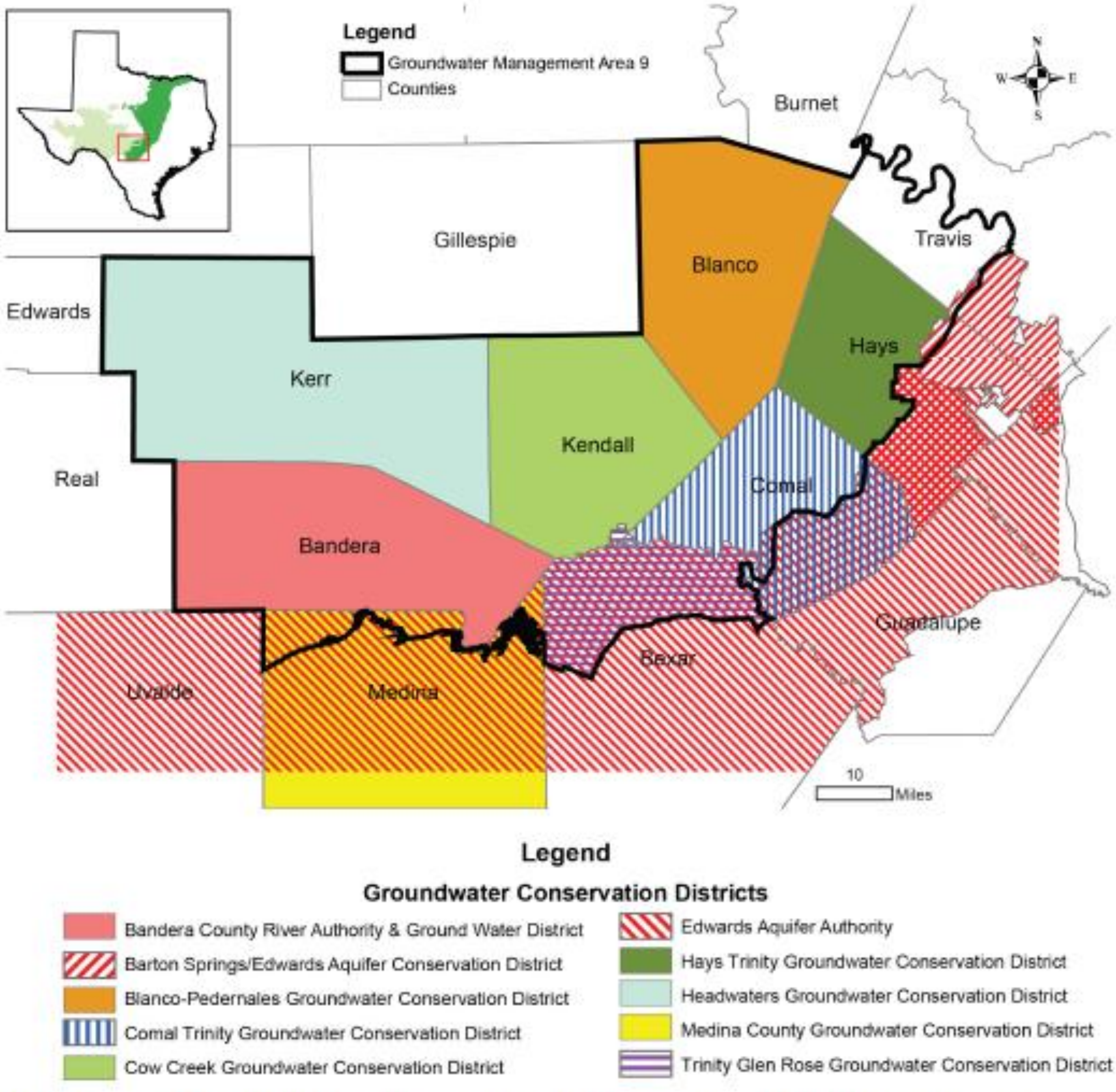

FIGURE 1. MAP SHOWING THE GROUNDWATER CONSERVATION DISTRICTS IN GROUNDWATER MANAGEMENT AREA 9. NOTE: THE BOUNDARIES OF THE EDWARDS AQUIFER AUTHORITY OVERLAP WITH THE MEDINA COUNTY, TRINITY GLEN ROSE, AND COMAL TRINITY GROUNDWATER CONSERVATION DISTRICTS AND THE BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT.

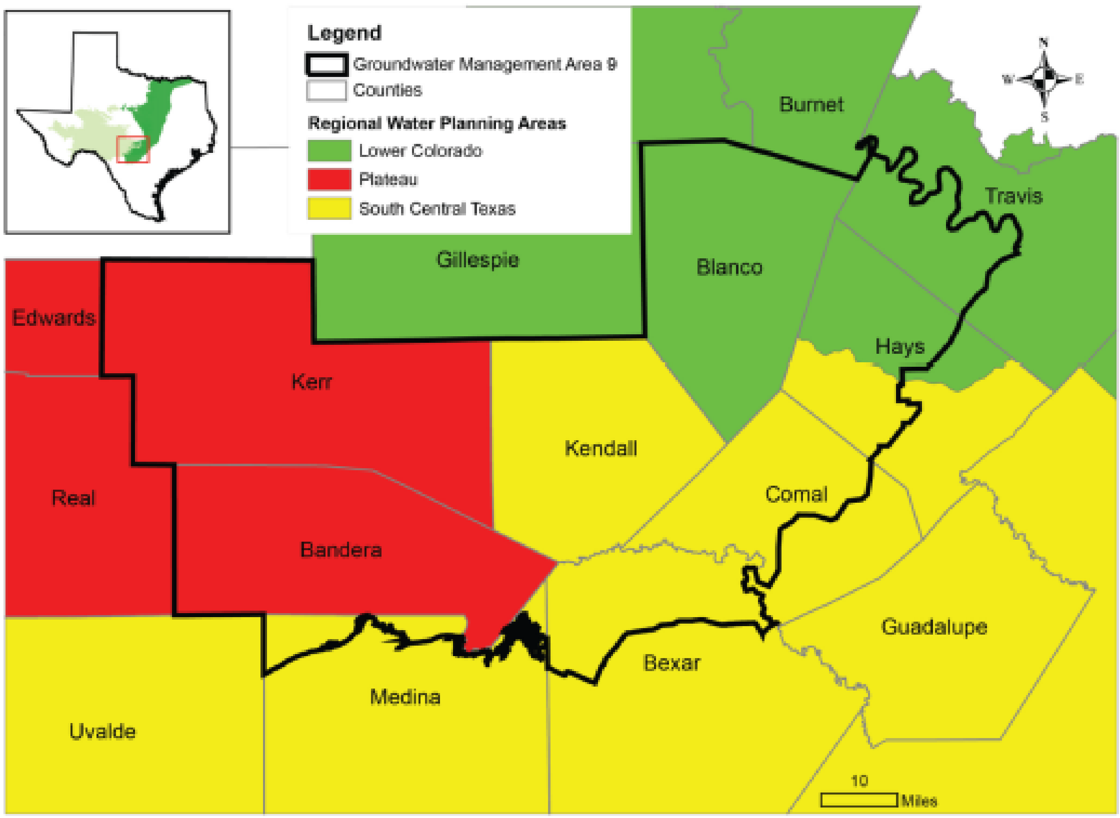

FIGURE 2. MAP SHOWING REGIONAL WATER PLANNING AREAS IN GROUNDWATER MANAGEMENT AREA 9.

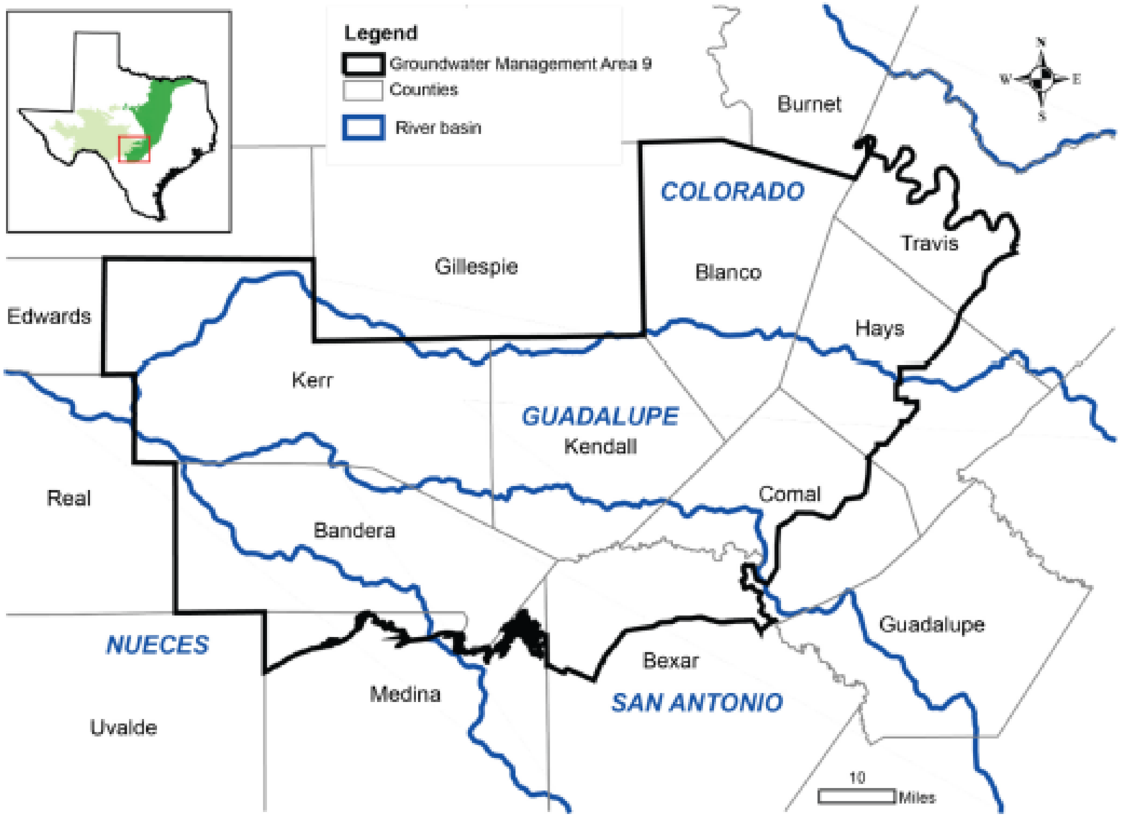

FIGURE 3. MAP SHOWING RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 9. THESE INCLUDE PARTS OF THE COLORADO, GUADALUPE, SAN ANTONIO, AND NUECES RIVER BASINS.

