April 30, 2020

Jeff Walker
Executive Administrator
Texas Water Development Board
1700 North Congress Avenue
P.O. Box 13231
Austin, Texas 78711-3231

RE: RECRD Adopted District Management Plan 2020

The Real-Edwards Conservation & Reclamation District approved and adopted the Groundwater Management Plan 2020-2025 at a public hearing and regular quarterly meeting on April 29, 2020. Attached is a copy of the Notice of Public Hearing, and a signed Resolution formally adopting the revised Groundwater Management Plan 2020.

No surface water entities are located within our District to whom we need to provide a copy of this Plan.

Warm regards,

Grady Douglass
GENERAL MANAGER

Attachment(s)

REAL-EDWARDS
CONSERVATION & RECLAMATION DISTRICT

Groundwater Management Plan

2020-2025

Revised and Adopted January 22, 2020

234 Evergreen Street

Leakey, Texas 78873

Phone: 830-232-5733 Fax: 830-232-5734 email: manager@recrd.org

Contact Information

Physical Address:	234 Evergreen Leakey, TX 78873
Mailing Address:	PO Box 1208 Leakey, TX 78873
Email:	manager@recrd.org
Telephone:	830-232-5733
Fax:	830-232-5734
Website:	www.recrd.org
District Rules:	https://recrd.org/wp-content/uploads/2018/10/Rule-Revision-2016-Final.pdf

Real-Edwards
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Groundwater Management Plan

Mission Statement

The Real-Edwards Conservation & Reclamation District (the District) was created to provide for the conservation, preservation, development and recharging of the underground waters and water-bearing formations within the District consistent with Article XVI, Section 59, of the Texas Constitution and Chapter 36 of the Texas Water Code.

Guiding Principles

The District has operated from its inception, with a strong belief in private property rights and that when some of those rights relating to the management of groundwater are relinquished for the benefit of the community, local control through an elected Board of Directors is the preferred way to manage those rights.

The District has adopted the principle of education first and regulation second in their effort to encourage conservation of groundwater. The rules of the District are designed to give landowners a fair and equal opportunity to use the groundwater underlying their property for beneficial purposes. The District will monitor groundwater quality and quantity in order to better understand the dynamics of the aquifer systems over which it has jurisdiction. This Groundwater Management Plan document is intended to be used as a tool to provide continuity in the management of the District. It will be used by the District staff as a guide to ensure that all aspects of the goals of the District are carried out and will be referred to by the Board of Directors for future planning.

The dynamic nature of this Management Plan shall be maintained in a manner that allows the District to best serve the needs of the constituents. At the very least, the Board of Directors will review and readopt this plan every five years.

The goals, management objectives, and performance standards put forth in this planning document have been set at a reasonable level considering existing and future fiscal and technical resources. Whatever the future holds, the following guidelines will be used to ensure that the management objectives are set at a sufficient level to be realistic and effective:

- The duly elected Board of Directors will guide and direct the District staff and will gauge the achievement of the goals set forth in this document.
- The interests and needs of the District's constituency including absentee landowners shall control the direction of the management of the District.
- The Board of Directors will endeavor to maintain local control of the privately-owned resource over which the District has jurisdictional authority.

- The District budget operates on an October 1st through September 30th fiscal year.
- The Board of Directors will evaluate District activities based upon the fiscal year, when considering stated goals, management objectives, and performance standards.

History

The Real-Edwards Conservation & Reclamation District was created by Senate Bill 447 in the 56th Texas Legislature in 1959. Initially, the District included parts of Edwards and Real counties; however, during the 71st Texas Legislature in 1989, House Bill 3127 was passed modifying the District's enabling legislation to include all of Edwards and Real counties. The District is funded through fees and a $0.02 per one hundred dollars valuation ad valorem tax on property within the District.

