KIMBLE COUNTY
GROUNDWATER CONSERVATION DISTRICT

GROUNDWATER MANAGEMENT PLAN
2019-2024

Adopted April 29, 2019

KIMBLE COUNTY GROUNDWATER CONSERVATION DISTRICT

GROUNDWATER MANAGEMENT PLAN

2019-2024

District Mission

The mission of the Kimble County Groundwater Conservation District is to develop, promote and implement water conservation and management strategies to conserve, preserve, and protect the groundwater supplies of the District, to protect and enhance recharge, prevent waste and pollution, and to effect efficient use of groundwater.. The District seeks to protect the owners of water rights within the District from impairment of their groundwater quality and quantity, pursuant to the powers and duties granted under Chapter 36, Subchapter D of the Texas Water Code.

Time Period for this Plan

This plan becomes effective upon adoption by the Board of Directors and approval by the Texas Water Development Board. The plan remains in effect for five years after the date of adoption by the Board of Directors and approval by the TWDB, or until such time as a revised or amended plan is approved. Per Texas Water Code 36.1072(e), the district must review and readopt the plan with or without revisions at least once every five years and resubmit the plan to the TWDB for an administrative completeness review.

Statement of Guiding Principles

The District recognizes that its groundwater resources are of utmost importance to the economy and environment, first to the citizens of Kimble County and then to the region.
The District is created for the purpose of conserving, preserving and protecting groundwater supply quantity and quality in the District by:

- Acquiring, understanding and beneficially employing scientific data about the District's aquifers and their hydrogeologic qualities and identifying the extent and location of water supply within the District, for the purpose of developing sustainable management of the resource;
- Preventing depletion of the aquifers underlying the District;
- Protecting the private property rights of landowners in groundwater by ensuring that they shall continue to have the opportunity to use the groundwater underlying their land;
- Promulgating rules for permitting and regulation of spacing, production and transportation of groundwater resources in the District to protect the quantity and quality of the resource;

- Educating the public and regulating to conserve the water resources and use them for beneficial purposes;
- Educating the public and regulating to prevent pollution of groundwater resources;
- Cooperating and coordinating with other groundwater conservation districts with which the District shares aquifer resources.

GENERAL DESCRIPTION OF THE DISTRICT

History

The enabling legislation creating the District, Senate Bill 2, was passed during the 77th Regular Legislative Session (2001). The confirmation election was held on May 4, 2002 with the majority of the votes cast in favor of confirming the creation of the District. On the same ballot, the proposition authorizing the District to levy taxes and setting the maximum tax rate at twenty cents ($.20) per $100 ad valorem value was passed.

The District is governed by a five-member locally elected Board of Directors. The directors serve staggered four-year terms, with the three directors elected in May of even numbered years and the other two directors elected to four-year terms two years later. The initial directors' terms were chosen by drawing lots in accordance with the provisions of the District's enabling legislation enacted in 2001. With elections of directors taking place every two years, the District is very responsive to voters' approval or disapproval of the local management of their groundwater and/or the services provided by the District.

Location, Extent, and Topography

The Kimble County Groundwater Conservation District comprises 97.45% of the land area of Kimble County, excluding that part of the county within the boundary of the Hickory Underground Water Conservation District No. 1. The District covers an area of approximately 766,864 acres (1198 square miles) in the west-central part of Texas. Kimble County ranges in elevation from approximately 1,783 to 2,372 feet above mean sea level. Total population in 2016 was 4,423 including the county seat, the City of Junction (population 2,461).

Drainage

The District lies within the Colorado River Basin and is bisected by the Llano River which arises, on the North Llano River, in Sutton County and, on the South Llano River, in Edwards County. The North and South Llano join within the District to become the Llano River at the city of Junction. Within the District there are numerous creeks which are tributaries of the Llano. Drainage of the river is in a generally eastward direction.

REGIONAL COOPERATION AND COORDINATION

West Texas Regional Groundwater Alliance

As a groundwater conservation district within the boundaries of the Region F Regional Water Planning Group, the District is a cooperating member of the West Texas Regional Groundwater Alliance. In 1988, four groundwater conservation districts; Coke County UWCD, Glasscock County UWCD, Irion County WCD, and Sterling County UWCD signed an original Cooperative Agreement. In the fall of 1996, the original Cooperative Agreement was redrafted and the West Texas Regional Groundwater Alliance was created.

The regional alliance presently has a membership of eighteen locally created and locally funded groundwater conservation districts that encompass almost 9.34 million acres or 14,594 square miles of West Texas.

This West Texas region is very diverse in aquifer characteristics, aquifer yields, types of agricultural production, water quality and other factors which make it necessary for each member district to develop its own unique management programs to best serve its constituents. At the same time, however, the member districts share data and technical information, co-ordinate management strategies, develop certain uniform procedures and forms, and conduct policy discussions.

The current member districts are:

Coke County UWCD	Crockett County GCD
Glasscock GCD	Hickory UWCD # 1
Hill Country UWCD	Irion County WCD
Jeff Davis County UWCD	Kimble County GCD
Lipan-Kickapoo WCD	Lone Wolf GCD
Menard County UWD	Middle Pecos GCD
Permian Basin UWCD	Plateau UWC & SD
Santa Rita UWCD	Sterling County UWCD
Sutton County UWCD	Wes-Tex GCD

Region F Regional Water Planning Group

The District lies entirely within the Region F Regional Water Planning Group, a 32-county area reaching from the Pecos River to the Colorado River. The District is in the Colorado River basin portion of Region F. The District's general manager regularly attends Region F meetings.

Groundwater Management Area 7

In 2003 the Texas Water Development Board designated the boundaries of 16 groundwater management areas in Texas. The District lies entirely within Groundwater Management Area 7, which encompasses 34 counties and 21 groundwater conservation districts within an area of approximately 42,000 square miles. The groundwater management area was designated for the Edwards-Trinity (Plateau) Aquifer, but also includes all or portions of the minor Lipan, Hickory, Ellenburger-San Saba, and Dockum, Capitan Reef and Rustler aquifers, as well as a small portion of the Ogallala and Trinity aquifers.

The District participates in the joint planning process mandated by 36.108 of the Texas Water Code and is actively working with the other 20 GMA 7 districts to develop desired future conditions (DFCs) for the Edwards-Trinity (Plateau) Aquifer. The District also meets with relevant GMA 7 districts and conferring regularly with the Texas Water Development Board to establish desired future conditions and assist in the calculation of modeled available groundwater (MAGs) for the Hickory and Ellenburger-San Saba aquifer formations.

GROUNDWATER RESOURCES

The Hickory Aquifer

The Hickory Aquifer is limited source of water in the northeastern corner of the District, primarily used for livestock purposes.

The aquifer occurs in parts of the counties in the Llano uplift region of Central Texas. Discontinuous outcrops of the Hickory Sandstone overlie or flank exposed Precambrian rocks that form the central core of the uplift. The down dip artesian portion of the aquifer encircles the uplift and extends to maximum depths approaching 4000 ft.

The Hickory Sandstone Member of the Cambrian Riley Formation is composed of some of the oldest sedimentary rocks found in Texas. In most of the northern and western portions of the aquifer, the Hickory can be differentiated into lower, middle, and upper units, which reach a maximum thickness of 480 feet in southwestern McCulloch County. Extensive block faulting has compartmentalized the Hickory Aquifer, thus restricting hydrologic connection from one area to another.[1]

Edwards-Trinity (Plateau) Aquifer

The Edwards-Trinity (Plateau) Aquifer is made up of early Cretaceous Period Trinity Group

[1]"Hickory Water Data" prepared for Hickory UWCD No. 1 by Harden and Associates, August 1986, and aquifer maps obtained from Water for Texas, 1997, TWDB

formations and overlying limestones and dolomites of the Comanche Peak, Edwards, and the Georgetown formations. It ranges in thickness up to 750 feet in the District, with the largest area being from 100 to 500 feet thick. Springs issuing from the aquifer form the headwaters for the Llano River, which flows eastward, and for numerous creeks which are tributary to it.

The Edwards-Trinity (Plateau) Aquifer is the principal aquifer in the District and underlies more than 797,000 acres of Kimble County. Most groundwater production in the District is from the Edwards-Trinity (Plateau) Aquifer.

The saturated thickness of the formation is from 100–300 feet throughout most of county. Water levels have generally remained constant or have fluctuated only with seasonal use. The formation is very fractured, with the water supply lying in joints and fractures of the limestone. The limestone is porous, and recharge to the aquifer is rapid because of the formation of horizontal and vertical dissolution channels in the limestone.

Water quality is good, though generally very hard, with 97.9% of the water supply in the District from this formation having total dissolved solids (TDS) concentrations below 1000 mg/l.[2]

The Edwards Limestone and the Trinity Group crop out over the majority of the area in the District with exception of the alluvial areas along the Llano River and its tributaries and a very small area in the northeastern corner of the county. Underlying the Edwards-Trinity (Plateau) Aquifer in the eastern half of the county is a downdip portion of the Hickory Aquifer, which does not have a significant amount of production within the district, and a down-dip portion of the Ellenburger-San Saba Aquifer which has a small amount of production within the District.

Ellenburger-San Saba Aquifer

The Ellenburger-San Saba Aquifer underlies 4,000 square miles in parts of 15 counties in the Llano Uplift area of Central Texas. Discontinuous outcrops of the aquifer generally encircle older rocks in the core of the Uplift. The remaining down-dip portion contains fresh to slightly saline water to depths of approximately 3,000 feet below land and surface. Water produced from the aquifer has a range in dissolved solids between 200 and 3,000 mg/l, but usually less than 1,000 mg/l. The quality of water deteriorates rapidly away from the outcrop areas. Approximately 20 miles or more downdip from the outcrop, water is typically unsuitable for most uses.[3]

MODELED AVAILABLE GROUNDWATER IN DISTRICT AQUIFERS

The District actively participates in joint planning with 19 other groundwater conservation districts (GCDs) in Groundwater Management Area (GMA) 7 pursuant to Section 36.108 of the Texas Water Code. The estimates of modeled available groundwater (MAG) for each GCD in GMA 7 are based on the Desired Future Conditions adopted by GMA 7's member districts on September 22, 2016 and March 22, 2017.

---

[2] Table 3-2, Edwards Trinity (Plateau) Aquifer, Water for Texas - 2002, TWDB 2002

[3] Ellenburger-San Saba Aquifer information obtained from TWDB website: http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/Brackish%20GW%20Manual/2-Ellenburger-SanSaba.pdf Report by LBG-Guyton Associates

The models used in determining the MAGS and the parameters and assumptions relied upon for the aquifers of the Kimble County Groundwater Conservation District are more fully described in pages 17-18 and page 20 of *GAM Run 16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers of Groundwater Management Area 7*, Texas Water Development Board, September 21, 2018, attached hereto as Appendix "B".

Edwards-Trinity (Plateau) Aquifer

Total modeled available groundwater for the Edwards-Trinity (Plateau) Aquifer within the District is 1,282 acre-feet/year for each decade of the 2010-2070 period.

See page 31 of Appendix B, *GAM Run 16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers of Groundwater Management Area 7* Texas Water Development Board, September 21, 2018, for the MAG for the Edwards-Trinity (Plateau) Aquifer located within the District.

A map showing the area of the aquifer is on page 28 of Appendix B, *GAM Run 16-026 MAG Version 2.*

Ellenburger-San Saba Aquifer

Total modeled available groundwater for the Ellenburger-San Saba Aquifer within the District is 178 acre-feet/year for each decade of the 2010-2070 period.

See page 38 of Appendix B, *GAM Run 16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers of Groundwater Management Area 7* Texas Water Development Board, September 21, 2018, for the MAG for the Ellenburger-San Saba Aquifer located within the District.

A map showing the area of the aquifer is on page 37 of Appendix B, *GAM Run 16-026 MAG Version 2.*

Hickory Aquifer

Total modeled available groundwater for the Hickory Aquifer is 123 acre-feet/year for each decade of the 2010-2070 period.

See page 41 of Appendix B, *GAM Run16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers of Groundwater Management Area 7*, Texas Water Development Board, September 21, 2018, for MAG for the Hickory Aquifer within District boundaries.

A map of the area of the aquifer is on page 40 of *GAM Run 16-026 MAG Version 2.*

ESTIMATES OF RECHARGE FROM PRECIPITATION, DISCHARGES TO SURFACE WATER BODIES, AND FLOWS INTO, OUT OF AND BETWEEN EDWARDS AND TRINITY GROUPS IN THE EDWARDS-TRINITY (PLATEAU) AQUIFER WITHIN DISTRICT BOUNDARIES

(all values in acre-feet/year and rounded to the nearest acre-foot)

Management Plan Requirement	Aquifer or confining unit	Results
Estimated annual recharge to the district from precipitation	Edwards-Trinity (Plateau) Aquifer	31,514
Estimated annual volume of water that discharges from the aquifer to springs and surface water bodies, including lakes, streams and rivers	Edwards-Trinity (Plateau) Aquifer	57,664
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	29,787
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	10,859
Estimated net annual volume of flow between each aquifer in the district	Edwards-Trinity (Plateau) Aquifer and adjacent formations	1

Source: GAM Run 18-015: Kimble County GCD Groundwater Management Plan
TWDB, September 28, 2018
See Appendix C for full text of GAM Run 18-015

ESTIMATES OF RECHARGE FROM PRECIPITATION, DISCHARGES TO SURFACE WATER BODIES, AND FLOWS INTO, OUT OF AND BETWEEN AQUIFERS FOR THE ELLENBURGER-SAN SABA AQUIFER WITHIN DISTRICT BOUNDARIES

(all values in acre-feet/year and rounded to the nearest acre-foot)

Management Plan Requirement	Aquifer or confining unit	Results
Estimated annual recharge to the district from precipitation	Ellenburger-San Saba Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and surface water bodies, including lakes, streams and rivers	Ellenburger-San Saba Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	3,261
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	5,625
Estimated annual volume of flow between each aquifer in the district	Flow into the Ellenburger-San Saba Aquifer from the Hickory Aquifer	1
	Flow into the Ellenburger-San Saba Aquifer from adjacent confining units	2,814
	Flow from the Ellenburger-San Saba Aquifer into the Marble Falls Aquifer	863
	Flow from the brackish Ellen-burger-San Saba strati-graphic unit into the Ellenburger-San Saba Aquifer	772

Source: GAM Run 18-015: Kimble County GCD Groundwater Management Plan, TWDB, September 28, 2018
See Appendix C for full text of GAM Run 18-015

ESTIMATES OF RECHARGE FROM PRECIPITATION, DISCHARGES TO SURFACE WATER BODIES, AND FLOWS INTO, OUT OF AND BETWEEN AQUIFERS FOR THE HICKORY AQUIFER WITHIN DISTRICT BOUNDARIES

(all values in acre-feet/year and rounded to the nearest acre-foot)

Management Plan Requirement	Aquifer or confining unit	Results
Estimated annual recharge to the District from precipitation	Hickory Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and surface water bodies, including lakes, streams and rivers	Hickory Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	3,699
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	8,206
Estimated annual volume of flow between each aquifer in the district	Flow from the Hickory Aquifer into the Ellen-burger San Saba Aquifer	2
	Flow into the Hickory Aquifer From adjacent confining units	4,822
	Flow from the Hickory Aquifer into the brackish Hickory Formation	279

Source: GAM Run 18-015: Kimble County GCD Groundwater Management Plan
TWDB, September 28, 2018
See Appendix C for full text of GAM Run 18-015

ESTIMATES OF RECHARGE FROM PRECIPITATION, DISCHARGES TO SURFACE WATER BODIES, AND FLOWS INTO, OUT OF AND BETWEEN AQUIFERS FOR THE MARBLE FALLS AQUIFER WITHIN DISTRICT BOUNDARIES

Management Plan Requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation in the district	Marble Falls Aquifer	14
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body, including lakes, streams and rivers	Marble Falls Aquifer	1,313
Estimated annual volume of flow into the district within each aquifer in the district	Marble Falls Aquifer	0
Estimated annual volume of flow out of the district within each aquifer in the district	Marble Falls Aquifer	77
Estimated net annual volume of flow between Each aquifer in the district	Flow into the Marble Falls Aquifer from the Edwards-Trinity (Plateau) Aquifer/ alluvium	1
	Flow into the Marble Falls Aquifer from the Ellenburger-San Saba Aquifer	861
	Flow into the Marble Falls Aquifer from the underlying confining unit	64
	Flow into the Marble Falls Aquifer from the Marble Falls stratigraphic unit	452

Source: GAM Run 18-015: Kimble County GCD Groundwater Management Plan
TWDB, September 28, 2018, pages 7-8
See Appendix C for full text of GAM Run18-015

Methodology for Calculating Values in Water Data Tables

Since 2.55% of the area of Kimble County lies outside the District boundaries in the northeast corner of the county, 97.45% of the projected surface water supplies, projected county-wide water demands (county other, manufacturing, steam electric power, irrigation, mining and livestock) in the water data tables in the Appendix are modified using the multiplier. WUG values for municipalities, water supply corporations, and utility districts are not apportioned. The other State Water Plan tables in the Appendix, Projected Water Supply Needs and Projected Water Management Strategies, are not apportioned because district-specific values are not statutorily required. (See Appendix, page 2)

Fractional acre-feet are rounded up to a full acre-foot.

HISTORICAL GROUNDWATER USE WITHIN THE DISTRICT

Historical groundwater use within the district between 2012 and 2016 varied between 808 acre-feet/year in 2012 and 402 acre-feet/year in 2015.

See Appendix A, Page 3
Estimated Historical Water Use

SURFACE WATER RESOURCES

There are 12,056 acre-feet of water rights permitted by the TCEQ in the Llano River and its tributaries in Kimble County, of which 1,000 acre-feet are permitted for municipal use, 2,466 for industrial, 100 for mining and the remaining 8,490 acre-feet are permitted for irrigation purposes.[4]

PROJECTED SURFACE WATER SUPPLY
(acre-feet/year)

Total surface water supply for the district is projected to be 1,206 acre-feet annually for the period 2020-2070. The largest amount of surface water use for the period is 1,105 acre-feet/year for irrigation.

See Appendix A, Page 4
Projected Surface Water Supplies

[4] Data from 1999 TNRCC water rights list

PROJECTED WATER TOTAL DEMAND FOR WATER
(acre-feet/year)

Projected total demand for water within district for the period 2020-2070 are projected to range downward from 4,832 acre-feet/year in 2020 to 4,544 acre-feet/year in 2070. The largest decrease will be in irrigation use.

See Appendix A, Page 5
Projected Water Demands

PROJECTED WATER SUPPLY NEEDS
(acre-feet/year)

Total projected water supply needs in Kimble County are projected to range from 2,835 acre-feet in 2020 to 2,556 acre-feet in 2070. The supply needs are primarily for manufacturing and irrigation

See Appendix A, Page 6
Projected Water Supply Needs

PROJECTED WATER MANAGEMENT STRATEGIES

Total projected water management strategies for Kimble County for the period 2020-2070 range from 1,121 acre-feet in 2020 to 1,304 acre-feet in 2070. Strategies include developing additional Edwards-Trinity (Plateau) Aquifer supplies, subordination of Colorado River run-of-river rights and conservation.

See Appendix A, Page 7
Projected Water Management Strategies

DISTRICT IMPLEMENTATION OF WATER MANAGEMENT STRATEGIES

The District will permit additional wells in the Edwards-Trinity (Plateau) Aquifer as needed for manufacturing, the City of Junction, and County-Other needs.

The District will implement the irrigation conservation strategy through Management Goal 1.0.

Surface water rights subordination agreements are outside the powers and jurisdiction of the District.

ANNUAL AMOUNT OF ADDITIONAL NATURAL OR ARTIFICIAL RECHARGE THAT COULD RESULT FROM IMPLEMENTATION OF A FEASIBLE METHOD FOR RECHARGE

Brush control

Historical accounts of Kimble County and historical photographs in the possession of the District make it apparent that during the period from 1850 through 1885, when Kimble County was experiencing early inflows of European settlers, the country was mostly open grassland with little brush and few trees, and there was considerably greater flow of water in the Llano River and its creeks and tributaries than occurs at present. Now there is extensive invasion of brush, particularly mesquite and juniper, over large areas of the district.

District personnel have observed that in the late Spring, when brush and trees come out of dormancy, creeks (including those from which there are no irrigation withdrawals at any time) and sections of the Llano River dry up and remain in that condition throughout the summer during droughts. In the Fall, when brush and trees become dormant, creeks begin to flow again, regardless of whether or not there has been rainfall.

A current study demonstrates that for the entire watershed of the North Concho river, which lies within the same region, average annual water yield level increases by 81%, or about 48,523 acre feet with removal of all growths of mesquite and juniper in areas with heavy and moderate brush coverage (leaving areas with light brush growth intact)[5]. The average annual water yield increase in subbasin 8 of the study, being the subbasin closest to Kimble County, is 89,889 gallons per acre, or 0.27 acre-foot/acre, annually.[6] Average annual rainfall for the Main Concho River basin averages 23.6 inches annually, compared with Kimble County's 23 inches. The study finds that the average annual evapo-transpiration for land in the Main Concho River basin with heavy to moderate brush on it is 22.04 inches (93% of precipitation) while it is 20.89 inches (89% of precipitation) for the no-brush condition.[7]

The Edwards-Trinity (Plateau) Aquifer crops out at the surface of subbasin 8 of the Main Concho basin and over all of Kimble County. The authors of the study believe that the re-evaporation coefficient of such shallow aquifers is higher for brush than other types of cover than it is in deeper aquifers because brush is deeper rooted. They base their assumptions on a re-

---

[5] "Main Concho River Watershed" in Brush Management/Water Yield Feasibility Studies of Eight Watersheds in Texas, TWRI Study 182, p. 3

[6] Ibid., p. 3

[7] Ibid., p. 3

evaporation coefficient for brush-covered units of 0.4, while non-brush units were estimated at a coefficient of 0.1.[8]

Applying those coefficients to areas of Kimble County heavily infested with brush, and assuming removal of only half the brush from those areas, and that Kimble County would, overall, only increase yield by the same average as the entire North Concho basin, (as opposed to the higher yield found in subbasin 8) surface water yield could be increased by 40%, and re-evaporation from the aquifer sufficiently reduced to result in the equivalent of a 70% increase in total annual recharge.

