WES-TEX GROUNDWATER CONSERVATION DISTRICT

GROUNDWATER MANAGEMENT PLAN
2020-2025

Adopted January 30, 2020

DISTRICT MISSION

The Wes-Tex Groundwater Conservation District is committed to providing for the conservation, protection, the enhancement of recharge, and the prevention of waste of groundwater within the District by developing and implementing an efficient, economical and environmentally sound conservation program with full consideration and respect for the individual citizens of the District.

TIME PERIOD FOR THIS PLAN

This plan becomes effective upon the adoption by the Board of Directors of the Wes-Tex Groundwater Conservation District and approval by the Texas Water Development Board. The plan will be readopted with or without changes by the District Board and submitted to the Texas Water Development Board for approval at least every five years. {TWC §36.1072(e)}

STATEMENT OF GUIDING PRINCIPLES

The citizens of Nolan County recognize the vital importance of groundwater to the economy and longevity of the county. Groundwater being the predominate water resource, the district recognizes the need to conserve and protect the quantity and the quality of groundwater through prudent and cost effective management. The goals of this plan can be best achieved through guidance from locally elected board members who have an understanding of local conditions as well as technical support from knowledgeable agencies. Management planning should be based upon an awareness of the hydrogeologic properties of the specific aquifers within the District as well as quantification of existing and future resource data. This management plan is intended only as a reference tool to provide guidance in the execution of district activities, but should allow flexibility in achieving its goals.

GENERAL DESCRIPTION

The District was created by the citizens of Nolan County through election in November, 2002. There are nine members of the District's Board of Directors, elected as follows: one Director representing each of the Nolan County Commissioner's precincts and a member from an incorporated area and an unincorporated area within each of the four precincts. Additionally, one director is elected as an at-large position from the entire county. The Wes-Tex Groundwater Conservation District is co-extensive with the boundaries of Nolan County, Texas.

The county has a diverse economy, with energy, agriculture and industry all represented. Livestock operations include cattle, sheep, goats, and hogs. Crops include cotton, sorghum, wheat, hay, pecans, and some fruits and vegetables. One of the major industries is United States Gypsum, which began operations in Nolan County in 1924. Wind energy has recently become a major economic force in the county, with several large wind fields constructed since 2000. Oil and gas production have been a part of Nolan County for several decades. Lone Star Industries has been a major economic force since 1950. Texas State Technical College in Sweetwater is a vocational training facility that opened in 1970. Communities in the county include Sweetwater, Roscoe, Blackwell, Maryneal, and Nolan-Divide. The largest tourist attraction is the Sweetwater Rattlesnake Roundup held in March of each year.

LOCATION AND EXTENT

The Wes-Tex Groundwater Conservation District shares a boundary with Nolan County. Nolan County is in west central Texas, bounded on the east by Taylor County, on the south by Coke and Runnels counties, on the west by Mitchell County, and on the north by Fisher County. The center of the county lies at 32°18' north latitude and 100°24' west longitude. Sweetwater, the county seat and largest population center, is forty-two miles west of Abilene, 125 miles southeast of Lubbock, and 130 miles northeast of Odessa. It lies on the lower plains, with the western end of the Callahan Divide in the southern section of the county. The loamy soils of the county are light to dark, with deep, clayey or loamy subsoils and lime accumulations. The county has very little timber; hackberry, scrubby post oak, cottonwood, and mesquite trees grow along the streams, and Rocky Mountain junipers or scrub cedars grow on the hillsides. Annual rainfall averages 22.19 inches, and the growing season averages 221 days. Temperatures range from an average minimum of 30° F in January to an average maximum of 96° F in July. The agricultural economy centers around cattle and livestock products, but 50 percent of the annual agricultural income is from crops, especially cotton, wheat, sorghum, and hay. Petroleum, natural gas, gypsum, rock, and sand and gravel are also produced in the county. *

* Taken from "NOLAN COUNTY." Handbook of Texas Online <http www.tshautexas.edu/handbook/online/view/NN/hcn4 html> [Accessed Tue Aug 17 9.43 US/Central 2004] *by Gerald McDaniel*

TOPOGRAPHY AND DRAINAGE

The land is predominantly rolling uplands to the north, with plateaus traversed by valleys in the south; altitudes range from 2,000 to 2,700 feet above sea level. Streams in the northern part of the county, including Cottonwood, Bitter, Stink, and Sweetwater Creeks, drain into the Clear Fork of the Brazos River. In the southern part of the county Silver, Wilson, Fish, and Oak Creeks drain into the Colorado River.* USDA Hydrogeologic Units include #4812060102 - Brazos Watershed in the northern half of the county, #481208002 – Upper Colorado and Champion Watershed in the middle western portion of the county, #4812080008 – Oak Creek / Spence Watershed in the southern third of the county, and #4812090101 – Valley Creek Watershed in the extreme southeastern portion of the county. *(Source: USDA Natural Resources Conservation Service, Abilene Field Office)*

*Source. "NOLAN COUNTY." Handbook of Texas Online <http www tshautexas.edu/handbook/online/view/NN/hcn4 html> [Accessed Tue Aug 17 9:43 US/Central 2004, By *Gerald McDaniel*

REGIONAL COOPERATION AND COORDINATION

West Texas Regional Groundwater Alliance

As a groundwater conservation district within the houndaries 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 G Regional Water Planning Group

The District is located within the Region G Regional Water Planning Group. The general manager of the District is currently the Groundwater Management Area 7 voting representative on the Brazos G Regional Water Planning Group and attends the meetings. Consequently the District participates in the exchange of information and coordination of groundwater and surface water management strategies between GMA 7 and the Brazos G RWPG.

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 aquifer, but also includes all or portions of the minor Lipan-Kickapoo, Hickory, Ellenburger-San Saba, Dockum, Capitan Reef and Rustler aquifers, as well as a small portion of the Ogallala and Trinity aquifers.

Wes-Tex GCD 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 for the Edwards-Trinity (Plateau), Dockum and Blaine Aquifers.

GROUNDWATER RESOURCES OF THE WES-TEX GROUNDWATER CONSERVATION DISTRICT

Only two formations constitute significant aquifers in Nolan County. These are the Antlers Sand of the Cretaceous Trinity Group and the Santa Rosa Formation of the Triassic Dockum Group. In many areas of western Nolan County, the Antlers Sand and the Santa Rosa Formation lie beneath the limestones of the Edwards Group. Where the Edwards limestone and the Antlers Sand have been stripped away by erosion, the Dockum Group is either exposed or buried beneath the sand and gravel deposits of the Ogallala Formation (Pliocene). In some areas, the Ogallala also lies above the Antlers Sand. Although a major aquifer in the High Plains of western Texas, the Ogallala Formation in Nolan County lies above the regional water table and provides a pathway for the downward movement of water to recharge the Antlers and the Santa Rosa. Permian rocks lie beneath the Dockum Group, and are present in the subsurface throughout the county. In the northern part of the county, these rocks form extensive outcrops where erosion has removed the younger Cretaceous and Triassic rocks. Permian Rocks are in this area of Texas, however, are not a significant source of water.

The Antlers Sand provides small volumes of stock water for farms and ranches. The yields of many of the wells producing from this formation are less than 20 gallons per minute (gpm), although a few irrigation wells are reported to have yields of greater than 100 gpm.

The Santa Rosa Formation is the only significant source of groundwater. The formation is present in western Nolan County, but disappears toward the east and south because of erosion preceding the deposition of the Cretaceous formations. The formation probably disappears slightly to the west of Maryneal and east of Roscoe. The aquifer is confined in areas where the Santa Rosa lies beneath the Antlers Sand and the Edwards limestone. Recharge occurs by leakage through the overlying formations. Where the Santa Rosa Formation lies beneath the Ogallala Formation, groundwater occurs under unconfined conditions, and recharge is traceable to leakage from the Ogallala. The Texas Water Development Board estimates there are 569,920 acre feet of groundwater in storage in the Dockum aquifer in Nolan County, with all of that water having less than 5,000 mg/l of total dissolved solids (TDS). This is an estimate of storage only, not recoverable water. The 2006 Brazos Region G Water Plan estimates that only 3500 acre feet are available each year from the Dockum aquifer in Nolan County. The Trinity Edwards and the Dockum aquifers combined are estimated have a total availability of 4000 acre feet of water per year in Nolan County.

The Blaine Aquifer occurs in a very small area in northern Nolan County and the groundwater produced from such aquifer is of poor quality and small volume. Based on data that is currently available, it is that the Blaine aquifer is not a significant source of water in Nolan County. Accordingly, the District Board does not anticipate including the aquifer in its joint planning efforts and will not be setting a Desired Future Condition for the aquifer. In the event additional data is discovered to the contrary, the District Board will re-evaluate its position with regard to the Blaine Aquifer and include a comprehensive discussion of same in a future management plan.

In western Nolan County, there is a strong possibility of contamination by herbicides, pesticides and fertilizers. There is also a possibility of contamination by oil field brine.*

* *Report on Potential Areas for Groundwater Development in the Vicinity of Sweetwater, Nolan County, Texas:* LBG-Guyton Associates, Austin, Texas February 1997 Used with permission from the City of Sweetwater

MODELED AVAILABLE GROUNDWATER

Pursuant to provisions of §36.108 of the Texas Water Code enacted by HB 1763 in 2005, the groundwater conservation districts (GCDs) in groundwater management areas (GMAs) designated by the Texas Water Development board are required to meet jointly and adopt, by a two-thirds vote of the districts, Desired Future Conditions (DFCs) for the aquifers within the respective GMAs. DFCs are defined as "a quantitative description of the desired condition of the groundwater resources in a management area at one or more specified future times."
Once DFCs have been adopted by the GMA, they are submitted to the Texas Water Development Board which, in turn, calculates for each district within the GMA the amount of modeled available groundwater (MAG) within the district.
Section 36.001 of the Texas Water Code defines modeled available groundwater as "the amount of water that the Executive Administrator (of the TWDB) determines may be produced on an average annual basis to achieve a desired future condition established under §36.108."

Desired Future Conditions were adopted by Groundwater Management Area 7 on September, 2016 for Dockum Aquifer and on March 23, 2017 for the Edwards-Trinity (Plateau) Aquifer. Both aquifers were declared not relevant for joint planning purposes in Nolan County.

For the Dockum this was a change from 2010 when the DFC for Nolan County was set at drawdown not to exceed 39 feet from 2010 through 2070. For discussion about the changes to the Dockum in Nolan County see Appendix D, *GMA 7 Explanatory Report Final, Ogallala and Dockum Aquifers* , William R. Hutchison, November 22, 2016 pp. 8-9.

The Edwards-Trinity (Plateau) Aquifer was found not relevant for joint planning purposes in Nolan County in both 2010 and 2016.

It was determined that withdrawals from the aquifers in the District do not impact the surrounding counties and therefore no DFCS were adopted for Nolan County. Consequently no MAGS were calculated for the District in *GAM Run 16-026 MAG Version 2 : Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7*. (See Appendix C)
There are also no current modeled available groundwater numbers for the Blaine Aquifer in the District. Only a very small area of the aquifer underlies the district in the northern part of the county. The water is generally of poor quality and primarily used for livestock.

HISTORICAL GROUNDWATER USE WITHIN THE DISTRICT

Historical Groundwater Use within the District between 2013 and 2017 has ranged from a low of 12,567 acre-feet/year in 2015 to highest use of 15,992 acre-feet/year in 2017.

See Appendix B, *Estimated Historical Water Use and 2017 State Water Plan Datasets*, TWDB, December 20, 2019, p. 3 for details of historic groundwater use.

TABLE 1. SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FOR WES-TEX 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	11,385
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	10,813
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	215
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	1,197
Estimated net annual volume of flow between each aquifer in the district	*Not Applicable (NA)	NA*

*Not applicable because model assumes a no-flow boundary at the base.

Source: GAM Run 19-012 Wes-Tex GCD Management Plan
TWDB June 3, 2019
See Appendix A for full text of GAM Run 19-012

TABLE 2. SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER FOR WES-TEX 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	Dockum Aquifer	1,759
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	1,040
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	1,505
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	878
Estimated net annual volume of flow between each aquifer in the district	*Not Applicable	NA*

*Not applicable because model assumes a no-flow boundary at the base.

Source: GAM Run 19-012 Wes-Tex GCD Management Plan
TWDB June 3, 2019
See Appendix A for full text of GAM Run 19-012

TABLE 3. SUMMARIZED INFORMATION FOR THE BLAINE AQUIFER FOR WES-TEX 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	Blaine Aquifer	459
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Blaine Aquifer	232
Estimated annual volume of flow into the district within each aquifer in the district	Blaine Aquifer	232
Estimated annual volume of flow out of the district within each aquifer in the district	Blaine Aquifer	593
Estimated net annual volume of flow between each aquifer in the district	From other Permian units to Blaine Aquifer	1,737

Source: GAM Run 19-012 Wes-Tex GCD Management Plan
TWDB Jun 3, 2019
See Appendix A for full text of GAM Run 19-012

SURFACE WATER RESOURCES OF THE DISTRICT

Surface water availability in the Wes-Tex GCD is limited to small allocations from the Brazos River and the Lake Sweetwater Reservoir. The City of Sweetwater has authorized storage in Lake Sweetwater of 10,000 acre feet, and an authorized diversion of 3,740 acre feet. The priority date of this right is 10/17/27.

However, the frequent and extended droughts since the late 1990's have forced the City of Sweetwater to depend upon groundwater withdrawals for municipal use.

With regard to Brazos River Rights, H&H Feedlot in Nolan County has a 45 acre feet per year authorized diversion from the Brazos River, with a 1958 of priority date. Additionally, there are 90 acre feet per year authorized diversions for irrigation use.

PROJECTED SURFACE WATER SUPPLY IN THE DISTRICT

Total surface water supply for the district is projected to be 427 acre-feet annually for the 2020-2070 planning period. The largest use of surface water is for livestock local supply.

See Appendix B, *Estimated Historical Water Use and 2017 State Water Plan Datasets*, TWDB, Decemher 20, 2019 p.5

PROJECTED WATER DEMAND

Total water demand within the district for the 2020-2070 planning period is projected to increase from 25,413 acre-feet/year in 2020 to 35,979 acre-feet in 2070. Steam electric power is projected to account for most of the increase. Demand for irrigation is projected to decrease between 2020 and 2070.

See Appendix B. *Estimated Historical Water Use and 2017 State Water Plan Datasets*, TWDB, December 20, 2019 p. 6

PROJECTED WATER SUPPLY NEEDS

The District considered total projected water supply needs over the 2020-2070 planning period will range from 18,568 acre-feet/year in 2020, to 29,095 acre-feet/year in 2070.

The largest water supply needs of concern to the District are the increase in need for steam electric power in Nolan County from 13,526 acre-feet in 2020 to 23,916 acre-feet in 2020, an increase of 10,390 acre feet; an increase in municipal need for the City of Sweetwater from 1,349 to 1,576 acre-feet in 2070, an increase of 228 acre-feet; and an increase for manufacturing from 881 acre-feet in 2020 to 1,770 acre-feet in 20270, an increase of 889 acre-feet. Irrigation and mining will be facing water supply needs throughout the period, but in decreasing amounts over the fifty years.

See Appendix B, *Estimated Historical Water Use and 2017 State Water Plan Datasets*, TWDB, Decemher 20, 2019 p. 7

PROJECTED WATER MANAGEMENT STRATEGIES

Total projected water management strategies for the District for the 2020-2070 planning period range from 16,374 acre-feet/year in 2020 to 30,376 acre-feet in 2030 and 28,115 acre-feet/year in 2070.

The increased demand for water for steam electric power, the City of Sweetwater and manufacturing are projected to be met met primarily with surface water supplies from Cedar Ridge Lake/Reservoir and Hubbard Creek Lake/Reservoir and demand reduction which will not negatively impact the District's groundwater supplies.
The District has considered meeting the increased mining water supply needs in the District with projected withdrawals of an additional 220 acre-feet from the Edwards-Trinity (Plateau) aquifer.

Irrigation needs will primarily be addressed through reduction in demand.

See Appendix B, *Estimated Historical Water Use and 2017 State Water Plan Datasets*, TWDB, December 20, 2019 pp. 8-9

How Natural or Artificial Recharge of Groundwater Within The District Might Be Increased

Brush Management: The eradication of mesquite *(Prosopis sp.)* and juniper *(Juniperus sp.)* from areas of moderate to heavy brush canopy would yield additional groundwater supplies.

Groundwater Recharge Structures: Structures designed to collect impound surface water in canyons and streambeds cut into fractured rock could increase the volume of water available for recharge by slowing the amount of surface runoff during flood events.

DISTRICT MANAGEMENT OF GROUNDWATER SUPPLY

Based on estimates of current supply and projections it is obvious that issues will arise when demand exceeds supply. The District will use available regulatory statutes to encourage the cities of Sweetwater and Roscoe, and the Water Supply Corporations in the District to develop conservation plans and additional surface water supplies. The District will also encourage the creation of additional water supplies through groundwater conservation education programs at the school and community levels.

The District will continue to identify and engage in such activities and practices that, if implemented, would result in the conservation and protection of the groundwater. The observation and monitoring network will continue to be reviewed and maintained in order to monitor changing conditions of groundwater within the District. The District will undertake investigations of the groundwater resources within the District and will make the results of those investigations available to the public.

The District will adopt, as necessary, rules to regulate the groundwater withdrawals by means of spacing and/or production limits. The relevant factors to be considered in making the determination to grant a permit or limit groundwater withdrawal will include:

1. The purpose of the District and its rules;
2. The equitable conservation and preservation of the resource, and;
3. The economic hardship resulting from granting or denying a permit or the terms prescribed by the rules.