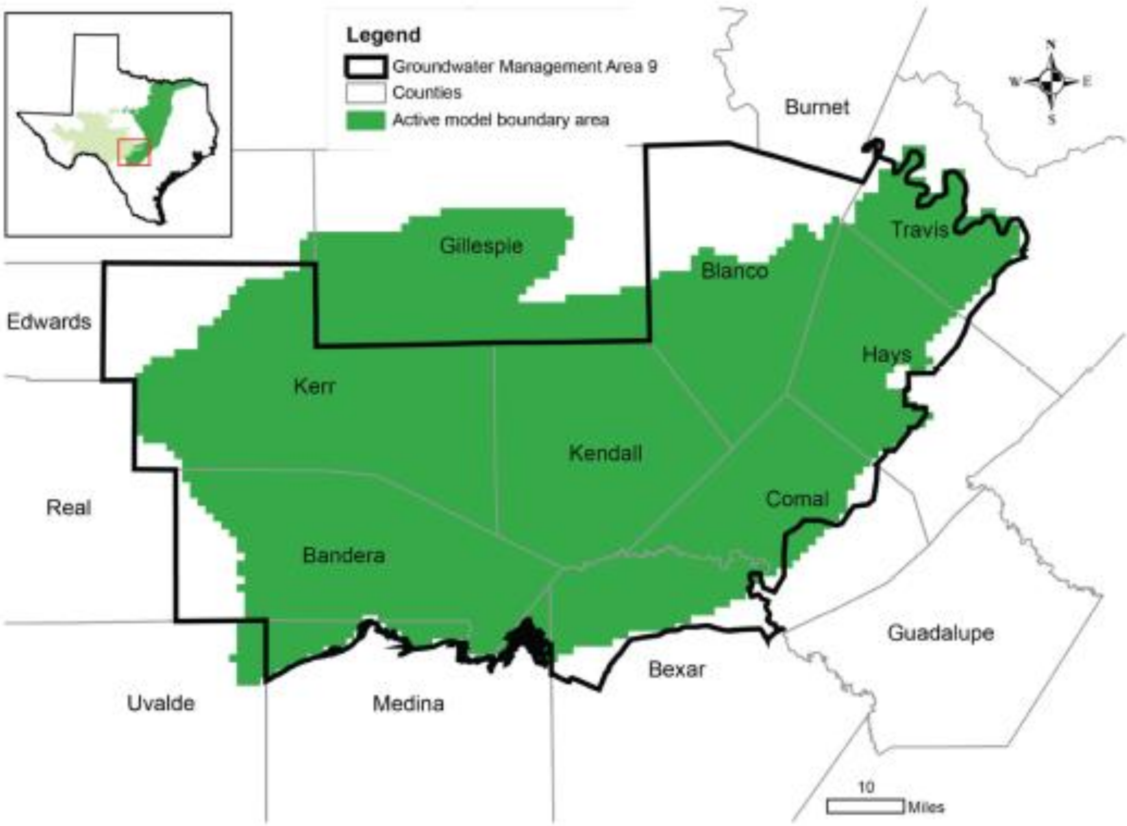

FIGURE 4. MAP SHOWING THE AREAS COVERED BY THE TRINITY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HILL COUNTRY PORTION OF THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 9.

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 9 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

District	County	Year					
		2010	2020	2030	2040	2050	2060
Bandera County River Authority & Groundwater District Total	Bandera	7,284	7,284	7,284	7,284	7,284	7,284
Barton Springs/Edwards Aquifer Conservation District Total	Hays	22	22	22	22	22	22
Blanco-Pedernales Groundwater Conservation District Total	Blanco	2,573	2,573	2,573	2,573	2,573	2,573
Comal Trinity Groundwater Conservation District Total	Comal	10,076	10,076	10,076	10,076	10,076	10,076
Cow Creek Groundwater Conservation District Total	Kendall	10,622	10,622	10,622	10,622	10,622	10,622
Hays Trinity Groundwater Conservation District Total	Hays	9,109	9,098	9,095	9,094	9,094	9,094
Headwaters Groundwater Conservation District Total	Kerr	16,435	14,918	14,845	14,556	14,239	14,223
Medina County Groundwater Conservation District Total	Medina	2,500	2,500	2,500	2,500	2,500	2,500

TABLE 1. CONTINUED.

District	County	Year					
		2010	2020	2030	2040	2050	2060
Trinity Glen Rose Groundwater Conservation District	Bexar	24,856	24,856	24,856	24,856	24,856	24,856
Trinity Glen Rose Groundwater Conservation District	Comal	138	138	138	138	138	138
Trinity Glen Rose Groundwater Conservation District	Kendall	517	517	517	517	517	517
Trinity Glen Rose Groundwater Conservation District Total		**25,511**	**25,511**	**25,511**	**25,511**	**25,511**	**25,511**
No district Total	**Travis**	**8,920**	**8,672**	**8,655**	**8,643**	**8,627**	**8,598**
GMA 9	**Total**	**93,052**	**91,276**	**91,183**	**90,881**	**90,548**	**90,503**

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 9 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2010	2020	2030	2040	2050	2060
Bandera	J	Guadalupe	76	76	76	76	76	76
		Nueces	903	903	903	903	903	903
		San Antonio	6,305	6,305	6,305	6,305	6,305	6,305
		Total	**7,284**	**7,284**	**7,284**	**7,284**	**7,284**	**7,284**
Bexar	L	San Antonio	24,856	24,856	24,856	24,856	24,856	24,856
		Total	**24,856**	**24,856**	**24,856**	**24,856**	**24,856**	**24,856**
Blanco	K	Colorado	1,322	1,322	1,322	1,322	1,322	1,322
		Guadalupe	1,251	1,251	1,251	1,251	1,251	1,251
		Total	**2,573**	**2,573**	**2,573**	**2,573**	**2,573**	**2,573**
Comal	L	Guadalupe	6,906	6,906	6,906	6,906	6,906	6,906
		San Antonio	3,308	3,308	3,308	3,308	3,308	3,308
		Total	**10,214**	**10,214**	**10,214**	**10,214**	**10,214**	**10,214**

TABLE 2. CONTINUED.

County	RWPA	River Basin	Year					
			2010	2020	2030	2040	2050	2060
Hays	K	Colorado	4,721	4,710	4,707	4,706	4,706	4,706
	L	Guadalupe	4,410	4,410	4,410	4,410	4,410	4,410
		Total	**9,131**	**9,120**	**9,117**	**9,116**	**9,116**	**9,116**
Kendall	L	Colorado	135	135	135	135	135	135
		Guadalupe	6,028	6,028	6,028	6,028	6,028	6,028
		San Antonio	4,976	4,976	4,976	4,976	4,976	4,976
		Total	**11,139**	**11,139**	**11,139**	**11,139**	**11,139**	**11,139**
Kerr	J	Colorado	318	318	318	318	318	318
		Guadalupe	15,646	14,129	14,056	13,767	13,450	13,434
		San Antonio	471	471	471	471	471	471
		Total	**16,435**	**14,918**	**14,845**	**14,556**	**14,239**	**14,223**
Medina	L	Nueces	1,575	1,575	1,575	1,575	1,575	1,575
		San Antonio	925	925	925	925	925	925
		Total	**2,500**	**2,500**	**2,500**	**2,500**	**2,500**	**2,500**

TABLE 2. CONTINUED.