NOTE ON PROJECTED DEMANDS FOR GROUNDWATER IN KIMBLE COUNTY

The Texas Water Development Board projects that total demand for water within the district will remain relatively stable at 4,832 to 4,544 acre-feet/year over the 2020-2070 period. (Appendix A, Page 5). However, the experience of the District in the last decade suggests that the character of water use in the county may be changing to the extent that there will be substantial reason for concern about supplies. The District has observed that:

a) New subdivision plats continue to be filed and there is extensive property fragmentation..
b) According to the Kimble County Appraisal District, over 60% of the landowners in the District are now non-residents. These non-residents utilize their properties in the District for hunting, recreational and vacation home purposes, using water that is not taken into account by the TWDB, which bases estimates for some projected demand categories, such as "county-other" on resident population.
c) Newcomers appear to be coming from areas where they are accustomed to higher levels of water use than the long-time residents. The District has experienced a significant increase in numbers of inquiries about irrigation wells from new county residents for properties that have not previously had irrigation.
d) New residents have impounded riparian waters for domestic and livestock use, pursuant to the statutory exemption, on creeks and streams where water was formerly withdrawn for those purposes on a daily-need basis, but not impounded.
e) Even though studies indicate that Kimble County has adequate water supplies, in the most recent several years of below-average rainfall the District has received a number of reports of wells going dry and drastic declines in surface water flows. There is increased drilling in the county, but driller's logs submitted to the District have indicated as many dry holes as successful wells.

It is apparent, then, that there is need for management of the groundwater resource, and, above all, for better information on water use within the district, as well as characteristics, recoverable supplies, and recharge of the aquifers.

---

[8] Ibid. p. 2

MANAGEMENT OF GROUNDWATER SUPPLIES

A primary function of the District is to obtain data about aquifer supplies and conditions in order to develop more effective management of the resource. The District has established monitor wells to gather baseline data in order to monitor changing storage conditions of groundwater supplies within the District. The District will obtain data from the monitor wells on a regular basis, make reports thereon to the Board of Directors, and maintain cumulative records of the water levels in the wells.

The District has adopted rules to regulate groundwater withdrawal by means of spacing, regulation and production limits. If regular monitoring indicates that aquifer levels are declining, the District will amend those rules, within the limitations imposed by Chapter 36 of the Texas Water Code, to protect the aquifer resources.
The District may deny a well permit or limit a high production permit in accordance with the provisions of the District Rules and this Management Plan. The relevant factors to be considered in denying or limiting a permit shall be:

1) Implementation of the Desired Future Conditions for the District's aquifers adopted by GMA 7 and the District.
2) the purpose of the District Rules, including but not limited to preserving and protecting the quality and quantity of the aquifer resources, and protecting existing uses
3) the equitable allocation of water resources
4) the economic hardship resulting from denial or limitation of a permit

The District will enforce the terms and conditions of permits and the Rules of the District.

The District recognizes the importance of public education to encourage efficient use, implement conservation practices, prevent waste, and preserve the integrity of groundwater, and will seek opportunities to educate the public on water conservation issues and other matters relevant to the protection of the aquifer resources through public meetings, newspaper articles, and other means which may become available.

ACTIONS, PROCEDURES, PERFORMANCE AND AVOIDANCE FOR PLAN IMPLEMENTATION

The District will implement the provisions of this plan and will utilize the provisions of this plan as a guide for determining the direction and/or priority for all District activities. All operations of the District and all agreements entered into by the District will be consistent with the provisions of this plan.
The District has adopted rules for the management of groundwater resources through permitting of wells and production of groundwater, pursuant to Chapter 36 of the Texas Water Code and the

provisions of this Plan, and will amend those rules as necessary to implement District management objectives. All rules will be adhered to and enforced. The promulgation and enforcement of the rules will be based on the best scientific and technical evidence available.
For good cause shown the District, in its discretion, and after notice and hearing, may grant an exception to the District Rules. In doing so, the Board shall consider the potential for adverse effect on adjacent landowners. The exercise of said discretion by the Board shall not be construed as limiting the power of the Board.
The District will seek cooperation in the implementation of this plan and the management of groundwater supplies within the District. The District will co-operate and co-ordinate with other water districts managing water resources from the same aquifers, and with other local water management entities.

Coordination With Surface Water Entities

The Board of Directors and Manager of the District will meet at least once yearly with the Kimble County Water Control and Improvement District or the City of Junction to discuss conjunctive use issues and joint water management goals.

Methodology for Tracking Progress

The District will hold regular Board Meetings for the purpose of conducting District business. Each month the Manager's Report will reflect the number of meetings attended; number of water levels monitored; articles published concerning water issues; number of water analysis samples collected and analyzed; resulting action regarding potential contamination, or remediation of actual contamination; reports on any school or civic group programs; meetings with the surface water management district; and other matters of district importance.
During the last monthly Board of Directors' meeting each fiscal year, beginning with October 1, 2001, The District manager will prepare and present an annual report to the Board of Directors on District performance in regard to achieving management goals and objectives. The annual report will be maintained on file at the District Office.

GOALS, MANAGEMENT OBJECTIVES AND PERFORMANCE STANDARDS

Goal 1.0 - Providing the Most Efficient Use of Groundwater

1.1. Management Objective

At least once each year the District will provide, in a public meeting or forum, available information on water conservation practices for the efficient use of water. These will include but are not limited to publications from the Texas Water Development Board, Texas Commission on Environmental Quality, Texas Agricultural Extension Service, and other sources

. 1.1 Performance Standard

Report to the Board of Directors on distribution of informational material on water conservation practices in a public meeting or forum at least once each year.

Goal 2.0 - Controlling and Preventing the Waste of Groundwater

2.1 Management Objective

At least twice each year the District will publish the availability of water analysis services in the local newspaper.

2.1 Performance Standard

Two advertisements for water testing services published each year.

2.2 Management Objective

To monitor water quality in the district, the District will sample and conduct water quality tests on selected monitor wells at least once each year for possible contamination which would jeopardize the integrity of the groundwater supply.

2.2 Performance Standard

Four water quality analysis tests performed each year on selected monitor wells.

Goal 3.0 - Addressing Conjunctive Surface Water Management Issues

3.0 Management Objective

Each year the District shall conduct a joint planning and/or policy meeting with the City of Junction to discuss conjunctive use issues.

3.0 Performance Standard

One joint planning and/or policy meeting conducted jointly with the City of Junction each year.

Goal 4.0 - Addressing Natural Resource Issues Which Impact the Use and Availability of Groundwater, and Which are Impacted by the Use of Groundwater

4.1. Management Objective

Although there is very little oil production in Kimble County the District will monitor one or more selected wells within areas of the District where there is oil production, for possible contamination problems which would jeopardize the quality of the groundwater resource.

4.1 Performance Standard

Once each year two well samples will be collected and analyzed for petroleum- related contamination in areas of the district where there is oil production.

Goal 5.0 - Addressing Drought Conditions.

5.1 Management Objective

Each year the District will monitor the TWDB "Water for Texas" website at: http://waterdatafortexas.org/drought, and the Palmer Drought Severity Index. If the latter index indicates that the District will experience severe drought conditions, the District will publish a notice or article in the local paper bringing attention to the severity of the drought and the need to practice water conservation.

5.1 Performance Standard

Annual report to Board of Directors listing number of times Palmer Drought Severity Index indicated severe drought conditions and the number of times a notice, including the link to the TWDB "Water for Texas" drought website, was published in the local newspaper.

Goal 6.1 – Addressing conservation.

6.1 Management Objective

At least once each year the District will distribute water conservation literature in a public forum such as a soil and water conservation district meeting, a livestock show, or a county function.

6.1 Performance Standard

Annual report to Board of Directors listing when and where water conservation information was distributed during the year.

Goal 6.2 – Addressing Recharge Enhancement

6.2 Management Objective

At least once each year meet with the Kimble County Spoil and Water Conservation District board of directors to discuss the prioritization of areas of the District where brush control contracts would enhance recharge to the aquifers.

6.2 Performance Standard

Annual report to the Board of Directors on the number of meetings with the Kimble County SWCD to discuss priority brush control areas.

Goal 6.3- Addressing rainwater harvesting

6.3 Management Objective

Include literature on rainwater harvesting in one public education presentation annually.

6.3 Performance Standard

Annual report to Board including the number of presentations of rainwater harvesting literature at educational presentation.

Goal 6.4 - Addressing brush control

6.4 Management Objective

Include literature on brush control in one public education presentation annually.

6.4 Performance Standards

Annual report to Board including the number of presentations on brush control literature at educational presentation

Goal 7.0 Addressing Desired Future Conditions Established under TWC 36.108

7.1 Management Objective

The District will, over the next five years, develop a network of 16 monitor wells in locations that will represent aquifer levels across the district and measure water levels in each well quarterly. The District annual report will show the change in water levels in the monitor wells from the previous year.

7.1 Performance Standard

Annual report to the board on the change in water levels in each monitor well from the previous year.

Goals Not Applicable to the Kimble County Groundwater Conservation District.

Goal 1.0 - Controlling and preventing subsidence.

The TWDB report ***Identification of the Vulnerability of the Major and Minor***

Aquifers of Texas to Subsidence with Regard to Groundwater Pumping
http://www.twdb.texas.gov/groundwater/models/research/subsidence/subsidence.asp
and other sources have been reviewed for applicability to the Kimble County GCD. There is no history of subsidence of aquifer formations within the resulting from water level depletion and available scientific information is that the formations are of sufficient rigidity that subsidence will not occur.

Goal 2.0 - Addressing Precipitation Enhancement

The District Manager has reported to the Board of Directors on Precipitation Enhancement programs conducted by neighboring groundwater conservation districts, but the Board of Directors has determined that there is not sufficient funding available to the district to participate in such a program.

Definitions and Concepts

"Board" - the Board of Directors of the Kimble County Groundwater Conservation District.

"District" - the Kimble County Groundwater Conservation District.

"Effective recharge" - the amount of water that enters the aquifer and is available for development

"Groundwater" - means water percolating below the surface of the earth.

"Integrity" - means the preservation of groundwater quality.

"Ownership" - pursuant to TWC Chapter 36, §36.002, means the recognition of the rights of the owners of the land pertaining to groundwater.

"Recharge" - the addition of water to an aquifer.

"Surface Water Entity" - TWC Chapter 15 Entities with authority to store, take divert, or supply surface water for use within the boundaries of a district.

"TCEQ" - Texas Commission on Environmental Quality.

"TWDB" - Texas Water Development Board.

"Waste" - pursuant to TWC Chapter 36, §36.001(8), means any one or more of the following:

(1) withdrawal of groundwater from a groundwater reservoir at a rate and in an amount that causes or threatens to cause intrusion into the reservoir of water unsuitable for agricultural, gardening, domestic, or stock raising purposes;

(2) the flowing or producing of wells from a groundwater reservoir if the water produced is not used for a beneficial purpose;

(3) escape of groundwater from a groundwater reservoir to any other reservoir or geologic strata that does not contain groundwater;

(4) pollution or harmful alteration of groundwater in a groundwater reservoir by saltwater or by other deleterious matter admitted from another stratum or from the surface of the ground;

(5) willfully or negligently causing, suffering, or allowing groundwater to escape into any river, creek, natural watercourse, depression, lake, reservoir, drain, sewer, street, highway, road, or road ditch, or onto any land other than that of the owner of the well unless such discharge is authorized by permit, rule, or order issued by the commission under Chapter 26;

(6) groundwater pumped for irrigation that escapes as irrigation tailwater onto land other than that of the owner of the well unless permission has been granted by the occupant of the land receiving the discharge; or

(7) for water produced from an artesian well, "waste" has the meaning assigned by Section 11.205.

"Well" - means an artificial excavation that is dug or drilled for the purpose of producing groundwater.

APPENDIX A

Estimated Historical Groundwater Use And 2017 State Water Plan Datasets:

Kimble County Groundwater Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
January 29, 2019

GROUNDWATER MANAGEMENT PLAN DATA:

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

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

The five reports included in this part are:

1. Estimated Historical Groundwater Use (checklist item 2)

   from the TWDB Historical Water Use Survey (WUS)

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

   from the 2017 Texas State Water Plan (SWP)

Part 2 of the 2-part package is the groundwater availability model (GAM) report for the District (checklist items 3 through 5). The District should have received, or will receive, this report from the Groundwater Availability Modeling Section. Questions about the GAM can be directed to Dr. Shirley Wade, shirley.wade@twdb.texas.gov, (512) 936-0883.

DISCLAIMER:

The data presented in this report represents the most up-to-date WUS and 2017 SWP data available as of 1/29/2019. Although it does not happen frequently, either of these datasets are subject to change pending the availability of more accurate WUS data or an amendment to the 2017 SWP. District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The WUS dataset can be verified at this web address:

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

The 2017 SWP dataset can be verified by contacting Sabrina Anderson (sabrina.anderson@twdb.texas.gov or 512-936-0886).

The values presented in the data tables of this report are county-based. In cases where groundwater conservation districts cover only a portion of one or more counties the data values are modified with an apportioning multiplier to create new values that more accurately represent conditions within district boundaries. The multiplier used in the following formula is a land area ratio: (data value * (land area of district in county / land area of county)). For two of the four SWP tables (Projected Surface Water Supplies and Projected Water Demands) only the county-wide water user group (WUG) data values (county other, manufacturing, steam electric power, irrigation, mining and livestock) are modified using the multiplier. WUG values for municipalities, water supply corporations, and utility districts are not apportioned; instead, their full values are retained when they are located within the district, and eliminated when they are located outside (we ask each district to identify these entity locations).

The remaining SWP tables (Projected Water Supply Needs and Projected Water Management Strategies) are not modified because district-specific values are not statutorily required. Each district needs only "consider" the county values in these tables.

In the WUS table every category of water use (including municipal) is apportioned. Staff determined that breaking down the annual municipal values into individual WUGs was too complex.

TWDB recognizes that the apportioning formula used is not perfect but it is the best available process with respect to time and staffing constraints. If a district believes it has data that is more accurate it can add those data to the plan with an explanation of how the data were derived. Apportioning percentages that the TWDB used are listed above each applicable table.

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

Estimated Historical Water Use

TWDB Historical Water Use Survey (WUS) Data

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2017. TWDB staff anticipates the calculation and posting of these estimates at a later date.

KIMBLE COUNTY *97.43% (multiplier)* All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2016	GW	53	2	0	0	335	153	543
	SW	495	530	0	0	1,980	65	3,070
2015	GW	116	2	0	0	133	151	402
	SW	497	603	0	0	2,234	64	3,398
2014	GW	163	2	0	0	287	148	600
	SW	510	519	0	0	2,119	63	3,211
2013	GW	214	2	179	0	172	146	713
	SW	510	588	45	0	2,234	62	3,439
2012	GW	246	2	0	0	384	176	808
	SW	561	588	0	0	2,220	76	3,445
2011	GW	256	2	9	0	301	313	881
	SW	626	571	10	0	2,327	134	3,668
2010	GW	227	2	10	0	523	309	1,071
	SW	596	503	11	0	2,375	133	3,618
2009	GW	218	2	5	0	751	227	1,203
	SW	607	469	6	0	2,190	97	3,369
2008	GW	210	2	0	0	182	228	622
	SW	560	12	1	0	2,657	97	3,327
2007	GW	191	2	0	0	447	275	915
	SW	560	12	0	0	1,070	117	1,759
2006	GW	229	2	0	0	23	255	509
	SW	608	64	0	0	2,952	109	3,733
2005	GW	215	2	0	0	160	265	642
	SW	608	63	0	0	2,300	114	3,085
2004	GW	198	3	0	0	86	294	581
	SW	608	63	0	0	2,148	73	2,892
2003	GW	205	2	0	0	51	284	542
	SW	667	11	0	0	2,552	71	3,301
2002	GW	207	2	0	0	50	322	581
	SW	703	28	0	0	572	80	1,383
2001	GW	206	2	0	0	50	355	613
	SW	760	2	0	0	572	88	1,422

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

KIMBLE COUNTY *97.43% (multiplier)* All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, KIMBLE	COLORADO	COLORADO RUN-OF-RIVER	0	0	0	0	0	0
F	IRRIGATION, KIMBLE	COLORADO	COLORADO RUN-OF-RIVER	1,105	1,105	1,105	1,105	1,105	1,105
F	JUNCTION	COLORADO	COLORADO RUN-OF-RIVER	0	0	0	0	0	0
F	LIVESTOCK, KIMBLE	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	87	87	87	87	87	87
F	MANUFACTURING, KIMBLE	COLORADO	COLORADO RUN-OF-RIVER	0	0	0	0	0	0
F	MINING, KIMBLE	COLORADO	COLORADO RUN-OF-RIVER	14	14	14	14	14	14
			Sum of Projected Surface Water Supplies (acre-feet)	**1,206**	**1,206**	**1,206**	**1,206**	**1,206**	**1,206**

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.

KIMBLE COUNTY *97.43% (multiplier)* All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, KIMBLE	COLORADO	248	242	235	232	231	231
F	IRRIGATION, KIMBLE	COLORADO	2,863	2,757	2,648	2,539	2,437	2,338
F	JUNCTION	COLORADO	627	620	610	605	604	604
F	LIVESTOCK, KIMBLE	COLORADO	392	392	392	392	392	392
F	MANUFACTURING, KIMBLE	COLORADO	683	733	783	830	892	960
F	MINING, KIMBLE	COLORADO	19	19	19	19	19	19
	Sum of Projected Water Demands (acre-feet)		**4,832**	**4,763**	**4,687**	**4,617**	**4,575**	**4,544**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

KIMBLE COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, KIMBLE	COLORADO	-13	-12	-12	-12	-12	-12
F	IRRIGATION, KIMBLE	COLORADO	-1,496	-1,387	-1,275	-1,163	-1,058	-957
F	JUNCTION	COLORADO	-627	-620	-610	-605	-604	-604
F	LIVESTOCK, KIMBLE	COLORADO	0	0	0	0	0	0
F	MANUFACTURING, KIMBLE	COLORADO	-699	-750	-802	-850	-914	-983
F	MINING, KIMBLE	COLORADO	0	0	0	0	0	0
		Sum of Projected Water Supply Needs (acre-feet)	**-2,835**	**-2,769**	**-2,699**	**-2,630**	**-2,588**	**-2,556**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

KIMBLE COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, KIMBLE, COLORADO (F)							
DEVELOP ADDITIONAL EDWARDS-TRINITY PLATEAU AQUIFER SUPPLIES - JUNCTION	EDWARDS-TRINITY-PLATEAU AQUIFER [KIMBLE]	13	12	12	12	12	12
		13	**12**	**12**	**12**	**12**	**12**
IRRIGATION, KIMBLE, COLORADO (F)							
IRRIGATION CONSERVATION - KIMBLE COUNTY	DEMAND REDUCTION [KIMBLE]	147	283	326	326	326	326
		147	**283**	**326**	**326**	**326**	**326**
JUNCTION, COLORADO (F)							
DEVELOP ADDITIONAL EDWARDS-TRINITY PLATEAU AQUIFER SUPPLIES - JUNCTION	EDWARDS-TRINITY-PLATEAU AQUIFER [KIMBLE]	203	208	208	208	208	208
MUNICIPAL CONSERVATION - JUNCTION	DEMAND REDUCTION [KIMBLE]	14	15	15	15	15	15
SUBORDINATION - KIMBLE COUNTY ROR	COLORADO RUN-OF-RIVER [KIMBLE]	412	412	412	412	412	412
WATER AUDITS AND LEAK - JUNCTION	DEMAND REDUCTION [KIMBLE]	31	31	31	30	30	30
		660	**666**	**666**	**665**	**665**	**665**
MANUFACTURING, KIMBLE, COLORADO (F)							
DEVELOP ADDITIONAL EDWARDS-TRINITY PLATEAU AQUIFER SUPPLIES - KIMBLE COUNTY MANUFACTURING	EDWARDS-TRINITY-PLATEAU AQUIFER [KIMBLE]	300	300	300	300	300	300
		300	**300**	**300**	**300**	**300**	**300**
MINING, KIMBLE, COLORADO (F)							
MINING CONSERVATION - KIMBLE COUNTY	DEMAND REDUCTION [KIMBLE]	1	1	1	1	1	1
		1	**1**	**1**	**1**	**1**	**1**
Sum of Projected Water Management Strategies (acre-feet)		**1,121**	**1,262**	**1,305**	**1,304**	**1,304**	**1,304**

APPENDIX B

GAM Run 16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7

Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
(512) 463-6641
September 21, 2018

STATE OF TEXAS
IAN C. JONES
GEOLOGY
No. 477
LICENSED
PROFESSIONAL GEOSCIENTIST

9/24/2018

GAM RUN 16-026 MAG VERSION 2: MODELED AVAILABLE GROUNDWATER FOR THE AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7

Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
(512) 463-6641
September 21, 2018

EXECUTIVE SUMMARY:

We have prepared estimates of the modeled available groundwater for the relevant aquifers of Groundwater Management Area 7—the Capitan Reef Complex, Dockum, Edwards-Trinity (Plateau), Ellenburger-San Saba, Hickory, Ogallala, Pecos Valley, Rustler, and Trinity aquifers. The estimates are based on the desired future conditions for these aquifers adopted by the groundwater conservation districts in Groundwater Management Area 7 on September 22, 2016 and March 22, 2018. The explanatory reports and other materials submitted to the Texas Water Development Board (TWDB) were determined to be administratively complete on June 22, 2018.