In pursuit of the District mission of conserving and protecting the resource, the District will enforce the terms and conditions of permits and rules of the District by enjoining the permit holder in a court of competent jurisdiction, as provided for in TWC §36.102, if necessary.

ACTIONS, PROCEDURES, PERFORMANCES AND AVOIDANCE FOR PLAN IMPLEMENTATION {31 TAC §356.5(a)(4)}

The District will implement the provisions of the plan and will utilize the provisions of the plan as a guidepost for determining the direction or priority for all District Activities. All operations of the District, all agreements entered into by the District, and any additional planning efforts in which the District may participate will be consistent with the provisions of the plan.

The District will adopt, as necessary, rules relating to the implementation of this plan. The rules adopted by the District shall be pursuant to TWC §36 and the provisions of this plan. All rules will be adhered and enforced. The promulgation and enforcement of the rules will be based upon the best technical evidence available. The current rules of the District are available in the District office and also online at http://westexgcd.org/files/wtgcdrules3.org .

The District shall treat its citizens non-discriminatorily. Citizens may apply to the District for a discretionary exception or variance in enforcement of the rules on grounds of adverse economic effect or unique local characteristics. In exercising such discretion, the District Board shall consider the potential for adverse effect on adjacent landowners, aquifer conditions across the district, and the effect on implementation of the District's Desired Future Conditions and negative precedent. The exercise of such discretion by The District Board shall not be construed as limiting the power of The District Board.

DISTRICT METHODOLOGY FOR TRACING PROGRESS IN ACHIEVING MANAGEMENT GOALS

The District Manager will prepare and present an annual report to The District Board of Directors on the District performance in regard to achieving management goals and objectives during the first monthly Board of Directors meeting each fiscal year, beginning October 1, 2005. This report will include the number of instances each activity was engaged in during the year.

The annual report will be maintained on file at the District office.

GOALS, MANAGEMENT OBJECTIVES AND PERFORMANCE STANDARDS

GOAL 1.0 – Providing for the Most Efficient Use of Groundwater {31 TAC §356.52(a)(1)(A)}

1.1 Management Objective

Each year, on two (2) or more occasions, the District will disseminate educational information relating to conservation practices for the efficient use of water resources. These will include but are not limited to publications from the Texas Water Development Board, the Texas Commission on Environmental Quality, Texas Cooperative Extension Service, the Texas Water Resource Institute, and other resources.

1.1 Performance Standard - Number of occasions, annually, that the District distributed educational information packets related to conservation practices for the efficient use of groundwater will be reported in the Annual Report to the Board of Directors

GOAL 2.0 – Controlling and preventing waste of groundwater {31 TAC §356.52(a)(1)(B)}

2.1 Management Objective

The District will track the number and status of reported wasteful practices and non-beneficial water use in the District. If a wasteful practice is reported to the District, the District will respond in writing within five (5) working days.

2.1 Performance Standard - All reports of wasteful practices will be summarized in the annual report to the Board of Directors. Summaries shall include all relevant dates, information, and any remedial action taken by the District (if applicable).

2.2 Management Objective

The general manager will disseminate educational information or article concerning beneficial use and the identification of wasteful practices on at least two occasions each year.

2.2 Performance Standard – The number of occasions the District submitted or disseminated information to district citizens shall be reported to the board of directors in the annual report each year.

GOAL 3.0 Addressing Conjunctive Surface Water Issues {TAC §356.52(a)(1)(D)}

3.1 Management Objective

The district will coordinate with the City of Roscoe to explore to opportunities for conjunctive use of surface water and groundwater for the City's public water supply.

3.1 Performance Standard – The district manager will meet once a year with the city manager and/or the city water utilities manager of Roscoe to discuss conjunctive water use implementation. Documentation of this meeting will be included in the annual report.

3.2 Management Objective

The District will actively participate in the Brazos Region G Regional Planning Process to monitor surface water issues and data that has potential for implementation of conjunctive use in the district.

3.2 Performance Standard – The general manager will attend at least two meetings of the Brazos G

RPG annually, will review the agenda of each meeting available on the Brazos G RPG website, and will include in the District annual report a report of relevant agenda items relating to conjunctive use that were discussed in the Brazos G RWPG meetings.

Goal 4.0 - Addressing Natural Resource Issues Which Impact the Use and Availability of Groundwater, and Which are Impacted by the Use of Groundwater {31 TAC §356.52(a)(1)(E)

4.1. Management Objective

Although there is very little oil production in the District, one or more selected wells within areas of the District where there is oil production will be tested for possible petroleum related contamination which would jeopardize the integrity 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 {31 TAC §356.52(a)(1)(F)}

5.1 Management Objective

On a monthly basis, provided updates have been posted, the district will download updated information from the U. S. Drought Monitor website www.droughtmonitor.unl.edu. In addition, the district will check for the periodic updates to drought monitoring information on www.waterdatafortexas.org/drought .

5.1 Performance Standard – At least quarterly, the District will assess the status of drought in the District and will provide information from the U. S. Drought Monitor website, if available, to the Board of Directors. The U. S. Drought Monitor and other downloaded drought monitor information will be included in the District annual report provided to the Directors.

GOAL 6.(a) – Addressing Conservation {TAC §356.52(a)(1)(G)}

6(a)1. Management Objective

The district will submit an article regarding water conservation for publication each year to at least one newspaper of general circulation in Nolan County.

6(a)1. Performance Standard – A copy of the article submitted by the District for publication will be included in the annual report given to the Board of Directors.

6(a)2. Management Objective

District personnel will at least once a year, present a water conservation program to school, 4-H, scouting, or a community group. Conservation literature will be distributed to participants at the program.

6(a)2. Performance Standard – A summary of programs presented, content, and audience group will be submitted in the annual report. A list of conservation literature distributed the audience will be included with the summary. The number of programs presented will be included in the report.

6 (a)3. Management Objective

The District will implement a district-wide monitoring network to evaluate whether the District groundwater resources are currently being managed sustainably or require additional conservation measures on the part of the District to implement sustainability. The monitoring network will be comprised of well owners who cooperate with the District in having their well levels measured. At least twenty wells will be monitored by district personnel (or assigns) for static water levels at least quarterly each year. The District will monitor well levels in at least one well in each aquifer in the district. The District will also review TWDB-measured groundwater levels, if any, in the District. The District annual report will show the change in water levels in each monitor wells from the previous year, and once a five-year record of well levels has been established, will show the change from levels taken five years previously.

6.(a) 3. Performance Standard - The number of wells involved in the monitoring network, and respective static water levels, will be reported to the Board of Directors annually, as well as levels in TWDB-measured wells, if any. Wells will be placed on a well numbering grid map for reference. The change in water levels in each monitor well from the previous year, and, once a five-year record of well levels has been established, the change from levels taken five years previously, will be included in the annual report.

GOAL 6 (b) Addressing Rainwater Harvesting {TAC §356.52(a)(1)(G)}

6 (b)1. Management Objective

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

6 (b)1. Performance Standard - Annual report to Board including the number of presentations of rainwater harvesting literature at educational presentation. The title of documents distributed will be included in the Annual Report to the Board of Directors.

GOAL 6(c) - Addressing brush control {TAC §356.52(a)(1)(G)}

6 (c)1. Management Objective

Include literature on brush control in one conservation presentation annually including information on the Texas State Soil and Water Conservation Board Water Supply Enhancement or the Natural Resources Conservation Service Environmental Quality Incentives Program cost-share programs.

6(c)1. Performance Standard - Annual report to Board will report the presentations at which brush control literature was distributed, including a list of literature provided.

Management Goals Not Applicable to the District

Controlling and Preventing Subsidence: The District has reviewed the TWDB *Final Report: Identification of the Vulnerability of The Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping* (March 21, 2017 with applicability to the District. The determination of risk for the District aquifers was reported as follows:

Edwards-Trinity (Plateau Aquifer): low to medium risk (p. 4-32)
Blaine Aquifer: low risk (p. 4-87)
Dockum Aquifer: low to medium risk ((p. 4-126)

Consequently the District is not currently developing management goals or objectives for subsidence but will remain alert for revised reports over the five- year plan period. {31 TAC §356.52(a)(1)(C)}

Recharge Enhancement: This management plan addresses groundwater recharge structures. Groundwater recharge structures, although a possible method for increase of recharge is not an economically feasible strategy for implementation at this time. {TWC §36.1071(a)(7)}

Precipitation Enhancement: There is no existing precipitation enhancement program operating in Nolan County or surrounding counties with which the District could participate and share costs.
The cost of operating a single county precipitation enhancement program is not economically feasible. {TWC §36.1071(a)(7)}

Addressing Desired Future Conditions: Not applicable because the aquifers within District boundaries were declared not-relevant by GMA 7 during the most recent joint planning process. Therefore there are no desired future conditions to address. { TWC §36.108}

ACTION REQUIRED FOR PLAN APPROVAL
{31 TAC §356.6}

The current management plan, approved by the Board on January 30, 2020, will remain in effect until the District adopts an amended plan that is approved by the TWDB. The amended management plan will become effective as of the date of approval by the TWDB. To comply with the requirements of Chapter 36 of the Texas Water Code, the District will review its existing management plan annually and readopt the plan with or without revisions at least every five years.

References

2017 State Water Plan – Texas Water Development Board.

Aquifers of the Edwards Plateau, Texas Water Development Board, Report 360, edited by Mace, Angle and Mullican, February, 2004.

Aquifers of Texas, Texas Water Development Board, Report 345, by Ashworth and Hopkins, Novemher, 1995.

GAM of the Edwards-Trinity (Plateau) Aquifer of Texas, Texas Water Development Board, by Anaya, R. and Ridgeway, C., October 2004.

GAM 09-013 of the Edwards-Trinity (Plateau) Aquifer of Texas, Texas Water Development Board.

Groundwater Availability in Texas, Texas Department of Water Resources, Report 238, by Muller, D.A. and Price, R.D., 1979.

"NOLAN COUNTY." Handbook of Texas Online.
<http:www.tshautexas.edu/handbook/online/view/NN/hcn4.html> [Accessed Tue Aug 17 9:43 US/Central 2004.] *by Gerald McDaniel*

Report on Potential Areas for Groundwater Development in the Vicinity of Sweetwater, Nolan County, Texas: LBG-Guyton Associates, Austin, Texas. February 1997. Used with permission from the City of Sweetwater.

Final Report: Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping TWDB Contract Number 1648302062, March 21, 2017

APPENDICES

APPENDIX A

GAM Run 19-012: Wes-Tex Groundwater Conservation District Management Plan
Texas Water Development Board
June 3, 2019

APPENDIX B

Estimated Historical Water Use and 2017 State Water Plan Datasets
TWDB , December 20, 2020

APPENDIX C

GAM Run 16-026 MAG version 2: Modeled Available Groundwater for Aquifers in Groundwater Management Area 7, TWDB, September 21, 2018

APPENDIX D

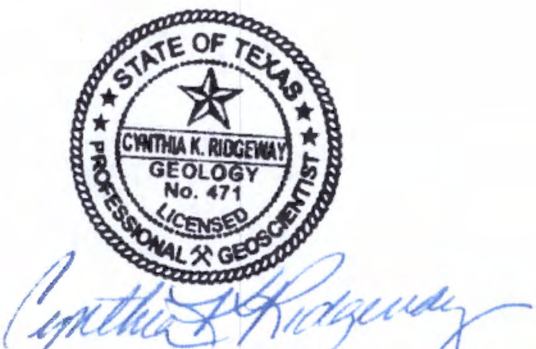
Groundwater Management Area 7 Explanatory Report-Final
Ogallala and Dockum Aquifers pp. 1-19
William R. Hutchison, November 22, 2016

APPENDIX A

This page is intentionally blank.

GAM Run 19-012: Wes-Tex Groundwater Conservation District Groundwater Management Plan

Daryn R. Hardwick, Ph.D.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-475-0470
June 3, 2019



Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Department and is responsible for oversight of work performed by Daryn R. Hardwick under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on June 3, 2019.

GAM RUN 19-012: WES-TEX GROUNDWATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Daryn R. Hardwick, Ph.D.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-475-0470
June 3, 2019

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 Wes-Tex 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 Wes-Tex Groundwater Conservation District should be adopted by the district on or before November 12, 2019 and submitted to the Executive Administrator of the TWDB on or before December 12, 2019. The current management plan for the Wes-Tex Groundwater Conservation District expires on February 10, 2020.

We used three groundwater availability models to estimate the management plan information for the aquifers within the Wes-Tex Groundwater Conservation District. 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). Information for the Dockum Aquifer is from version 1.01 of the groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015). Information for the Blaine Aquifer is from version 1.01 of the groundwater availability model for the Seymour and Blaine aquifers (Ewing and others, 2004).

This report replaces the results of GAM Run 13-030 (Goswami, 2014), as the approach used for analyzing model results has been since refined and GAM Run 19-012 includes results from the groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015), which was released after GAM Run 13-030. Tables 1, 2, and 3 summarize the groundwater availability model data required by statute and Figures 1, 2, and 3 show the area of the models from which the values in the tables were extracted. If, after review of the figures, the Wes-Tex 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 three groundwater availability models mentioned above were used to estimate information for the Wes-Tex Groundwater Conservation District groundwater management plan. Water budgets were extracted for the (post 1980) historical model periods for the Edwards-Trinity (Plateau) Aquifer (1980 through 2000), Dockum Aquifer (1980 through 2012), and Blaine Aquifer (1980 through 1999). We used ZONEBUDGET Version 3.01 (Harbaugh, 2009) to extract water budgets from the model results. The average annual water budget values for recharge, surface-water outflow, 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).

High Plains Aquifer System

- We used version 1.01 of the groundwater availability model for the High Plains Aquifer System for this analysis. See Deeds and Jigmond (2015) for assumptions and limitations of the model.
- The model has four layers which represent the Ogallala Aquifer (Layer 1), the Edwards-Trinity (High Plains) Aquifer (Layer 2), and the Dockum Units (Layers 3 and 4). We lumped layers 3 and 4 for calculating water budgets in the Dockum Aquifer within the district.
- Water budgets for the Dockum Aquifer within the district were averaged over the historical calibration period (1980 to 2012).
- The model was run with MODFLOW-NWT (Niswonger and others, 2011).

Blaine Aquifer

- Version 1.01 of the groundwater availability model for the Seymour and Blaine aquifers was used for this analysis. See Ewing and others (2004) for assumptions and limitations of the groundwater availability model.

- This groundwater availability model includes two layers which represent the Seymour Aquifer (Layer 1) and the Blaine Aquifer or its non-aquifer equivalent (Layer 2).
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).
- An overall water budget for the district was determined using Layer 2 for the Blaine Aquifer. The Seymour Aquifer (Layer 1) is not present in Wes-Tex Groundwater Conservation District.

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 Edwards-Trinity (Plateau), Dockum, and Blaine aquifers located within Wes-Tex Groundwater Conservation District and averaged over the historical calibration periods, as shown in Tables 1 through 3.

1. Precipitation recharge—the areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.
2. Surface-water outflow—the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.
3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.
4. Flow between aquifers—the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

The information needed for the district's management plan is summarized in Tables 1 through 3. 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 EDWARDS-TRINITY (PLATEAU) AQUIFER FOR WES-TEX 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	11,385
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	10,813
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	215
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	1,197
Estimated net annual volume of flow between each aquifer in the district	Flow to other aquifers	NA[1]

[1]Not applicable. Model assumes a no-flow boundary at the base.

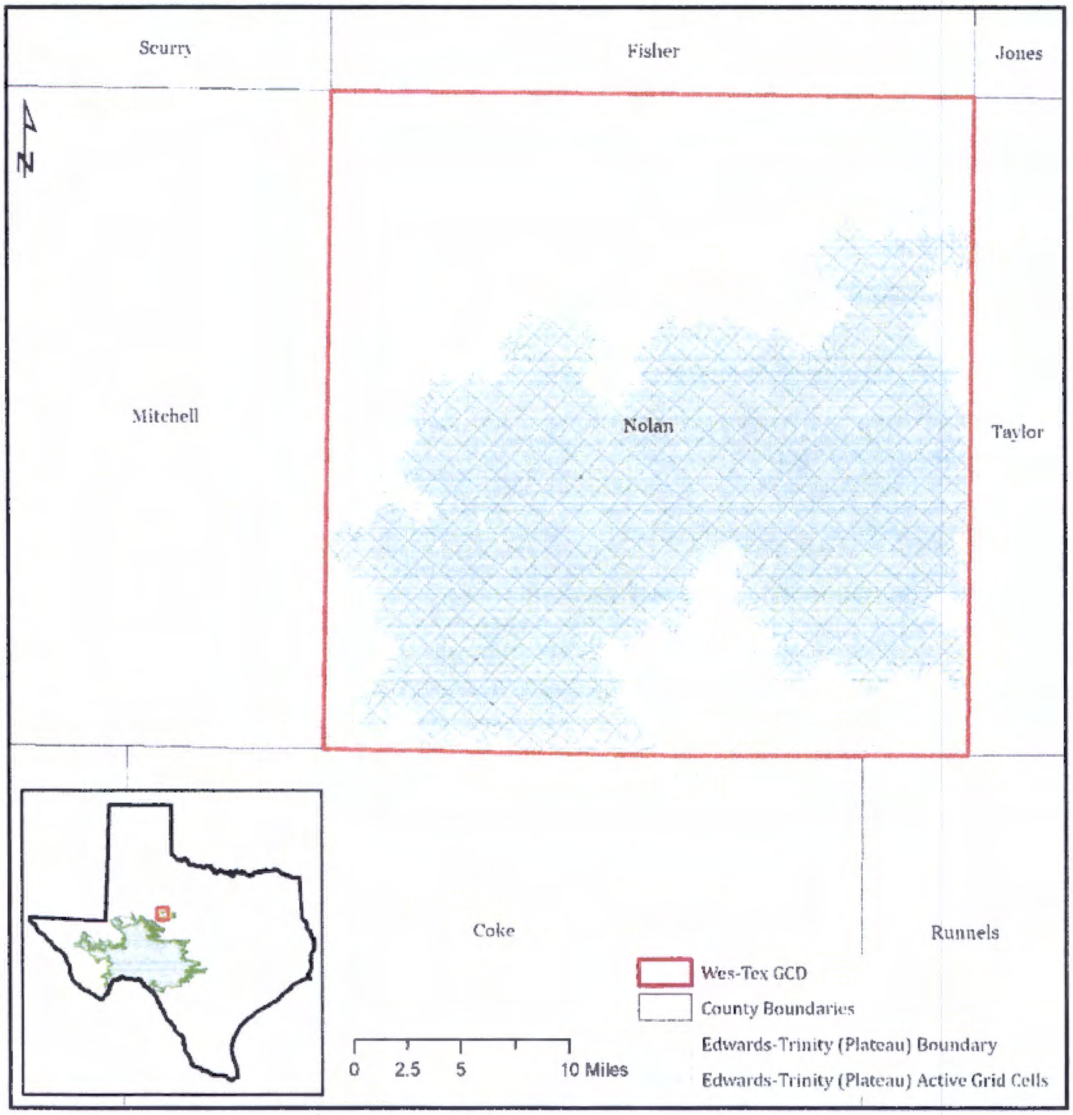


FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER FOR WES-TEX 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	Dockum Aquifer	1,759
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Dockum Aquifer	1,040
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	1,505
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	878
Estimated net annual volume of flow between each aquifer in the district	Flow to other aquifers	NA[2]

[2]Not applicable. Model assumes a no-flow boundary at the base.