County	RWPA	River Basin	Year					
			2010	2020	2030	2040	2050	2060
Travis	K	Colorado (Total)	8,920	8,672	8,655	8,643	8,627	8,598
GMA 9			93,052	91,276	91,183	90,881	90,548	90,503

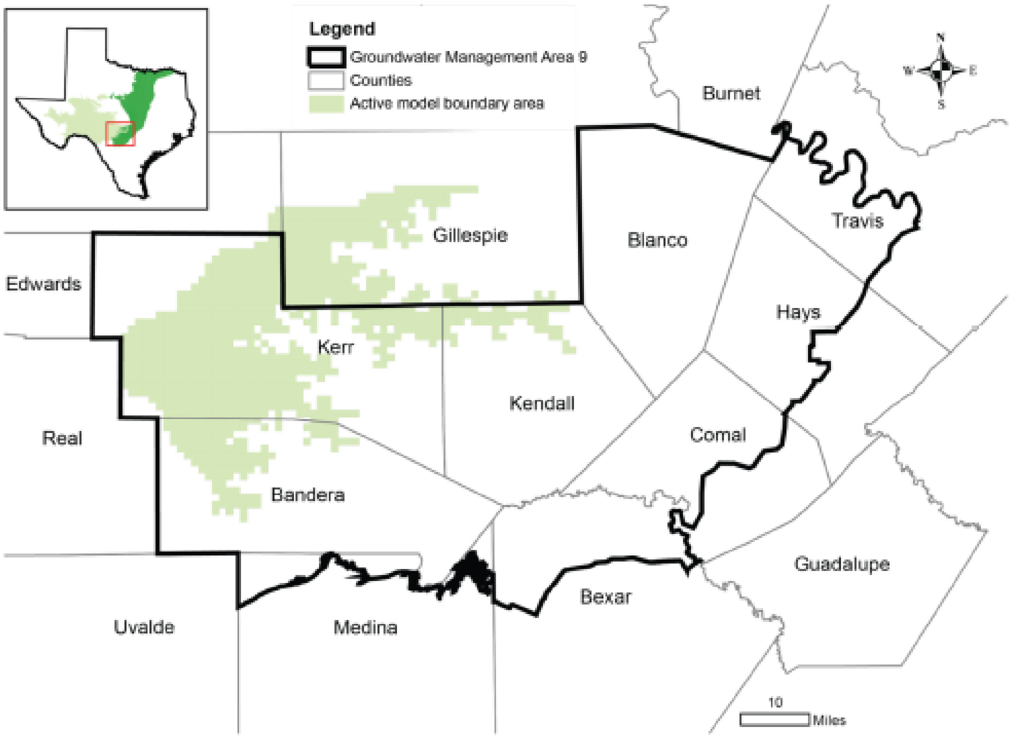

FIGURE 5. MAP SHOWING THE AREAS COVERED BY THE EDWARDS GROUP OF THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HILL COUNTRY PORTION OF THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 9.

TABLE 3. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS GROUP OF THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA 9 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY, FOR EACH DECADE BETWEEN 2010 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

District	County	Year						
		2010	2020	2030	2040	2050	2060	2070
Bandera County River Authority & Groundwater District Total	Bandera	2,009	2,009	2,009	2,009	2,009	2,009	2,009
Cow Creek Groundwater Conservation District Total	Kendall	199	199	199	199	199	199	199
Grand Total		2,208	2,208	2,208	2,208	2,208	2,208	2,208

TABLE 4. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE EDWARDS GROUP OF THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA 9 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2010 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year						
			2010	2020	2030	2040	2050	2060	2070
Bandera	Plateau (J)	Guadalupe	81	81	81	81	81	81	81
		Nueces	38	38	38	38	38	38	38
		San Antonio	1,890	1,890	1,890	1,890	1,890	1,890	1,890
		Total	**2,009**	**2,009**	**2,009**	**2,009**	**2,009**	**2,009**	**2,009**
Kendall	South Central Texas (L)	Colorado	69	69	69	69	69	69	69
		Guadalupe	130	130	130	130	130	130	130
		Total	**199**	**199**	**199**	**199**	**199**	**199**	**199**
Grand Total			**2,208**	**2,208**	**2,208**	**2,208**	**2,208**	**2,208**	**2,208**

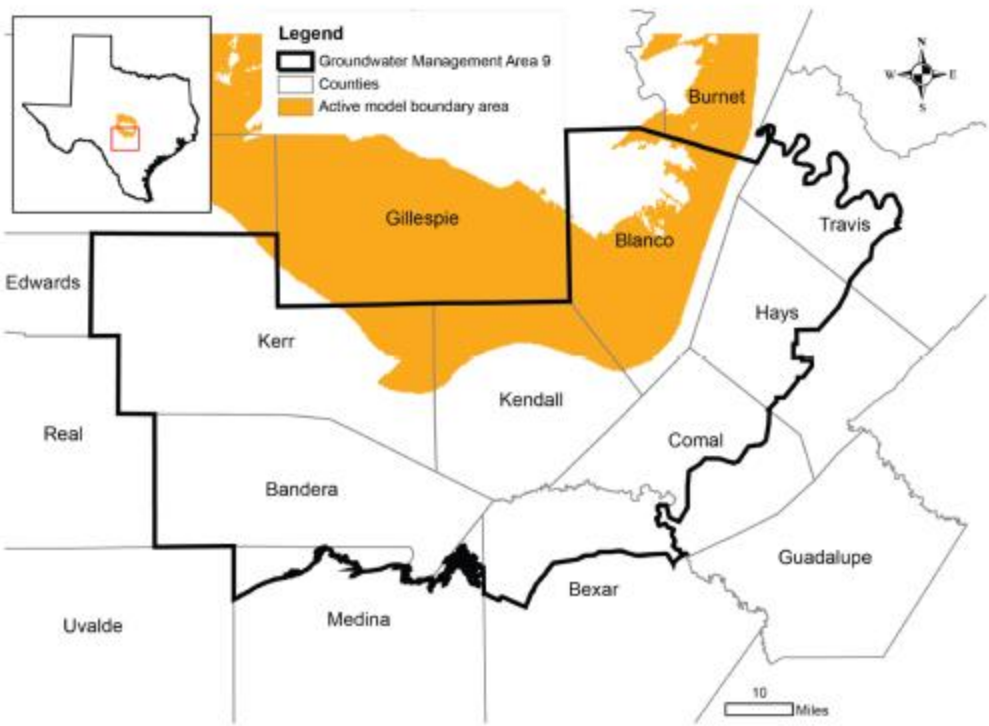

FIGURE 6. MAP SHOWING THE AREAS COVERED BY THE ELLENBURGER-SAN SABA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 9.

TABLE 5. MODELED AVAILABLE GROUNDWATER FOR THE ELLENBURGER-SAN SABA AQUIFER IN GROUNDWATER MANAGEMENT AREA 9 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

District	County	Year						
		2010	2020	2030	2040	2050	2060	2070
Cow Creek Groundwater Conservation District Total	**Kendall**	**75**	**75**	**75**	**75**	**75**	**75**	**75**

TABLE 6. MODELED AVAILABLE GROUNDWATER FOR THE ELLENBURGER-SAN SABA AQUIFER IN GROUNDWATER MANAGEMENT AREA 9 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2010 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year						
			2010	2020	2030	2040	2050	2060	2070
Kendall	South Central Texas (L)	Colorado	10	10	10	10	10	10	10
		Guadalupe	64	64	64	64	64	64	64
		Total	**75**	**75**	**75**	**75**	**75**	**75**	**75**

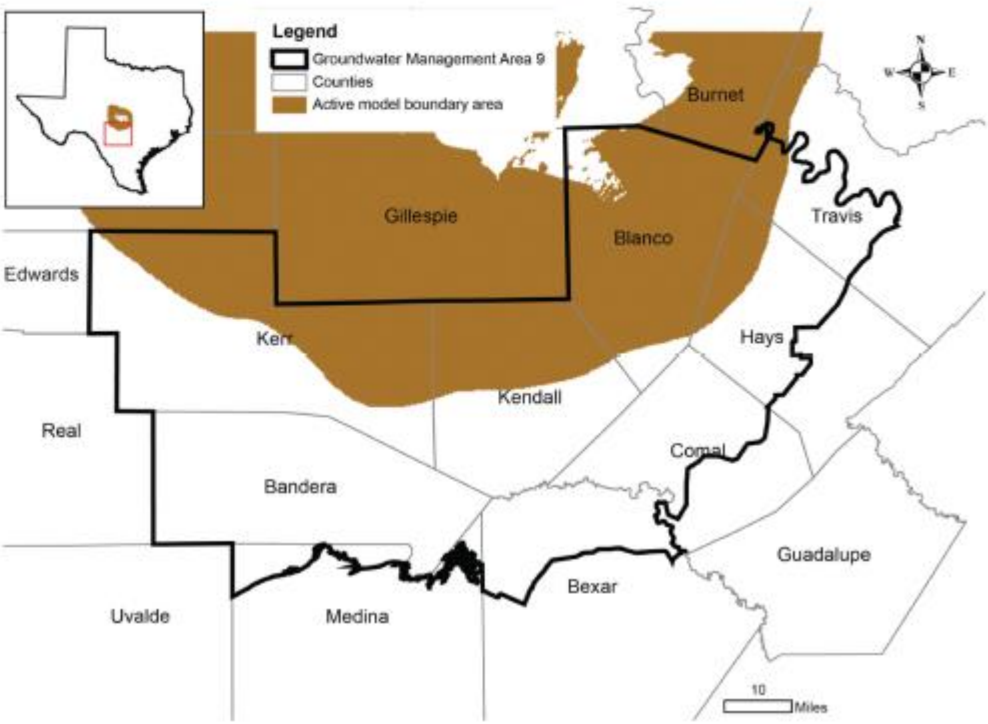

FIGURE 7. MAP SHOWING AREAS COVERED BY THE HICKORY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 9.

TABLE 7. MODELED AVAILABLE GROUNDWATER FOR THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 9 SUMMARIZED BY DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

District	County	Year						
		2010	2020	2030	2040	2050	2060	2070
Cow Creek Groundwater Conservation District Total	Kendall	140	140	140	140	140	140	140

TABLE 8. MODELED AVAILABLE GROUNDWATER FOR THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 9 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2010 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RPWA	River Basin	Year						
			2010	2020	2030	2040	2050	2060	2070
Kendall	South Central Texas (L)	Colorado	12	12	12	12	12	12	12
		Guadalupe	128	128	128	128	128	128	128
		Total	140	140	140	140	140	140	140

LIMITATIONS:

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> *"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."*

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of 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 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 groundwater pumping and groundwater levels in 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.