The original version of GAM Run 16-026 MAG inadvertently included modeled available groundwater estimates for areas declared not relevant by the groundwater management area and areas that had no desired future conditions for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers. GAM Run 16-026 MAG Version 2 (this report) contains updates to reported total modeled available groundwater estimates and to Tables 5 and 6 that reflect only relevant portions of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers.

The modeled available groundwater values are summarized by decade for the groundwater conservation districts (Tables 1, 3, 5, 7, 9, 11, 13) and for use in the regional water planning process (Tables 2, 4, 6, 8, 10, 12, 14). The modeled available groundwater estimates are 26,164 acre-feet per year in the Capitan Reef Complex Aquifer; 2,324 acre-feet per year in the Dockum Aquifer; 474,464 acre-feet per year in the undifferentiated Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers; 22,616 acre-feet per year in the Ellenburger-San Saba Aquifer; 49,936 acre-feet per year in the Hickory Aquifer; 6,570 to 8,019 acre-feet per year in the Ogallala Aquifer; and 7,040 acre-feet per year in the Rustler Aquifer. The modeled available groundwater estimates were extracted from results of model runs using

the groundwater availability models for the Capitan Reef Complex Aquifer (Jones, 2016); the High Plains Aquifer System (Deeds and Jigmond, 2015); the minor aquifers of the Llano Uplift Area (Shi and others, 2016), and the Rustler Aquifer (Ewing and others, 2012). In addition, the alternative 1-layer model for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers (Hutchison and others, 2011) was used for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers, except for Kinney and Val Verde counties. In these two counties, the alternative Kinney County model (Hutchison and others, 2011) and the model associated with a hydrogeological study for Val Verde County and the City of Del Rio (EcoKai Environmental, Inc. and Hutchison, 2014), respectively, were used to estimate modeled available groundwater. The Val Verde County/Del Rio model covers Val Verde County. This model was used to simulate multiple pumping scenarios indicating the effects of a proposed wellfield. The model indicated the effects of varied pumping rates and wellfield locations. These model runs were used by Groundwater Management Area 7 as the basis for the desired future conditions for Val Verde County.

REQUESTOR:

Mr. Joel Pigg, chair of Groundwater Management Area 7 districts.

DESCRIPTION OF REQUEST:

In letters dated November 22, 2016 and March 26, 2018, Dr. William Hutchison on behalf of Groundwater Management Area 7 provided the TWDB with the desired future conditions for the Capitan, Dockum, Edwards-Trinity (Plateau), Ellenburger-San Saba, Hickory, Ogallala, Pecos Valley, Rustler, and Trinity aquifers in Groundwater Management Area 7. Groundwater Management Area 7 provided additional clarifications through emails to the TWDB on March 23, 2018 and June 12, 2018 for the use of model extents (Dockum, Ellenburger-San Saba, Hickory, Ogallala, Rustler aquifers), the use of aquifer extents (Capitan Reef Complex, Edwards-Trinity [Plateau], Pecos Valley, and Trinity aquifers), and desired future conditions for the Edwards-Trinity (Plateau) Aquifer of Kinney and Val Verde counties.

The final adopted desired future conditions as stated in signed resolutions for the aquifers in Groundwater Management Area 7 are reproduced below:

Capitan Reef [Complex] Aquifer

> Total net drawdown of the Capitan Reef [Complex] Aquifer not to exceed 56 feet in Pecos County (Middle Pecos [Groundwater Conservation District]) in 2070 as compared with 2006 aquifer levels (Reference: Scenario 4, GMA 7 Technical Memorandum 15-06, 4-8-2015).

Dockum Aquifer

Total net drawdown of the Dockum Aquifer not to exceed 14 feet in Reagan County (Santa Rita [Groundwater Conservation District]) in 2070, as compared with 2012 aquifer levels.

Total net drawdown of the Dockum Aquifer not to exceed 52 feet in Pecos County (Middle Pecos [Groundwater Conservation District]) in 2070, as compared with 2012 aquifer levels.

Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers

Average drawdown for [the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers] in the following [Groundwater Management Area] 7 counties not to exceed drawdowns from 2010 to 2070 [...].

County	[...] Average Drawdowns from 2010 to 2070 [feet]
Coke	0
Crockett	10
Ector	4
Edwards	2
Gillespie	5
Glasscock	42
Irion	10
Kimble	1
Menard	1
Midland	12
Pecos	14
Reagan	42
Real	4
Schleicher	8
Sterling	7
Sutton	6

Taylor	0
Terrell	2
Upton	20
Uvalde	2

Total net drawdown *[of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers]* in Kinney County in 2070, as compared with 2010 aquifer levels, shall be consistent with maintenance of an annual average flow of 23.9 [cubic feet per second] and an annual median flow of 23.9 [cubic feet per second] at Las Moras Springs [...].

Total net drawdown [of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers] in Val Verde County in 2070, as compared with 2010 aquifer levels, shall be consistent with maintenance of an average annual flow of 73-75 [million gallons per day] at San Felipe Springs.

Minor Aquifers of the Llano Uplift Area

Total net drawdowns of [Ellenburger-San Saba Aquifer] levels in 2070, as compared with 2010 aquifer levels, shall not exceed the number of feet set forth below, respectively, for the following counties and districts:

County	[Groundwater Conservation District]	Drawdown in 2070 (feet)
Gillespie	Hill Country [Underground Water Conservation District]	8
Mason	Hickory [Underground Water Conservation District] no. 1	14
McCulloch	Hickory [Underground Water Conservation District] no. 1	29
Menard	Menard County [Underground Water District] and Hickory [Underground Water Conservation District] no. 1	46
Kimble	Kimble County [Groundwater Conservation District] and Hickory	18

	[Underground Water Conservation District] no. 1	
San Saba	Hickory [Underground Water Conservation District] no. 1	5

Total net drawdown of [Hickory Aquifer] levels in 2070, as compared with 2010 aquifer levels, shall not exceed the number of feet set forth below, respectively, for the following counties and districts:

County	[Groundwater Conservation District]	Drawdown in 2070 (feet)
Concho	Hickory [Underground Water Conservation District No. 1]	53
Gillespie	Hill Country UWCD	9
Mason	Hickory [Underground Water Conservation District No. 1]	17
McCulloch	Hickory [Underground Water Conservation District No. 1]	29
Menard	Menard UWD and Hickory [Underground Water Conservation District No. 1]	46
Kimble	Kimble County [Groundwater Conservation District] and Hickory [Underground Water Conservation District No. 1]	18
San Saba	Hickory [Underground Water Conservation District No. 1]	6

Ogallala Aquifer

Total net [drawdown] of the Ogallala Aquifer in Glasscock County (Glasscock [Groundwater Conservation District]) in 2070, as compared with 2012 aquifer levels, not to exceed 6 feet [...].

Rustler Aquifer

Total net drawdown of the Rustler Aquifer in Pecos County (Middle Pecos GCD) in 2070 not to exceed 94 feet as compared with 2009 aquifer levels.

Additionally, districts in Groundwater Management Area 7 voted to declare that the following aquifers or parts of aquifers are non-relevant for the purposes of joint planning:

- The Blaine, Igneous, Lipan, Marble Falls, and Seymour aquifers.
- The Edwards-Trinity (Plateau) Aquifer in Hickory Underground Water Conservation District No. 1, the Lipan-Kickapoo Water Conservation District, Lone Wolf Groundwater Conservation District, and Wes-Tex Groundwater Conservation District.
- The Ellenburger-San Saba Aquifer in Llano County.
- The Hickory Aquifer in Llano County.
- The Dockum Aquifer outside of Santa Rita Groundwater Conservation District and Middle Pecos Groundwater Conservation District.
- The Ogallala Aquifer outside of Glasscock County.

In response to a several requests for clarifications from the TWDB in 2017 and 2018, the Groundwater Management Area 7 Chair, Mr. Joel Pigg, and Groundwater Management Area 7 consultant, Dr. William R. Hutchison, indicated the following preferences for verifying the desired future condition of the aquifers and calculating modeled available groundwater volumes in Groundwater Management Area 7:

Capitan Reef Complex Aquifer

Calculate modeled available groundwater values based on the official aquifer boundaries.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers

Calculate modeled available groundwater values based on the official aquifer boundaries.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Kinney County

Use the modeled available groundwater values and model assumptions from GAM Run 10-043 MAG Version 2 (Shi, 2012) to maintain annual average springflow of 23.9 cubic feet per second and a median flow of 24.4 cubic feet per second at Las Moras Springs from 2010 to 2060.

Val Verde County

There is no associated drawdown as a desired future condition. The desired future condition is based solely on simulated springflow conditions at San Felipe Spring of 73 to 75 million gallons per day. Pumping scenarios—50,000 acre-feet per year—in three well field locations, and monthly hydrologic conditions for the historic period 1969 to 2012 meet the desired future conditions set by Groundwater Management Area 7 (EcoKai and Hutchison, 2014; Hutchison 2018b).

Minor Aquifers of the Llano Uplift Area

Calculate modeled available groundwater values based on the spatial extent of the Ellenburger-San Saba and Hickory aquifers in the groundwater availability model for the aquifers of the Llano Uplift Area and use the same model assumptions used in Groundwater Management Area 7 Technical Memorandum 16-02 (Hutchison 2016g).

Drawdown calculations do not take into consideration the occurrence of dry cells where water levels are below the base of the aquifer.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Dockum Aquifer

Calculate modeled available groundwater values based on the spatial extent of the groundwater availability model for the Dockum Aquifer.

Modeled available groundwater analysis excludes pass-through cells.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Ogallala Aquifer

Calculate modeled available groundwater values based on the official aquifer boundary and use the same model assumptions used in Groundwater Management Area Technical Memorandum 16-01 (Hutchison, 2016f).

Modeled available groundwater analysis excludes pass-through cells.

Well pumpage decreases as the saturated thickness of the aquifer decreases below a 30-foot threshold.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Rustler Aquifer

Use 2008 as the baseline year and run the model from 2009 through 2070 (end of 2008/beginning of 2009 as initial conditions), as used in the submitted predictive model run.

Use 2008 recharge conditions throughout the predictive period.

Calculate modeled available groundwater values based on the spatial extent of the groundwater availability model for the Rustler Aquifer.

General-head boundary heads decline at a rate of 1.5 feet per year.

Use the same model assumptions used in Groundwater Management Area 7 Technical Memorandum 15-05 (Hutchison, 2016d).

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

METHODS:

As defined in Chapter 36 of the Texas Water Code (TWC, 2011), "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.

For relevant aquifers with desired future conditions based on water-level drawdown, water levels simulated at the end of the predictive simulations were compared to specified baseline water levels. In the case of the High Plains Aquifer System (Dockum and Ogallala aquifers) and the minor aquifers of the Llano Uplift area (Ellenburger-San Saba and Hickory aquifers), baseline water levels represent water levels at the end of the calibrated transient model are the initial water level conditions in the predictive simulation—water levels at the end of the preceding year. In the case of the Capitan Reef Complex, Edwards-Trinity (Plateau), Pecos Valley, and Trinity, and Rustler aquifers, the baseline water levels may occur in a specified year, early in the predictive simulation. These baseline years are 2006 in the groundwater availability model for the Capitan Reef Complex Aquifer, 2010 in the alternative model for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers, 2012 in the groundwater availability model for the High Plains Aquifer System, 2010 in the groundwater availability model for the minor aquifers of the Llano Uplift area, and 2009 in the groundwater availability model for the Rustler Aquifer. The predictive model runs used average pumping rates from the historical period for the respective model except in the aquifer or area of interest. In those areas, pumping rates are varied until they produce drawdowns consistent with the adopted desired future conditions. Pumping rates or modeled available groundwater are reported in 10-year intervals.

Water-level drawdown averages were calculated for the relevant portions of each aquifer. Drawdown for model cells that became dry during the simulation—when the water level dropped below the base of the cell—were excluded from the averaging. In Groundwater Management Area 7, dry cells only occur during the predictive period in the Ogallala Aquifer of Glasscock County. Consequently, estimates of modeled available groundwater decrease over time as continued simulated pumping predicts the development of increasing numbers of dry model cells in areas of the Ogallala Aquifer in Glasscock County. The calculated water-level drawdown averages were compared with the desired future conditions to verify that the pumping scenario achieved the desired future conditions.

In Kinney and Val Verde counties, the desired future conditions are based on discharge from selected springs. In these cases, spring discharge is estimated based on simulated average spring discharge over a historical period maintaining all historical hydrologic conditions—such as recharge and river stage—except pumping. In other words, we assume that past average hydrologic conditions—the range of fluctuation—will continue in the future. In the cases of Kinney and Val Verde counties, simulated spring discharge is based on hydrologic variations that took place over the periods 1950 through 2005 and 1968 through 2013, respectively. The desired future condition for the Edwards-Trinity (Plateau) Aquifer in Kinney County is similar to the one adopted in 2010 and the associated modeled available groundwater is based on a specific model run—GAM Run 10-043 (Shi, 2012).

Modeled available groundwater values for the Ellenburger-San Saba and Hickory aquifers were determined by extracting pumping rates by decade from the model results using

ZONBUDUSG Version 1.01 (Panday and others, 2013). For the remaining relevant aquifers in Groundwater Management Area 7 modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Decadal modeled available groundwater for the relevant aquifers are reported by groundwater conservation district and county (Figure 1; Tables 1, 3, 5, 7, 9, 11, 13), and by county, regional water planning area, and river basin (Figures 2 and 3; Tables 2, 4, 6, 8, 10, 12, 14).

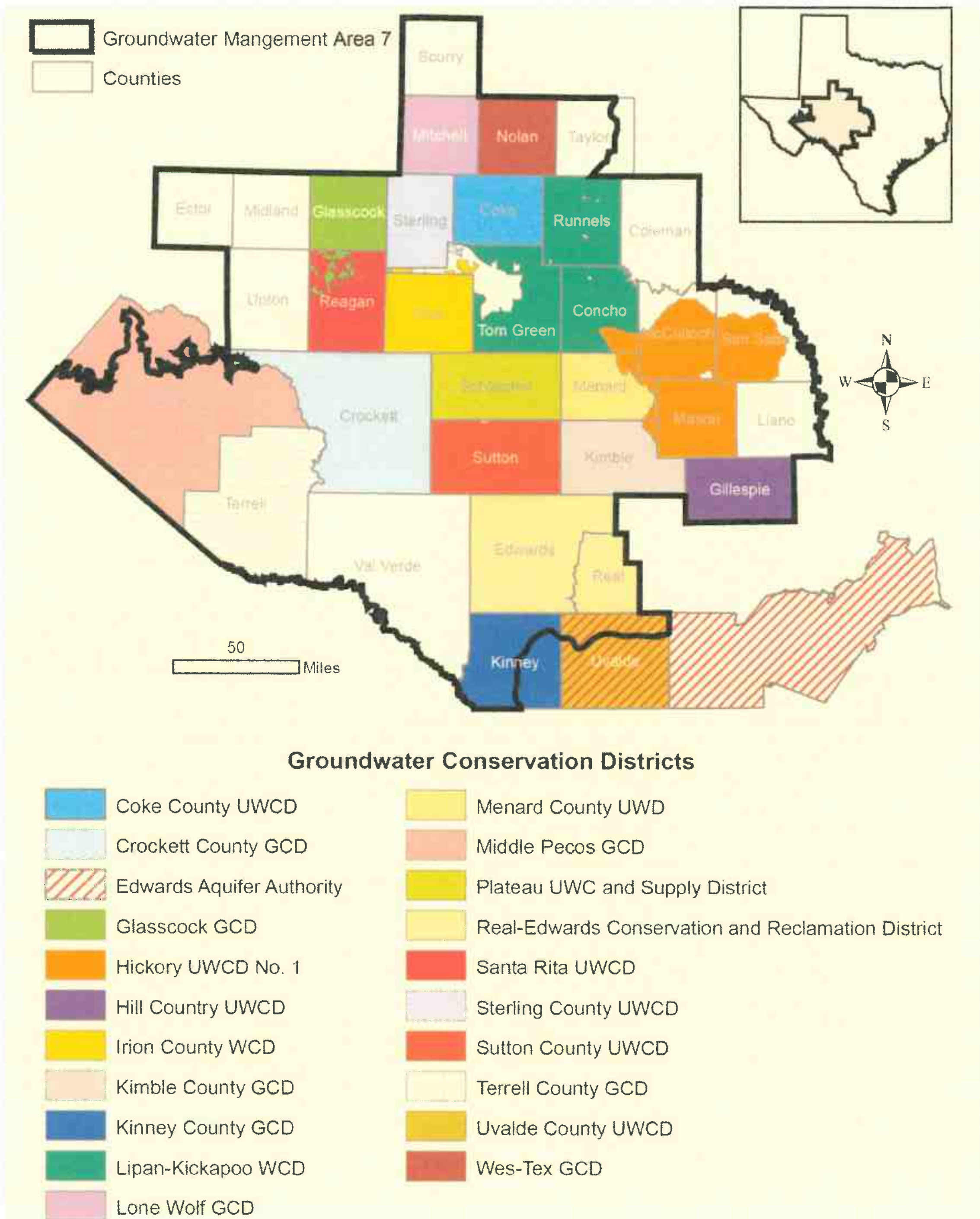

FIGURE 1. **MAP SHOWING THE GROUNDWATER CONSERVATION DISTRICTS (GCD) IN GROUNDWATER MANAGEMENT AREA 7. NOTE: THE BOUNDARIES OF THE EDWARDS AQUIFER AUTHORITY OVERLAP WITH THE UVALDE COUNTY UNDERGROUND WATER CONSERVATION DISTRICT (UWCD).**