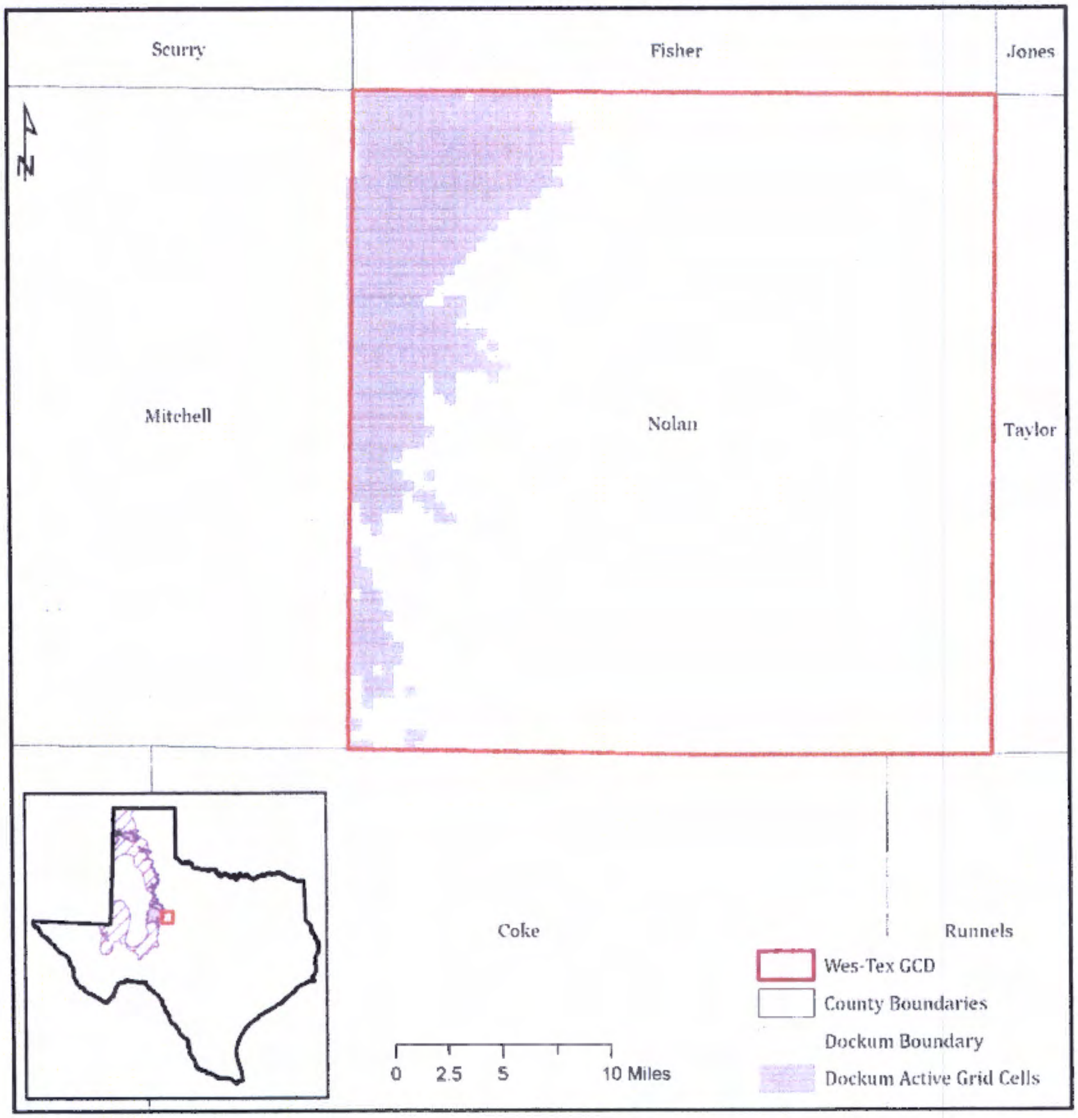


FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE BLAINE AQUIFER FOR WES-TEX 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	Blaine Aquifer	459
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Blaine Aquifer	232
Estimated annual volume of flow into the district within each aquifer in the district	Blaine Aquifer	232
Estimated annual volume of flow out of the district within each aquifer in the district	Blaine Aquifer	593
Estimated net annual volume of flow between each aquifer in the district	From other Permian units to Blaine Aquifer	1,737

Source: GAM Run 19-012 Wes-Tex GCD Management Plan
TWDB Jun 3, 2019
See Appendix A for full text of GAM Run 19-012

TABLE 3. SUMMARIZED INFORMATION FOR THE BLAINE AQUIFER FOR WES-TEX 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	Blaine Aquifer	459
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Blaine Aquifer	232
Estimated annual volume of flow into the district within each aquifer in the district	Blaine Aquifer	232
Estimated annual volume of flow out of the district within each aquifer in the district	Blaine Aquifer	593
Estimated net annual volume of flow between each aquifer in the district	From other Permian units to the Blaine Aquifer	1,737

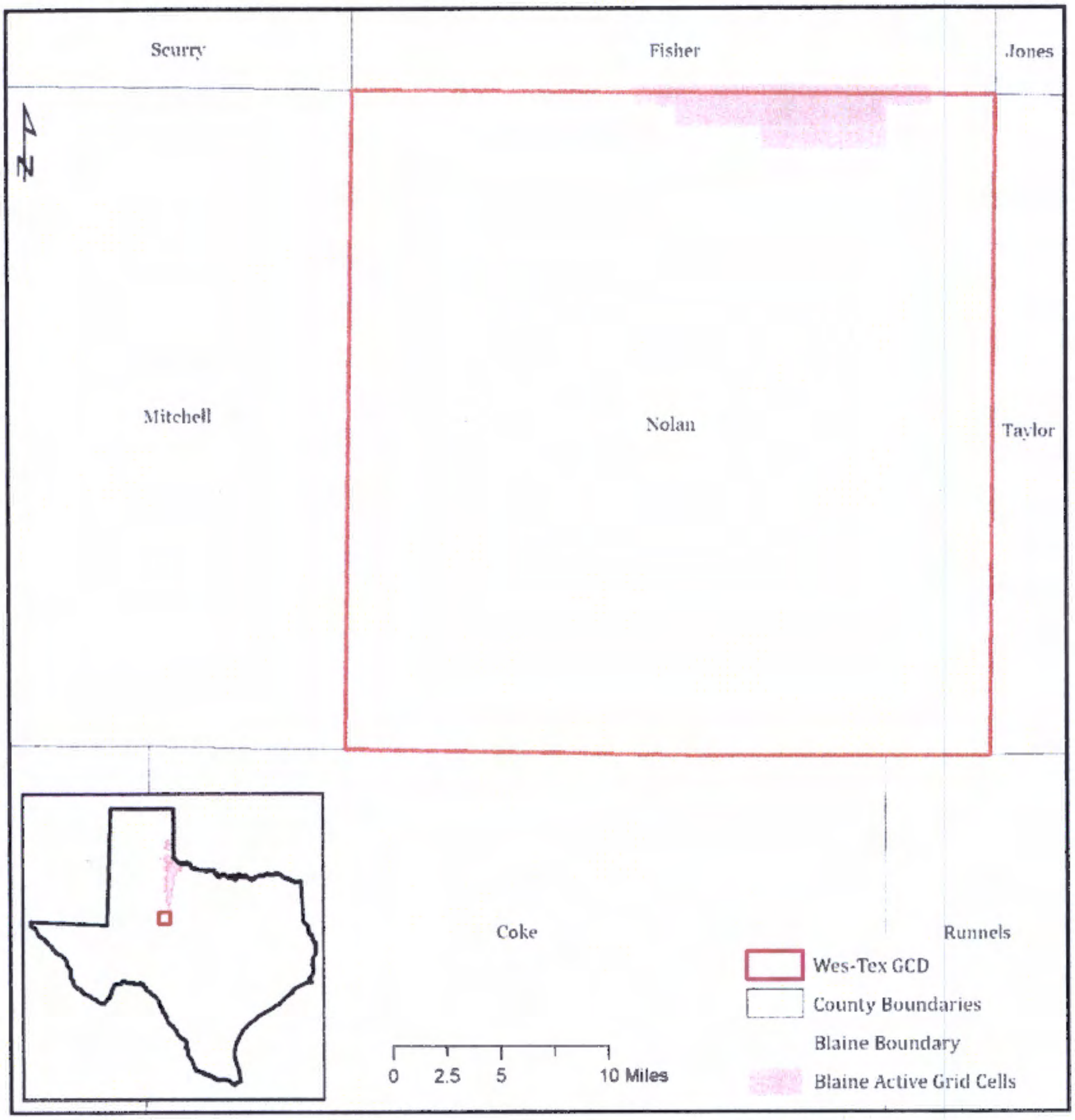


FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE BLAINE AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

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., 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/ETPlateau_Full.pdf.

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

Ewing, J.E., Jones, T.L., Pickens, J.F., Chastaun-Howley, A., Dean, K.E., Spear, A.A., 2004, Groundwater availability model for the Seymour Aquifer: Final report prepared for the Texas Water Development Board by INTERA, Inc., 533p., http://www.twdb.texas.gov/groundwater/models/gam/symr/SYMR_Model_Report.pdf.

Goswami, R. R., 2014, GAM Run 13-030: Wes-Tex Groundwater Conservation District Management Plan, 15 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR13-030.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., Banta, E. R., Hill, M. C., and McDonald, M. G., 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, 121 p.

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.

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

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

APPENDIX B

Estimated Historical Water Use And 2017 State Water Plan Datasets:

Wes-Tex Groundwater Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
December 20, 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 Water Use (checklist item 2)

   from the TWDB Historical Water Use Survey (WUS)

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

   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 12/20/2019. 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).

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 2018. TWDB staff anticipates the calculation and posting of these estimates at a later date.

NOLAN COUNTY

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2017	GW	1,501	297	0	0	14,046	148	15,992
	SW	269	136	0	0	30	98	533
2016	GW	1,244	292	6	0	11,839	153	13,534
	SW	434	159	0	0	258	103	954
2015	GW	1,622	214	1	0	10,578	152	12,567
	SW	234	135	0	0	278	101	748
2014	GW	1,793	229	26	0	11,788	148	13,984
	SW	247	140	0	0	12	99	498
2013	GW	1,585	271	51	0	12,468	150	14,525
	SW	388	121	0	0	3	100	612
2012	GW	1,567	255	22	0	12,449	182	14,475
	SW	354	136	0	0	0	121	611
2011	GW	1,974	252	0	0	12,243	205	14,674
	SW	318	129	0	0	0	137	584
2010	GW	1,603	310	59	0	8,055	203	10,230
	SW	256	138	16	0	67	135	612
2009	GW	1,794	230	76	0	11,218	223	13,541
	SW	118	13	21	0	112	149	413
2008	GW	2,026	606	95	0	10,111	235	13,073
	SW	0	123	25	0	35	157	340
2007	GW	2,338	445	0	0	5,783	236	8,802
	SW	24	123	0	0	0	157	304
2006	GW	2,692	459	0	0	5,208	249	8,608
	SW	207	123	0	0	88	166	584
2005	GW	1,836	600	0	0	5,356	216	8,008
	SW	597	176	0	0	155	144	1,072
2004	GW	2,115	531	0	0	4,138	16	6,800
	SW	428	154	0	0	93	301	976
2003	GW	3,204	79	0	0	3,158	14	6,455
	SW	795	455	0	0	13	268	1,531
2002	GW	2,591	79	0	0	2,865	22	5,557
	SW	1,167	444	0	0	216	410	2,237

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

NOLAN COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
G	IRRIGATION, NOLAN	BRAZOS	BRAZOS RUN-OF-RIVER	24	24	24	24	24	24
G	IRRIGATION, NOLAN	COLORADO	BRAZOS RUN-OF-RIVER	16	16	16	16	16	16
G	LIVESTOCK, NOLAN	BRAZOS	BRAZOS LIVESTOCK LOCAL SUPPLY	232	232	232	232	232	232
G	LIVESTOCK, NOLAN	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	155	155	155	155	155	155
G	SWEETWATER	BRAZOS	OAK CREEK LAKE/RESERVOIR	0	0	0	0	0	0
G	SWEETWATER	BRAZOS	SWEETWATER LAKE/RESERVOIR	0	0	0	0	0	0
G	SWEETWATER	BRAZOS	TRAMMEL LAKE/RESERVOIR	0	0	0	0	0	0
	Sum of Projected Surface Water Supplies (acre-feet)			**427**	**427**	**427**	**427**	**427**	**427**

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.

NOLAN COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
G	BITTER CREEK WSC	BRAZOS	162	164	165	170	175	179
G	COUNTY-OTHER, NOLAN	BRAZOS	130	132	132	135	139	142
G	COUNTY-OTHER, NOLAN	COLORADO	98	99	100	102	104	107
G	IRRIGATION, NOLAN	BRAZOS	4,448	4,330	4,214	4,105	3,998	3,898
G	IRRIGATION, NOLAN	COLORADO	2,965	2,887	2,810	2,737	2,665	2,599
G	LIVESTOCK, NOLAN	BRAZOS	232	232	232	232	232	232
G	LIVESTOCK, NOLAN	COLORADO	155	155	155	155	155	155
G	MANUFACTURING, NOLAN	BRAZOS	1,420	1,611	1,799	1,965	2,130	2,309
G	MINING, NOLAN	BRAZOS	101	100	90	80	71	63
G	MINING, NOLAN	COLORADO	124	122	110	98	87	78
G	ROSCOE	BRAZOS	200	204	205	211	217	222
G	STEAM ELECTRIC POWER, NOLAN	BRAZOS	13,526	23,916	23,916	23,916	23,916	23,916
G	SWEETWATER	BRAZOS	1,852	1,893	1,913	1,977	2,030	2,079
		Sum of Projected Water Demands (acre-feet)	**25,413**	**35,845**	**35,841**	**35,883**	**35,919**	**35,979**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

NOLAN COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
G	BITTER CREEK WSC	BRAZOS	237	243	249	248	249	248
G	COUNTY-OTHER, NOLAN	BRAZOS	-104	-107	-108	-113	-119	-125
G	COUNTY-OTHER, NOLAN	COLORADO	0	0	0	0	0	0
G	IRRIGATION, NOLAN	BRAZOS	-1,490	-1,372	-1,257	-1,147	-1,040	-940
G	IRRIGATION, NOLAN	COLORADO	-993	-915	-837	-765	-693	-627
G	LIVESTOCK, NOLAN	BRAZOS	0	0	0	0	0	0
G	LIVESTOCK, NOLAN	COLORADO	0	0	0	0	0	0
G	MANUFACTURING, NOLAN	BRAZOS	-881	-1,072	-1,260	-1,426	-1,591	-1,770
G	MINING, NOLAN	BRAZOS	-101	-100	-90	-80	-71	-63
G	MINING, NOLAN	COLORADO	-124	-122	-110	-98	-87	-78
G	ROSCOE	BRAZOS	84	80	79	73	67	62
G	STEAM ELECTRIC POWER, NOLAN	BRAZOS	-13,526	-23,916	-23,916	-23,916	-23,916	-23,916
G	SWEETWATER	BRAZOS	-1,349	-1,390	-1,410	-1,474	-1,527	-1,576
	Sum of Projected Water Supply Needs (acre-feet)		**-18,568**	**-28,994**	**-28,988**	**-29,019**	**-29,044**	**-29,095**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