Planning Period

This Management Plan becomes effective upon review and approval by the Texas Water Development Board (TWDB) and remains in effect until a revised plan is approved or five (5) years from the date of approval, whichever is earlier. The plan may be reviewed annually. The Groundwater Management Plan must be reviewed by the Board of Directors, readopted with or without revisions, and be resubmitted to the TWDB for approval at least once every five years.

As outlined in Chapter 36.1071, Texas Water Code, the District's Management Plan is required, as applicable, to address the following management goals:

- Providing the most efficient use of groundwater §36.1071(a)(1);
- Controlling and preventing waste of groundwater §36.1071(a)(2);
- Controlling and preventing subsidence §36.1071(a)(3);
- Addressing conjunctive surface water management issues §36.1071(a)(4);
- Addressing natural resource issues §36.1071(a)(5);
- Addressing drought conditions §36.1071(a)(6);
- Addressing conservation, recharge enhancement, rainwater harvesting, precipitation enhancement, or brush control where appropriate and cost effective, §36.1071(a)(7) and;
- Addressing the desired future conditions established under TWC §36.108. §36.1071(a)(8).

The following goals referenced in Chapter 36.1071, Texas Water Code, have been determined not applicable to the District:

§36.1071(a)(3) Controlling and preventing subsidence;
§36.1071(a)(7) Addressing recharge enhancement and; precipitation enhancement.

General Description

The District is governed by nine Directors who are elected by local voters and serve four-year staggered terms of office. District rules were revised in April 2016 which will affect this Groundwater Management Plan. The District encompasses the total of Real and Edwards counties, located in the southwestern part of the Texas Hill Country with Leakey and Rocksprings as the county seats, respectively. Real and Edwards counties' economies are primarily based on agriculture, tourism, and hunting industries. The rugged terrain with its winding roads, magnificent vistas, and crystal-clear springs, streams, and rivers, along with some of the best hunting in Texas, have made the area a favorite for vacationers and absentee landowners alike.

Geographical Information

The District lies within the Edwards Plateau and consists of approximately 1,810,169 acres in Real and Edwards counties. The land is generally rolling to mountainous with elevations from 1500 to 4000 ft. The District is included in three different river basins, the Nueces, Colorado, and the Rio Grande. The headwaters of the Nueces River and Frio River and a portion of the headwaters of the Sabinal River and the South Llano River are located within the District. The western half of Edwards County slopes southwestward into the Devils River. The eastern part of Edwards County drains into the Nueces River and the northern part drains into the Llano River. Real County drains into the Nueces River on the west and into the Frio River on the east with a small northern portion draining into the South Llano River. The land also includes many shallow depressions that catch rainfall and runoff to be either evaporated or infiltrated into the soil.

Groundwater Resources

Aquifers within Edwards and Real counties have been divided by the Texas Water Development Board (TWDB) into two types; namely, major and minor aquifers. The TWDB has classified two major aquifers within the District: the Edwards-Trinity (Plateau) Aquifer and the Trinity Aquifer in the southeast corner of Real County. The District, along with the Region J Planning Group, has identified two minor aquifers in the District; the Frio River Alluvium Aquifer and the Nueces River Alluvium Aquifer. These minor aquifers were included in the last Plateau Region (Region J) Water Plan that was approved by the TWDB in May 2015. There are numerous wells completed in the alluvial, with a majority being used for domestic and/or livestock purposes; others are used for irrigation and municipal purposes. The City of Leakey's well field is completed in the Frio River Alluvium Aquifer, and the Barksdale Water Supply Corporation's wells are completed in the Nueces River Alluvium Aquifer approximately one-half mile from the Nueces River in the community of Barksdale.