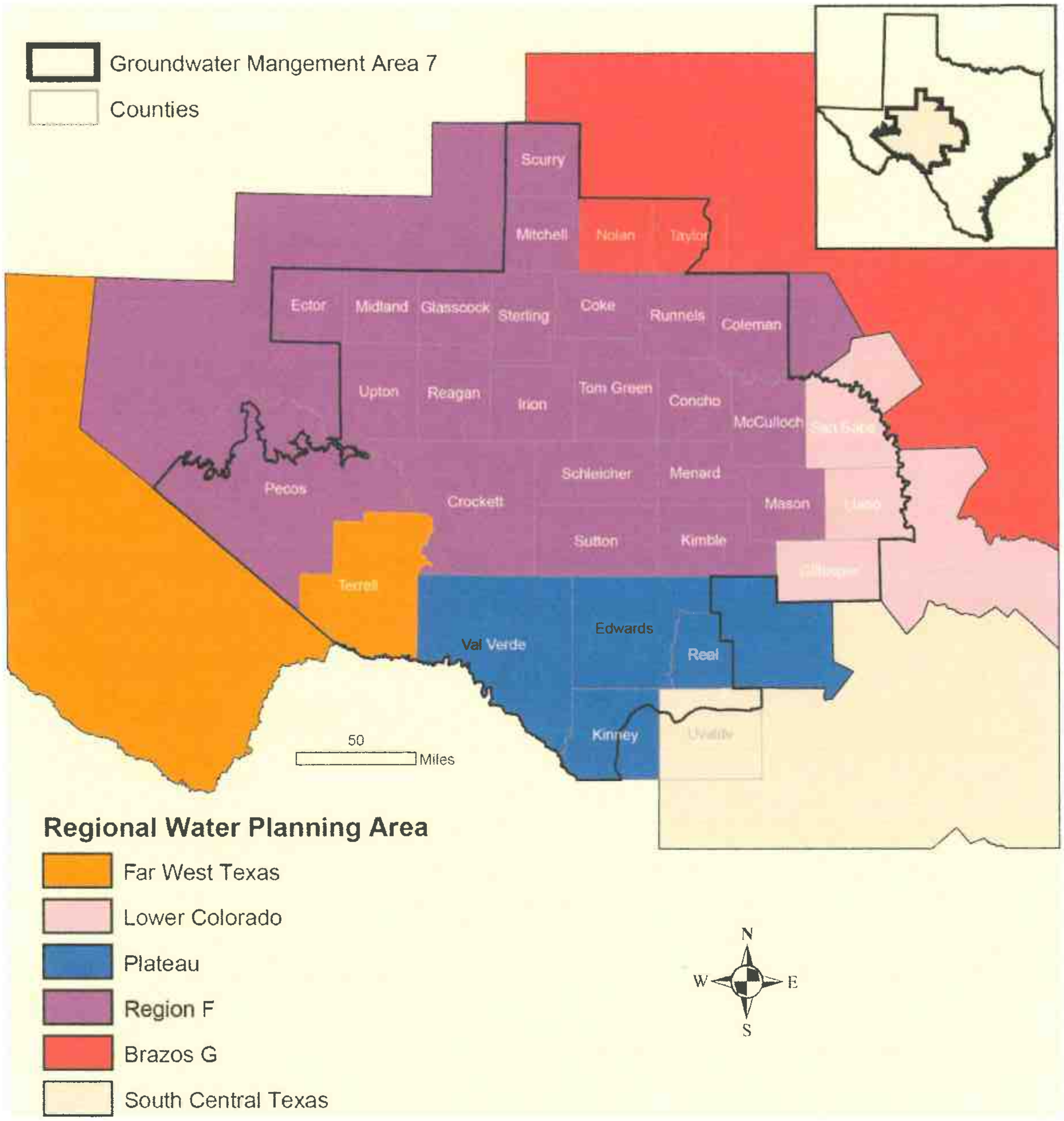

FIGURE 2. **MAP SHOWING REGIONAL WATER PLANNING AREAS IN GROUNDWATER MANAGEMENT AREA 7.**

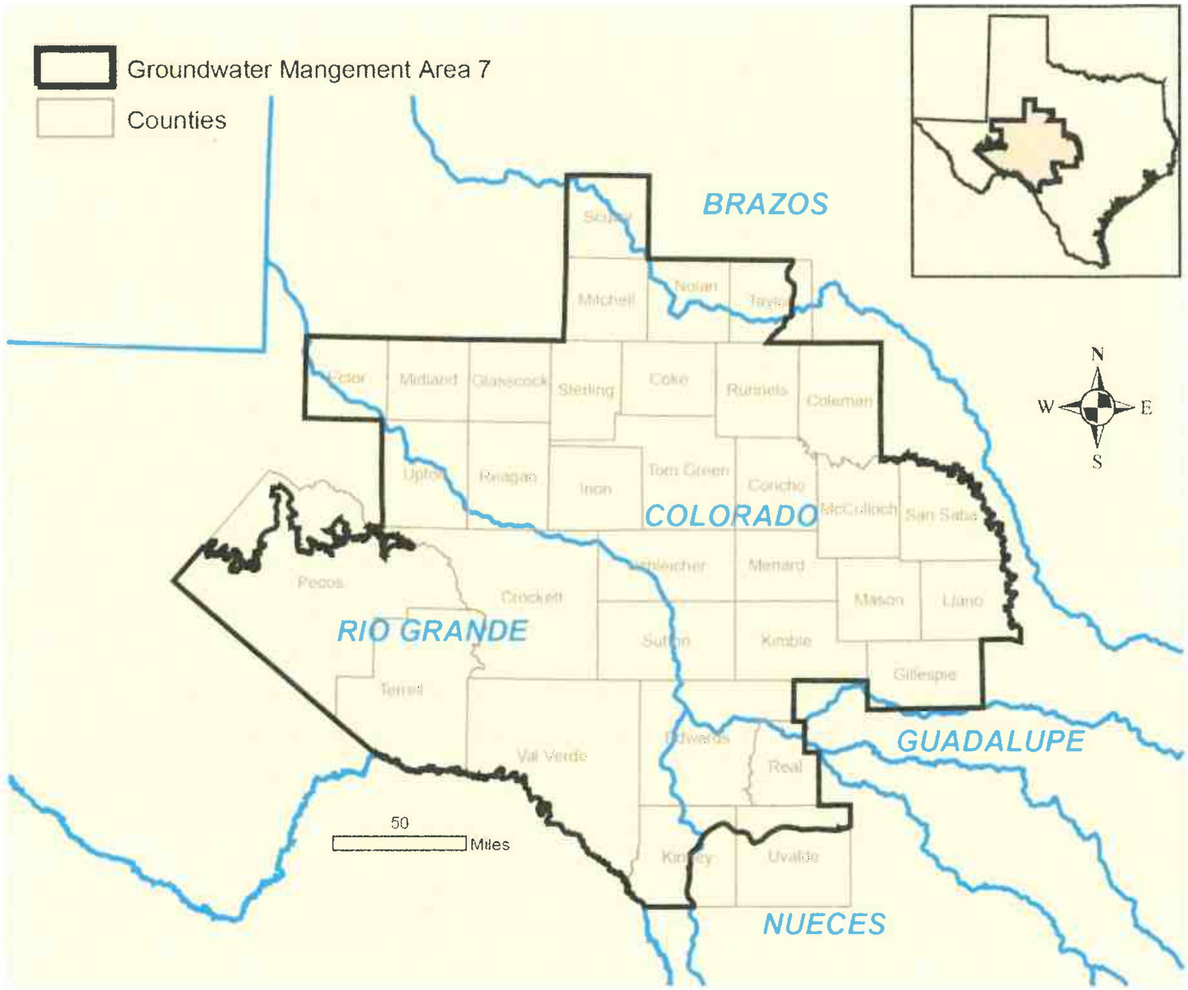

FIGURE 3. **MAP SHOWING RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 7. THESE INCLUDE PARTS OF THE BRAZOS, COLORADO, GUADALUPE, NUECES, AND RIO GRANDE RIVER BASINS.**

PARAMETERS AND ASSUMPTIONS:

Capitan Reef Complex Aquifer

Version 1.01 of the groundwater availability model of the eastern arm of the Capitan Reef Complex Aquifer was used. See Jones (2016) for assumptions and limitations of the groundwater availability model. See Hutchison (2016h) for details on the assumptions used for predictive simulations.

The model has five layers: Layer 1, the Edwards-Trinity (Plateau) and Pecos Valley aquifers; Layer 2, the Dockum Aquifer and the Dewey Lake Formation; Layer 3, the Rustler Aquifer; Layer 4, a confining unit made up of the Salado and Castile formations, and the overlying portion of the Artesia Group; and Layer 5, the Capitan Reef Complex Aquifer, part of the Artesia Group, and the Delaware Mountain Group. Layers 1 through 4 are intended to act solely as boundary conditions facilitating groundwater inflow and outflow relative to the Capitan Reef Complex Aquifer (Layer 5).

The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

The model was run for the interval 2006 through 2070 for a 64-year predictive simulation. Drawdowns were calculated by subtracting 2006 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7.

During predictive simulations, there were no cells where water levels were below the base elevation of the cell ("dry" cells). Therefore, all drawdowns were included in the averaging.

Drawdown averages and modeled available groundwater volumes are based on the official aquifer boundary within Groundwater Management Area 7.

Dockum and Ogallala Aquifers

Version 1.01 of the groundwater availability model for the High Plains Aquifer System by Deeds and Jigmond (2015) was used to construct the predictive model simulation for this analysis. See Hutchison (2016f) for details of the initial assumptions.

The model has four layers which represent the Ogallala and Pecos Valley Alluvium aquifers (Layer 1), the Edwards-Trinity (High Plains) and Edwards-Trinity (Plateau) aquifers (Layer 2), the Upper Dockum Aquifer (Layer 3), and the Lower Dockum Aquifer (Layer 4). Pass-through cells exist in layers 2 and 3 where the Dockum Aquifer was absent but provided pathway for flow between the Lower Dockum and the Ogallala or Edwards-Trinity (High Plains) aquifers vertically. These pass-through cells were excluded from the calculations of drawdowns and modeled available groundwater.

The model was run with MODFLOW-NWT (Niswonger and others, 2011). The model uses the Newton formulation and the upstream weighting package, which automatically reduces pumping as heads drop in a particular cell, as defined by the user. This feature may simulate the declining production of a well as saturated thickness decreases. Deeds and Jigmond (2015) modified the MODFLOW-NWT code to use a saturated thickness of 30 feet as the threshold—instead of percent of the saturated thickness—when pumping reductions occur during a simulation. It is important for groundwater management areas 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.

The model was run for the interval 2013 through 2070 for a 58-year predictive simulation. Drawdowns were calculated by subtracting 2012 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7.

During predictive simulations, there were no cells where water levels were below the base elevation of the cell ("dry" cells). Therefore, all drawdowns were included in the averaging. Modeled available groundwater analysis excludes pass-through cells.

Drawdown averages and modeled available groundwater volumes are based on the model boundaries within Groundwater Management Area 7 for the Dockum Aquifer and official aquifer boundaries for the Ogallala Aquifer.

Pecos Valley, Edwards-Trinity (Plateau) and Trinity Aquifers

The single-layer alternative groundwater flow model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers used for this analysis. This model is an update to the previously developed groundwater availability model documented in Anaya and Jones (2009). See Hutchison and others (2011a) and Anaya and Jones (2009) for assumptions and limitations of the model. See Hutchison (2016e; 2018c) for details on the assumptions used for predictive simulations.

The groundwater model has one layer representing the Pecos Valley Aquifer and the Edwards-Trinity (Plateau) Aquifer. In the relatively narrow area where both aquifers are present, the model is a lumped representation of both aquifers.

The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

The model was run for the interval 2006 through 2070 for a 65-year predictive simulation. Drawdowns were calculated by subtracting 2010 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7. Comparison of 2010 simulated and measured water levels indicate a root mean squared error of 84 feet or 3 percent of the range in water-level elevations.

Drawdowns for cells with water levels below the base elevation of the cell ("dry" cells) were included in the averaging.

Drawdown averages and modeled available groundwater volumes are based on the official aquifer boundaries within Groundwater Management Area 7.

Edwards-Trinity (Plateau) Aquifer of Kinney County

All parameters and assumptions for the Edwards-Trinity (Plateau) Aquifer of Kinney County in Groundwater Management Area 7 are described in GAM Run 10-043 MAG Version 2 (Shi, 2012). This report assumes a planning period from 2010 to 2070.

The Kinney County Groundwater Conservation District model developed by Hutchison and others (2011b) was used for this analysis. The model was calibrated to water level and spring flux collected from 1950 to 2005.

The model has four layers representing the following hydrogeologic units (from top to bottom): Carrizo-Wilcox Aquifer (layer 1), Upper Cretaceous Unit (layer 2), Edwards (Balcones Fault Zone) Aquifer/Edwards portion of the Edwards-Trinity (Plateau) Aquifer (layer 3), and Trinity portion of the Edwards-Trinity (Plateau) Aquifer (layer 4).

The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

The model was run for the interval 2006 through 2070 for a 65-year predictive simulation. Drawdowns were calculated by subtracting 2010 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7.

Modeled available groundwater volumes are based on the official aquifer boundaries within Groundwater Management Area 7 in Kinney County.

Edwards-Trinity (Plateau) Aquifer of Val Verde County

The single-layer numerical groundwater flow model for the Edwards-Trinity (Plateau) Aquifer of Val Verde County was used for this analysis. This model is based on the previously developed alternative groundwater model of the Kinney County area documented in Hutchison and others (2011b). See EcoKai (2014) for assumptions and limitations of the model. See Hutchison (2016e; 2018b) for details on the assumptions used for predictive simulations, including recharge and pumping assumptions.

The groundwater model has one layer representing the Edwards-Trinity (Plateau) Aquifer of Val Verde County.

The model was run with MODFLOW-2005 (Harbaugh, 2005).

The model was run for a 45-year predictive simulation representing hydrologic conditions of the interval 1968 through 2013. Simulated spring discharge from San Felipe Springs was then averaged over duration of the simulation. The resultant pumping rate that met the desired future conditions was applied to the predictive period—2010 through 2070—based on the assumption that average conditions over the predictive period are the same as those over the historic period represented by the model run.

Modeled available groundwater volumes are based on the official aquifer boundaries within Groundwater Management Area 7 in Val Verde County.

Rustler Aquifer

Version 1.01 of the groundwater availability model for the Rustler Aquifer by Ewing and others (2012) was used to construct the predictive model simulation for this analysis. See Hutchison (2016d) for details of the initial assumptions, including recharge conditions.

The model has two layers, the top one representing the Rustler Aquifer, and the other representing the Dewey Lake Formation and the Dockum Aquifer.

The model was run with MODFLOW-NWT (Niswonger and others, 2011).

The model was run for the interval 2009 through 2070 for a 61-year predictive simulation. Drawdowns were calculated by subtracting 2009 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7. During predictive simulations, there were no cells where water levels were below the base elevation of the cell ("dry" cells). Therefore, all drawdowns were included in the averaging.

Drawdown averages and modeled available groundwater volumes are based on the model boundaries within Groundwater Management Area 7.

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. See Hutchison (2016g) for details of the initial assumptions.

The model contains eight layers: Trinity Aquifer, Edwards-Trinity (Plateau) Aquifer, and younger alluvium deposits (Layer 1), confining units (Layer 2), Marble Falls Aquifer and equivalent units (Layer 3), confining units (Layer 4), Ellenburger-San Saba Aquifer and equivalent units (Layer 5), confining units (Layer 6), Hickory Aquifer and equivalent units (Layer 7), and Precambrian units (Layer 8).

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.

Drawdown averages and modeled available groundwater volumes are based on the model boundaries within Groundwater Management Area 7.

The model was run for the interval 2011 through 2070 for a 60-year predictive simulation. Drawdowns were calculated by subtracting 2010 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7. During predictive simulations, there were no cells where water levels were below the base elevation of the cell ("dry" cells). Therefore, all drawdowns were included in the averaging.

RESULTS:

The modeled available groundwater estimates are 26,164 acre-feet per year in the Capitan Reef Complex Aquifer, 474,464 acre-feet per year in the undifferentiated Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers, 22,616 acre-feet per year in the Ellenburger-San Saba Aquifer, 49,936 acre-feet per year in the Hickory Aquifer, 6,570 to 7,925 acre-feet per year in the Ogallala Aquifer, 2,324 acre-feet per year in the Dockum Aquifer, and 7,040 acre-feet per year in the Rustler Aquifer.

The modeled available groundwater for the respective aquifers has been summarized by aquifer, county, and groundwater conservation district (Tables 1, 3, 5, 7, 9, 11, and 13). 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, 8, 10, 12, and 14). The modeled available groundwater for the Ogallala Aquifer that achieves the desired future conditions adopted by districts in Groundwater Management Area 7 decreases from 7,925 to 6,570 acre-feet per year between 2020 and 2070 (Tables 9 and 10). This decline is attributable to the occurrence of increasing numbers of cells where water levels were below the base elevation of the cell ("dry" cells) in parts of Glasscock County. Please note that MODFLOW-NWT automatically reduces pumping as water levels decline.

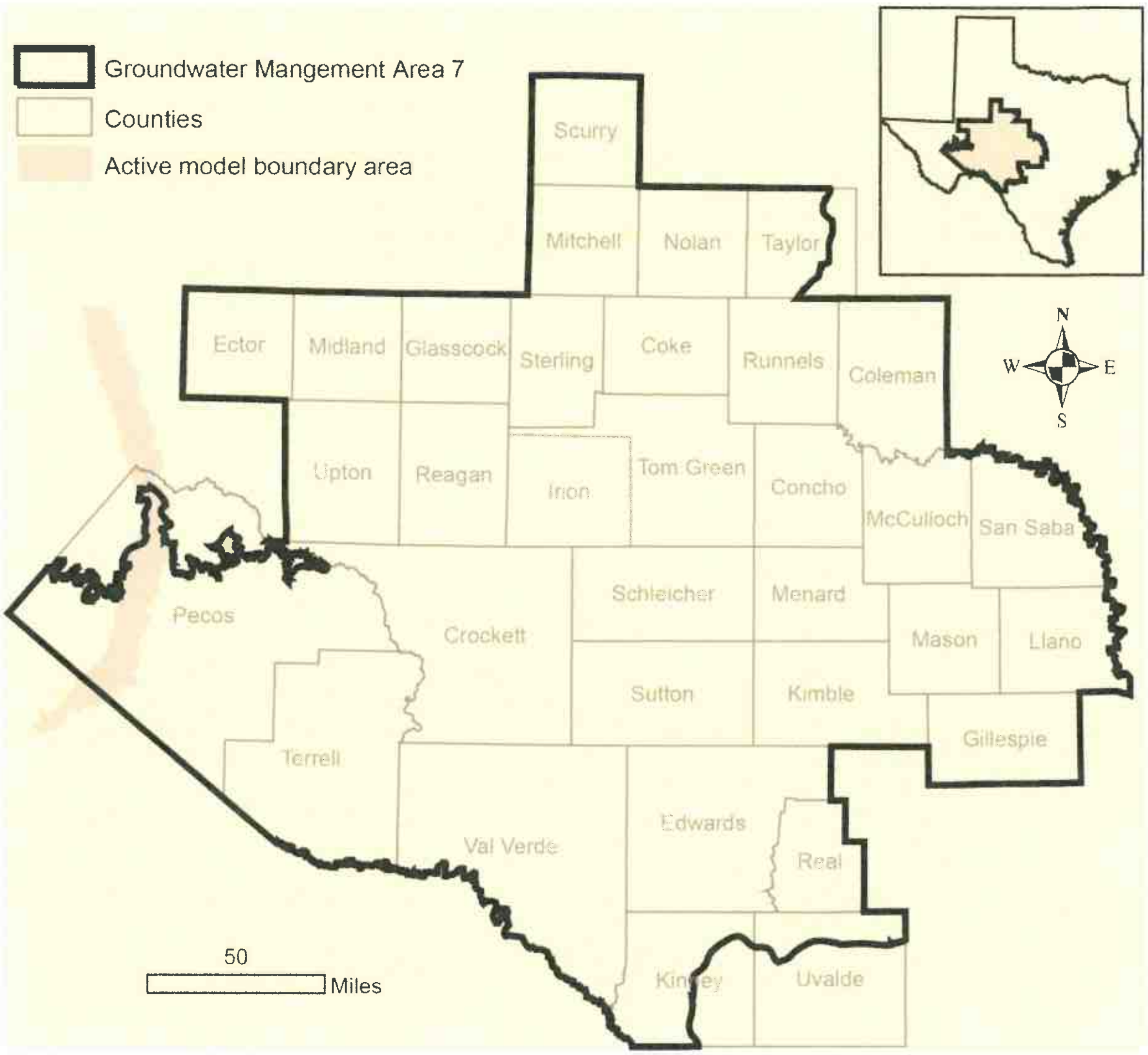

FIGURE 4. **MAP SHOWING THE AREAS COVERED BY THE CAPITAN REEF COMPLEX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EASTERN ARM OF THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.**

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2006 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. GCD IS THE ABBREVIATION FOR GROUNDWATER CONSERVATION DISTRICT.

District	County	Year							
		2006	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Middle Pecos GCD	Pecos	26,164	26,164	26,164	26,164	26,164	26,164	26,164	26,164
	Total	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**
GMA 7		**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	**2030**	**2040**	**2050**	**2060**	**2070**
Pecos	F	Rio Grande	26,164	26,164	26,164	26,164	26,164	26,164
		Total	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**
GMA 7			**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**

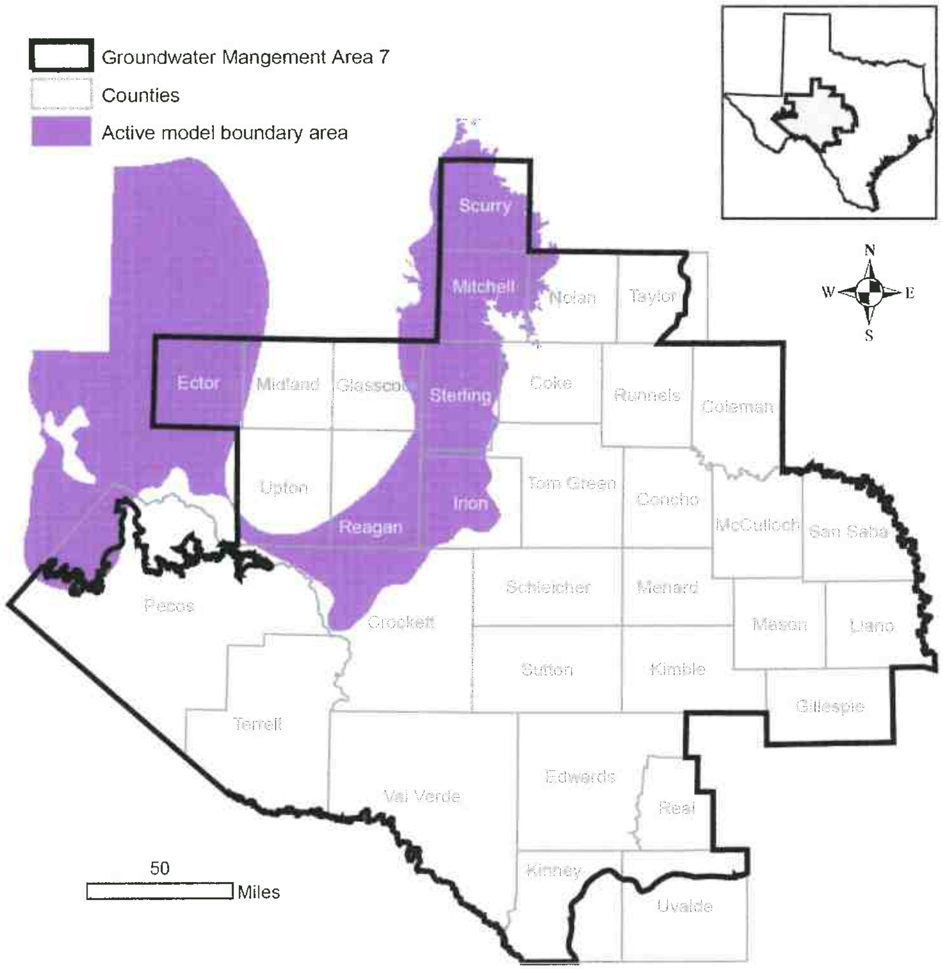

FIGURE 5. MAP SHOWING AREAS COVERED BY THE DOCKUM AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 3. MODELED AVAILABLE GROUNDWATER FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2013 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. GCD AND UWCD ARE THE ABBREVIATIONS FOR GROUNDWATER CONSERVATION DISTRICT AND UNDERGROUND WATER CONSERVATION DISTRICT, RESPECTIVELY.

District	County	Year						
		2013	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Middle Pecos GCD	Pecos	2,022	2,022	2,022	2,022	2,022	2,022	2,022
	Total	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**
Santa Rita UWCD	Reagan	302	302	302	302	302	302	302
	Total	**302**	**302**	**302**	**302**	**302**	**302**	**302**
GMA 7		**2324**	**2,324**	**2,324**	**2,324**	**2,324**	**2,324**	**2,324**

Note: The modeled available groundwater for Santa Rita Underground Water Conservation District excludes parts of Reagan County that fall within Glasscock Groundwater Conservation District. The year 2013 is used because the 2012 desired future condition baseline year for the Dockum Aquifer is an initial condition in the predictive model run.