NOLAN COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, NOLAN, BRAZOS (G)							
CEDAR RIDGE RESERVOIR	CEDAR RIDGE LAKE/RESERVOIR [RESERVOIR]	104	107	108	113	119	125
		104	**107**	**108**	**113**	**119**	**125**
COUNTY-OTHER, NOLAN, COLORADO (G)							
CEDAR RIDGE RESERVOIR	CEDAR RIDGE LAKE/RESERVOIR [RESERVOIR]	64	61	60	55	49	43
		64	**61**	**60**	**55**	**49**	**43**
IRRIGATION, NOLAN, BRAZOS (G)							
IRRIGATION WATER CONSERVATION	DEMAND REDUCTION [NOLAN]	133	217	295	287	280	273
		133	**217**	**295**	**287**	**280**	**273**
IRRIGATION, NOLAN, COLORADO (G)							
IRRIGATION WATER CONSERVATION	DEMAND REDUCTION [NOLAN]	89	144	197	192	186	182
		89	**144**	**197**	**192**	**186**	**182**
MANUFACTURING, NOLAN, BRAZOS (G)							
CEDAR RIDGE RESERVOIR	CEDAR RIDGE LAKE/RESERVOIR [RESERVOIR]	0	0	0	0	0	33
INDUSTRIAL WATER CONSERVATION	DEMAND REDUCTION [NOLAN]	43	81	126	138	149	162
OAK CREEK RESERVOIR-CONJUNCTIVE USE	OAK CREEK LAKE/RESERVOIR [RESERVOIR]	838	991	1,134	1,288	1,442	1,575
		881	**1,072**	**1,260**	**1,426**	**1,591**	**1,770**
MINING, NOLAN, BRAZOS (G)							
EDWARDS AQUIFER DEVELOPMENT	EDWARDS-TRINITY-PLATEAU AQUIFER [NOLAN]	99	99	99	99	99	98
INDUSTRIAL WATER CONSERVATION	DEMAND REDUCTION [NOLAN]	3	5	6	5	5	4
		102	**104**	**105**	**104**	**104**	**102**
MINING, NOLAN, COLORADO (G)							
EDWARDS AQUIFER DEVELOPMENT	EDWARDS-TRINITY-PLATEAU AQUIFER [NOLAN]	121	121	121	121	121	122

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

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

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
INDUSTRIAL WATER CONSERVATION	DEMAND REDUCTION [NOLAN]	4	6	8	7	6	6
		125	**127**	**129**	**128**	**127**	**128**
STEAM ELECTRIC POWER, NOLAN, BRAZOS (G)							
CEDAR RIDGE RESERVOIR	CEDAR RIDGE LAKE/RESERVOIR [RESERVOIR]	0	9,999	9,298	7,901	6,602	5,383
JONES COUNTY REALLOCATION TO NOLAN COUNTY SE	HUBBARD CREEK LAKE/RESERVOIR [RESERVOIR]	7,914	11,543	11,441	11,473	11,353	11,319
REDUCE DEMAND THROUGH ALTERNATIVE COOLING	DEMAND REDUCTION [NOLAN]	5,612	5,612	5,612	5,612	5,961	7,214
		13,526	**27,154**	**26,351**	**24,986**	**23,916**	**23,916**
SWEETWATER, BRAZOS (G)							
CEDAR RIDGE RESERVOIR	CEDAR RIDGE LAKE/RESERVOIR [RESERVOIR]	574	806	969	1,187	1,394	1,576
MUNICIPAL WATER CONSERVATION (RURAL) - SWEETWATER	DEMAND REDUCTION [NOLAN]	39	0	0	0	0	0
OAK CREEK RESERVOIR-CONJUNCTIVE USE	OAK CREEK LAKE/RESERVOIR [RESERVOIR]	737	584	441	287	133	0
		1,350	**1,390**	**1,410**	**1,474**	**1,527**	**1,576**
Sum of Projected Water Management Strategies (acre-feet)		**16,374**	**30,376**	**29,915**	**28,765**	**27,899**	**28,115**

APPENDIX C

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

This page is intentionally left blank.

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).

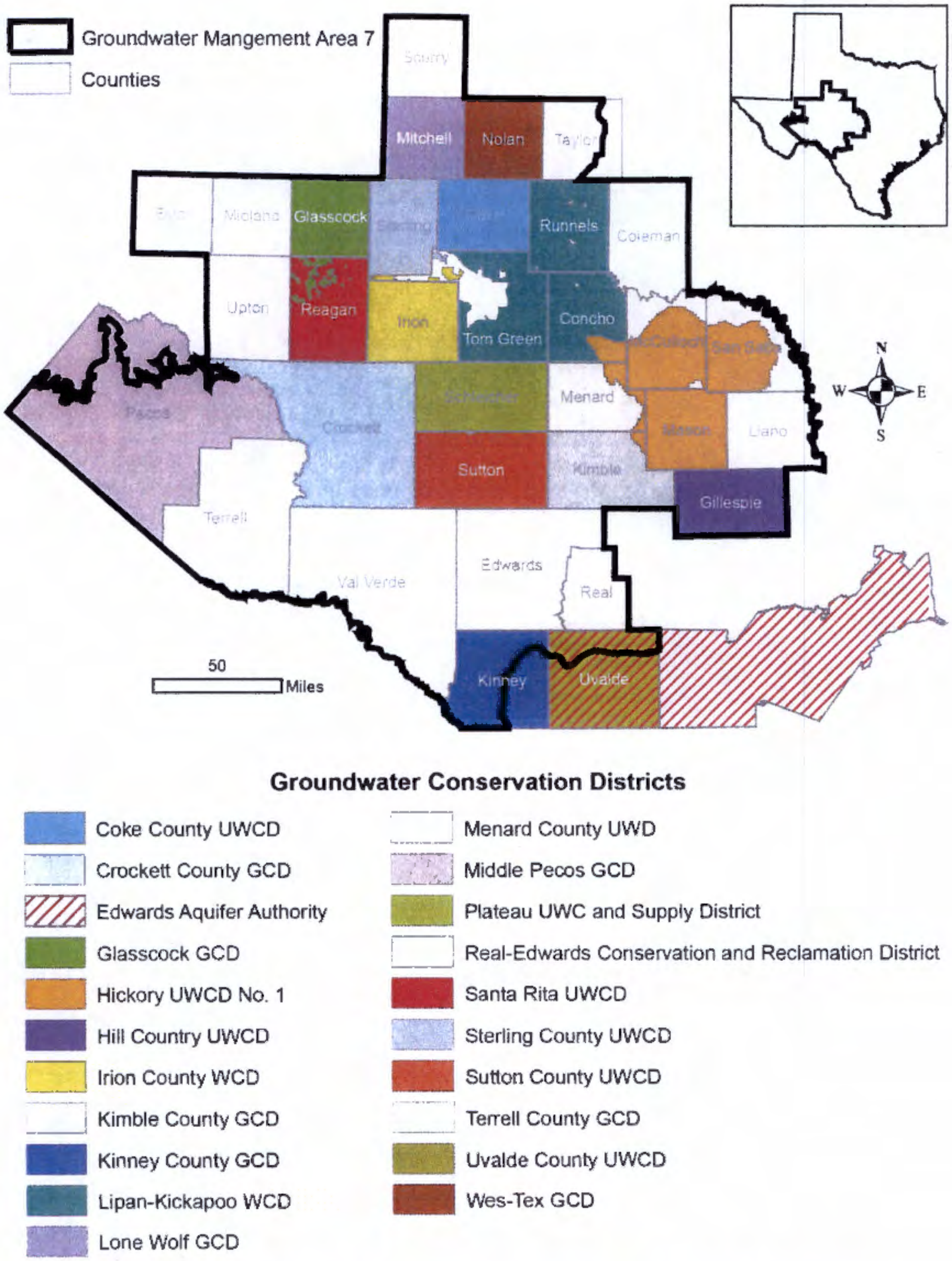


FIGURE 1. MAP SHOWING THE GROUNDWATER CONSERVATION DISTRICTS (GCD) IN GROUNDWATER MANAGEMENT AREA 7. NOTE: THE BOUNDARIES OF THE EDWARDS AQUIFER AUTHORITY OVERLAP WITH THE UVALDE COUNTY UNDERGROUND WATER CONSERVATION DISTRICT (UWCD).

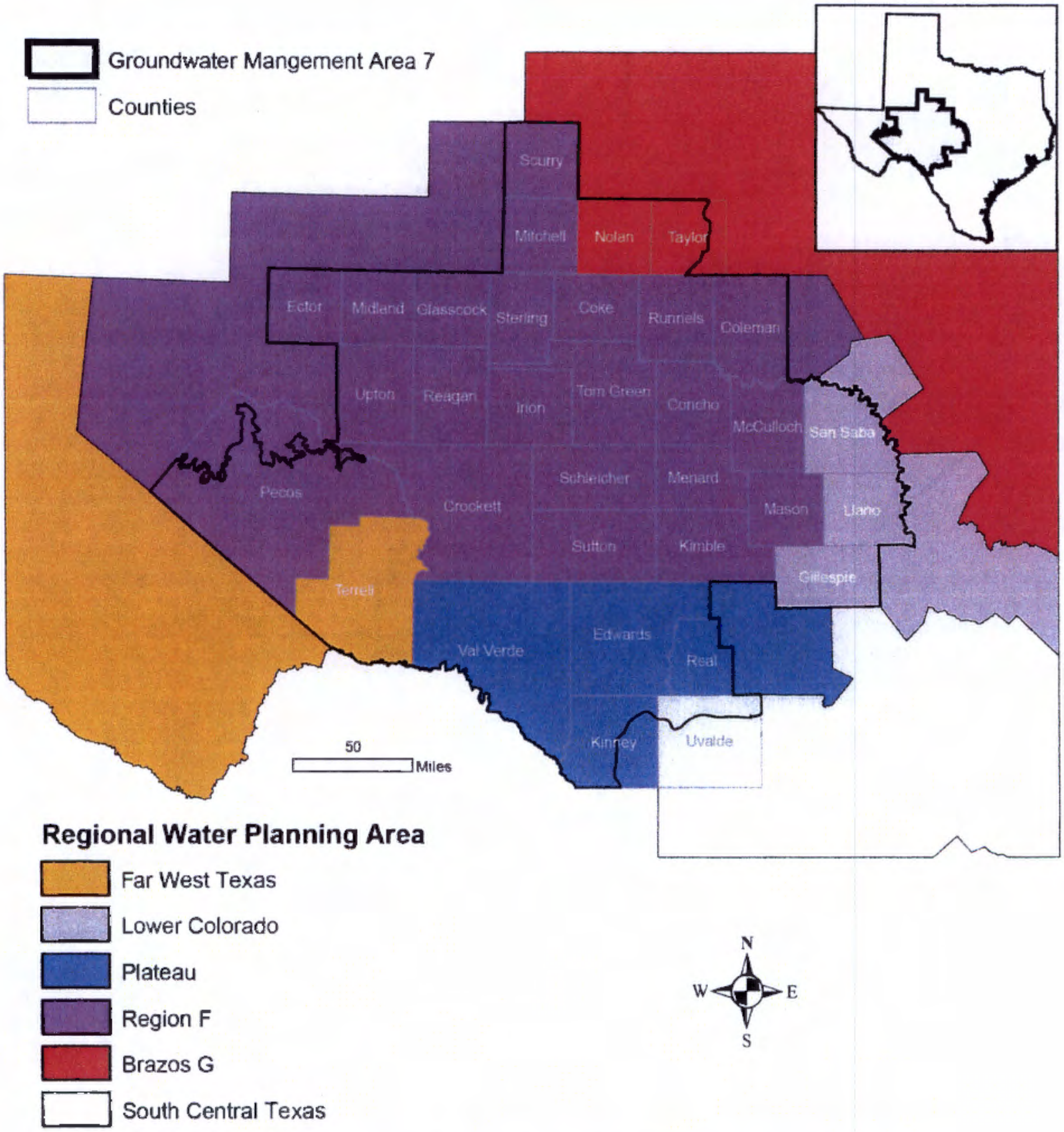


FIGURE 2. MAP SHOWING REGIONAL WATER PLANNING AREAS IN GROUNDWATER MANAGEMENT AREA 7.

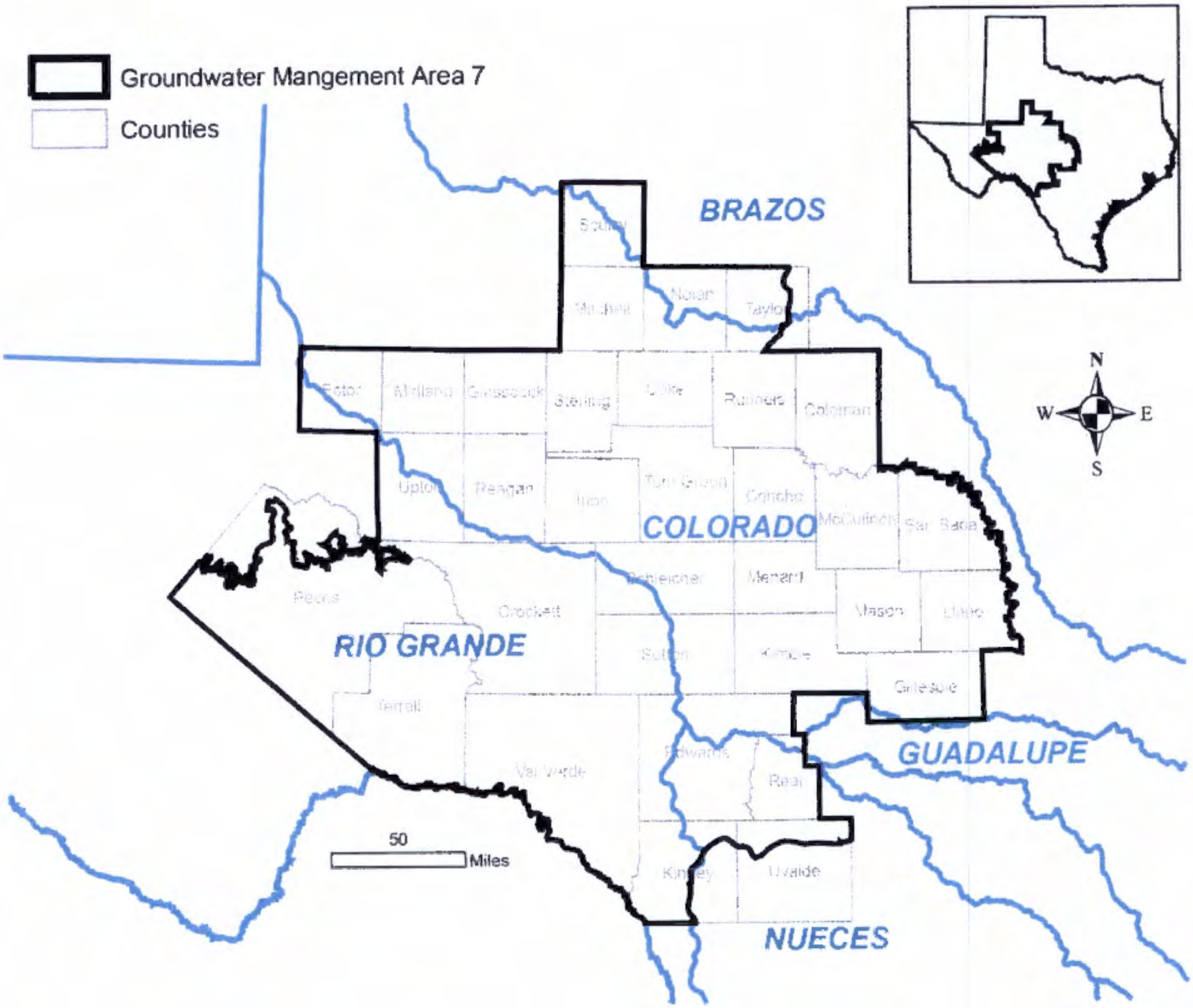


FIGURE 3. **MAP SHOWING RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 7. THESE INCLUDE PARTS OF THE BRAZOS, COLORADO, GUADALUPE, NUECES, AND RIO GRANDE RIVER BASINS.**

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.