Model "Dry" Cells

The predictive model run for this analysis results in water levels in some model cells dropping below the base elevation of the cell during the simulation. In terms of water level, the cells have gone dry. However, as noted in the model assumptions the transmissivity of the cell remains constant and will produce water.

A total of 18 cells out of 23,805 active cells simulating the Trinity Aquifer cells go "dry" during the predictive period through 2060. These dry cells are located in western Travis County, central Hays County and Kerr County. These dry cells are associated either with areas of high pumping or thin parts of the Trinity Aquifer.

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APPENDIX B – GAM Run 16-022: Comal Trinity Groundwater Conservation District Management Plan

GAM Run 16-022: Comal Trinity Groundwater Conservation District Management Plan

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June 10, 2016

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GAM RUN 16-022: COMAL TRINITY GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

Shirley Wade, Ph.D., P.G.
Texas Water Development Board
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Groundwater Availability Modeling Section
(512) 936-0883
June 10, 2016

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2015), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the executive administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the executive administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

- the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;
- 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 the Comal Trinity Groundwater Conservation District—fulfills the requirements noted above. Part 1 of the two-part package is the Estimated 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 Comal Trinity Groundwater Conservation District should be adopted by the district on or before March 19, 2018 and submitted to the Executive Administrator of the TWDB on or before April 18, 2018. The due date for Comal Trinity Groundwater Conservation District's first management plan is June 17, 2018.

This report discusses the methods, assumptions, and results from a model run using the groundwater availability model for the Hill Country portion of the Trinity Aquifer System (Jones and others, 2011). Please note that the Edwards (Balcones Fault Zone) Aquifer occurs within the boundaries of the Comal Trinity Groundwater Conservation District but is excluded from this report because the district does not have jurisdiction over that aquifer. Additionally, it should be noted that the portion of the Trinity Aquifer System underlying the Edwards (Balcones Fault Zone) Aquifer within the Comal Trinity Groundwater Conservation District is not included in the groundwater availability model for the Hill Country portion of the Trinity Aquifer System. If the district would like information for the Trinity Aquifer System underlying the Edwards (Balcones Fault Zone) Aquifer please contact Mr. Stephen Allen, stephen.allen@twdb.texas.gov, (512) 463-7317.

Table 1 summarizes the groundwater availability model data required by statute, and Figure 1 shows the area of the model from which the values in the table were extracted. If after review of the figure, Comal Trinity Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability model for the Hill Country portion of the Trinity Aquifer System was run for this analysis. The water budget for the Comal Trinity Groundwater Conservation District was extracted for the historical model period (1981through 1997) 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 system located within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Trinity Aquifer System

- We used version 2.01 of the groundwater availability model for the Hill Country portion of the Trinity Aquifer System. See Jones and others (2011) for assumptions and limitations of the groundwater availability model.
- The groundwater availability model includes four layers, representing (from top to bottom):

    1. the Edwards Group of the Edwards-Trinity (Plateau) Aquifer,
    2. the Upper Trinity Aquifer,
    3. the Middle Trinity Aquifer, and
    4. the Lower Trinity Aquifer.

  Layer 1 is not present in the district. An individual water budget for the district was determined for the remaining layers of the Hill Country portion of the Trinity Aquifer System (Layer 2 to Layer 4, collectively).

- The General-Head Boundary (GHB) package of MODFLOW was used to represent flow between the Hill Country portion of the Trinity Aquifer System and the Edwards (Balcones Fault Zone) Aquifer or the confined parts of the Trinity Aquifer System underlying the Edwards (Balcones Fault Zone) Aquifer.
- The groundwater availability model includes some portions of the Edwards Group outside the official boundary of the Edwards-Trinity (Plateau) Aquifer. Though flow for these areas is not explicitly reported, the interaction between the Edwards Group (outside the Edwards-Trinity Plateau Aquifer) and the underlying Trinity Aquifer System would be shown in the "flow between aquifers" segment of Table 1, if Layer 1 was present in the district.
- Only the outcrop area of the Hill County portion of the Trinity Aquifer System was modeled, and the down-dip extent that underlies the Edwards (Balcones Fault Zone) Aquifer is not included.
- 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 springs.
- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent counties.
- Flow between aquifers—The net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer 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 a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

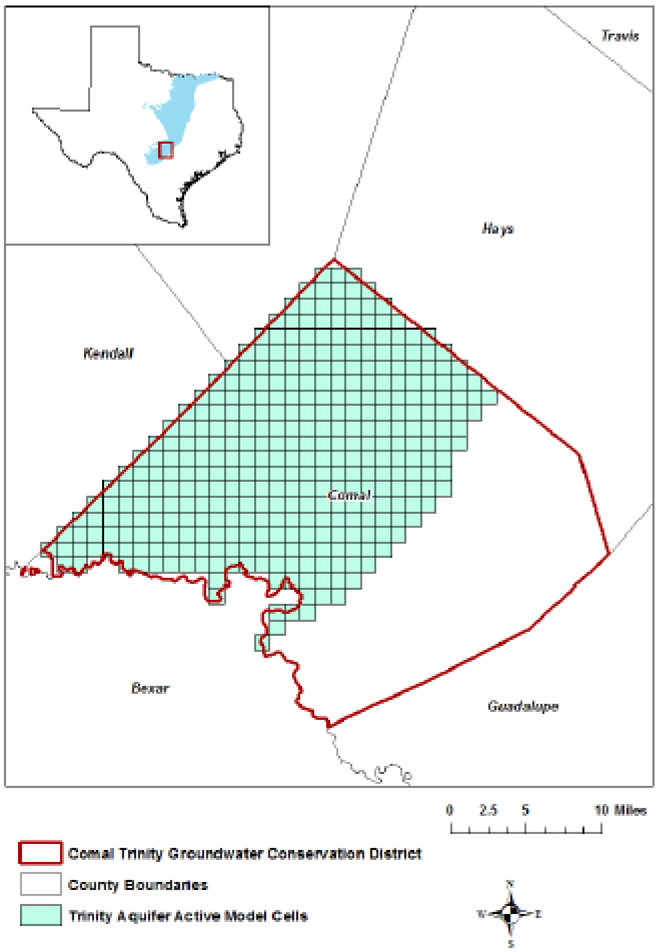

FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE HILL COUNTRY PORTION OF THE TRINITY AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED [THE TRINITY AQUIFER SYSTEM EXTENT MODELED WITHIN THE DISTRICT BOUNDARY].

TABLE 1: SUMMARIZED INFORMATION FOR THE HILL COUNTRY PORTION OF THE TRINITY AQUIFER SYSTEM THAT IS NEEDED FOR COMAL TRINITY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer System	42,457
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer System	15,601
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer System	38,106
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer System	28,422
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer System to the Edwards (Balcones Fault Zone) Aquifer and deep Trinity Aquifer	38,912*

* in the Comal Trinity Groundwater Conservation District, groundwater generally flows east from the Trinity Aquifer System to the Edwards (Balcones Fault Zone) Aquifer and the confined parts of the Trinity Aquifer System that underlie the Edwards (Balcones Fault Zone) Aquifer.

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 interaction with streams are specific to particular historic time periods.

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

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

REFERENCES:

Harbaugh, A. W., 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.

Jones, I. C., Anaya, R., and Wade, S. C., 2011, Groundwater availability model: Hill Country portion of the Trinity Aquifer of Texas: Texas Water Development Board Report 377, 165 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.

Texas Water Code, 2015, http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf.

APPENDIX C – CTGCD Board Resolution 2202017

STATE OF TEXAS §
§ **RESOLUTION #2202017**
COUNTY OF COMAL §

COMAL TRINITY GROUNDWATER CONSERVATION DISTRICT

ADOPTION OF DESIRED FUTURE CONDITIONS AND NON-RELEVANT AQUIFERS FOR COMAL COUNTY IN ACCORDANCE WITH GROUNDWATER MANAGEMENT AREA # 9 JOINT PLANNING

WHEREAS, the Comal Trinity Groundwater Conservation District (CTGCD) is a groundwater conservation district created in accordance with and subject to Chapter 36, Texas Water Code and;

WHEREAS, the CTGCD is required under Chapter 36.108, Texas Water Code; to participate in Groundwater Management Area Joint Planning and;

WHEREAS, the CTGCD is located in Groundwater Management Area # 9 and;

WHEREAS, Groundwater Management Area # 9 has completed the joint planning required under Chapter 36.108 and by resolution, has adopted Desired Future Conditions (DFCs) for relevant aquifers and declared portions of certain aquifers as non-relevant for regional planning purposes, and submitted the resolution and an Explanatory Report to the Texas Water Development Board (TWDB) and;

WHEREAS Chapter 36.108 (d-4) and TWDB Rule 356.34 require districts within GMA 9 to adopt the DFCs as soon as possible after being notified that the GMA 9 resolution and Explanatory Report are administratively complete and;

WHEREAS, the TWDB has notified GMA 9 both by email on January 31, 2017 and in person at a GMA 9 meeting held on February 6, 2017 that the DFCs and the Explanatory Report are administratively complete;

NOW THEREFORE BE IT RESOLVED, that the Board of Directors of the Comal Trinity Groundwater Conservation District does hereby adopt the following DFCs and non-relevant aquifers for Comal County as described in the GMA 9 resolution and Explanatory Report:

- Trinity Aquifer (Upper, Middle, and Lower undifferentiated) - Allow for an increase in average drawdown of approximately 30 feet through 2060 consistent with "Scenario 6" in TWDB Draft GAM Task 10-005

  Note: The above DFC is for GMA 9 as a whole. In Appendix A of Draft GAM Task 10-005, the DFC calculation for the overall Trinity Aquifer located in Comal County under Scenario 6 would allow for an increase in average drawdown of approximately 23.9 feet in Comal County.