TABLE 4. MODELED AVAILABLE GROUNDWATER FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Pecos	F	Rio Grande	2,022	2,022	2,022	2,022	2,022	2,022
		Total	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**
Reagan	F	Colorado	302	302	302	302	302	302
		Rio Grande	0	0	0	0	0	0
		Total	**302**	**302**	**302**	**302**	**302**	**302**
GMA 7			**2,324**	**2,324**	**2,324**	**2,324**	**2,324**	**2,324**

Note: The modeled available groundwater for Reagan County excludes parts of Reagan County that fall outside of Santa Rita Underground Water Conservation District.

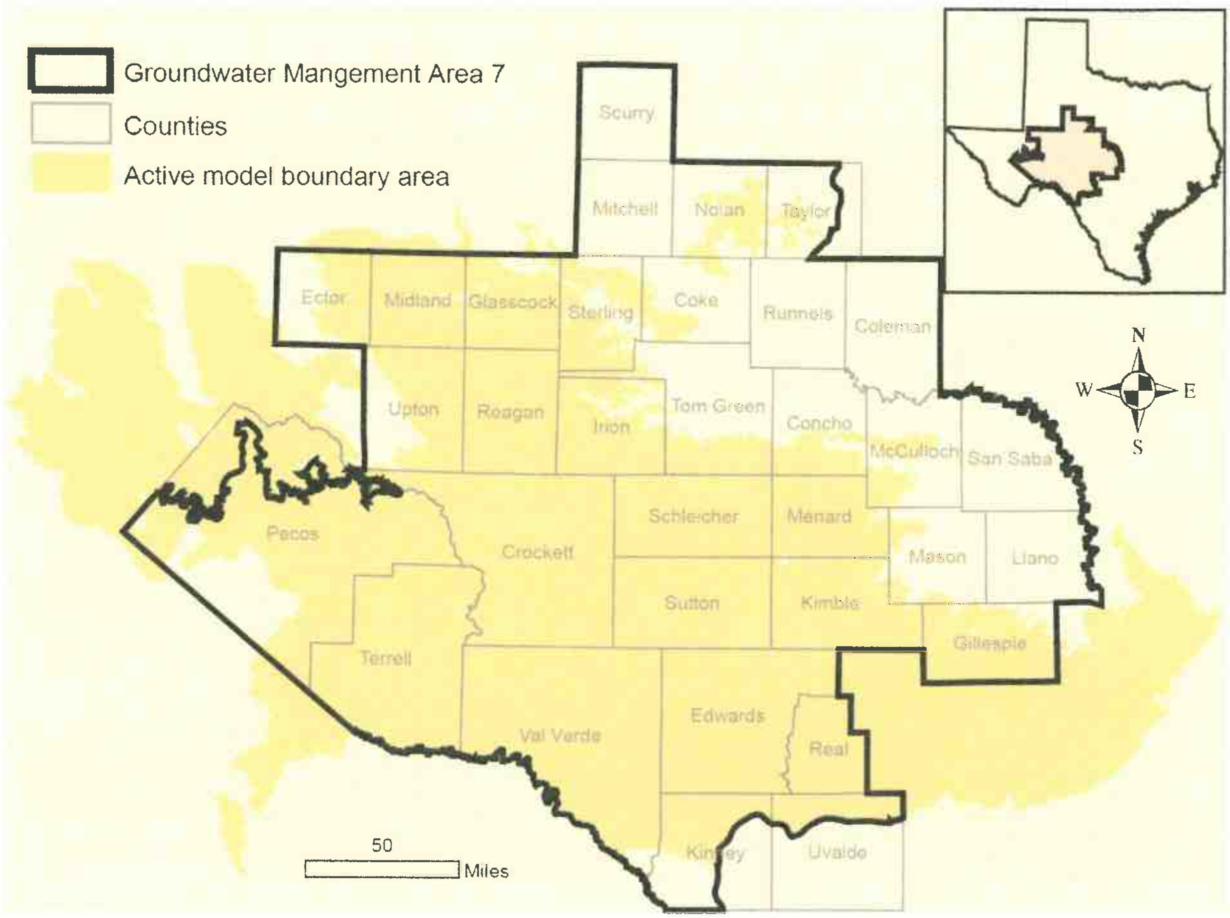

FIGURE 6. **MAP SHOWING THE AREAS COVERED BY THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7.**

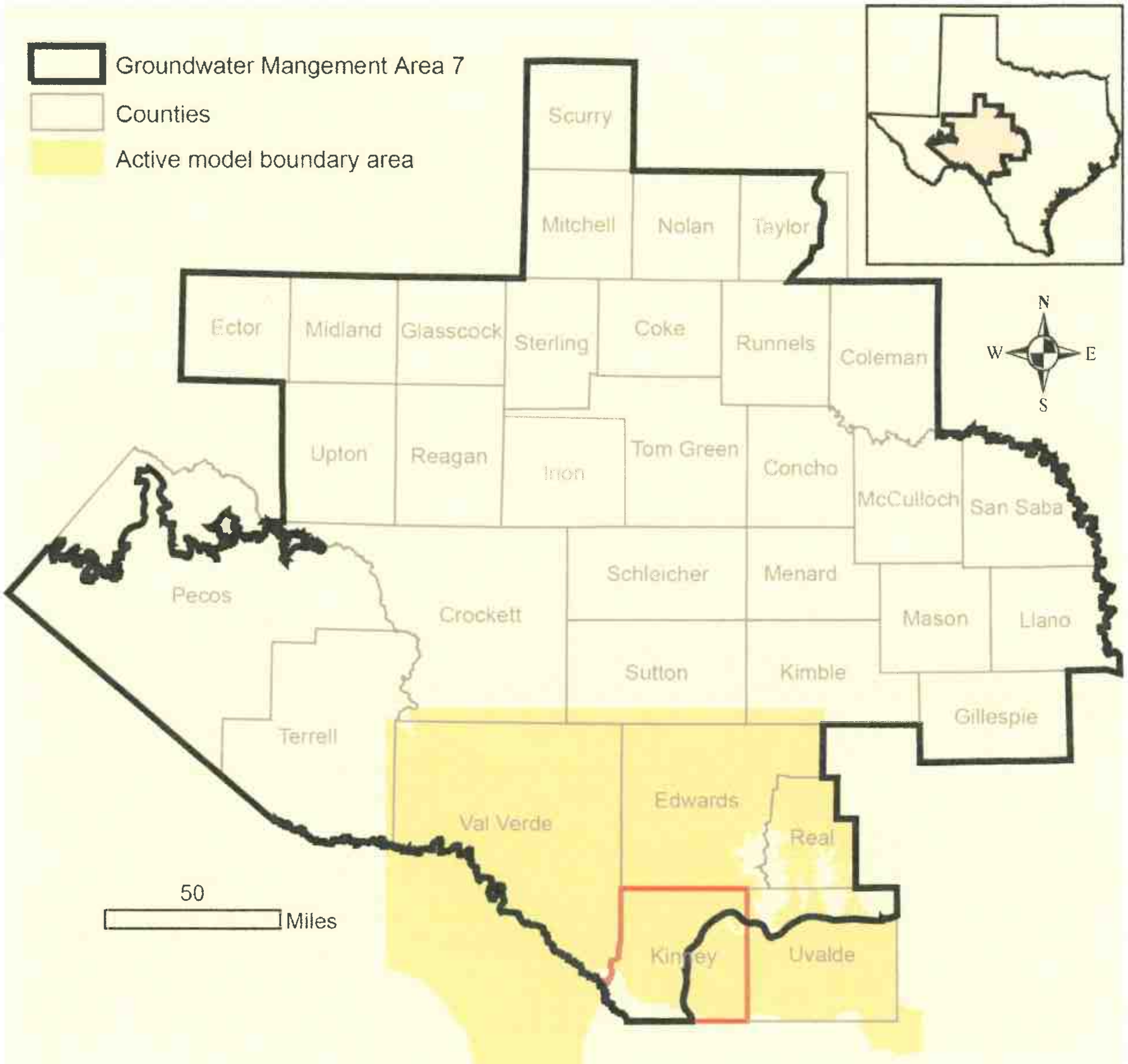

FIGURE 7. **MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE ALTERNATIVE MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN KINNEY COUNTY.**

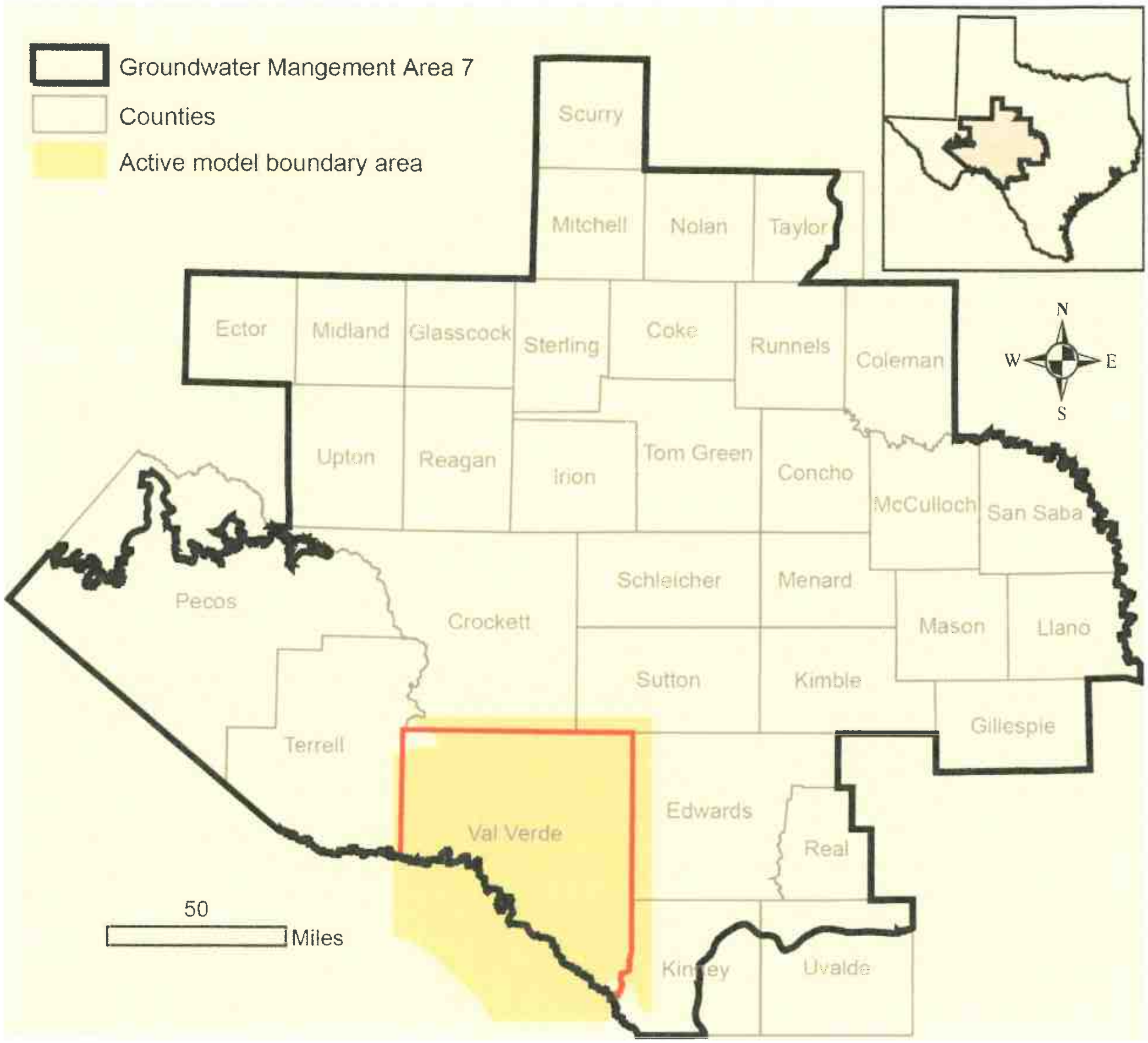

FIGURE 8. MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE GROUNDWATER FLOW MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN VAL VERDE COUNTY.

TABLE 5. MODELED AVAILABLE GROUNDWATER FOR THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY, FOR EACH DECADE BETWEEN 2006 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. UWCD IS ABBREVIATION FOR UNDERGROUND WATER CONSERVATION DISTRICT, WCD IS WATER CONSERVATION DISTRICT, UWD IS UNDERGROUND WATER DISTRICT, UWC IS UNDERGROUND WATER CONSERVATION, AND C AND R DISTRICT IS CONSERVATION AND RECLAMATION DISTRICT.

District	County	Year						
		2010	2020	2030	2040	2050	2060	2070
Coke County UWCD	Coke	997	997	997	997	997	997	997
	Total	**997**	**997**	**997**	**997**	**997**	**997**	**997**
Crockett County GCD	Crockett	4,675	4,675	4,675	4,675	4,675	4,675	4,675
	Total	**4,675**	**4,675**	**4,675**	**4,675**	**4,675**	**4,675**	**4,675**
Glasscock GCD	Glasscock	65,186	65,186	65,186	65,186	65,186	65,186	65,186
	Reagan	40,835	40,835	40,835	40,835	40,835	40,835	40,835
	Total	**106,021**	**106,021**	**106,021**	**106,021**	**106,021**	**106,021**	**106,021**
Hill Country UWCD	Gillespie	4,979	4,979	4,979	4,979	4,979	4,979	4,979
	Total	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**
Irion County WCD*	Irion	3,289	3,289	3,289	3,289	3,289	3,289	3,289
	Total	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**
Kimble County GCD	Kimble	1,282	1,282	1,282	1,282	1,282	1,282	1,282
	Total	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**
Kinney County GCD	Kinney	70,341	70,341	70,341	70,341	70,341	70,341	70,341
	Total	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**

TABLE 5. (CONTINUED).

District	County	Year						
		2010	2020	2030	2040	2050	2060	2070
Menard County UWD	Menard	2,217	2,217	2,217	2,217	2,217	2,217	2,217
	Total	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**
Middle Pecos GCD	Pecos	117,309	117,309	117,309	117,309	117,309	117,309	117,309
	Total	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**
Plateau UWC and Supply District	Schleicher	8,034	8,034	8,034	8,034	8,034	8,034	8,034
	Total	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**
Real-Edwards C and R District	Edwards	5,676	5,676	5,676	5,676	5,676	5,676	5,676
	Real	7,523	7,523	7,523	7,523	7,523	7,523	7,523
	Total	**13,199**	**13,199**	**13,199**	**13,199**	**13,199**	**13,199**	**13,199**
Santa Rita UWCD	Reagan	27,398	27,398	27,398	27,398	27,398	27,398	27,398
	Total	**27,398**	**27,398**	**27,398**	**27,398**	**27,398**	**27,398**	**27,398**
Sterling County UWCD	Sterling	2,495	2,495	2,495	2,495	2,495	2,495	2,495
	Total	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**
Sutton County UWCD	Sutton	6,400	6,400	6,400	6,400	6,400	6,400	6,400
	Total	**6,400**	**6,400**	**6,400**	**6,400**	**6,400**	**6,400**	**6,400**
Terrell County GCD	Terrell	1,420	1,420	1,420	1,420	1,420	1,420	1,420
	Total	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**
Uvalde County UWCD	Uvalde	1,993	1,993	1,993	1,993	1,993	1,993	1,993
	Total	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**

TABLE 5. (CONTINUED).

District	County	Year						
		2010	2020	2030	2040	2050	2060	2070
No district		102,415	102,415	102,415	102,415	102,415	102,415	102,415
GMA 7		**474,464**	**474,464**	**474,464**	**474,464**	**474,464**	**474,464**	**474,464**

*The modeled available groundwater for Irion County WCD only includes the portion of the district that falls within Irion County.

TABLE 6. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Coke	F	Colorado	997	997	997	997	997	997
		Total	**997**	**997**	**997**	**997**	**997**	**997**
Crockett	F	Colorado	20	20	20	20	20	20
		Rio Grande	5,427	5,427	5,427	5,427	5,427	5,427
		Total	**5,447**	**5,447**	**5,447**	**5,447**	**5,447**	**5,447**
Ector	F	Colorado	4,925	4,925	4,925	4,925	4,925	4,925
		Rio Grande	617	617	617	617	617	617
		Total	**5,542**	**5,542**	**5,542**	**5,542**	**5,542**	**5,542**
Edwards	J	Colorado	2,305	2,305	2,305	2,305	2,305	2,305
		Nueces	1,631	1,631	1,631	1,631	1,631	1,631
		Rio Grande	1,740	1,740	1,740	1,740	1,740	1,740
		Total	**5,676**	**5,676**	**5,676**	**5,676**	**5,676**	**5,676**
Gillespie	K	Colorado	4,843	4,843	4,843	4,843	4,843	4,843
		Guadalupe	136	136	136	136	136	136
		Total	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**
Glasscock	F	Colorado	65,186	65,186	65,186	65,186	65,186	65,186
		Total	**65,186**	**65,186**	**65,186**	**65,186**	**65,186**	**65,186**

TABLE 6. (CONTINUED).

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Irion	F	Colorado	3,289	3,289	3,289	3,289	3,289	3,289
		Total	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**
Kimble*	F	Colorado	1,282	1,282	1,282	1,282	1,282	1,282
		Total	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**
Kinney	J	Nueces	12	12	12	12	12	12
		Rio Grande	70,329	70,329	70,329	70,329	70,329	70,329
		Total	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**
Menard*	F	Colorado	2,217	2,217	2,217	2,217	2,217	2,217
		Total	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**
Midland	F	Colorado	23,233	23,233	23,233	23,233	23,233	23,233
		Total	**23,233**	**23,233**	**23,233**	**23,233**	**23,233**	**23,233**
Pecos	F	Rio Grande	117,309	117,309	117,309	117,309	117,309	117,309
		Total	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**
Reagan	F	Colorado	68,205	68,205	68,205	68,205	68,205	68,205
		Rio Grande	28	28	28	28	28	28
		Total	**68,233**	**68,233**	**68,233**	**68,233**	**68,233**	**68,233**
Real	J	Colorado	277	277	277	277	277	277
		Guadalupe	3	3	3	3	3	3
		Nueces	7,243	7,243	7,243	7,243	7,243	7,243
		Total	**7,523**	**7,523**	**7,523**	**7,523**	**7,523**	**7,523**

TABLE 6. (CONTINUED).

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Schleicher	F	Colorado	6,403	6,403	6,403	6,403	6,403	6,403
		Rio Grande	1,631	1,631	1,631	1,631	1,631	1,631
		Total	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**
Sterling	F	Colorado	2,495	2,495	2,495	2,495	2,495	2,495
		Total	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**
Sutton	F	Colorado	388	388	388	388	388	388
		Rio Grande	6,022	6,022	6,022	6,022	6,022	6,022
		Total	**6,410**	**6,410**	**6,410**	**6,410**	**6,410**	**6,410**
Taylor	G	Brazos	331	331	331	331	331	331
		Colorado	158	158	158	158	158	158
		Total	**489**	**489**	**489**	**489**	**489**	**489**
Terrell	E	Rio Grande	1,420	1,420	1,420	1,420	1,420	1,420
		Total	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**
Upton	F	Colorado	21,243	21,243	21,243	21,243	21,243	21,243
		Rio Grande	1,126	1,126	1,126	1,126	1,126	1,126
		Total	**22,369**	**22,369**	**22,369**	**22,369**	**22,369**	**22,369**
Uvalde	L	Nueces	1,993	1,993	1,993	1,993	1,993	1,993
		Total	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**
Val Verde	J	Rio Grande	50,000	50,000	50,000	50,000	50,000	50,000
		Total	**50,000**	**50,000**	**50,000**	**50,000**	**50,000**	**50,000**
GMA 7			**474,464**	**474,464**	**474,464**	**474,464**	**474,464**	**474,464**

*The modeled available groundwater for Kimble and Menard counties excludes the parts of the counties that fall within Hickory Underground Water Conservation District No. 1.