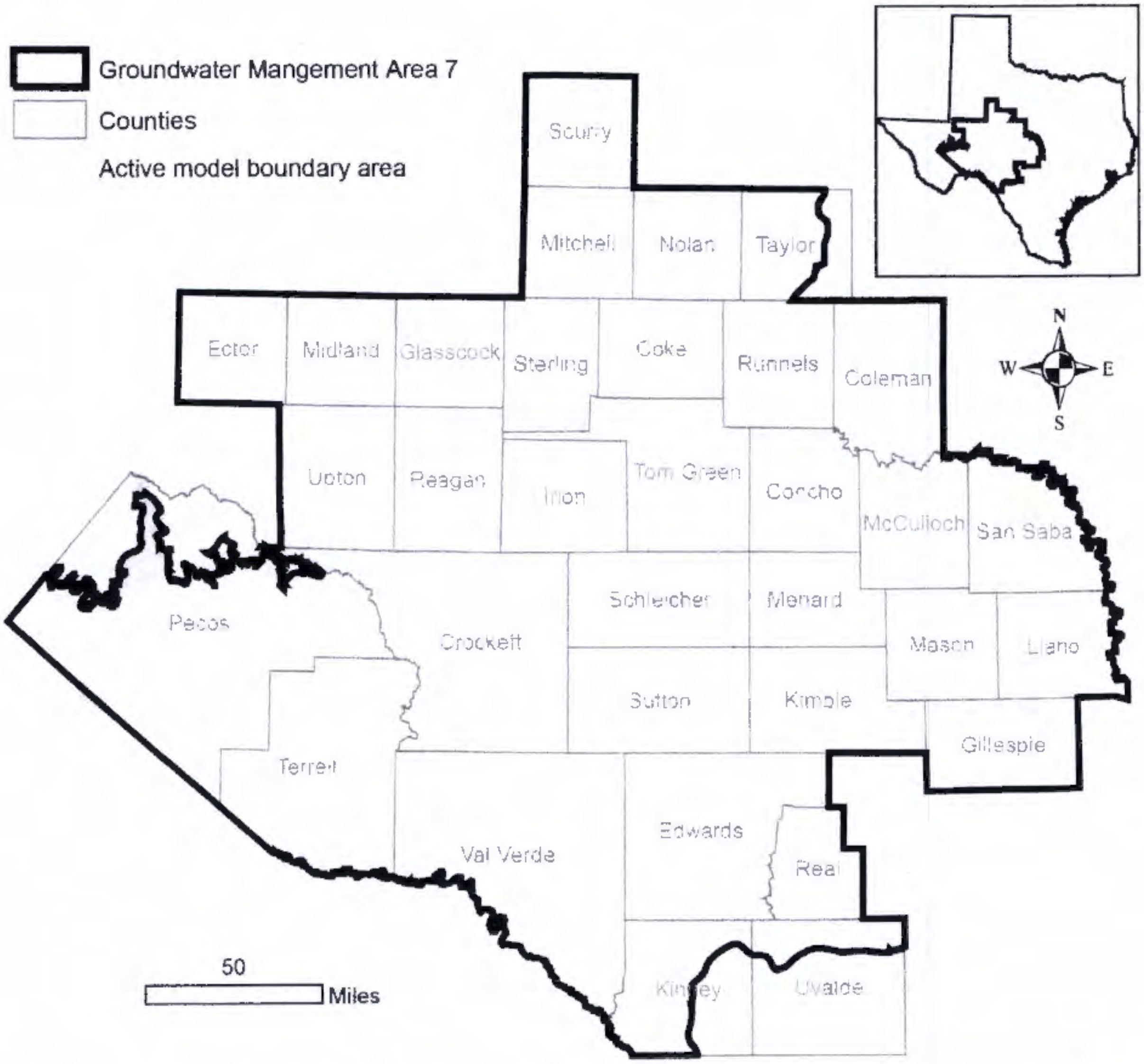


FIGURE 4. **MAP SHOWING THE AREAS COVERED BY THE CAPITAN REEF COMPLEX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EASTERN ARM OF THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.**

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**

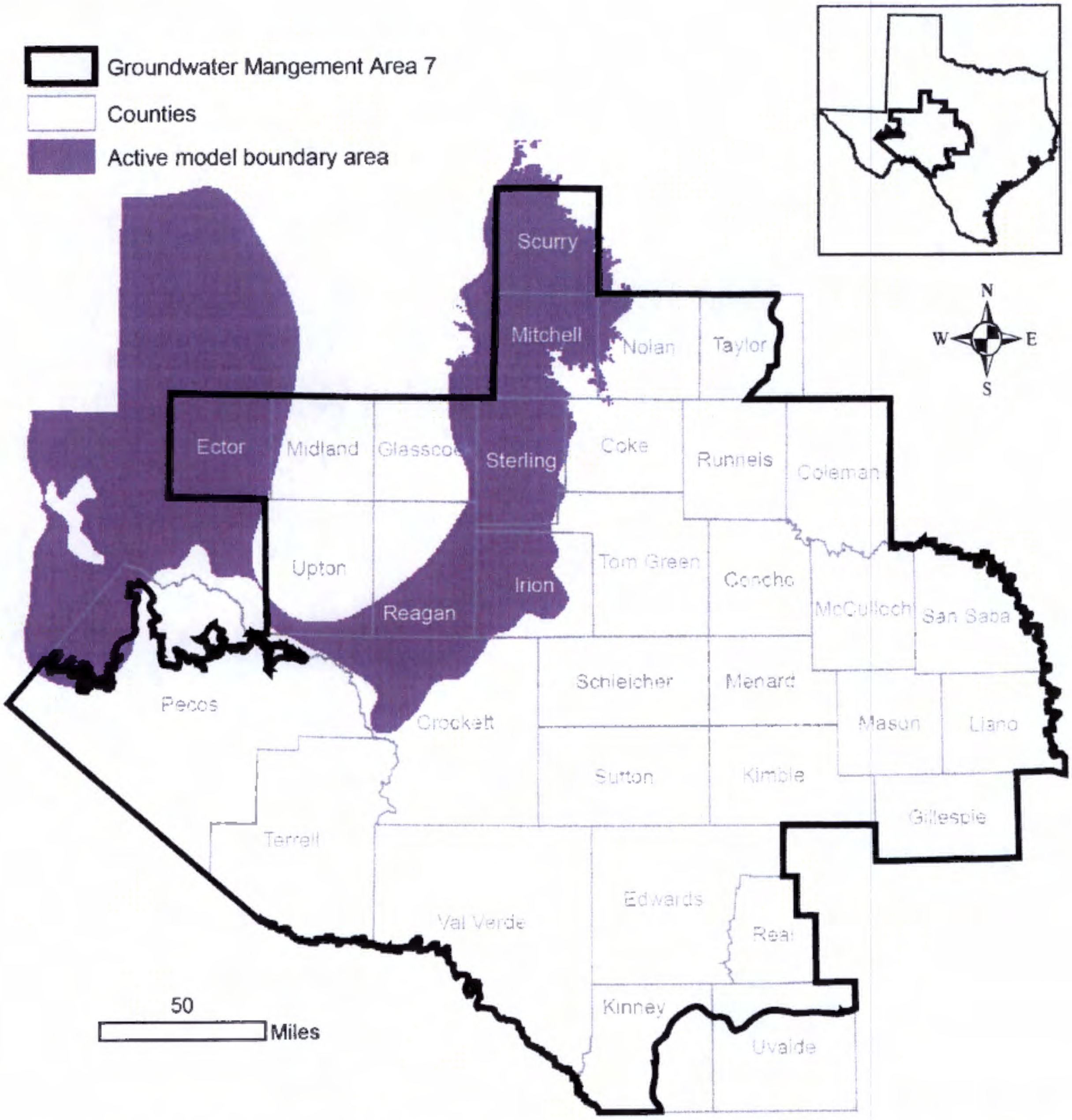


FIGURE 5. **MAP SHOWING AREAS COVERED BY THE DOCKUM AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.**

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.

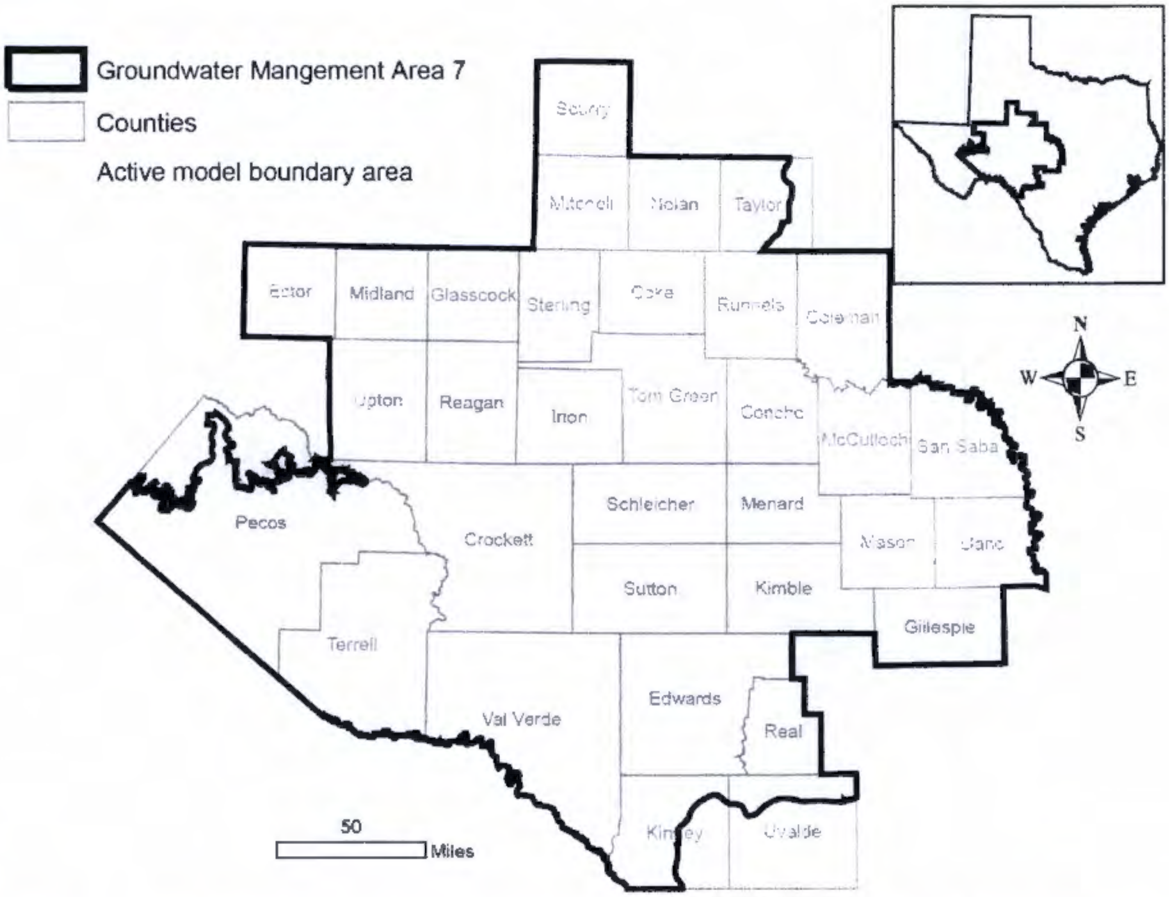


FIGURE 6. **MAP SHOWING THE AREAS COVERED BY THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7.**

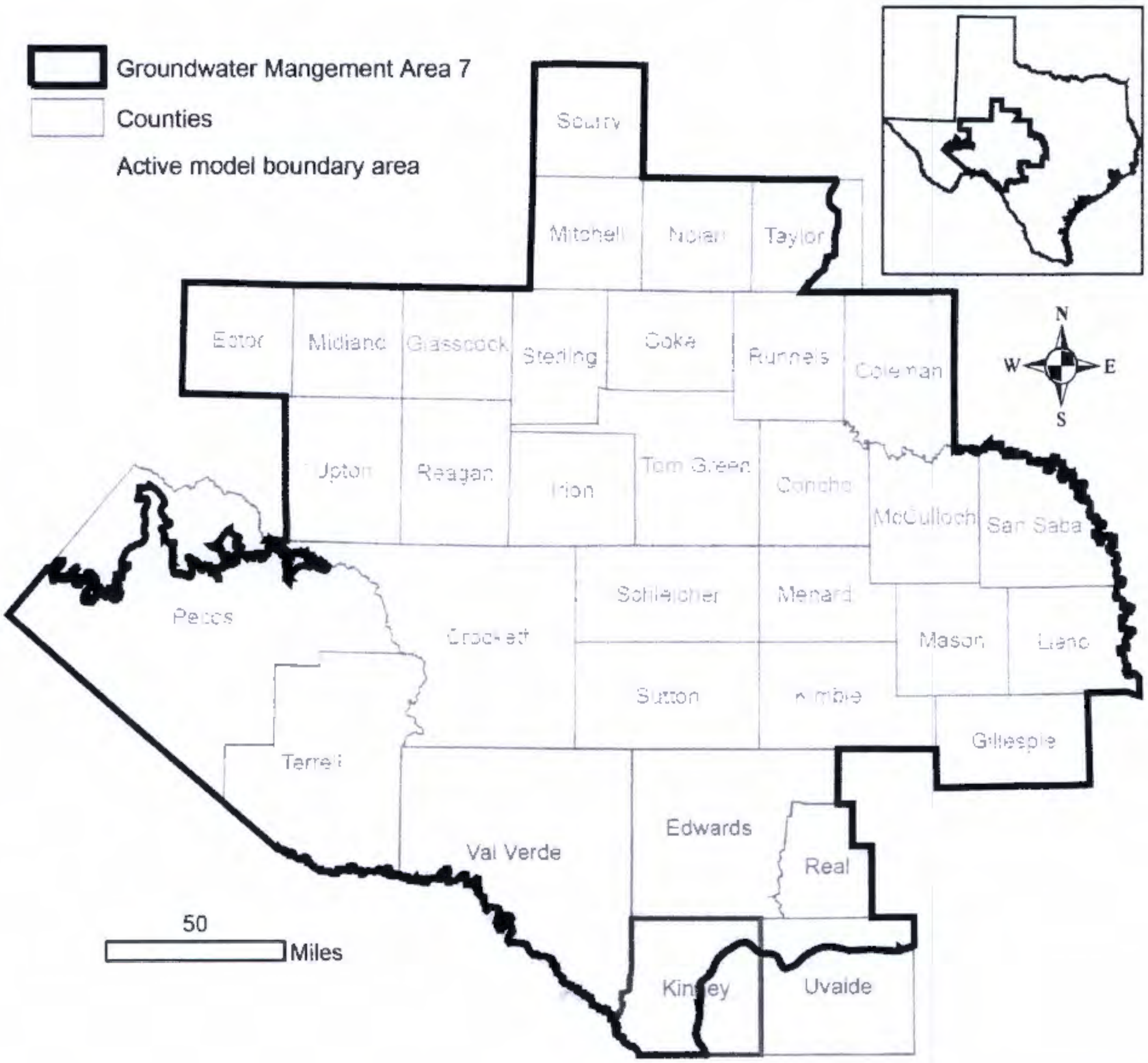


FIGURE 7. **MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE ALTERNATIVE MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN KINNEY COUNTY.**

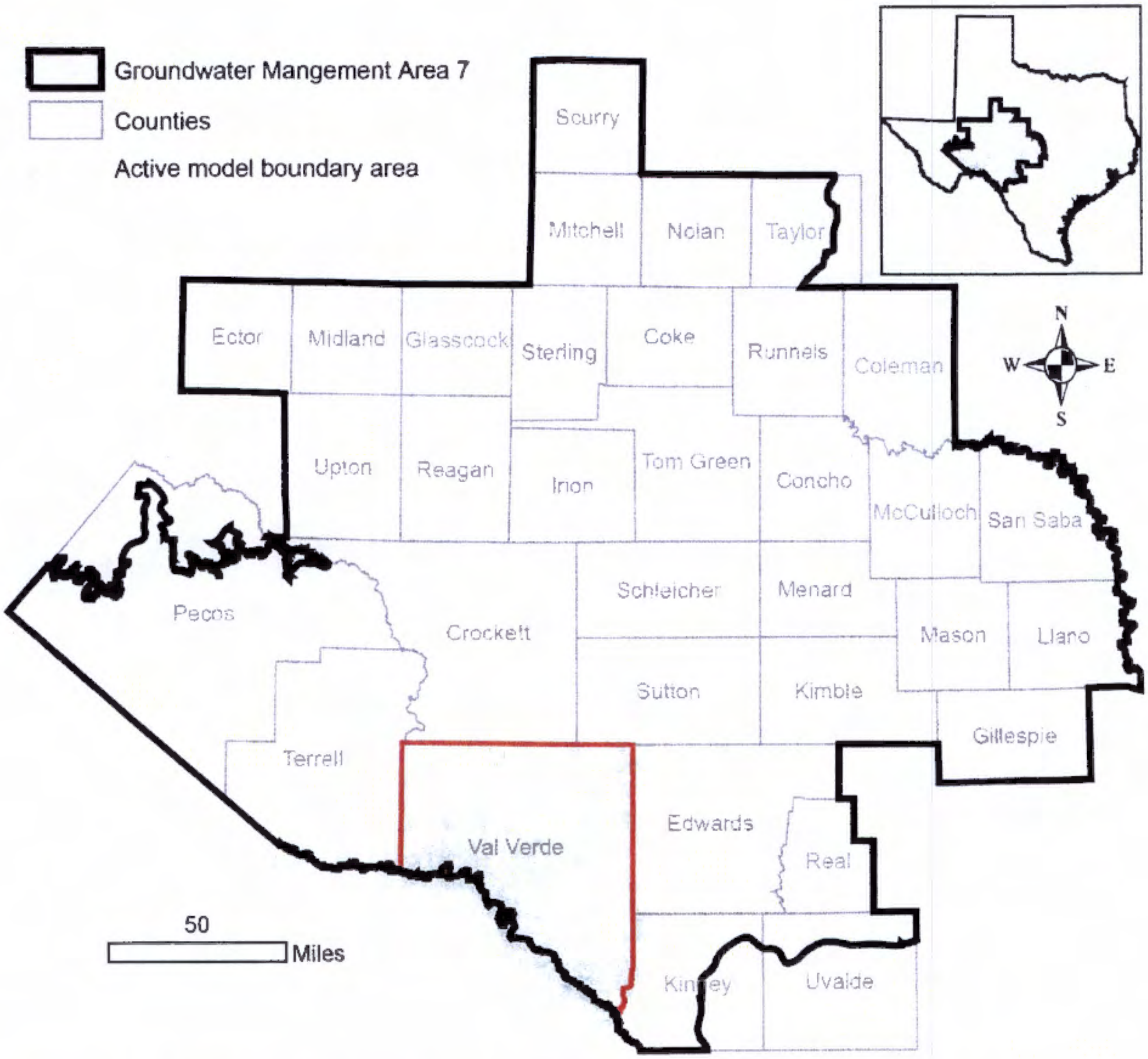


FIGURE 8. **MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE GROUNDWATER FLOW MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN VAL VERDE COUNTY.**

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.