The following aquifers or portions of aquifers are classified as Non-Relevant for regional planning purposes:

- Edwards Aquifer (Balcones Fault Zone) located in Comal County.

PASSED AND APPROVED THIS 20th DAY OF February, 2017 with 6 ayes, 0 nays, and 0 abstentions.

Larry Hull, Board President

Dr. Larry Sunn, Board Secretary

APPENDIX D – GTA Aquifer Assessment 10-29 MAG

GTA Aquifer Assessment 10-29 MAG
Groundwater Management Area 10
Trinity Aquifer
Modeled Available Groundwater estimates
November 29, 2011

GTA Aquifer Assessment 10-29 MAG

by David Thorkildsen, P.G. and Sarah Backhouse
Texas Water Development Board
Groundwater Technical Assistance Section
(512) 936-0871

David Thorkildsen, P.G. 705 authorized the seal appearing on this document on November 29, 2011.

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EXECUTIVE SUMMARY:

The modeled available groundwater for the Trinity Aquifer as a result of the desired future condition adopted by members of Groundwater Management Area 10 is approximately 59,746 acre-feet per year. This is divided by county, regional water planning area, and river basin in Table 2 for use in the regional water planning process. Modeled available groundwater is summarized by county, regional water planning area, river basin, and groundwater conservation district in tables 3 through 6. Pumping estimates, as well as parameters and assumptions to determine additional modeled available groundwater estimates were extracted from GTA Aquifer Assessment 10-06, which Groundwater Management Area 10 used as the basis for developing a desired future condition stating that "*except as otherwise provided herein: regional average well drawdown during average recharge conditions that does not exceed 25 feet; within the jurisdiction of Hays-Trinity GCD: regional average well drawdown during average recharge conditions of zero (0) feet; and in the Uvalde County part of GMA-10: regional average well drawdown during average recharge conditions of no more than twenty (20) feet*" and declaring "*the Trinity Aquifer in the part of GMA 10 that is in the Trinity-Glen Rose GCD as a non-relevant aquifer*".

REQUESTOR:

Mr. Rick Illgner of the Edwards Aquifer Authority acting on behalf of the member groundwater conservation districts of Groundwater Management Area 10.

DESCRIPTION OF REQUEST:

In a letter received August 30, 2010, Mr. Illgner provided the Texas Water Development Board (TWDB) with the desired future condition of the Trinity Aquifer adopted by the members of Groundwater Management Area 10. The desired future condition for the Trinity Aquifer, as described in Resolution No. 2010-10 and adopted August 23, 2010 by the groundwater conservation districts in Groundwater Management Area 10 is described below:

1) *except as otherwise provided herein: regional average well drawdown during average recharge conditions that does not exceed 25 feet (including exempt and non-exempt well use);*
2) *within the jurisdiction of Hays-Trinity GCD: regional average well drawdown during average recharge conditions of zero (0) feet (including exempt and non-exempt use);*
3) *in the Uvalde County part of GMA-10: regional average well drawdown during average recharge conditions of no more than twenty (20) feet (including exempt and non-exempt well use);*

4) *declare the Trinity Aquifer in the part of GMA 10 that is in the Trinity-Glen Rose GCD as a non-relevant aquifer*

In response to receiving the adopted desired future condition, TWDB has estimated the modeled available groundwater that achieves the above desired future condition for Groundwater Management Area 10.

METHODS:

Groundwater Management Area 10, located in South Central Texas, includes part of the Trinity Aquifer (Figure 1). At the request of Groundwater Management Area 10 the TWDB previously analyzed several water level decline scenarios for the Trinity Aquifer, documented in GTA Aquifer Assessment 10-06. One of the scenarios included the desired future condition of 25 feet of water level decline, and one included the desired future condition of 20 feet of water level decline. For these two scenarios the pumping results presented here for Groundwater Management Area 10 are taken directly from GTA Aquifer Assessment 10-06 with the exception of the area in the Hays Trinity Groundwater Conservation District (GCD). The assessment did not include a 0 foot water level decline scenario, therefore new calculations to determine modeled available groundwater estimates were completed for this area (Table 1)

To calculate modeled available groundwater estimates for the desired future condition of 0 feet of water level decline for the Hays Trinity GCD parameters and assumptions for the volumetric storage, recharge, inflow calculations, map areas, and areal extent were obtained from GTA Aquifer Assessment 10-06 (Thorkildsen and Backhouse, 2010). It is important to note that only 3 percent (6,363 acres) of the total Hays Trinity GCD area occurs in Groundwater Management Area 10.

To calculate change in aquifer storage for the Hays Trinity GCD based on the desired future condition, map areas were multiplied by the estimated aquifer storativity or specific yield and then by a uniform water level decline of 0 feet. These volumes were then divided by 50 years to obtain a yearly volume. In cases where unconfined and confined conditions existed, those were calculated separately.

Modeled available groundwater estimates are divided by county, regional water planning area, river basin, and groundwater conservation district. These areas are shown in Figure 2.

PARAMETERS AND ASSUMPTIONS:

- Parameters, assumptions, volumetric calculations, and areas were obtained from GTA Aquifer Assessment 10-06 (Thorkildsen and Backhouse, 2010).
- Water-level declines were estimated to be uniform across the aquifer.
- The Edwards Aquifer Authority is not included in this assessment because they are restricted by their enabling legislation to manage only the Edwards Aquifer.

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 January 10, 2011, 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.

RESULTS:

The estimated modeled available groundwater for the Trinity Aquifer in Groundwater Management Area 10 consistent with the adopted desired future condition is approximately 59,746 acre-feet per year. The volumetric calculations to determine the estimates for Hays Trinity GCD are shown in Table 1. The relatively small totals reflect the small percentage (3%) of the total district area that occurs in Groundwater Management Area 10.

Table 2 shows the modeled available groundwater by decade divided by county, regional water planning area, and river basin for use in the regional water planning process. Modeled available groundwater estimates are also summarized by county, regional water planning area, river basin, and groundwater conservation district and are shown in tables 3, 4, 5, and 6 respectively.

Table 1. Volumetric calculations estimating annual modeled available groundwater for the Trinity Aquifer in Hays Trinity GCD. Map areas and parameters were obtained from GTA Aquifer Assessment 10-06 (Thorkildsen and Backhouse, 2010).

GMA	Aquifer	County	GCD	Map Areas	Estimated storage coefficient	Areal extent (acres)	Desired total aquifer water level decline (feet)	Estimated total volume from water level decline (acre-feet)	Estimated annual volume from water level decline (acre-feet)	Estimated annual effective recharge (ac-ft/yr)	Estimated annual lateral inflow (ac-ft/yr)	Estimated annual total volume (ac-ft/yr)
10	Trinity	Hays	Hays Trinity Groundwater Conservation District	7	0.00001	994	0	0	0	0	39	39
				8	0.00001	4,342	0	0	0	0	60	60
				22	0.05	554	0	0	0	64	9	73
				23	0.05	473	0	0	0	57	9	66

GMA = groundwater management area ac-ft/yr = acre-feet per year

The formulas for this table are: storage coefficient * areal extent * desired total aquifer water level decline = estimated total volume from water level decline. Estimated total volume from water level decline/50 = estimated annual volume from water level decline. Then estimated annual volume from water level decline + estimated annual effective recharge + estimated annual lateral inflow = estimated annual total volume.

Table 2. Modeled available groundwater by decade for the Trinity Aquifer in Groundwater Management Area 10. Results are in acre-feet per year and are divided by county, regional water planning area, and river basin.

County	Regional Water Planning Area	River Basin	Year					
			2010	2020	2030	2040	2050	2060
Bexar	L	San Antonio	19,998	19,998	19,998	19,998	19,998	19,998
Caldwell	L	Guadalupe	0	0	0	0	0	0
Comal	L	Guadalupe	27,176	27,176	27,176	27,176	27,176	27,176
		San Antonio	2,108	2,108	2,108	2,108	2,108	2,108
Guadalupe	L	Guadalupe	0	0	0	0	0	0
		San Antonio	0	0	0	0	0	0
Hays	K	Colorado	955	955	955	955	955	955
	L	Guadalupe	2,860	2,860	2,860	2,860	2,860	2,860
Medina	L	Nueces	4,373	4,373	4,373	4,373	4,373	4,373
		San Antonio	996	996	996	996	996	996
Travis	K	Colorado	634	634	634	634	634	634
		Guadalupe	7	7	7	7	7	7
Uvalde	L	Nueces	639	639	639	639	639	639
Total			59,746	59,746	59,746	59,746	59,746	59,746

Table 3. Modeled available groundwater for the Trinity Aquifer summarized by county in Groundwater Management Area 10 for each decade between 2010 and 2060. Results are in acre-feet per year.

County	Year					
	2010	2020	2030	2040	2050	2060
Bexar	19,998	19,998	19,998	19,998	19,998	19,998
Caldwell	0	0	0	0	0	0
Comal	29,284	29,284	29,284	29,284	29,284	29,284
Guadalupe	0	0	0	0	0	0
Hays	3,815	3,815	3,815	3,815	3,815	3,815
Medina	5,369	5,369	5,369	5,369	5,369	5,369
Travis	641	641	641	641	641	641
Uvalde	639	639	639	639	639	639
Total	**59,746**	**59,746**	**59,746**	**59,746**	**59,746**	**59,746**

Table 4. Modeled available groundwater for the Trinity Aquifer summarized by regional water planning area in Groundwater Management Area 10 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
K	1,596	1,596	1,596	1,596	1,596	1,596
L	58,150	58,150	58,150	58,150	58,150	58,150
Total	**59,746**	**59,746**	**59,746**	**59,746**	**59,746**	**59,746**

Table 5. Modeled available groundwater for the Trinity Aquifer summarized by river basin in Groundwater Management Area 10 for each decade between 2010 and 2060. Results are in acre-feet per year.