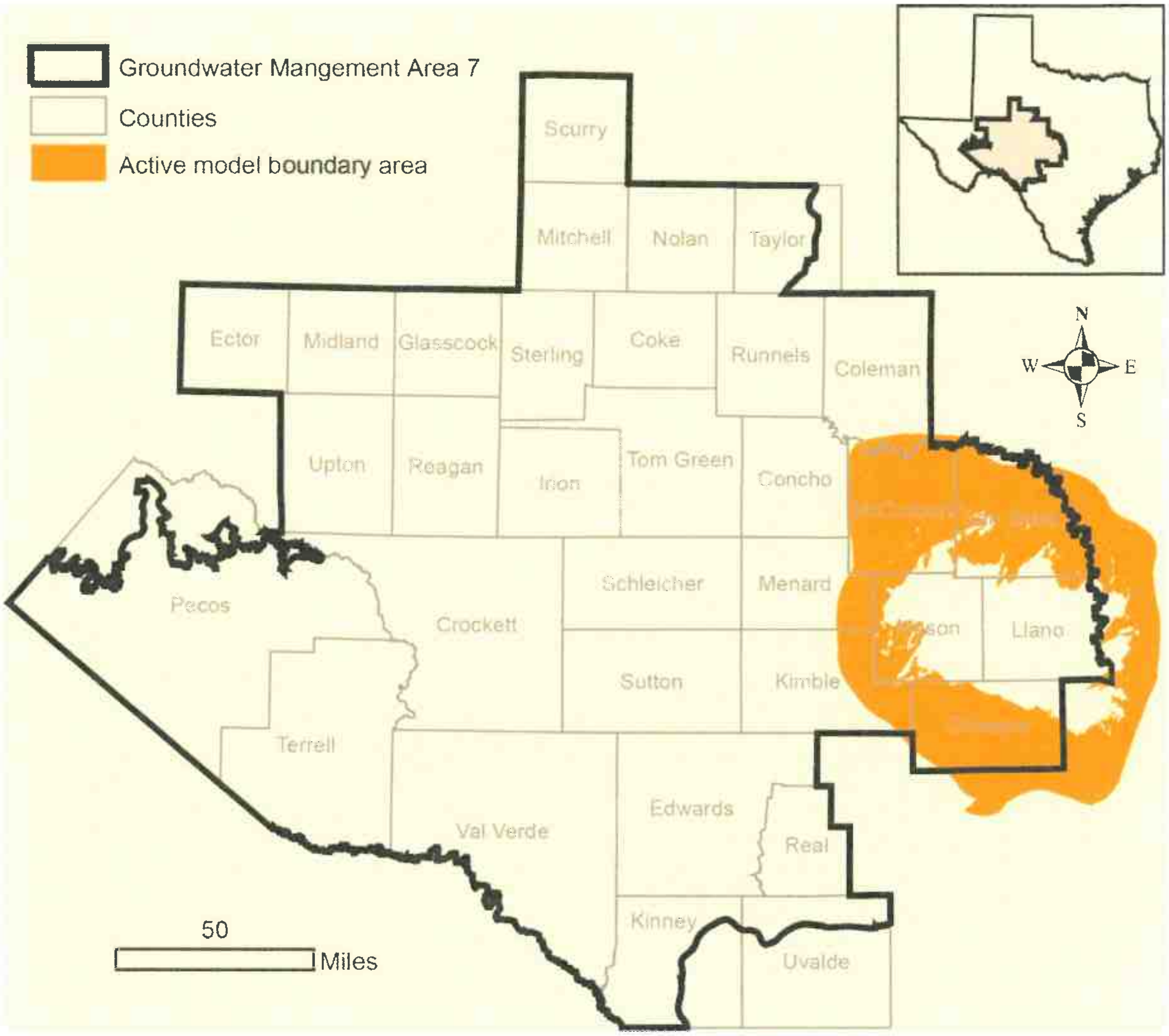

FIGURE 9. MAP SHOWING THE AREAS COVERED BY THE ELLENBURGER-SAN SABA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 7. MODELED AVAILABLE GROUNDWATER FOR THE ELLENBURGER-SAN SABA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2011 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. UWCD IS THE ABBREVIATION FOR UNDERGROUND WATER CONSERVATION DISTRICT AND UWD IS UNDERGROUND WATER DISTRICT.

District	County	Year						
		2011	2020	2030	2040	2050	2060	2070
Hickory UWCD No. 1	Kimble	344	344	344	344	344	344	344
	Mason	3,237	3,237	3,237	3,237	3,237	3,237	3,237
	McCulloch	3,466	3,466	3,466	3,466	3,466	3,466	3,466
	Menard	282	282	282	282	282	282	282
	San Saba	5,559	5,559	5,559	5,559	5,559	5,559	5,559
	Total	**12,887**	**12,887**	**12,887**	**12,887**	**12,887**	**12,887**	**12,887**
Hill Country UWCD	Gillespie	6,294	6,294	6,294	6,294	6,294	6,294	6,294
	Total	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**
Kimble County GCD	Kimble	178	178	178	178	178	178	178
	Total	**178**	**178**	**178**	**178**	**178**	**178**	**178**
Menard County UWD	Menard	27	27	27	27	27	27	27
	Total	**27**	**27**	**27**	**27**	**27**	**27**	**27**
No District	McCulloch	898	898	898	898	898	898	898
	San Saba	2,331	2,331	2,331	2,331	2,331	2,331	2,331
	Total	**3,229**	**3,229**	**3,229**	**3,229**	**3,229**	**3,229**	**3,229**
GMA 7		**22,616**	**22,616**	**22,616**	**22,616**	**22,616**	**22,616**	**22,616**

Note: The year 2011 is used because the 2010 desired future condition baseline year for the Ellenburger-San Saba Aquifer is an initial condition in the predictive model run.

TABLE 8. **MODELED AVAILABLE GROUNDWATER FOR THE ELLENBURGER-SAN SABA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.**

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Gillespie	K	Colorado	6,294	6,294	6,294	6,294	6,294	6,294
		Total	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**
Kimble	F	Colorado	521	521	521	521	521	521
		Total	**521**	**521**	**521**	**521**	**521**	**521**
Mason	F	Colorado	3,237	3,237	3,237	3,237	3,237	3,237
		Total	**3,237**	**3,237**	**3,237**	**3,237**	**3,237**	**3,237**
McCulloch	F	Colorado	4,364	4,364	4,364	4,364	4,364	4,364
		Total	**4,364**	**4,364**	**4,364**	**4,364**	**4,364**	**4,364**
Menard	F	Colorado	309	309	309	309	309	309
		Total	**309**	**309**	**309**	**309**	**309**	**309**
San Saba	K	Colorado	7,890	7,890	7,890	7,890	7,890	7,890
		Total	**7,890**	**7,890**	**7,890**	**7,890**	**7,890**	**7,890**
GMA 7			**22,616**	**22,616**	**22,616**	**22,616**	**22,616**	**22,616**

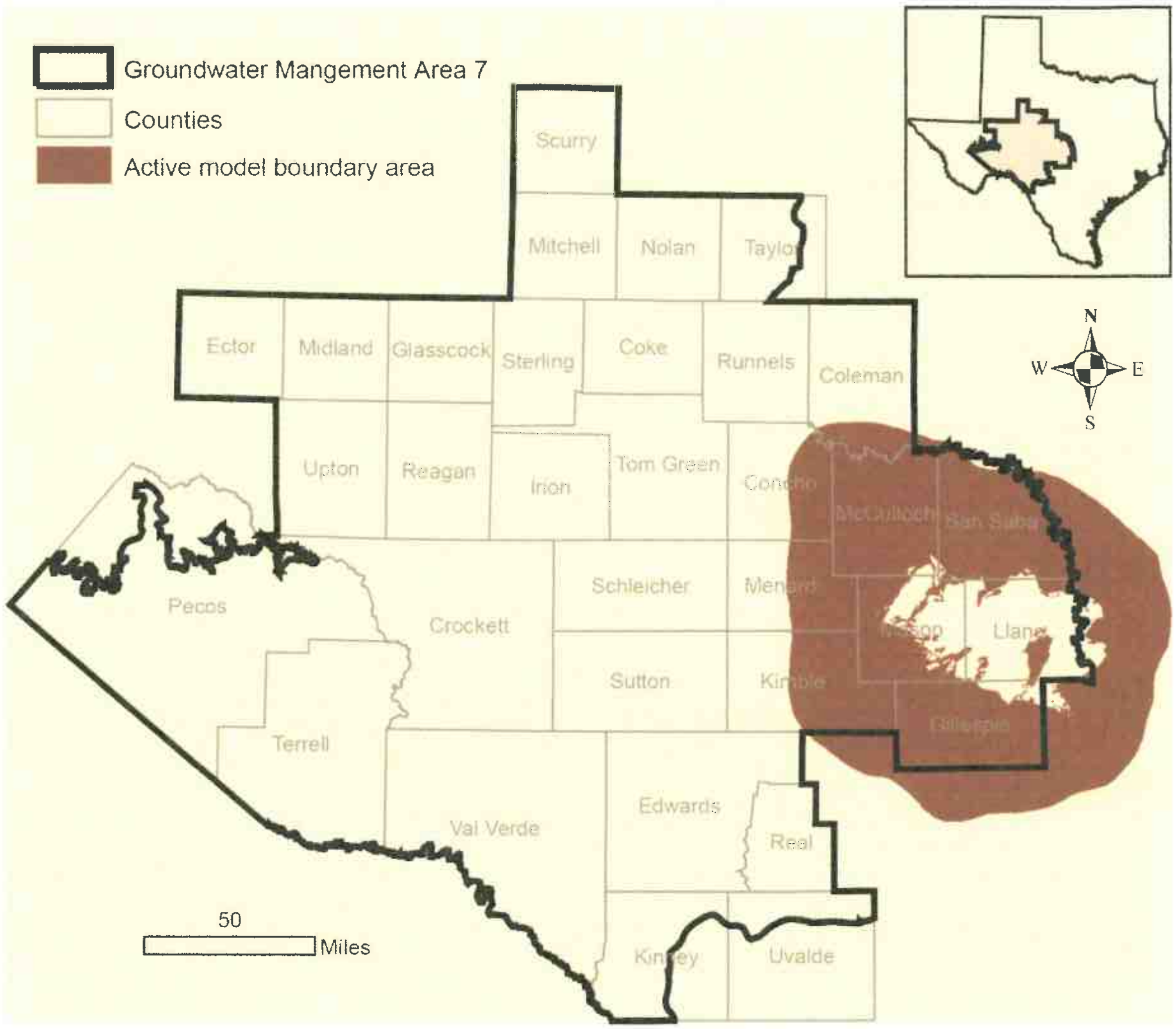

FIGURE 10. **MAP SHOWING AREAS COVERED BY THE HICKORY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.**

TABLE 9. MODELED AVAILABLE GROUNDWATER FOR THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2011 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. UWCD IS THE ABBREVIATION FOR UNDERGROUND WATER CONSERVATION DISTRICT AND UWD IS UNDERGROUND WATER DISTRICT.

District	County	Year						
		2011	2020	2030	2040	2050	2060	2070
Hickory UWCD No. 1	Concho	13	13	13	13	13	13	13
	Kimble	42	42	42	42	42	42	42
	Mason	13,212	13,212	13,212	13,212	13,212	13,212	13,212
	McCulloch	21,950	21,950	21,950	21,950	21,950	21,950	21,950
	Menard	2,600	2,600	2,600	2,600	2,600	2,600	2,600
	San Saba	7,027	7,027	7,027	7,027	7,027	7,027	7,027
	Total	**44,843**	**44,843**	**44,843**	**44,843**	**44,843**	**44,843**	**44,843**
Hill Country UWCD	Gillespie	1,751	1,751	1,751	1,751	1,751	1,751	1,751
	Total	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**
Kimble County GCD	Kimble	123	123	123	123	123	123	123
	Total	**123**	**123**	**123**	**123**	**123**	**123**	**123**
Lipan-Kickapoo WCD	Concho	13	13	13	13	13	13	13
	Total	**13**	**13**	**13**	**13**	**13**	**13**	**13**
Menard County UWD	Menard	126	126	126	126	126	126	126
	Total	**126**	**126**	**126**	**126**	**126**	**126**	**126**
No District	McCulloch	2,427	2,427	2,427	2,427	2,427	2,427	2,427
	San Saba	652	652	652	652	652	652	652
	Total	**3,080**	**3,080**	**3,080**	**3,080**	**3,080**	**3,080**	**3,080**
GMA 7		**49,936**	**49,936**	**49,936**	**49,936**	**49,936**	**49,936**	**49,936**

Note: The year 2011 is used because the 2010 desired future condition baseline year for the Hickory Aquifer is an initial condition in the predictive model run.

TABLE 10. MODELED AVAILABLE GROUNDWATER FOR THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Concho	F	Colorado	27	27	27	27	27	27
		Total	**27**	**27**	**27**	**27**	**27**	**27**
Gillespie	K	Colorado	1,751	1,751	1,751	1,751	1,751	1,751
		Total	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**
Kimble	F	Colorado	165	165	165	165	165	165
		Total	**165**	**165**	**165**	**165**	**165**	**165**
Mason	F	Colorado	13,212	13,212	13,212	13,212	13,212	13,212
		Total	**13,212**	**13,212**	**13,212**	**13,212**	**13,212**	**13,212**
McCulloch	F	Colorado	24,377	24,377	24,377	24,377	24,377	24,377
		Total	**24,377**	**24,377**	**24,377**	**24,377**	**24,377**	**24,377**
Menard	F	Colorado	2,725	2,725	2,725	2,725	2,725	2,725
		Total	**2,725**	**2,725**	**2,725**	**2,725**	**2,725**	**2,725**
San Saba	K	Colorado	7,680	7,680	7,680	7,680	7,680	7,680
		Total	**7,680**	**7,680**	**7,680**	**7,680**	**7,680**	**7,680**
GMA 7			**49,936**	**49,936**	**49,936**	**49,936**	**49,936**	**49,936**

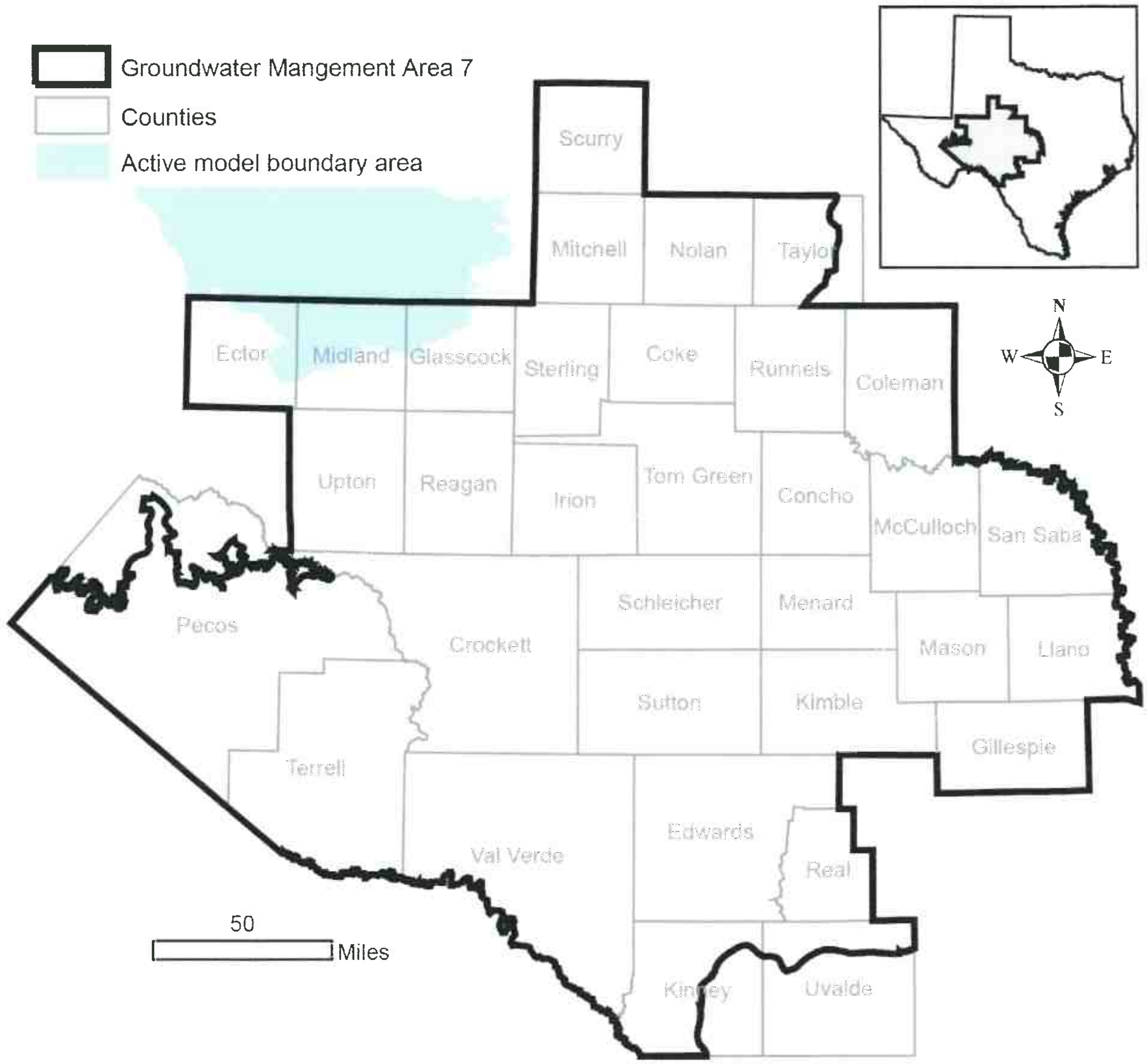

FIGURE 11. **MAP SHOWING THE AREAS COVERED BY THE OGALLALA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.**

TABLE 11. MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2013 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

District	County	Year						
		2013	2020	2030	2040	2050	2060	2070
Glasscock GCD	Glasscock	8,019	7,925	7,673	7,372	7,058	6,803	6,570
	Total	**8,019**	**7,925**	**7,673**	**7,372**	**7,058**	**6,803**	**6,570**
GMA 7		**8,019**	**7,925**	**7,673**	**7,372**	**7,058**	**6,803**	**6,570**

Note: The year 2013 is used because the 2012 desired future condition baseline year for the Ogallala Aquifer is an initial condition in the predictive model run.

TABLE 12. MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Glasscock	F	Colorado	7,925	7,673	7,372	7,058	6,803	6,570
		Total	**7,925**	**7,673**	**7,372**	**7,058**	**6,803**	**6,570**
GMA 7			**7,925**	**7,673**	**7,372**	**7,058**	**6,803**	**6,570**

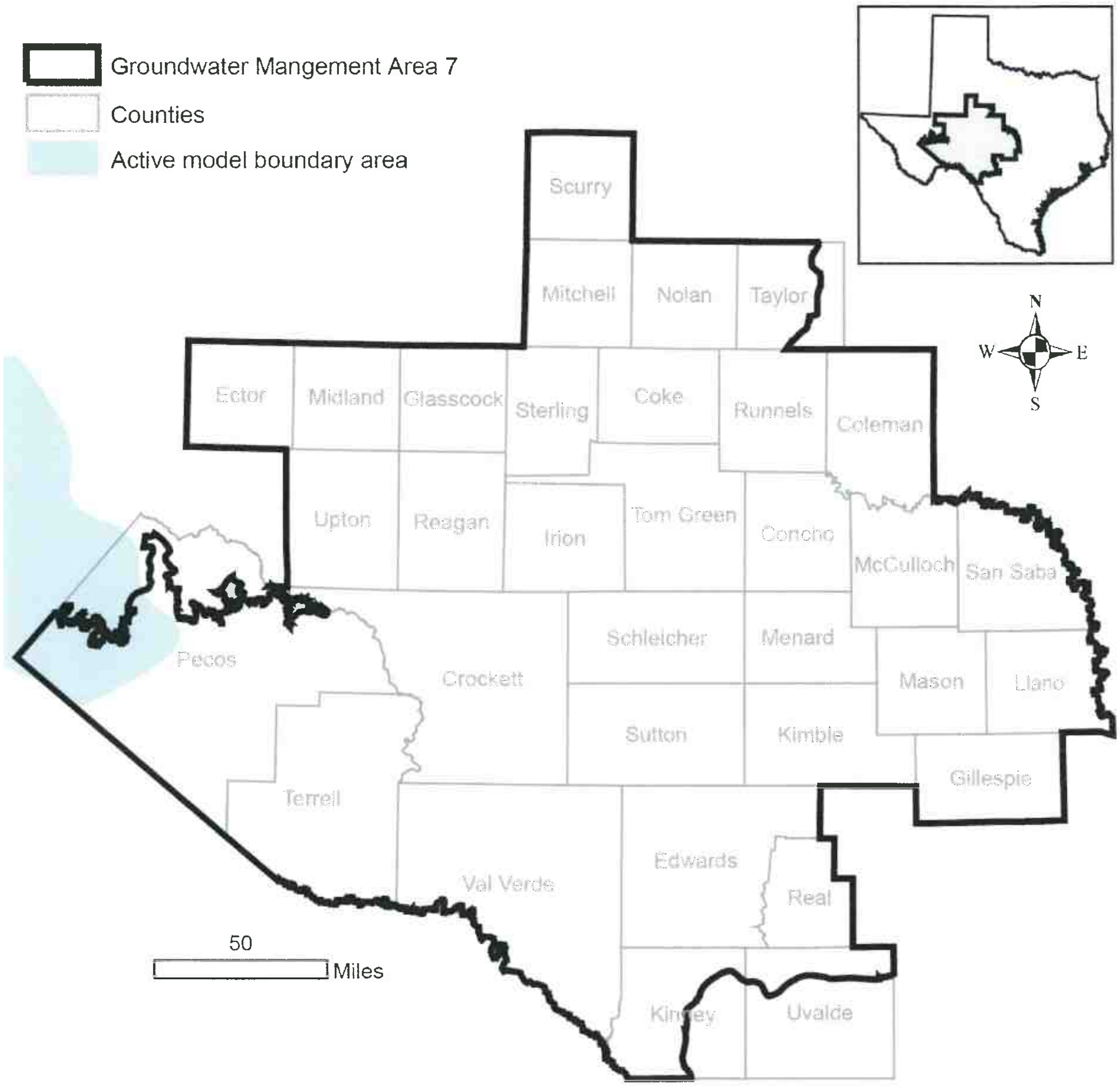

FIGURE 12. MAP SHOWING AREAS COVERED BY THE RUSTLER AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 13. MODELED AVAILABLE GROUNDWATER FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2009 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

District	County	Year							
		2009	2010	2020	2030	2040	2050	2060	2070
Middle Pecos GCD	Pecos	7,040	7,040	7,040	7,040	7,040	7,040	7,040	7,040
	Total	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**

TABLE 14. MODELED AVAILABLE GROUNDWATER FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Pecos	F	Rio Grande	7,040	7,040	7,040	7,040	7,040	7,040
		Rio Grande	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**

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 historical groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historical pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historical 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.

REFERENCES:

Anaya, R., and Jones, I. C., 2009, Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas: Texas Water Development Board Report 373, 103p. http://www.twdb.texas.gov/groundwater/models/gam/eddt_p/ET-Plateau_Full.pdf

Deeds, N. E. and Jigmond, M., 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model, Prepared by INTERA Incorporated for Texas Water Development Board, 640p. http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf

EcoKai Environmental, Inc. and Hutchison, W. R., 2014, Hydrogeological Study for Val Verde and Del Rio, Texas: Prep. For Val Verde County and City of Del Rio, 167 p.