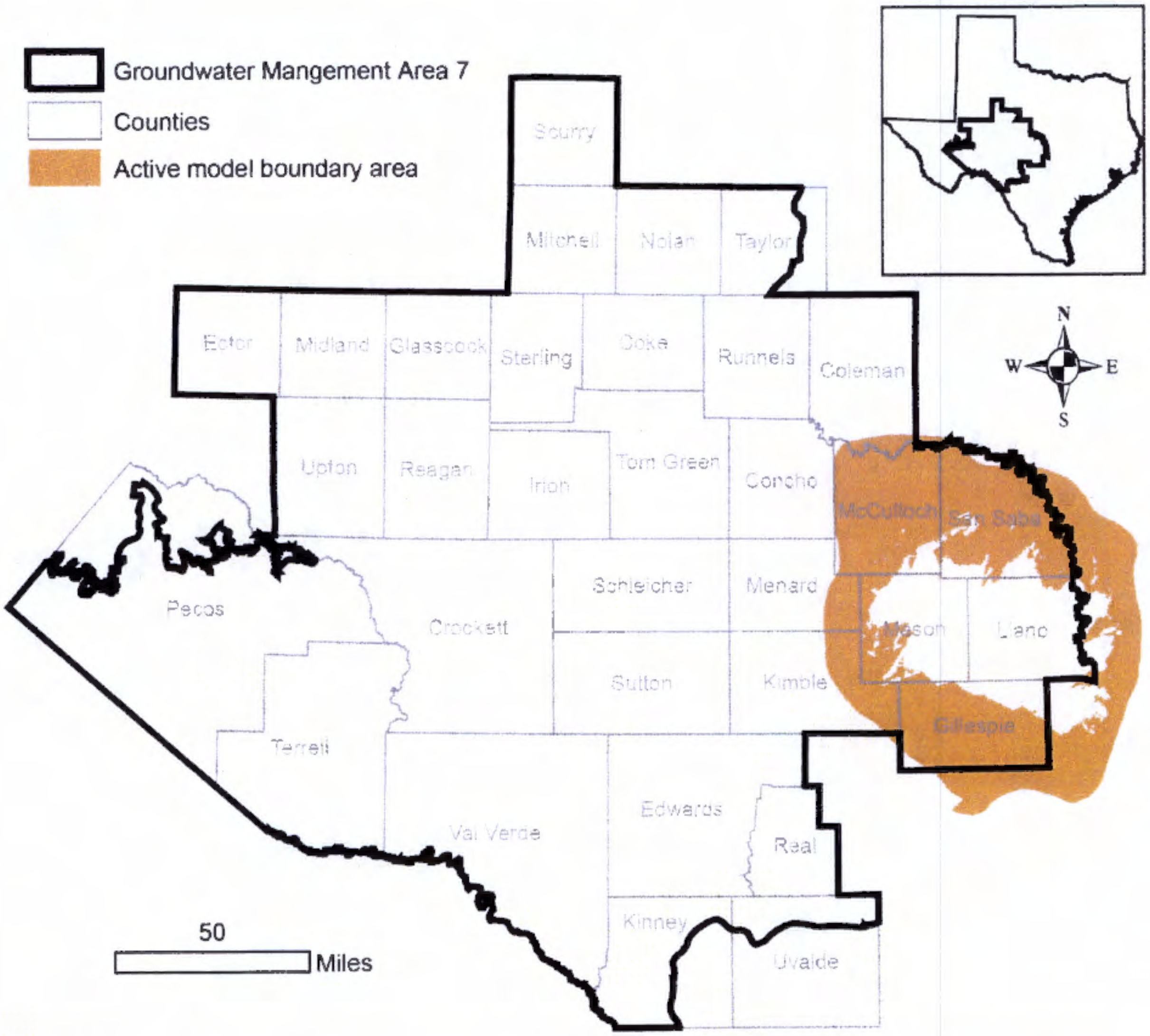


FIGURE 9. **MAP SHOWING THE AREAS COVERED BY THE ELLENBURGER-SAN SABA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.**

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**

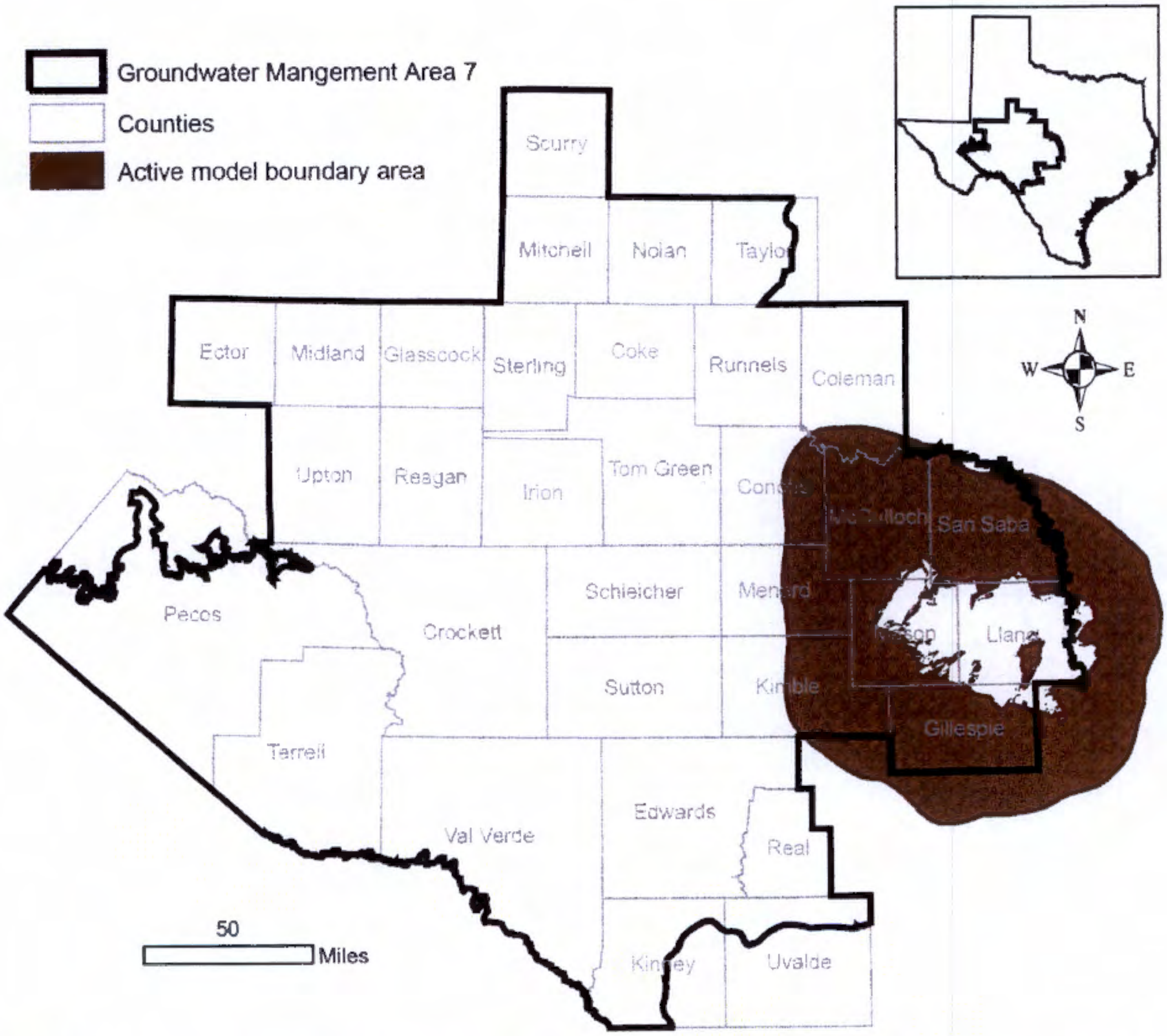


FIGURE 10. **MAP SHOWING AREAS COVERED BY THE HICKORY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.**

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**

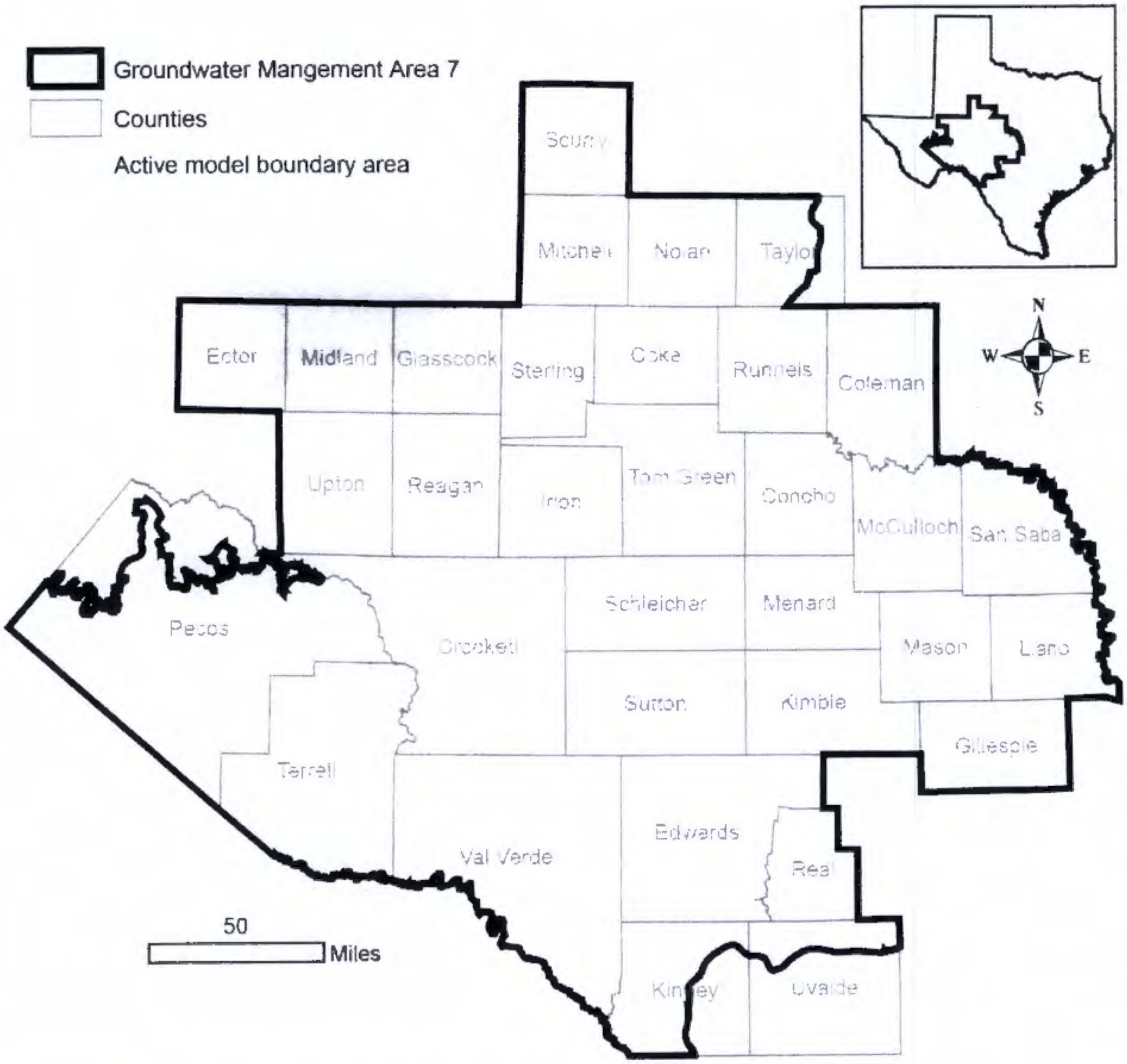


FIGURE 11. **MAP SHOWING THE AREAS COVERED BY THE OGALLALA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.**

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**

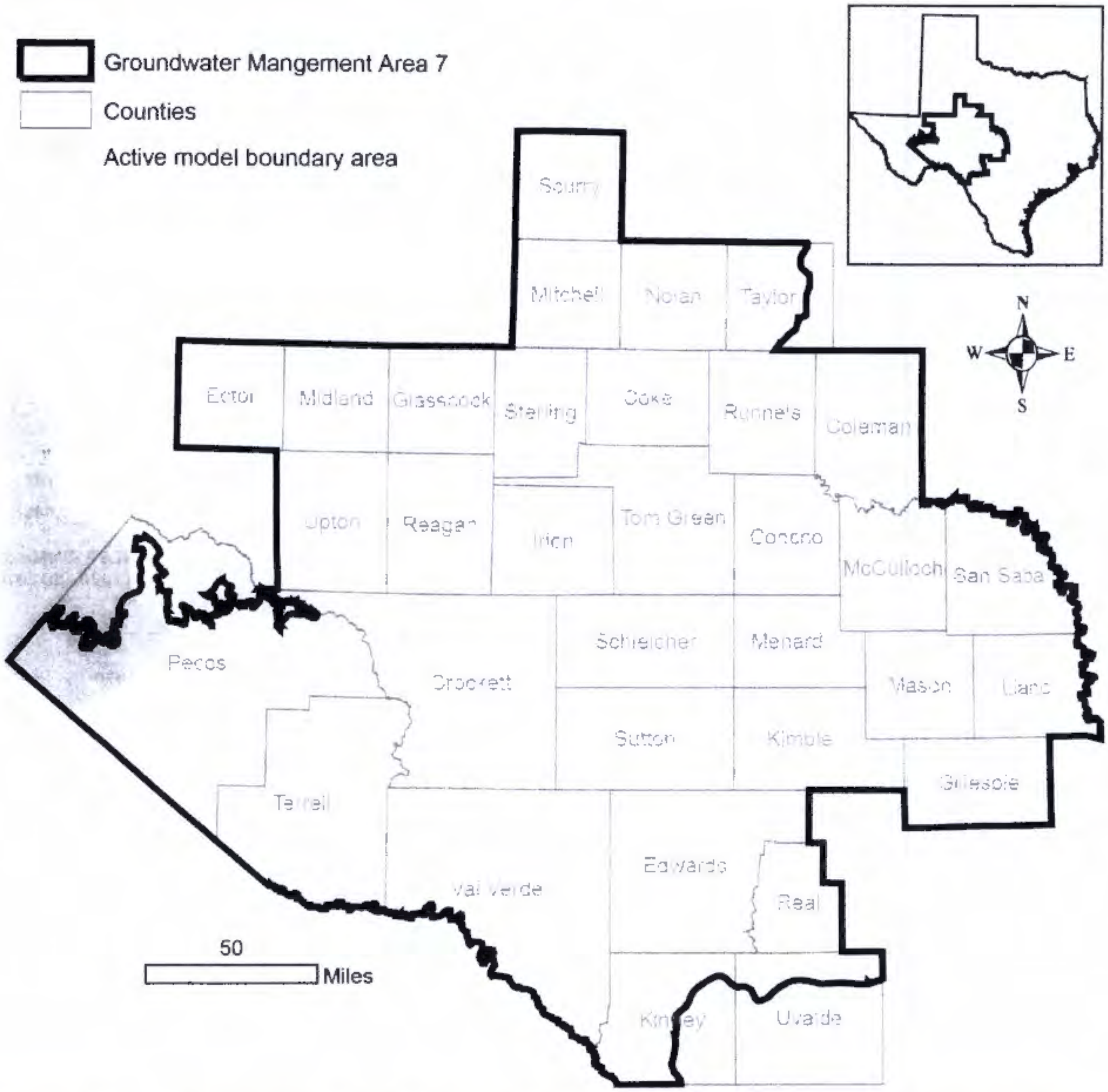


FIGURE 12. MAP SHOWING AREAS COVERED BY THE RUSTLER AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

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.

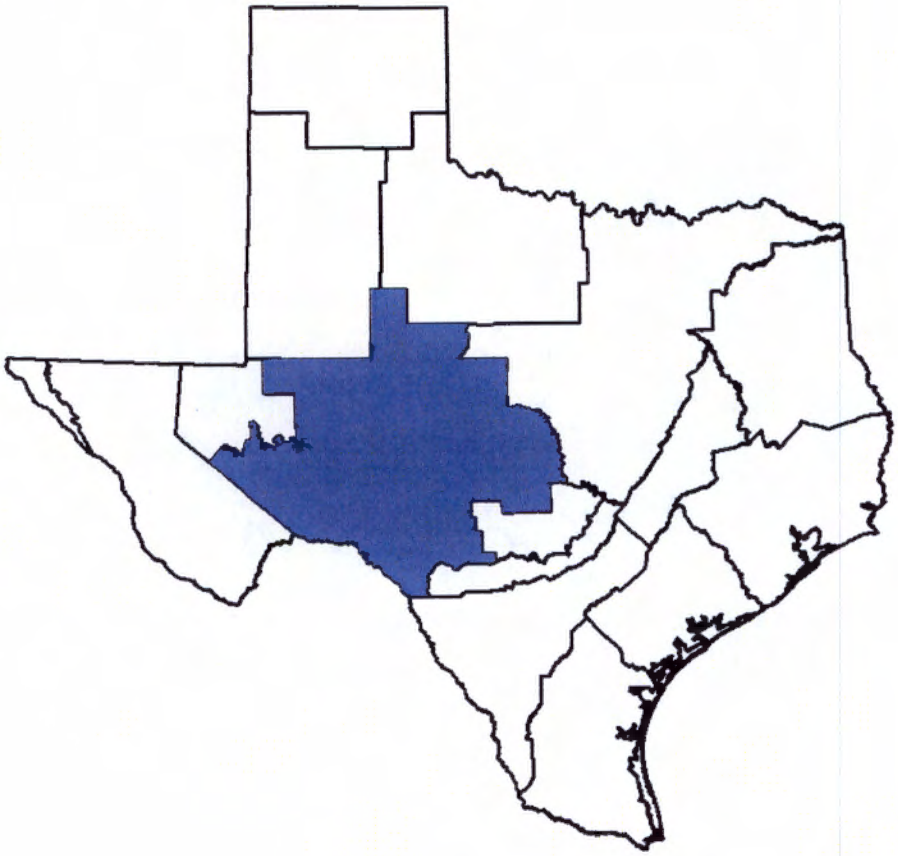
Shi, J, 2012, GAM Run 10-043 MAG (Version 2): Modeled Available Groundwater for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers in Groundwater Management Area 7, Texas Water Development Board GAM Run Report 10-043, 15 p. www.twdb.texas.gov/groundwater/docs/GAMruns/GR10-043_MAG_v2.pdf

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 D

GMA 7 Explanatory Report - Final
Ogallala and Dockum Aquifers



Prepared for:
Groundwater Management Area 7

Prepared by:
William R. Hutchison, Ph.D., P.E., P.G.
Independent Groundwater Consultant
9305 Jamaica Beach
Jamaica Beach, TX 77554
512-745-0599
billhutch@texasgw.com

November 22, 2016

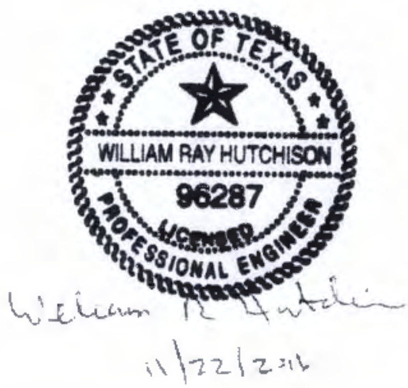
GMA 7 Explanatory Report - Final
Ogallala and Dockum Aquifers

Geoscientist and Engineering Seal

This report documents the work and supervision of work of the following licensed Texas Professional Geoscientist and licensed Texas Professional Engineers:

William R. Hutchison, Ph.D., P.E. (96287), P.G. (286)

Dr. Hutchison completed the analyses and model simulations described in this report, and was the principal author of the final report.