River Basin	Year					
	2010	2020	2030	2040	2050	2060
Colorado	1,589	1,589	1,589	1,589	1,589	1,589
Guadalupe	30,043	30,043	30,043	30,043	30,043	30,043
Nueces	5,012	5,012	5,012	5,012	5,012	5,012
San Antonio	23,102	23,102	23,102	23,102	23,102	23,102
Total	**59,746**	**59,746**	**59,746**	**59,746**	**59,746**	**59,746**

Table 6. Modeled available groundwater for the Trinity Aquifer summarized by groundwater conservation district in Groundwater Management Area 10 for each decade between 2010 and 2060. Results are in acre-feet per year.

Groundwater Conservation District	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Barton Springs/Edwards Aquifer CD	1,288	1,288	1,288	1,288	1,288	1,288
Hays Trinity GCD	258	258	258	258	258	258
Medina County GCD	5,369	5,369	5,369	5,369	5,369	5,369
Plum Creek CD	238	238	238	238	238	238
Uvalde County UWCD	639	639	639	639	639	639
Total (excluding non-district areas)	**7,792**	**7,792**	**7,792**	**7,792**	**7,792**	**7,792**
No District	51,954	51,954	51,954	51,954	51,954	51,954
Total (including non-district areas)	**59,746**	**59,746**	**59,746**	**59,746**	**59,746**	**59,746**

GCD = Groundwater Conservation District CD = Conservation District UWCD = Underground Water Conservation District

LIMITATIONS:

The water budget in this analysis was determined to be the best method to calculate estimates of modeled available groundwater, however this method has limitations and should be replaced with better tools, including groundwater models and additional data that are not currently available, whenever possible.

This analysis assumes homogeneous and isotropic aquifers; however, aquifer conditions may not be uniform. In addition, certain assumptions have been made regarding future precipitation, recharge, and streamflow in developing these pumping estimates. These assumptions need to be considered and compared to actual future data when evaluating achievement of the desired future condition.

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. 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 and water levels to know if they are achieving their desired future conditions. Because of the limitations and assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine these 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:

Thorkildsen and Backhouse, 2010, GTA Aquifer Assessment 10-06:Texas Water Development Board, GTA Aquifer Assessment 10-06 Report, 20 p.

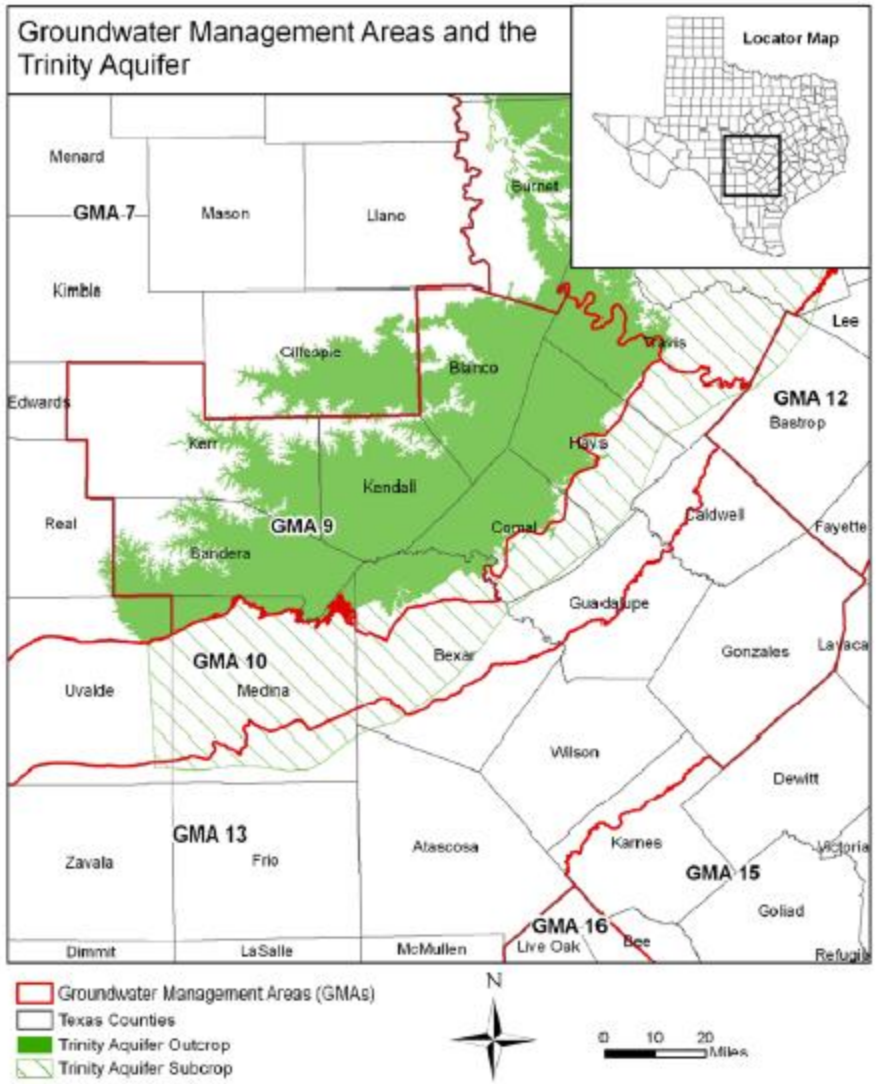

Figure 1. Map showing the areas covered by the Trinity Aquifer in and neighboring Groundwater Management Area 10.

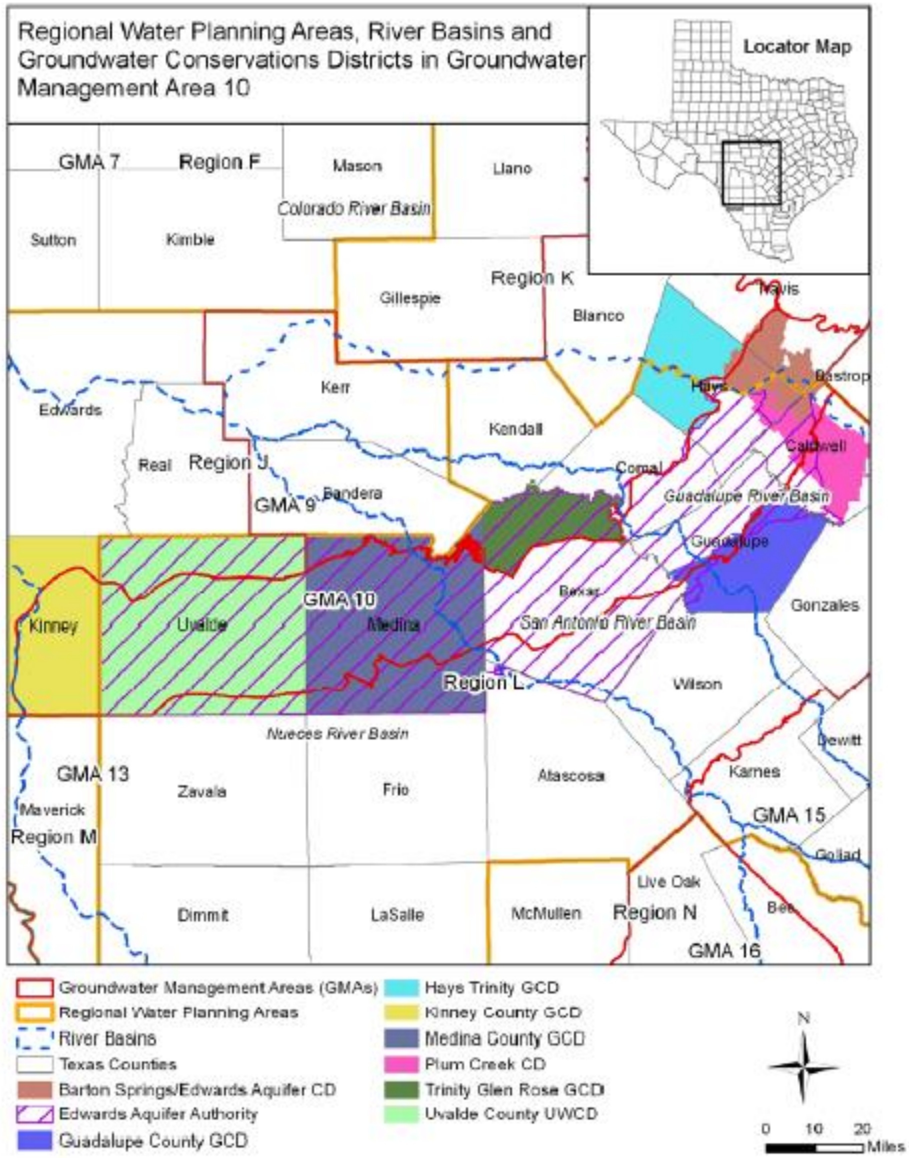

Figure 2. Map showing regional water planning areas, river basins, groundwater conservation districts and counties in and neighboring Groundwater Management Area 10. CD = Conservation District, GCD = Groundwater Conservation District, UWCD = Underground Water Conservation District

APPENDIX E - Estimated Historical Groundwater Use and 2017 State Water Plan Datasets: Comal Trinity Groundwater Conservation District

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

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2016. TWDB staff anticipates the calculation and posting of these estimates at a later date.