Ewing, J. E., Kelley, V. A., Jones, T. L., Yan, T., Singh, A., Powers, D. W., Holt, R. M., and Sharp, J. M., 2012, Final Groundwater Availability Model Report for the Rustler Aquifer, Prepared for the Texas Water Development Board, 460p. http://www.twdb.texas.gov/groundwater/models/gam/rslr/RSLR_GAM_Report.pdf

Harbaugh, A. W., 2005, MODFLOW-2005, The US Geological Survey Modular Groundwater-Model – the Ground-Water Flow Process. Chapter 16 of Book 6. Modeling techniques, Section A Ground Water: U.S. Geological Survey Techniques and Methods 6-A16. 253p.

Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing sub-regional water budgets for MODFLOW ground-water flow models: U.S. Geological Survey Groundwater Software.

Harbaugh, A. W., Banta, E. R., Hill, M. C., 2000, MODFLOW-2000, the U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process: U.S. Geological Survey, Open-File Report 00-92, 121p.

Hutchison, W. R., Jones, I. C, and Anaya, R., 2011a, Update of the Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas, Texas Water Development Board, 61 p. http://www.twdb.texas.gov/groundwater/models/alt/eddt_p_2011/ETP_PV_One_Layer_Model.pdf

Hutchison, W. R., Shi, J., and Jigmond, M., 2011b, Groundwater Flow Model of the Kinney County Area, Texas Water Development Board, 217 p. http://www.twdb.texas.gov/groundwater/models/alt/knny/Kinney_County_Model_Report.pdf

Hutchison, W. R., 2016a, GMA 7 Explanatory Report—Final, Aquifers of the Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls): Prep. For Groundwater Management Area 7, 79 p.

Hutchison, W. R., 2016b, GMA 7 Explanatory Report—Final, Ogallala and Dockum Aquifers: Prep. For Groundwater Management Area 7, 78 p.

Hutchison, W. R., 2016c, GMA 7 Explanatory Report—Final, Rustler Aquifer: Prep. For Groundwater Management Area 7, 64 p.

Hutchison, W. R., 2016d, GMA 7 Technical Memorandum 15-05—Final, Rustler Aquifer: Nine Factor Documentation and Predictive Simulation with Rustler GAM, 27 p.

Hutchison, W. R., 2016e, GMA 7 Technical Memorandum 15-06—Final, Edwards-Trinity (Plateau) and Pecos Valley Aquifers: Nine Factor Documentation and Predictive Simulation, 60 p.

Hutchison, W. R., 2016f, GMA 7 Technical Memorandum 16-01—Final, Dockum and Ogallala Aquifers: Initial Predictive Simulations with HPAS, 29 p.

Hutchison, W. R., 2016g, GMA 7 Technical Memorandum 16-02—Final, Llano Uplift Aquifers: Initial Predictive Simulations with Draft GAM, 24 p.

Hutchison, W. R., 2016h, GMA 7 Technical Memorandum 16-03—Final, Capitan Reef Complex Aquifer: Initial Predictive Simulations with Draft GAM, 8 p.

Hutchison, W. R., 2018a, GMA 7 Explanatory Report—Final, Capitan Reef Complex Aquifer: Prep. For Groundwater Management Area 7, 63 p.

Hutchison, W. R., 2018b, GMA 7 Explanatory Report—Final, Edwards-Trinity, Pecos Valley and Trinity Aquifers: Prep. For Groundwater Management Area 7, 173 p.

Hutchison, W. R., 2018c, GMA 7 Technical Memorandum 18-01—Final, Edwards-Trinity (Plateau) and Pecos Valley Aquifers: Update of Average Drawdown Calculations, 10 p.

Jones, I. C., 2016, Groundwater Availability Model: Eastern Arm of the Capitan Reef Complex Aquifer of Texas. Texas Water Development Board, March 2016, 488p. http://www.twdb.texas.gov/groundwater/models/gam/crcx/CapitanModelReportFinal.pdf

National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p., http://www.nap.edu/catalog.php?record_id=11972.

Niswonger, R.G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, a Newton formulation for MODFLOW-2005: United States Geological Survey, Techniques and Methods 6-A37, 44 p.

Panday, S., Langevin, C. D., Niswonger, R. G., Ibaraki, M., and Hughes, J. D., 2013, MODFLOW–USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p.

Shi, J, 2012, GAM Run 10-043 MAG (Version 2): Modeled Available Groundwater for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers in Groundwater Management Area 7, Texas Water Development Board GAM Run Report 10-043, 15 p. www.twdb.texas.gov/groundwater/docs/GAMruns/GR10-043_MAG_v2.pdf

Shi, J., Boghici, R., Kohlrenken, W., and Hutchison, W., 2016, Numerical model report: minor aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory): Texas Water Development Board published report, 400 p. http://www.twdb.texas.gov/groundwater/models/gam/llano/Llano_Uplift_Numerical_Model_Report_Final.pdf

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

APPENDIX C

GAM Run 18-015: Kimble County Groundwater Conservation District Groundwater Management Plan

Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-463-6641
September 28, 2018

STATE OF TEXAS
IAN C. JONES
GEOLOGY
No. 477
LICENSED
PROFESSIONAL GEOSCIENTIST

9/28/18

This page is intentionally blank.

GAM RUN 18-015: KIMBLE COUNTY GROUNDWATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-463-6641
September 28, 2018

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2011), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator.

The TWDB provides data and information to the Kimble County Groundwater Conservation District in two parts. Part 1 is the Estimated Historical Water Use/State Water Plan dataset report, which will be provided to you separately by the TWDB Groundwater Technical Assistance Department. Please direct questions about the water data report to Mr. Stephen Allen at 512-463-7317 or stephen.allen@twdb.texas.gov. Part 2 is the required groundwater availability modeling information and this information includes:

1. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;
2. for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface-water bodies, including lakes, streams, and rivers; and
3. the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

The groundwater management plan for the Kimble County Groundwater Conservation District should be adopted by the district on or before April 12, 2019, and submitted to the Executive Administrator of the TWDB on or before May 12, 2019. The current management plan for the Kimble County Groundwater Conservation District expires on July 11, 2019.

We used two groundwater availability models to estimate the management plan information for the aquifers within the Kimble County Groundwater Conservation District. Information for the Marble Falls, Ellenburger-San Saba, and Hickory aquifers is from version 1.01 of the groundwater availability model for the minor aquifers of the Llano Uplift Region (Shi and others, 2016). Information for the Edwards-Trinity (Plateau) Aquifer is from version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Anaya and Jones, 2009).

This report replaces the results of GAM Run 13-018 (Seiter-Weatherford, 2013). GAM Run 18-015 includes results from the groundwater availability model for the minor aquifers of the Llano Uplift Region (Shi and others, 2016). Tables 1 through 4 summarize the groundwater availability model data required by statute and Figures 1 through 4 show the area of the models from which the values in the tables were extracted. If, after review of the figures, the Kimble County 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 two groundwater availability models mentioned above were used to estimate information for the Kimble County Groundwater Conservation District management plan. Water budgets were extracted for the historical model periods for the Marble Falls, Ellenburger-San Saba, and Hickory aquifers (1981 through 2010) using ZONEBUDGET-USG (Panday and others, 2013). The water budget for the Edwards-Trinity (Plateau) Aquifer was extracted for the historical model period (1981 through 2000) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface-water outflow, flows between aquifers in the district, inflow to the district, and outflow from the district for the aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Edwards-Trinity (Plateau) Aquifer

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers. See Anaya and Jones (2009) for assumptions and limitations of the model.

- The groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers contains 2 layers: Layer 1—represents the Edwards Group and equivalent limestone hydrostratigraphic units of the Edwards-Trinity (Plateau) Aquifer, and Layer 2—comprised of the undifferentiated Trinity Group hydrostratigraphic units or equivalent units of the Edwards-Trinity (Plateau) Aquifer. The two layers were lumped for calculating water budgets in the Edwards-Trinity (Plateau) Aquifer within the district.

- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

Marble Falls, Ellenburger-San Saba, and Hickory aquifers

- We used version 1.01 of the groundwater availability model for the minor aquifers in the Llano Uplift Region. See Shi and others (2016) for assumptions and limitations of the model.

- The groundwater availability model for the minor aquifers in Llano Uplift Region 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
    - Layer 4 — confining units
    - Layer 5 — the Ellenburger-San Saba Aquifer and equivalent
    - Layer 6 — confining units
    - Layer 7 — the Hickory Aquifer and equivalent
    - Layer 8 — confining (Precambrian) units

- Perennial rivers and reservoirs were simulated using the MODFLOW-USG river package. Springs were simulated using MODFLOW-USG drain package. For this management plan, groundwater discharge to surface water includes groundwater leakage to rivers and springs.

- The model was run with MODFLOW-USG beta (development) version (Panday and others, 2013).

- These aquifers are part of a complex geological environment in the Llano Uplift Region characterized by numerous faults that can offset and/or juxtapose multiple aquifer layers with different hydrologic properties and water-quality characteristics. Therefore the water budget and flow information provided in the summary tables is footnoted where appropriate to clarify these aquifer relationships.

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Marble Falls, Ellenburger-San Saba, Hickory, and Edwards-Trinity (Plateau) aquifers located within Kimble County Groundwater Conservation District and averaged over the historical calibration periods, as shown in Tables 1 through 4.

1. Precipitation recharge—the areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.

2. Surface-water outflow—the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.

3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.

4. Flow between aquifers—the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

The information needed for the district's management plan is summarized in Tables 1 through 4. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

TABLE 1. SUMMARIZED INFORMATION FOR THE MARBLE FALLS AQUIFER FOR KIMBLE COUNTY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Marble Falls Aquifer	14
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Marble Falls Aquifer	1,313
Estimated annual volume of flow into the district within each aquifer in the district	Marble Falls Aquifer	0
Estimated annual volume of flow out of the district within each aquifer in the district	Marble Falls Aquifer	77
Estimated net annual volume of flow between each aquifer in the district	Flow into the Marble Falls Aquifer from the Edwards-Trinity (Plateau) Aquifer/alluvium	1
	Flow into the Marble Falls Aquifer from the Ellenburger-San Saba Aquifer	861
	Flow into the Marble Falls Aquifer from the underlying confining unit	64
	Flow into the Marble Falls Aquifer from the Marble Falls stratigraphic unit	452

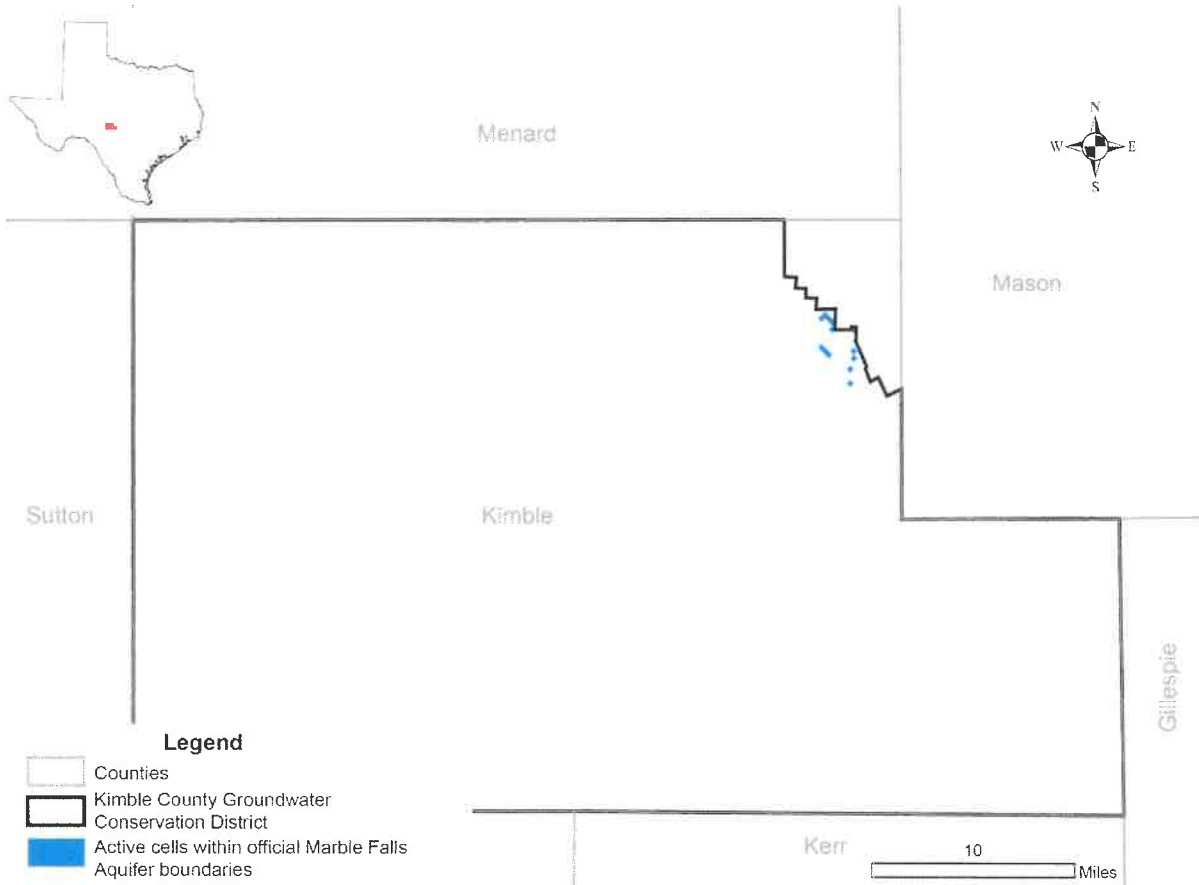

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE MARBLE FALLS AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE ELLENBURGER-SAN SABA AQUIFER FOR KIMBLE COUNTY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ellenburger-San Saba Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ellenburger-San Saba Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	3,261
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	5,625
Estimated net annual volume of flow between each aquifer in the district	Flow into the Ellenburger-San Saba Aquifer from the Hickory Aquifer	1
	Flow into the Ellenburger-San Saba Aquifer from adjacent confining units	2,814
	Flow from the Ellenburger-San Saba Aquifer into the Marble Falls Aquifer	863
	Flow from the brackish Ellenburger-San Saba stratigraphic unit into the Ellenburger-San Saba Aquifer	772

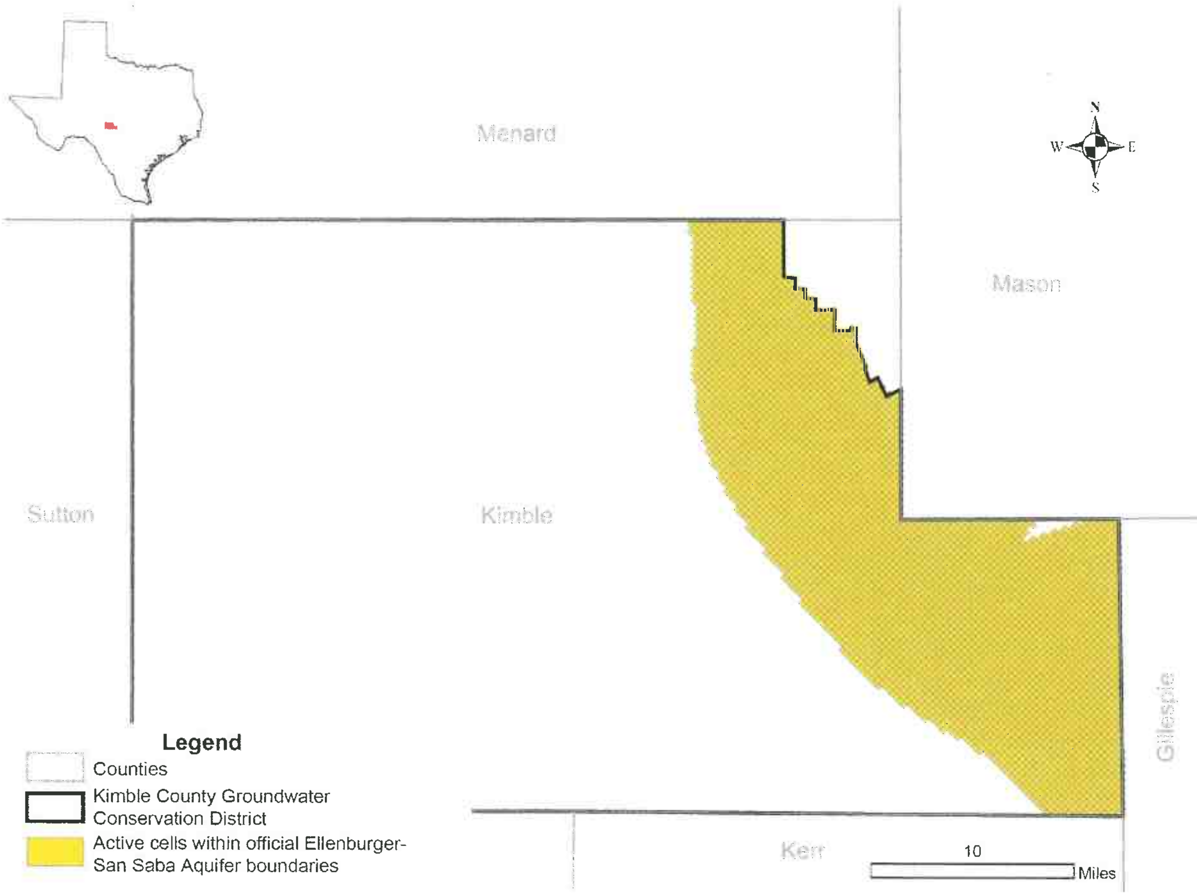

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE ELLENBURGER-SAN SABA AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE HICKORY AQUIFER FOR KIMBLE COUNTY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Hickory Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Hickory Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	3,699
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	8,206
Estimated net annual volume of flow between each aquifer in the district	Flow from the Hickory Aquifer into the Ellenburger-San Saba Aquifer	2
	Flow into the Hickory Aquifer from adjacent confining units	4,822
	Flow from the Hickory Aquifer into the brackish Hickory Formation	279

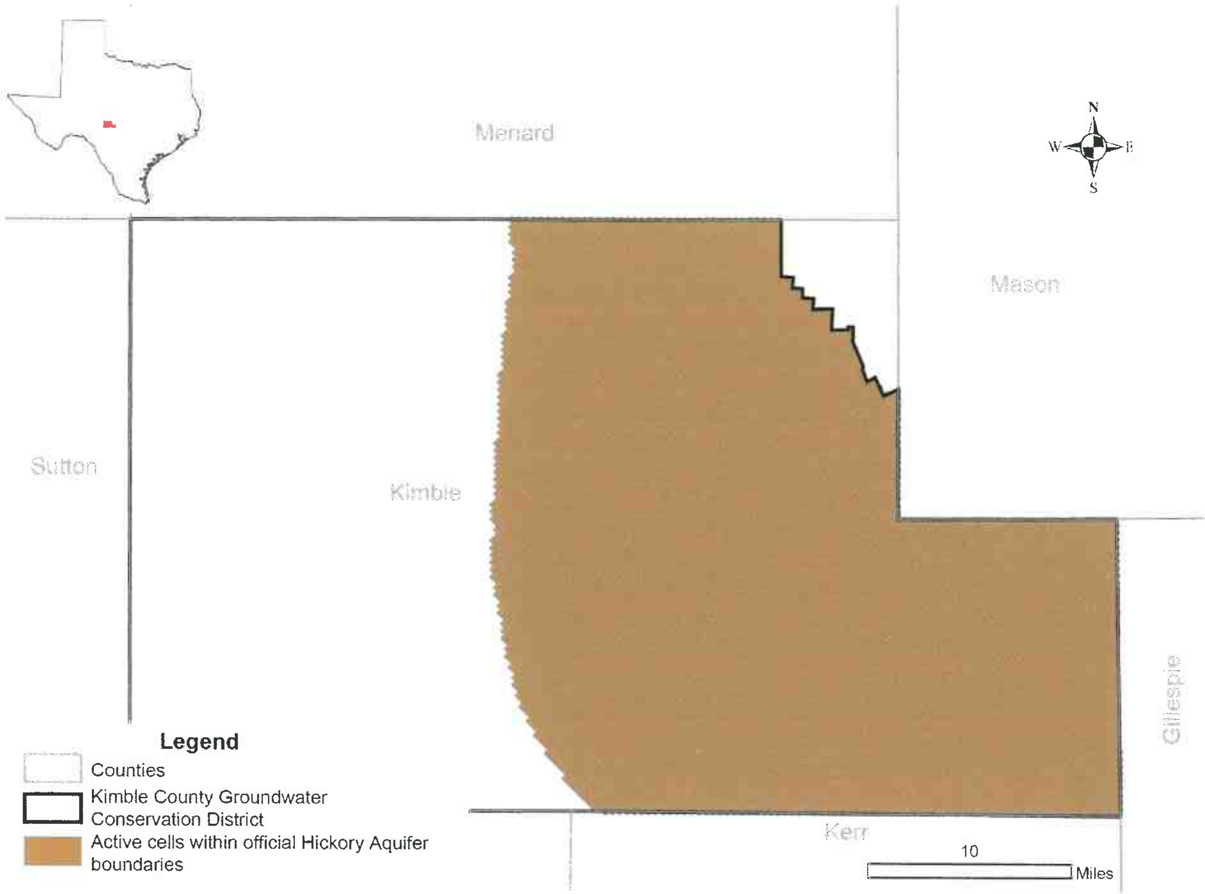

FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE HICKORY AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 4. SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FOR KIMBLE COUNTY 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	Edwards-Trinity (Plateau) Aquifer	31,514
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	57,664
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	29,787
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	10,859
Estimated net annual volume of flow between each aquifer in the district	Flow between the Edwards-Trinity (Plateau) Aquifer and adjacent formations	1*

*—From the groundwater availability model for the minor aquifers in the Llano Uplift Region (Shi and others, 2016).