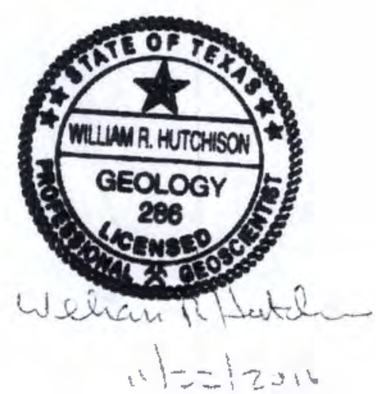


Table of Contents

List of Figures

List of Tables

Appendices

A – Desired Future Conditions Resolution
B – TWDB Pumping Estimates – Dockum Aquifer
C – TWDB Pumping Estimates – Ogallala Aquifer
D – Region F Socioeconomic Impact Report from TWDB

1.0 Groundwater Management Area 7

Groundwater Management Area 7 is one of sixteen groundwater management areas in Texas, and covers that portion of west Texas that is underlain by the Edwards-Trinity (Plateau) Aquifer (Figure 1).

Figure 1. Groundwater Management Area 7

Groundwater Management Area 3 covers all or part of the following counties: Coke, Coleman, Concho, Crockett, Ector, Edwards, Gillespie, Glasscock, Irion, Kimble, Kinney, Llano, Mason, McCulloch, Menard, Midland, Mitchell, Nolan, Pecos, Reagan, Real, Runnels, San Saba, Schleicher, Scurry, Sterling, Sutton, Taylor, Terrell, Tom Green, Upton, and Uvalde (Figure 2).

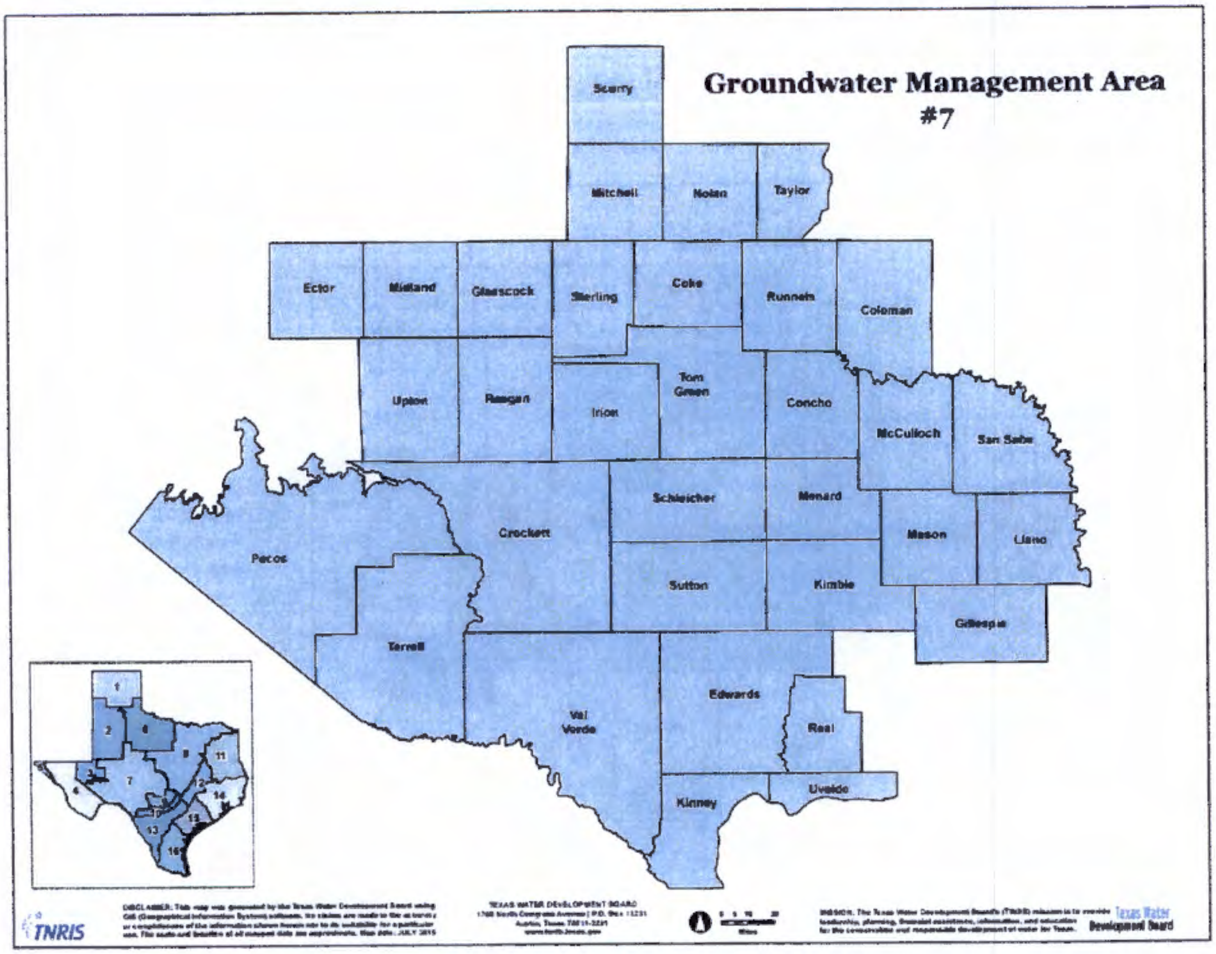


Figure 2. GMA 7 Counties (from TWDB)

There are 20 groundwater conservation districts in Groundwater Management Area 7: Coke County Underground Water Conservation District, Crockett County Groundwater Conservation District, Glasscock Groundwater Conservation District, Hickory Underground Water Conservation District No. 1, Hill County Underground Water Conservation District, Irion County Water Conservation District, Kimble County Groundwater Conservation District, Kinney County Groundwater Conservation District, Lipan-Kickapoo Water Conservation District, Lone Wolf Groundwater Conservation District, Menard County Underground Water District, Middle Pecos Groundwater Conservation District, Plateau Underground Water Conservation and Supply District, Real-Edwards Conservation and Reclamation District Santa Rita Underground Water Conservation District, Sterling County Underground Water Conservation District, Sutton County Underground Water Conservation District, Terrell County Groundwater Conservation District, Uvalde County Underground Water Conservation District, and Wes-Tex Groundwater Conservation District (Figure 3).

The Edwards Aquifer Authority is also partially inside of the boundaries of GMA 7, but are exempt from participation in the joint planning process.

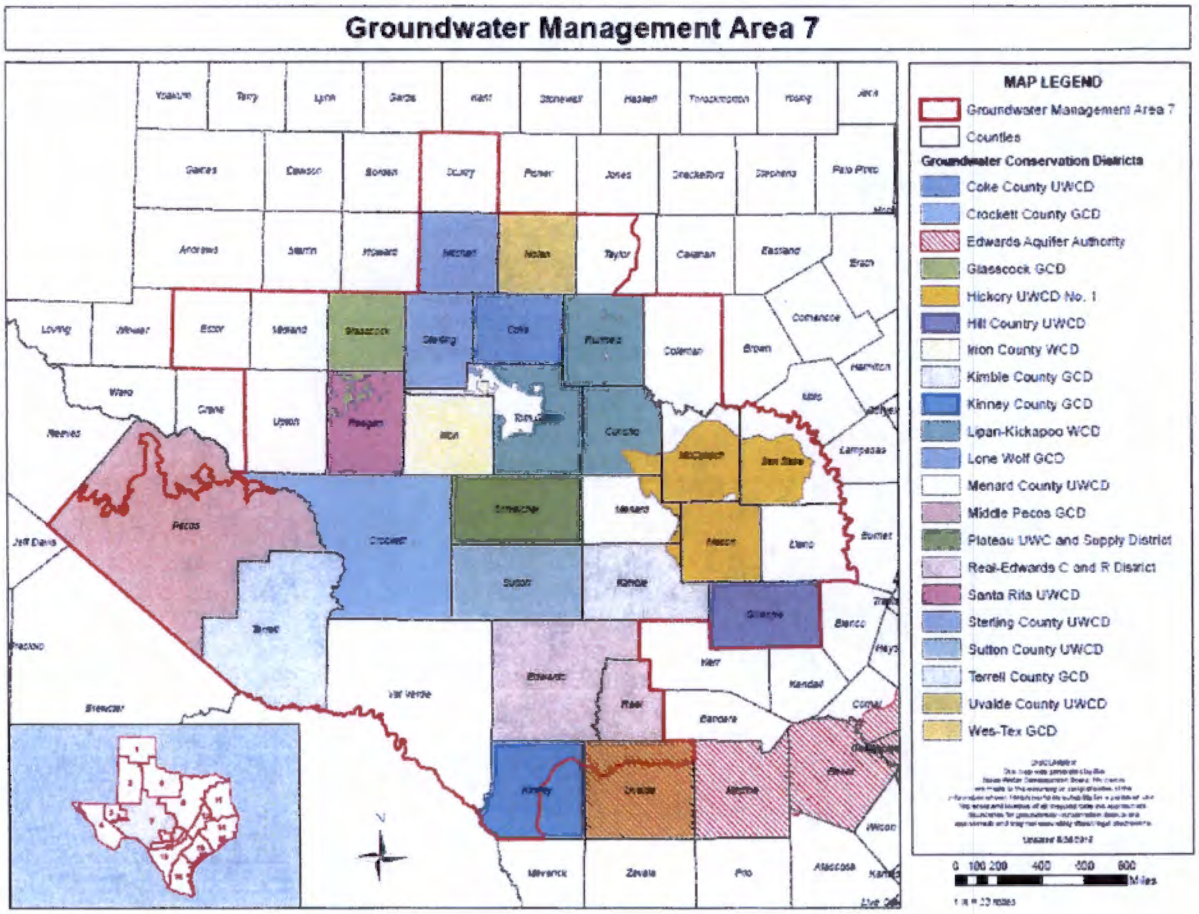


Figure 3. Groundwater Conservation Districts in GMA 7 (from TWDB)

The explanatory report covers the Dockum and Ogallala aquifers. As described in George and others (2011):

> ***The Dockum Aquifer*** *is a minor aquifer found in the northwest part of the state. It is defined stratigraphically by the Dockum Group and includes, from oldest to youngest, the Santa Rosa Formation, the Tecovas Formation, the Trujillo Sandstone, and the Cooper Canyon Formation. The Dockum Group consists of gravel, sandstone, siltstone, mudstone, shale, and conglomerate. Groundwater located in the sandstone and conglomerate units is recoverable, the highest yields coming from the coarsest grained deposits located at the middle and base of the group. Typically, the water-bearing sandstones are locally referred to as the Santa Rosa Aquifer. The water quality in the aquifer is generally poor—with freshwater in outcrop areas in the east and brine in the western subsurface portions of the aquifer—and the water is very hard. Naturally occurring radioactivity from uranium present within the aquifer has resulted in gross alpha radiation in excess of the state's primary drinking water standard. Radium-226 and -228 also occur in amounts above acceptable standards. Groundwater from the aquifer is used for irrigation, municipal water supply, and oil field waterflooding operations, particularly in the southern High Plains. Water level*

declines and rises have occurred in different areas of the aquifer. The regional water planning groups, in their 2006 Regional Water Plans, recommended several water management strategies that use the Dockum Aquifer, including new wells, desalination, and reallocation.

***The Ogallala Aquifer** is the largest aquifer in the United States and is a major aquifer of Texas underlying much of the High Plains region. The aquifer consists of sand, gravel, clay, and silt and has a maximum thickness of 800 feet. Freshwater saturated thickness averages 95 feet. Water to the north of the Canadian River is generally fresh, with total dissolved solids typically less than 400 milligrams per liter; however, water quality diminishes to the south, where large areas contain total dissolved solids in excess of 1,000 milligrams per liter. High levels of naturally occurring arsenic, radionuclides, and fluoride in excess of the primary drinking water standards are also present. The Ogallala Aquifer provides significantly more water for users than any other aquifer in the state. The availability of this water is critical to the economy of the region, as approximately 95 percent of groundwater pumped is used for irrigated agriculture. Throughout much of the aquifer, groundwater withdrawals exceed the amount of recharge, and water levels have declined fairly consistently through time. Although water level declines in excess of 300 feet have occurred in several areas over the last 50 to 60 years, the rate of decline has slowed, and water levels have risen in a few areas. The regional water planning groups for the Panhandle and Llano Estacado regions, in their 2006 Regional Water Plans, recommended numerous water management strategies using the Ogallala Aquifer, including drilling new wells, developing well fields, overdrafting, and reallocating supplies.*

2.0 Desired Future Condition

2.1 Existing Desired Future Conditions

GMA 7 adopted a desired future condition for the Ogallala Aquifer on July 29, 2010 as follows:

".. through the year 2060:

1) *Total decline in volume of water within Ector, Glasscock, and Midland counties in the southern portion of the Ogallala aquifer within GMA 7 at the end of the fifty-year period shall not exceed 50 percent of the volume of the aquifer in 2010.*
2) *The Ogallala Aquifer is not relevant for joint planning purposes in all other areas of GMA 7.*

GMA 7 adopted a desired future condition for the Dockum Aquifer on July 29, 2010 as follows:

".. through the year 2060:

1) *Upper Dockum, as delineated in figure 1 of TWDB GAM Run 10-001: net total drawdown not to exceed 29 feet in Midland County; and*
2) *Lower Dockum, as delineated in figure 1 of TWDB GAM Run 10-001: net total drawdown not to exceed 4 feet in Ector, Mitchell, Pecos, Scurry, and Upton Counties (Lone Wolf GCD, Middle Pecos GCD); and*
3) *Lower Dockum Aquifer as delineated in Figure 1 of TWDB GAM Run 10-001: Drawdown not to exceed a net total of 39 feet in Nolan County (Wes-Tex GCD); and*
4) *The Dockum Aquifer is not relevant for joint planning purposes in all other areas of GMA 7.*

The desired future conditions were adopted based on two separate groundwater availability models for the Ogallala and Dockum aquifers. In 2015, the TWDB received a final updated model that includes both the Ogallala and Dockum aquifers (High Plains Aquifer System Groundwater Availability Model, or HPAS).

2.2 High Plains Aquifer System Groundwater Availability Model

The DFCs were developed based on predictive simulations with the recently released High Plains Aquifer System Groundwater Availability Model (Deeds and Jigmond, 2015). The model is also known as the HPAS GAM, or simply the GAM. The GAM includes the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers.

2.3 Desired Future Condition

The desired future conditions for the Dockum Aquifer in GMA 7 are based on Scenario 17 as described in Technical Memorandum 16-01:

1) Total net drawdown of the Dockum Aquifer not to exceed 14 feet in Reagan County (Santa Rita GCD) in 2070 as compared with 2012 aquifer levels;
2) Total net drawdown of the Dockum Aquifer not to exceed 52 feet in Pecos County (Middle Pecos GCD) in 2070 as compared with 2012 aquifer levels; and
3) The Dockum Aquifer is not relevant for joint planning purposes in all other areas of GMA 7.

The desired future conditions for the Ogallala Aquifer in GMA 7 are based on Scenario 10 as described in Technical Memorandum 16-01:

1) Total net drawdown of the Ogallala Aquifer in Glasscock County (Glasscock GCD) in 2070, as compared with 2012 aquifer levels, not to exceed 6 feet; and
2) The Ogallala Aquifer is not relevant for joint planning purposes in all other areas of GMA 7.

The resolution adopted for the desired future conditions is presented in Appendix A. Please note that the Pecos County DFC covers all of Pecos County (GMA 3 and GMA 7 portions).

2.4 Discussion of Changes to Desired Future Conditions from 2010 to 2016.

The desired future conditions that have been adopted by GMA 7 for the Dockum and Ogallala aquifers relied on a new model (HPAS GAM). The new GAM is an updated tool that replaces the old Ogallala Aquifer GAM and the alternative GAM for the Dockum Aquifer that were the basis for the current DFC and MAG. However, use of this new tool and the updated information that it yields have resulted in changes to the DFCs and MAGs from 2010. Many of the changes are simply reflective of the updated model. These changes to the DFC and/or the MAG could be easily misinterpreted and misused.