COMAL COUNTY *99.4% (multiplier)* All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2015	GW	12,141	2,596	3,263	0	231	74	18,305
	SW	9,077	29	0	0	294	171	9,571
2014	GW	11,401	4,484	5,553	0	158	73	21,669
	SW	9,481	37	0	0	30	168	9,716
2013	GW	10,695	2,169	4,548	0	224	69	17,705
	SW	8,384	34	0	0	26	162	8,606
2012	GW	12,252	2,950	3,095	0	283	64	18,644
	SW	8,630	60	0	0	199	148	9,037
2011	GW	14,669	4,067	2,801	0	422	77	22,036
	SW	8,831	59	185	0	177	180	9,432
2010	GW	10,366	2,982	6,092	0	220	72	19,732
	SW	12,315	57	3,626	0	236	166	16,400
2009	GW	12,022	362	9,515	0	521	85	22,505
	SW	8,090	729	3,496	0	0	197	12,512
2008	GW	12,599	435	10,273	0	0	80	23,387
	SW	8,890	745	3,907	0	170	184	13,896
2007	GW	7,778	470	6,601	0	250	83	15,182
	SW	7,600	736	539	0	164	192	9,231
2006	GW	8,886	528	6,611	0	730	68	16,823
	SW	8,047	734	539	0	0	157	9,477
2005	GW	8,696	491	6,590	0	60	73	15,910
	SW	7,647	727	539	0	448	169	9,530
2004	GW	6,434	417	7,646	0	152	151	14,800
	SW	7,675	723	539	0	427	101	9,465
2003	GW	6,527	396	7,977	0	100	161	15,161
	SW	7,736	724	539	0	643	107	9,749
2002	GW	6,875	484	8,053	0	45	170	15,627
	SW	6,369	362	539	0	30	113	7,413
2001	GW	6,575	656	6,298	0	32	178	13,739
	SW	7,526	170	0	0	21	119	7,836
2000	GW	7,276	746	11,696	0	30	237	19,985
	SW	7,577	285	0	0	20	59	7,941

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

COMAL COUNTY *99.4% (multiplier)* All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
L	BULVERDE	GUADALUPE	CANYON LAKE/RESERVOIR	9	10	11	13	14	15
L	BULVERDE	SAN ANTONIO	CANYON LAKE/RESERVOIR	794	929	1,070	1,215	1,363	1,506
L	CANYON LAKE WATER SERVICE COMPANY	GUADALUPE	CANYON LAKE/RESERVOIR	3,908	3,773	3,641	3,514	3,387	3,266
L	CANYON LAKE WATER SERVICE COMPANY	SAN ANTONIO	CANYON LAKE/RESERVOIR	961	938	915	889	862	836
L	COUNTY-OTHER, COMAL	GUADALUPE	CANYON LAKE/RESERVOIR	1,370	1,370	1,370	1,370	1,370	1,370
L	CRYSTAL CLEAR WSC	GUADALUPE	CANYON LAKE/RESERVOIR	153	149	144	140	136	133
L	FAIR OAKS RANCH	SAN ANTONIO	CANYON LAKE/RESERVOIR	95	96	96	98	98	99
L	GREEN VALLEY SUD	GUADALUPE	CANYON LAKE/RESERVOIR	16	18	18	19	19	20
L	IRRIGATION, COMAL	GUADALUPE	CANYON LAKE/RESERVOIR	248	248	248	248	248	248
L	IRRIGATION, COMAL	GUADALUPE	GUADALUPE RUN-OF-RIVER	206	206	206	206	206	206
L	LIVESTOCK, COMAL	GUADALUPE	GUADALUPE LIVESTOCK LOCAL SUPPLY	119	119	119	119	119	119
L	LIVESTOCK, COMAL	SAN ANTONIO	SAN ANTONIO LIVESTOCK LOCAL SUPPLY	9	9	9	9	9	9
L	MANUFACTURING, COMAL	GUADALUPE	CANYON LAKE/RESERVOIR	4	4	4	4	4	4
L	MANUFACTURING, COMAL	GUADALUPE	GUADALUPE RUN-OF-RIVER	99	99	99	99	99	99
L	NEW BRAUNFELS	GUADALUPE	CANYON LAKE/RESERVOIR	8,072	8,124	8,158	8,188	8,207	8,218
L	NEW BRAUNFELS	GUADALUPE	GUADALUPE RUN-OF-RIVER	1,075	1,082	1,086	1,090	1,093	1,094
L	SAN ANTONIO WATER SYSTEM	GUADALUPE	GUADALUPE RUN-OF-RIVER	0	0	0	0	0	0
L	SAN ANTONIO WATER SYSTEM	GUADALUPE	SAN ANTONIO RUN-OF-RIVER	88	113	135	153	169	182
L	SAN ANTONIO WATER SYSTEM	SAN ANTONIO	GUADALUPE RUN-OF-RIVER	0	0	0	0	0	0
L	SAN ANTONIO WATER SYSTEM	SAN ANTONIO	SAN ANTONIO RUN-OF-RIVER	75	97	116	132	145	158
		Sum of Projected Surface Water Supplies (acre-feet)		**17,301**	**17,384**	**17,445**	**17,506**	**17,548**	**17,582**

Projected Water Demands
TWDB 2017 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.

COMAL COUNTY

99.4% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
L	BULVERDE	GUADALUPE	9	10	11	13	14	15
L	BULVERDE	SAN ANTONIO	794	929	1,070	1,215	1,363	1,506
L	CANYON LAKE WATER SERVICE COMPANY	GUADALUPE	3,112	4,314	5,554	6,812	8,067	9,275
L	CANYON LAKE WATER SERVICE COMPANY	SAN ANTONIO	771	1,068	1,375	1,686	1,996	2,295
L	COUNTY-OTHER, COMAL	GUADALUPE	3,931	3,893	3,820	3,789	3,719	3,672
L	COUNTY-OTHER, COMAL	SAN ANTONIO	208	237	278	289	315	311
L	CRYSTAL CLEAR WSC	GUADALUPE	301	336	374	415	458	500
L	FAIR OAKS RANCH	SAN ANTONIO	106	125	140	150	168	186
L	GARDEN RIDGE	GUADALUPE	1,062	1,430	1,806	2,188	2,570	2,936
L	GARDEN RIDGE	SAN ANTONIO	600	808	1,021	1,237	1,452	1,660
L	GREEN VALLEY SUD	GUADALUPE	28	34	39	45	52	58
L	IRRIGATION, COMAL	GUADALUPE	384	349	314	279	246	226
L	IRRIGATION, COMAL	SAN ANTONIO	43	39	35	31	28	25
L	LIVESTOCK, COMAL	GUADALUPE	239	239	239	239	239	239
L	LIVESTOCK, COMAL	SAN ANTONIO	18	18	18	18	18	18
L	MANUFACTURING, COMAL	GUADALUPE	8,426	9,166	9,885	10,502	11,368	12,308
L	MANUFACTURING, COMAL	SAN ANTONIO	85	92	99	106	115	124
L	MINING, COMAL	GUADALUPE	8,206	9,538	10,821	11,940	13,342	14,913
L	MINING, COMAL	SAN ANTONIO	342	398	451	498	556	621
L	NEW BRAUNFELS	GUADALUPE	12,380	15,203	18,118	21,108	24,127	27,039
L	SAN ANTONIO WATER SYSTEM	GUADALUPE	661	956	1,254	1,558	1,866	2,157
L	SAN ANTONIO WATER SYSTEM	SAN ANTONIO	566	821	1,076	1,335	1,600	1,863
L	SCHERTZ	GUADALUPE	247	394	587	813	1,094	1,379
L	SCHERTZ	SAN ANTONIO	6	10	15	20	27	34
L	SELMA	SAN ANTONIO	3	4	5	6	6	7
		Sum of Projected Water Demands (acre-feet)	**42,528**	**50,411**	**58,405**	**66,292**	**74,806**	**83,367**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

COMAL COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
L	BULVERDE	GUADALUPE	0	0	0	0	0	0
L	BULVERDE	SAN ANTONIO	0	0	0	0	0	0
L	CANYON LAKE WATER SERVICE COMPANY	GUADALUPE	796	-541	-1,913	-3,298	-4,680	-6,009
L	CANYON LAKE WATER SERVICE COMPANY	SAN ANTONIO	190	-130	-460	-797	-1,134	-1,459
L	COUNTY-OTHER, COMAL	GUADALUPE	722	754	822	851	918	965
L	COUNTY-OTHER, COMAL	SAN ANTONIO	92	69	33	24	2	6
L	CRYSTAL CLEAR WSC	GUADALUPE	40	-5	-54	-103	-156	-207
L	FAIR OAKS RANCH	SAN ANTONIO	88	71	56	50	33	16
L	GARDEN RIDGE	GUADALUPE	-653	-1,021	-1,398	-1,780	-2,161	-2,528
L	GARDEN RIDGE	SAN ANTONIO	-370	-578	-790	-1,006	-1,222	-1,429
L	GREEN VALLEY SUD	GUADALUPE	-2	-4	-9	-14	-21	-26
L	IRRIGATION, COMAL	GUADALUPE	493	528	563	598	632	652
L	IRRIGATION, COMAL	SAN ANTONIO	3	7	11	15	18	21
L	LIVESTOCK, COMAL	GUADALUPE	0	0	0	0	0	0
L	LIVESTOCK, COMAL	SAN ANTONIO	0	0	0	0	0	0
L	MANUFACTURING, COMAL	GUADALUPE	-4,089	-4,832	-5,556	-6,176	-7,049	-7,993
L	MANUFACTURING, COMAL	SAN ANTONIO	-41	-49	-56	-63	-71	-81
L	MINING, COMAL	GUADALUPE	0	0	0	0	0	0
L	MINING, COMAL	SAN ANTONIO	0	0	0	0	0	0
L	NEW BRAUNFELS	GUADALUPE	2,069	-661	-3,515	-6,452	-9,435	-12,329
L	SAN ANTONIO WATER SYSTEM	GUADALUPE	-104	-329	-540	-749	-972	-1,194
L	SAN ANTONIO WATER SYSTEM	SAN ANTONIO	-89	-283	-463	-639	-833	-1,030
L	SCHERTZ	GUADALUPE	0	0	-56	-221	-452	-718
L	SCHERTZ	SAN ANTONIO	0	0	-2	-5	-11	-18
L	SELMA	SAN ANTONIO	2	-1	0	-1	-1	-1
		Sum of Projected Water Supply Needs (acre-feet)	**-5,348**	**-8,434**	**-14,812**	**-21,304**	**-28,198**	**-35,022**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