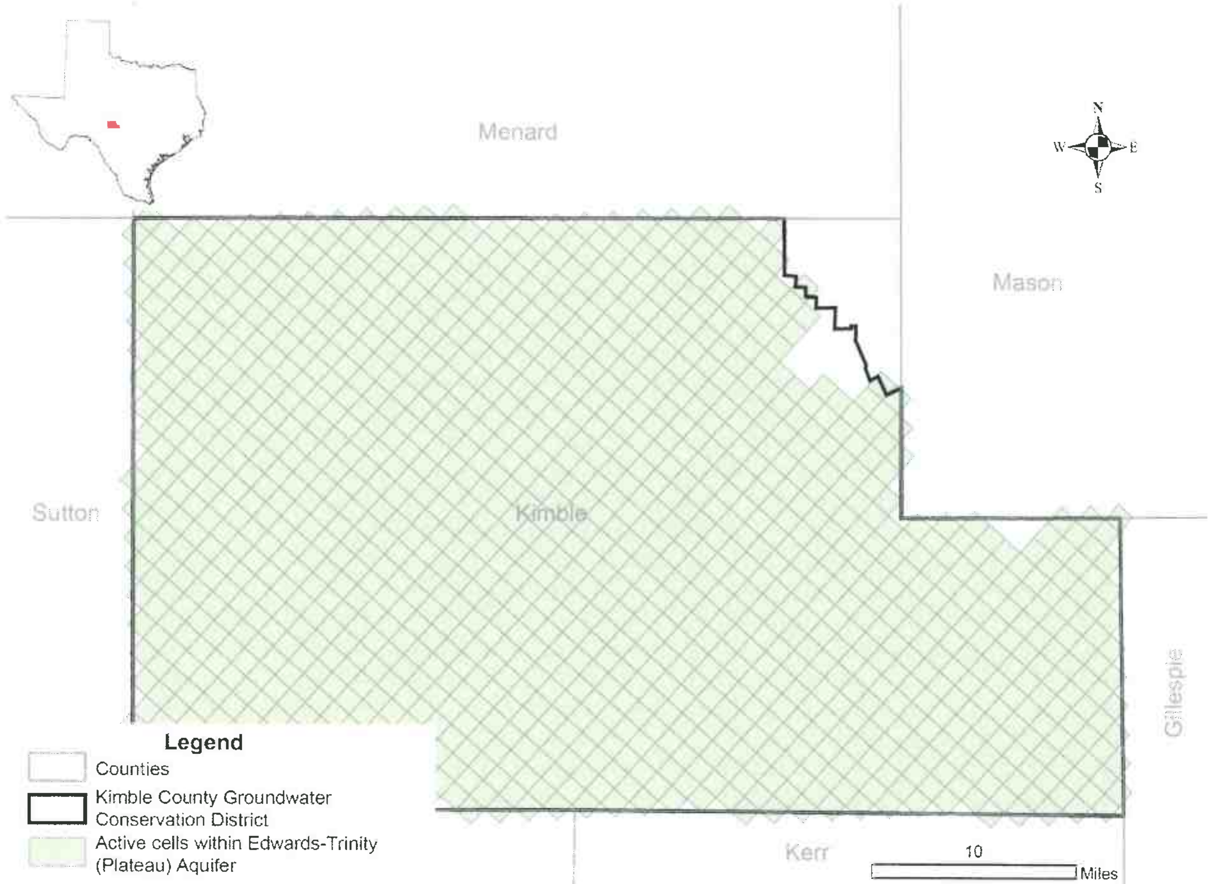

FIGURE 4. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS:

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

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

A key aspect of using the groundwater model to evaluate historical groundwater flow conditions includes the assumptions about the location in the aquifer where historical pumping was placed. Understanding the amount and location of historical pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and interaction with streams are specific to particular historical 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. Historical 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:

Anaya, R., and Jones, I. C., 2009, Groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers of Texas: Texas Water Development Board Report 373, 103 p. http://www.twdb.texas.gov/groundwater/models/gam/eddt_p/ET-Plateau_Full.pdf

Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models: U.S. Geological Survey Groundwater Software.

Harbaugh, A. W., and McDonald, M. G., 1996, User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 96–485, 56 p.

National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p., http://www.nap.edu/catalog.php?record_id=11972.

Panday, S., Langevin, C.D., Niswonger, R.G., Ibaraki, M., and Hughes, J.D., 2013, MODFLOW-USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6 chap. A45, 66 p.

Seiter-Weatherford, C., 2013, GAM Run 13-018: Kimble County Groundwater Conservation District Management Plan, 10 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR13-018.pdf

Shi, J., Boghici, R., Kohlrenken, W., and Hutchison, W.R., 2016, Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory). Texas Water Development Board, draft report, June 2016 (under final review), 403p.

Texas Water Code, 2011, https://statutes.capitol.texas.gov/docs/WA/pdf/WA.36.pdf

APPENDIX C

This page is intentionally blank.

management plan for the Kimble County Groundwater Conservation District expires on July 11, 2019.

We used two groundwater availability models to estimate the management plan information for the aquifers within the Kimble County Groundwater Conservation District. Information for the Marble Falls, Ellenburger-San Saba, and Hickory aquifers is from version 1.01 of the groundwater availability model for the minor aquifers of the Llano Uplift Region (Shi and others, 2016). Information for the Edwards-Trinity (Plateau) Aquifer is from version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Anaya and Jones, 2009).

This report replaces the results of GAM Run 13-018 (Seiter-Weatherford, 2013). GAM Run 18-015 includes results from the groundwater availability model for the minor aquifers of the Llano Uplift Region (Shi and others, 2016). Tables 1 through 4 summarize the groundwater availability model data required by statute and Figures 1 through 4 show the area of the models from which the values in the tables were extracted. If, after review of the figures, the Kimble County 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 two groundwater availability models mentioned above were used to estimate information for the Kimble County Groundwater Conservation District management plan. Water budgets were extracted for the historical model periods for the Marble Falls, Ellenburger-San Saba, and Hickory aquifers (1981 through 2010) using ZONEBUDGET-USG (Panday and others, 2013). The water budget for the Edwards-Trinity (Plateau) Aquifer was extracted for the historical model period (1981 through 2000) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface-water outflow, flows between aquifers in the district, inflow to the district, and outflow from the district for the aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Edwards-Trinity (Plateau) Aquifer

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers. See Anaya and Jones (2009) for assumptions and limitations of the model.

summary tables is footnoted where appropriate to clarify these aquifer relationships.

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Marble Falls, Ellenburger-San Saba, Hickory, and Edwards-Trinity (Plateau) aquifers located within Kimble County Groundwater Conservation District and averaged over the historical calibration periods, as shown in Tables 1 through 4.

1. Precipitation recharge—the areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.

2. Surface-water outflow—the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.

3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.

4. Flow between aquifers—the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

The information needed for the district's management plan is summarized in Tables 1 through 4. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

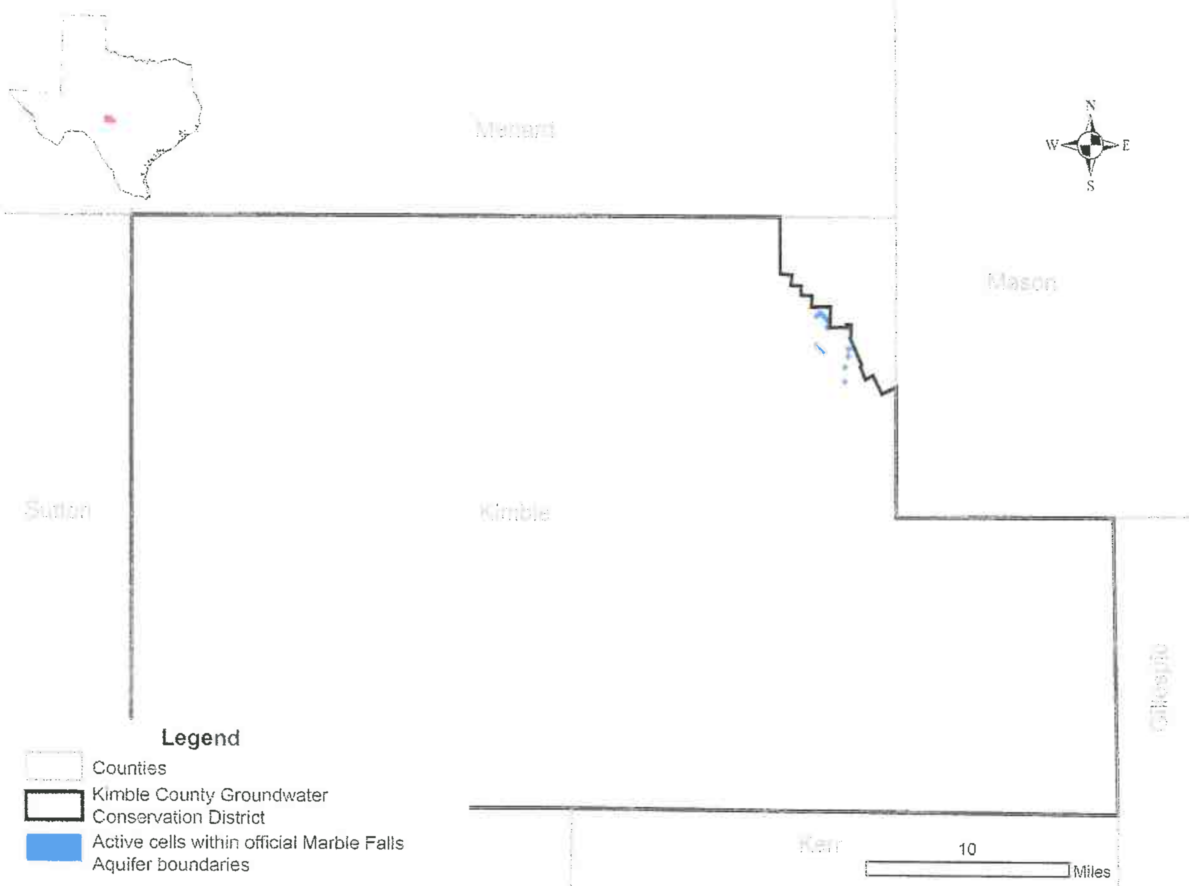

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE MARBLE FALLS AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

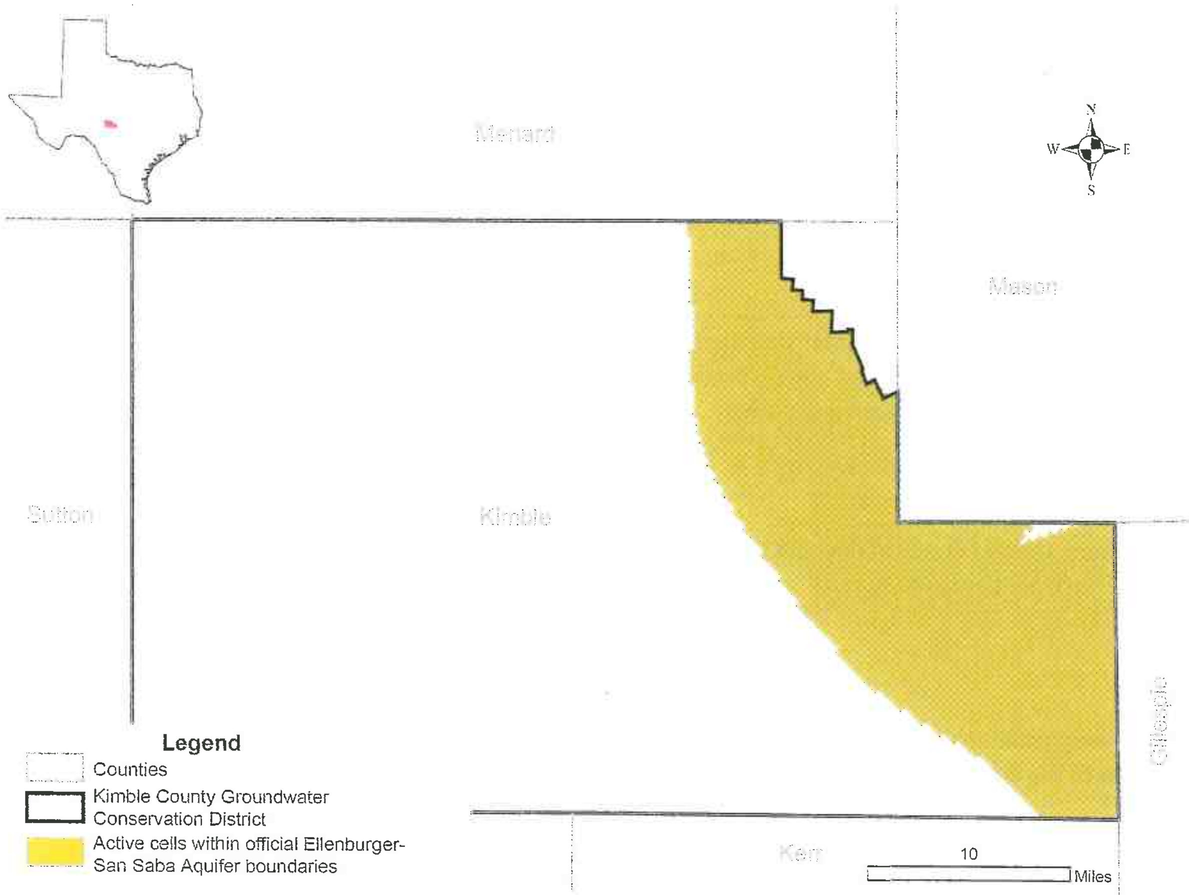

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE ELLENBURGER-SAN SABA AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

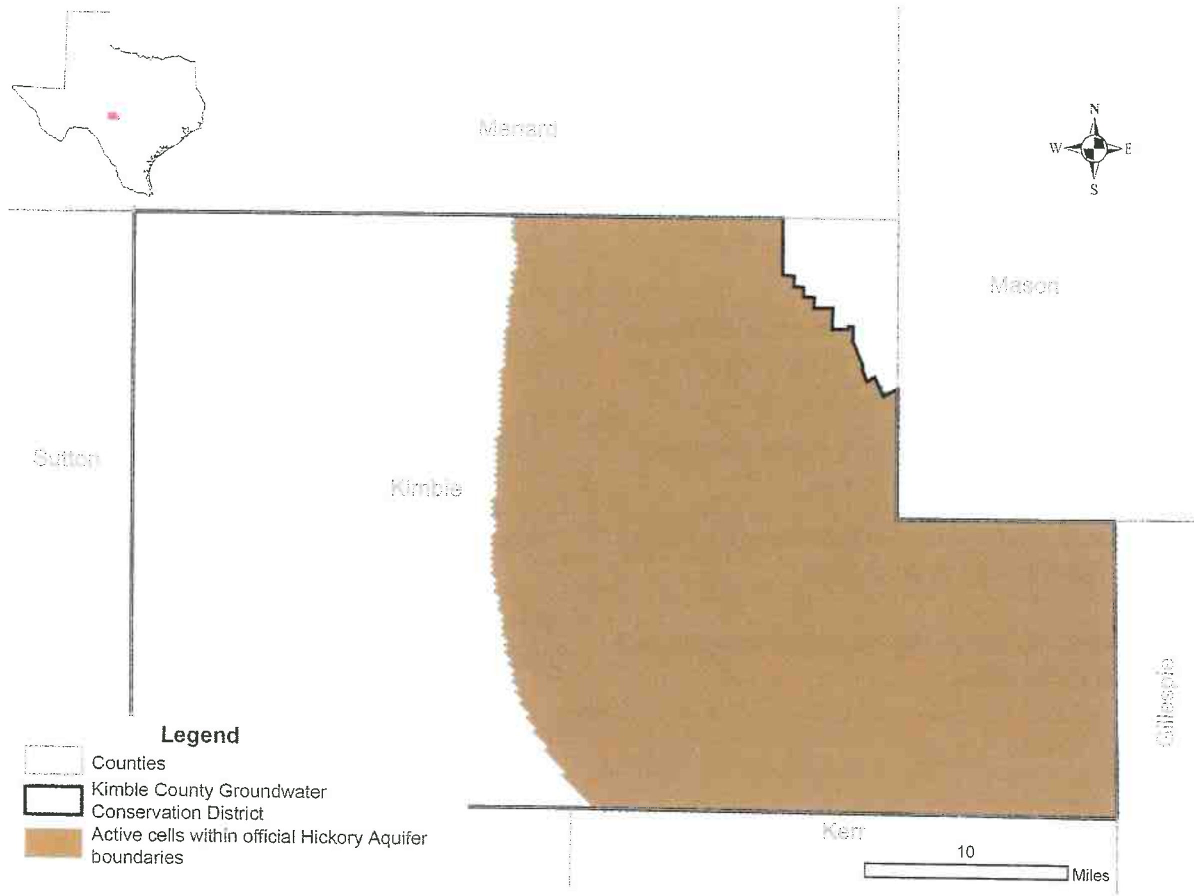

FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE HICKORY AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

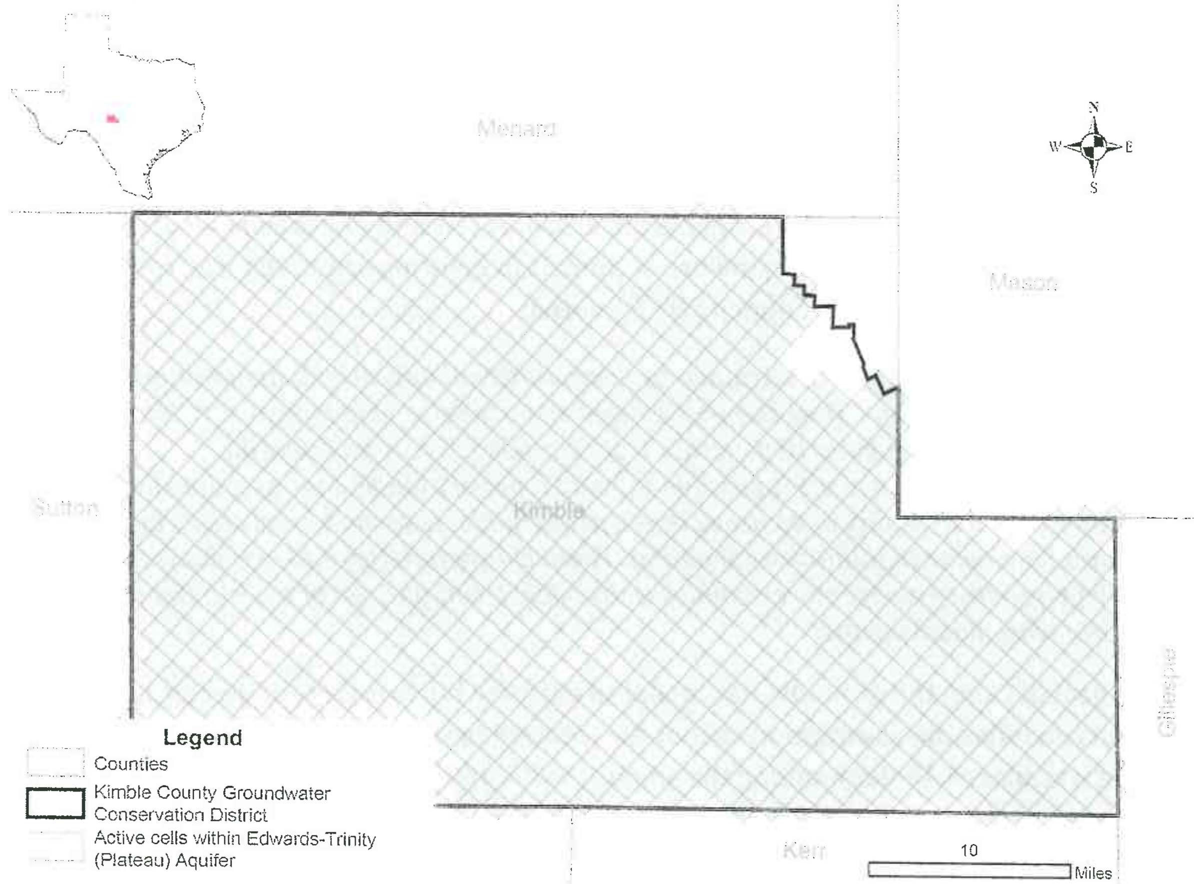

FIGURE 4. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

REFERENCES:

Anaya, R., and Jones, I. C., 2009, Groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers of Texas: Texas Water Development Board Report 373, 103 p. http://www.twdb.texas.gov/groundwater/models/gam/eddt_p/ET-Plateau_Full.pdf

Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models: U.S. Geological Survey Groundwater Software.

Harbaugh, A. W., and McDonald, M. G., 1996, User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 96–485, 56 p.

National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p., http://www.nap.edu/catalog.php?record_id=11972.

Panday, S., Langevin, C.D., Niswonger, R.G., Ibaraki, M., and Hughes, J.D., 2013, MODFLOW-USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6 chap. A45, 66 p.

Seiter-Weatherford, C., 2013, GAM Run 13-018: Kimble County Groundwater Conservation District Management Plan, 10 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR13-018.pdf

Shi, J., Boghici, R., Kohlrenken, W., and Hutchison, W.R., 2016, Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory). Texas Water Development Board, draft report, June 2016 (under final review), 403p.

Texas Water Code, 2011, https://statutes.capitol.texas.gov/docs/WA/pdf/WA.36.pdf