2.4.1 Ogallala Aquifer

An example of this is the recently released report by TWDB (Hermitte and others, 2015). This report summarizes differences between 2012 State Water Plan groundwater availability numbers and the MAGs developed from the DFCs that were adopted in 2010. There are many reasons for the noted differences, but Hermitte and others (2015) provided no context to the changes. In fact, there was no opportunity for stakeholders to provide comments to this report, it simply was published. In many cases, the differences are directly attributable to updates in models, and the improved understanding that is the result of updating a model. However, the data and comparisons in this report provide opportunities to mischaracterize these differences as simple policy choices to reduce groundwater availability. It is unfortunate that Hermitte and others (2015) chose not to provide context to their comparisons, and leave so much room for misinterpretation of a complex process that relies on imperfect models.

In this case, the updated simulations of the Ogallala Aquifer were designed to evaluate the effects of a declining saturated thickness on well pumping rates. In reviewing the results and comparing them to the results of model runs using the old model in 2010, it is apparent that the MAG from 2010 reflects a large increase in pumping in Glasscock County during the first several years of the simulation to achieve an arbitrary 50/50 standard. Scenario 10 (on which the Glasscock County DFC is established assumed that the pumping in the first year of the simulation is 150 percent of the current pumping (a significant increase). Essentially, the achievement of an arbitrary 50/50 DFC would require an immediate increase in pumping that could not be sustained over the first few years of the simulation period. The new model shows the decrease in pumping associated with the declining groundwater levels, and is a more realistic simulation of what could occur in the future.

2.4.2 Dockum Aquifer

The Dockum Aquifer includes a DFC for Pecos County that is includes all of Pecos County in both GMA 3 and GMA 7. In 2010, the DFC was adopted separately for GMA 3 and GMA 7.

Also, in 2010, the Dockum Aquifer was classified as not relevant for purposes of joint planning in Reagan County. In 2016, a DFC has been established for Reagan County.

Other areas of GMA 7 (specifically Ector, Midland, Mitchell, Nolan, Scurry, and Upton counties) had DFCs in 2010, and are now classified as not relevant for purposes of joint planning. The new model was released in preliminary form in the spring of 2015, and comments were submitted prior to finalizing the model and its report in August 2015.

Appendix D of the final report on the numerical model included comments and responses to the draft model. In summary, some changes were made to the aquifer parameters in Mitchell County, but only to make the numerical model consistent with the previously released conceptual model. No changes were made to recharge in the final model, which means that recharge is assumed constant every year (no variation with variation in precipitation). The assumed constant recharge was also deemed consistent with the conceptual model.

On pages D-26 and D-27 of the final report, the basis for the assumed constant recharge is summarized. Essentially, the Bureau of Economic Geology completed an analysis of the entire model area, which was focused on the Ogallala region in the panhandle region of Texas, and concluded that rises in groundwater levels are due to "post development-recharge rates" that are different due to changed land use conditions, not precipitation.

On page D-28, in response to comments about the model's calibration, there is a response that acknowledges that some groundwater level recoveries are not simulated by the model. However, the authors of the report state that simulation of those recoveries would require a "point-calibration" to pumping or recharge, and state that such an effort would not improve the confidence in the model or improve its predictive capability. Based on these statements, the authors were focused on the regional aspects of the model only. While the calibration of the model is within industry standards, and may be useful for regional simulations of the Ogallala Aquifer over the entire areas of the model domain, it is not suitable to simulate conditions in the eastern areas of the Dockum, especially Mitchell and Nolan counties.

In general, the classification of portions of an aquifer as not relevant for purposes of joint planning are made when the area of an aquifer is small, when uses are insignificant, or where the management and regulation of groundwater in one GCD would not affect neighboring GCDs. Another way to view joint planning is that DFCs should be set only for those areas where impacts of pumping would cross GCD boundaries.

From a regional perspective, the HPAS is an adequate model (as defined by the TWDB through its acceptance of the model). Based on model results, pumping in Mitchell County and Nolan County does not impact surrounding counties. Given the lack of interaction between counties, the Dockum Aquifer has been classified as not relevant for purposes of joint planning in these counties.

3.0 Policy Justification

As developed more fully in this report, the proposed desired future condition was adopted after considering:

- Aquifer uses and conditions within Groundwater Management Area 7
- Water supply needs and water management strategies included in the 2012 State Water Plan
- Hydrologic conditions within Groundwater Management Area 7 including total estimated recoverable storage, average annual recharge, inflows, and discharge
- Other environmental impacts, including spring flow and other interactions between groundwater and surface water
- The impact on subsidence
- Socioeconomic impacts reasonably expected to occur
- The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 7 in groundwater as recognized under Texas Water Code Section 36.002
- The feasibility of achieving the desired future condition
- Other information

In addition, the proposed desired future condition provides a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater in Groundwater Management Area 7.

There is no set formula or equation for calculating groundwater availability. This is because an estimate of groundwater availability requires the blending of policy and science. Given that the tools for scientific analysis (groundwater models) contain limitations and uncertainty, policy provides the guidance and defines the bounds that science can use to calculate groundwater availability.

As developed more fully below, many of these factors could only be considered on a qualitative level since the available tools to evaluate these impacts have limitations and uncertainty.

4.0 Technical Justification

The process of using the groundwater model in developing desired future conditions revolves around the concept of incorporating many of the elements of the nine factors (e.g. current uses and water management strategies in the regional plan). For the Dockum and Ogallala aquifers, 17 scenarios were completed, and the results discussed prior to adopting a desired future condition.

Some critics of the process asserted that the districts were "reverse-engineering" the desired future conditions by specifying pumping (e.g., the modeled available groundwater) and then adopting the resulting drawdown as the desired future condition. However, it must be remembered that among the input parameters for a predictive groundwater model run is pumping, and among the outputs of a predictive groundwater model run is drawdown. Thus, an iterative approach of running several predictive scenarios with models and then evaluating the results is a necessary (and time-consuming) step in the process of developing desired future conditions.

One part of the reverse-engineering critique of the process has been that "science" should be used in the development of desired future conditions. The critique plays on the unfortunate name of the groundwater models in Texas (Groundwater Availability Models) which could suggest that the models yield an availability number. This is simply a mischaracterization of how the models work (i.e. what is a model input and what is a model output).

The critique also relies on a fairly narrow definition of the term *science* and fails to recognize that the adoption of a desired future condition is primarily a policy decision. The call to use science in the development of desired future conditions seems to equate the term *science* with the terms *facts* and *truth*. Although the Latin origin of the word means knowledge, the term *science* also refers to the application of the scientific method. The scientific method is discussed in many textbooks and can be viewed as a means to quantify cause-and-effect relationships and to make useful predictions.

In the case of groundwater management, the scientific method can be used to understand the relationship between groundwater pumping and drawdown, or groundwater pumping and spring flow. A groundwater model is a tool that can be used to run "experiments" to better understand the cause-and-effect relationships within a groundwater system as they relate to groundwater management.

Much of the consideration of the nine statutory factors involves understanding the effects or the impacts of a desired future condition (e.g. groundwater-surface water interaction and property rights). The use of the models in this manner in evaluating the impacts of alternative futures is an effective means of developing information for the groundwater conservation districts as they develop desired future conditions.

5.0 Factor Consideration

Senate Bill 660, adopted by the legislature in 2011, changed the process by which groundwater conservation districts within a groundwater management area develop and adopt desired future conditions. The new process includes nine steps as presented below:

- The groundwater conservation districts within a groundwater management area consider nine factors outlined in the statute.
- The groundwater conservation districts adopt a "proposed" desired future condition
- The "proposed" desired future condition is sent to each groundwater conservation district for a 90-day comment period, which includes a public hearing by each district
- After the comment period, each district compiles a summary report that summarizes the relevant comments and includes suggested revisions. This summary report is then submitted to the groundwater management area.
- The groundwater management area then meets to vote on a desired future condition.
- The groundwater management area prepares an "explanatory report".
- The desired future condition resolution and the explanatory report are then submitted to the Texas Water Development Board and the groundwater conservation districts within the groundwater management area.
- Districts then adopt desired future conditions that apply to that district.

The nine factors that must be considered before adopting a proposed desired future condition are:

1. Aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another.
2. The water supply needs and water management strategies included in the state water plan.
3. Hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator (of the Texas Water Development Board), and the average annual recharge, inflows and discharge.
4. Other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water.
5. The impact on subsidence.
6. Socioeconomic impacts reasonably expected to occur.
7. The impact on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees and assigns in groundwater as recognized under Section 36.002 (of the Texas Water Code).
8. The feasibility of achieving the desired future condition.
9. Any other information relevant to the specific desired future condition.

In addition to these nine factors, statute requires that the desired future condition provide a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the management area.

5.1 Groundwater Demands and Uses

County-level groundwater demands and uses from 2000 to 2012 for the Dockum Aquifer are presented in Appendix B. County-level groundwater demands and uses from 2000 to 2012 for the Ogallala Aquifer are presented in Appendix C. Data were obtained from the Texas Water Development Board historic pumping database:

http://www.twdb.state.tx.us/waterplanning/waterusesurvey/historical-pumpage.asp

These data, and a comparison to current modeled available groundwater numbers were discussed at the GMA 7 meeting of December 18, 2014 in San Angelo, Texas.

5.2 Groundwater Supply Needs and Strategies

The 2016 Region F Plan lists county-by-county shortages and strategies. Shortages are identified when current supplies (e.g. existing wells) cannot meet future demands. Strategies are then recommended (e.g. new wells) to meet the future demands. No strategies are listed for the Ogallala or Dockum aquifers in GMA 7.

5.3 Hydrologic Conditions, including Total Estimated Recoverable Storage

The groundwater budget for the GMA 7 portion of the Dockum Aquifer for the calibration period of the HPAS (1929 to 2012) is presented in Table 1 along with the groundwater budget for the predictive period (2013 to 2070) under Scenario 17, the basis for the adopted desired future condition.

Table 1. Groundwater Budget for the GMA 7 Portion of the Dockum Aquifer

Inflow	1929 to 2012 Average (AF/yr)	2013 to 2070 Average (AF/yr)
Recharge from Precipitation	21,012	27,986
Inflow from Overlying Formations	5,645	7,026
Inflow from GMA 2	640	674
Total Inflow	27,297	35,686
Outflow		
Pumping	8,478	35,724
Spring Flow	3,125	3,597
Outflow to Surface Water and Boundary Outflow	11,359	11,883
Evapotranspiration	4,961	5,846
Outflow to GMA 3	1,838	1,389
Outflow to GMA 6	342	323
Total Outflow	30,104	58,761
Inflow - Outflow	-2,807	-23,075
Model Estimated Storage Change	-2,807	-23,075
Model Error	0	0

The groundwater budget for the GMA 7 portion of the Ogallala Aquifer for the calibration period of the HPAS (1929 to 2012) is presented in Table 2 along with the groundwater budget for the predictive period (2013 to 2070) under Scenario 10, the basis for the adopted desired future condition.

Table 2. Groundwater Budget for the GMA 7 Portion of the Ogallala Aquifer

Inflow	1929 to 2012 Average (AF/yr)	2013 to 2070 Average (AF/yr)
Recharge from Precipitation	3,555	7,670
Inflow from GMA 2	1,750	2,432
Inflow from Surface Water and Boundary Outflow	N/A	1,621
Total Inflow	5,305	11,723
Outflow		
Pumping	16,447	22,585
Spring Flow	617	528
Outflow to Surface Water and Boundary Outflow	34,205	N/A
Evapotranspiration	2,538	1,371
Outflow to GMA 3	1,855	986
Outflow to GMA 6	20	20
Outflow to Underlying Formations	5,645	7,026
Total Outflow	61,327	32,516
Inflow - Outflow	-56,021	-20,793
Model Estimated Storage Change	-56,021	-20,793
Model Error	0	0

Table 3 presents the total estimated recoverable storage for the GMA 7 portion of the Dockum Aquifer. Table 4 presents the total estimated recoverable storage for the GMA 7 portion of the Ogallala Aquifer.

Table 3. Total Estimated Recoverable Storage - Dockum Aquifer

County	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Coke	520,000	130,000	390,000
Crockett	14,000,000	3,500,000	10,500,000
Ector	100,000,000	25,000,000	75,000,000
Glasscock	11,000,000	2,750,000	8,250,000
Irion	9,100,000	2,275,000	6,825,000
Midland	10,000,000	2,500,000	7,500,000
Mitchell	27,000,000	6,750,000	20,250,000
Nolan	2,100,000	525,000	1,575,000
Pecos	2,500,000	625,000	1,875,000
Reagan	17,000,000	4,250,000	12,750,000
Scurry	32,000,000	8,000,000	24,000,000
Sterling	33,000,000	8,250,000	24,750,000
Tom Green	1,100,000	275,000	825,000
Upton	9,300,000	2,325,000	6,975,000
Total	268,620,000	67,155,000	201,465,000

Table 4. Total Estimated Recoverable Storage - Ogallala Aquifer

County	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Ector	840,000	210,000	630,000
Glasscock	2,000,000	500,000	1,500,000
Midland	3,500,000	875,000	2,625,000
Total	6,340,000	1,585,000	4,755,000

5.4 Other Environmental Impacts, including Impacts on Spring Flow and Surface Water

Tables 1 and 2 above includes groundwater budget estimates of spring flow and surface water interactions with groundwater for the Dockum and Ogallala aquifers as estimated by the HPAS GAM.

5.5 Subsidence

Subsidence is not an issue in the Dockum and Ogallala aquifers in GMA 7.

5.6 Socioeconomic Impacts

The Texas Water Development Board prepared reports on the socioeconomic impacts of not meeting water needs for each of the Regional Planning Groups during development of the 2011

Regional Water Plans. Because the development of this desired future condition used the State Water Plan demands and water management strategies as an important foundation, it is reasonable to conclude that the socioeconomic impacts associated with this proposed desired future condition can be evaluated in the context of not meeting the listed water management strategies. Groundwater Management Area 7 is covered by Regional Planning Group F. The socioeconomic impact report for Regions F is included in Appendix D.

5.7 Impact on Private Property Rights

The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 3 in groundwater is recognized under Texas Water Code Section 36.002.

The desired future conditions adopted by GMA 7 are consistent with protecting property rights of landowners wbo are currently pumping groundwater and landowners who have chosen to conserve groundwater by not pumping. All current and projected uses (as defined in the 2015 Region F plan) can be met based on the simulations. In addition, the pumping associated with achieving the desired future condition (the modeled available groundwater) will cause impacts to exiting well owners and to surface water. However, as required by Chapter 36 of the Water Code, GMA 7 considered these impacts and balanced them with the increasing demand of water in the GMA 7 area, and concluded that, on balance and with appropriate monitoring and project specific review during the permitting process, the desired future condition is consistent with protection of private property rights.

5.8 Feasibility of Achieving the Desired Future Condition

Groundwater levels are routinely monitored by the districts and by the TWDB in GMA 7. Evaluating the monitoring data is a routine task for the districts, and the comparison of these data with the model results that were used to develop the DFCs is covered in each district's management plan. These comparisons will be useful to guide the update of the DFCs that are required every five years.

5.9 Other Information

GMA 7 did not consider any other information in developing the DFCs.

6.0 Discussion of Other Desired Future Conditions Considered

There were 16 GAM scenarios completed that included a range of future pumping scenarios that were based on historic use (Scenarios 1 to 15). After review of those results, GMA 7 representatives expressed a desire to evaluate a simulation based on pumping that was consistent with the current modeled available groundwater, and included establishing a DFC in Reagan County. This scenario was labeled Scenario 17. Scenario 16 using the HPAS was used in simulations for GMA 2.

Results of the first 15 scenarios were presented and discussed at the GMA 7 meeting of January 14, 2016. Scenario 17 results were presented and discussed at the April 21, 2016 GMA 7 meeting. Results of all scenarios were summarized on Technical Memorandum 16-01.

7.0 Discussion of Other Recommendations

Public comments were invited and each district held a public hearing on the proposed desired future condition for aquifers within their boundaries. Since the DFC for the Ogallala Aquifer was only established for Glasscock County, the Glasscock GCD is the only district that held a public hearing for this DFC. Since DFCs were only established for Pecos and Reagan counties, the only districts to hold public hearings were Middle Pecos GCD and Santa Rita GCD. Dates of the public hearings are summarized below:

Groundwater Conservation District	Date of Public Hearing	Number of Comments Received
Glasscock GCD	July 22, 2016	None
Middle Pecos GCD	July 19, 2016	None
Santa Rita UWCD	July 19, 2016	None

No comments (oral or written) were received on the desired future conditions for the Ogallala and Dockum aquifers.

8.0 References

Bradley, R.G., 2011, GTA Aquifer Assessment 10-13 MAG. Texas Water Development Board, Groundwater Technical Assistance Section, November 18, 2011, 8p.

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.

Hermitte, S.M., Backhouse S., Kalaswad, S., and Mace, R.E., 2015. Groundwater Availability in Texas: Comparing Estimates from the 2012 State Water Plan and Desired Future Conditions. Texas Water Development Board Technical Note 15-05. August 2015, 102p.

George, P.G., Mace, R.E., and Petrossian, R., 2011. Aquifers of Texas. Texas Water Development Board Report 380, July 2011, 182p.

Jones, I.C., Bradley, R., Boghici, R., Kohlrenken, W., Shi, J., 2013. GAM Task 13-030: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 7. Texas Water Development Board, Groundwater Resources Division, October 2, 2013, 53 p.