COMAL COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
BULVERDE, GUADALUPE (L)							
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	0	0	0	0	0	1
		0	**0**	**0**	**0**	**0**	**1**
BULVERDE, SAN ANTONIO (L)							
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	0	0	0	1	32	70
		0	**0**	**0**	**1**	**32**	**70**
CANYON LAKE WATER SERVICE COMPANY, GUADALUPE (L)							
MUNICIPAL WATER CONSERVATION (RURAL)	DEMAND REDUCTION [COMAL]	0	0	0	59	253	504
TWA REGIONAL CARRIZO AQUIFER DEVELOPMENT	CARRIZO-WILCOX AQUIFER [GONZALES]	0	541	1,913	3,298	4,680	6,009
		0	**541**	**1,913**	**3,357**	**4,933**	**6,513**
CANYON LAKE WATER SERVICE COMPANY, SAN ANTONIO (L)							
MUNICIPAL WATER CONSERVATION (RURAL)	DEMAND REDUCTION [COMAL]	0	0	0	15	63	125
TWA REGIONAL CARRIZO AQUIFER DEVELOPMENT	CARRIZO-WILCOX AQUIFER [GONZALES]	0	130	460	797	1,134	1,459
		0	**130**	**460**	**812**	**1,197**	**1,584**
CRYSTAL CLEAR WSC, GUADALUPE (L)							
CRWA WELLS RANCH PROJECT PHASE II	CARRIZO-WILCOX AQUIFER [GUADALUPE]	36	122	143	0	0	0
HAYS/CALDWELL PUA PROJECT	CARRIZO-WILCOX AQUIFER [CALDWELL]	59	138	110	246	239	233
MUNICIPAL WATER CONSERVATION (RURAL)	DEMAND REDUCTION [COMAL]	0	0	0	0	0	9
		95	**260**	**253**	**246**	**239**	**242**
FAIR OAKS RANCH, SAN ANTONIO (L)							
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	6	17	30	43	60	75
		6	**17**	**30**	**43**	**60**	**75**
GARDEN RIDGE, GUADALUPE (L)							
DROUGHT MANAGEMENT - GARDEN RIDGE	DEMAND REDUCTION [COMAL]	53	0	0	0	0	0
LOCAL TRINITY AQUIFER DEVELOPMENT	TRINITY AQUIFER [COMAL]	1,278	1,278	1,278	1,278	1,278	1,278
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	65	204	399	644	928	1,240

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

WUG, Basin (RWPG) All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
REGIONAL CARRIZO FOR SSLGC PROJECT EXPANSION	CARRIZO-WILCOX AQUIFER [GONZALES]	96	96	96	96	96	96
		1,492	**1,578**	**1,773**	**2,018**	**2,302**	**2,614**
GARDEN RIDGE, SAN ANTONIO (L)							
DROUGHT MANAGEMENT - GARDEN RIDGE	DEMAND REDUCTION [COMAL]	30	0	0	0	0	0
LOCAL TRINITY AQUIFER DEVELOPMENT	TRINITY AQUIFER [COMAL]	722	722	722	722	722	722
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	36	115	226	364	525	701
REGIONAL CARRIZO FOR SSLGC PROJECT EXPANSION	CARRIZO-WILCOX AQUIFER [GONZALES]	54	54	54	54	54	54
		842	**891**	**1,002**	**1,140**	**1,301**	**1,477**
GREEN VALLEY SUD, GUADALUPE (L)							
BRACKISH WILCOX GROUNDWATER FOR CRWA	CARRIZO-WILCOX AQUIFER [WILSON]	0	0	0	0	0	11
CRWA SIESTA PROJECT	DIRECT REUSE [BEXAR]	0	0	0	6	0	52
CRWA SIESTA PROJECT	SAN ANTONIO RUN-OF-RIVER [WILSON]	0	0	0	5	0	41
CRWA WELLS RANCH PROJECT PHASE II	CARRIZO-WILCOX AQUIFER [GUADALUPE]	54	75	77	139	140	105
DROUGHT MANAGEMENT - GREEN VALLEY SUD	DEMAND REDUCTION [COMAL]	1	0	0	0	0	0
		55	**75**	**77**	**150**	**140**	**209**
MANUFACTURING, COMAL, GUADALUPE (L)							
GBRA - MBWSP - SURFACE WATER W/ ASR (OPTION 3C)	GUADALUPE RUN-OF-RIVER [GONZALES]	4,089	4,832	5,556	6,176	7,049	7,993
		4,089	**4,832**	**5,556**	**6,176**	**7,049**	**7,993**
MANUFACTURING, COMAL, SAN ANTONIO (L)							
GBRA - MBWSP - SURFACE WATER W/ ASR (OPTION 3C)	GUADALUPE RUN-OF-RIVER [GONZALES]	41	49	56	63	71	81
		41	**49**	**56**	**63**	**71**	**81**
NEW BRAUNFELS, GUADALUPE (L)							
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	535	1,817	3,556	4,738	5,853	7,057
NEW BRAUNFELS UTILITY - ASR	TRINITY AND/OR BRACKISH EDWARDS AQUIFER ASR [COMAL]	6,893	6,937	6,967	6,992	7,008	7,018
NEW BRAUNFELS UTILITY - TRINITY DEVELOPMENT	TRINITY AQUIFER [COMAL]	0	3,343	3,357	3,370	3,377	3,382
REUSE - NEW BRAUNFELS	DIRECT REUSE [COMAL]	5,834	6,604	7,191	8,095	9,047	9,900
		13,262	**18,701**	**21,071**	**23,195**	**25,285**	**27,357**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

WUG, Basin (RWPG) — All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
SAN ANTONIO WATER SYSTEM, GUADALUPE (L)							
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	0	0	0	0	0	31
REGIONAL CARRIZO FOR SSLGC PROJECT EXPANSION	CARRIZO-WILCOX AQUIFER [GONZALES]	29	132	0	0	0	0
SAWS SEAWATER DESALINATION	GULF OF MEXICO [GULF OF MEXICO]	0	0	190	216	239	257
VISTA RIDGE PROJECT	CARRIZO-WILCOX AQUIFER [BURLESON]	75	197	350	533	733	936
		104	**329**	**540**	**749**	**972**	**1,224**
SAN ANTONIO WATER SYSTEM, SAN ANTONIO (L)							
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	0	0	0	0	0	27
REGIONAL CARRIZO FOR SSLGC PROJECT EXPANSION	CARRIZO-WILCOX AQUIFER [GONZALES]	25	113	0	0	0	0
SAWS SEAWATER DESALINATION	GULF OF MEXICO [GULF OF MEXICO]	0	0	163	185	205	222
VISTA RIDGE PROJECT	CARRIZO-WILCOX AQUIFER [BURLESON]	64	170	300	454	628	809
		89	**283**	**463**	**639**	**833**	**1,058**
SCHERTZ, GUADALUPE (L)							
CIBOLO VALLEY LGC CARRIZO PROJECT	CARRIZO-WILCOX AQUIFER [WILSON]	0	0	0	0	170	409
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	9	16	33	62	107	165
REGIONAL CARRIZO FOR SSLGC PROJECT EXPANSION	CARRIZO-WILCOX AQUIFER [GONZALES]	18	39	56	221	282	310
		27	**55**	**89**	**283**	**559**	**884**
SCHERTZ, SAN ANTONIO (L)							
CIBOLO VALLEY LGC CARRIZO PROJECT	CARRIZO-WILCOX AQUIFER [WILSON]	0	0	0	0	4	10
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	0	0	1	2	3	4
REGIONAL CARRIZO FOR SSLGC PROJECT EXPANSION	CARRIZO-WILCOX AQUIFER [GONZALES]	0	1	1	5	7	8
		0	**1**	**2**	**7**	**14**	**22**
SELMA, SAN ANTONIO (L)							
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [COMAL]	0	0	0	1	1	1
REGIONAL CARRIZO FOR SSLGC PROJECT EXPANSION	CARRIZO-WILCOX AQUIFER [GONZALES]	0	1	0	1	1	1

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

WUG, Basin (RWPG) All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
		0	**1**	**0**	**2**	**2**	**2**
Sum of Projected Water Management Strategies (acre-feet)		**20,102**	**27,743**	**33,285**	**38,881**	**44,989**	**51,406**