Edwards-Trinity (Plateau) Aquifer

Limestone is the predominant rock underlying the Edwards Plateau soils. The permeability of the limestone is not necessarily due to inter-granular pore space as in sandstone, but more to joints, crevices, and solution openings that have been enlarged by solvent action of water charged with carbon dioxide. The Edwards-Trinity (Plateau) Aquifer covers all or part of thirty-three (33) counties, or the boundary of Groundwater Management Area 7 (GMA 7). Real and Edwards counties sit on the southeastern edge of this aquifer. Groundwater availability data from GAM Run 16-026 MAG (Version 2) of the groundwater availability model for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers were used for this report and show that there is approximately 13,199 acre-feet/year of water per year available to the District from this aquifer. Appendix 3 The Pecos Valley Aquifer does not occur within the District; therefore, no groundwater budget values are included in this report. Within the District, groundwater is fresh, with total dissolved solids of less than 500 milligrams per liter in most sampled wells. The permeability of the formation is such that a well's pumping capacity may vary from as little as one (1) gallon per minute (gpm) to several hundred gallons per minute in limited locations. For the most part, wells completed in this formation within Edwards and Real counties consistently yield between 3 and 10 gpm.

Trinity Aquifer

The Trinity Aquifer is composed of marine sediments (primarily limestone) deposited during the Cretaceous Period. The Trinity Group in Edwards and Real counties includes the Glen Rose and underlying Travis Peak formations. In some areas, the Glen Rose consists of up to approximately 1,000 feet of limestone with embedded shale, marl and occasional anhydrite (gypsum) and is the primary unit in the Trinity Aquifer in the southern part of the Edwards Plateau area. The Travis Peak contains sands, clays and limestones that are subdivided into water-bearing members of the Glen Rose Limestone, Hensell Sand, Cow Creek Limestone, Sligo Limestone, and Hosston Sand water-bearing formations. Samples from the Trinity Aquifer have total dissolved solids (TDS) concentrations above the secondary standard of slightly saline (1,000 - 3,000 mg/l).

Groundwater availability data from GAM Run 16-026 MAG (Version 2) of the groundwater availability model for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers were used for this report and show there is approximately 52 acre-feet/year available to the District from this aquifer. Wells completed within the Trinity Formation of the District (southeast Real County) tend to yield substantially more water (50 -150+ gpm). However, as noted above, often the high TDS and sulfate content requires water from this formation to undergo extensive treatment prior to becoming potable.

Frio River Alluvium Aquifer

The Frio River Alluvium Aquifer in central Real County extends over an area of approximately 9,530 acres. The alluvial (clay, silt, gravel, etc. deposited by running water) generally follows the flood plain of the Frio River in Real County. The aquifer's width varies from almost nonexistent to over a mile. As with the width, the aquifer's thickness varies but is thought to not exceed 42 feet. Wells in the Frio River Alluvium Aquifer are generally shallow and provide water in small quantities for domestic and livestock purposes within Real County. However, as mentioned above, there are several large capacity wells completed in this zone and the City of Leakey's well field is completed in this aquifer.

Because of the limited extent of this aquifer and its shallow water table, the aquifer system is potentially susceptible to contamination from surface sources. Recharge to the aquifer is from stream loss and direct infiltration of precipitation. Estimates indicate there is approximately 2,145 acre-feet/year available within this aquifer. Plateau Region Water Plan 2015 Appendix 5

Nueces River Alluvium Aquifer

The Nueces River Alluvium Aquifer lies between Edwards and Real counties and extends over an area of approximately 24,450 acres. As with the Frio Alluvium Aquifer, the Nueces River Alluvium Aquifer is readily susceptible to diminished supplies during drought conditions, potentially from over-pumping, and from contaminated surface sources. Recharge of this aquifer is much like that of the Frio River Alluvium Aquifer, from stream loss and direct infiltration of precipitation. Alluvial deposits of the Pleistocene and Holocene Epoch materials occur along nearly all the stream courses on the Edwards Plateau. These deposits consist of sand, gravel, silt and clay derived from the erosion of the underlying rocks and occur primarily as terrace and flood plain alluvial. As with the defined Frio River Alluvium Aquifer, the alluvial deposits along the flood plains of the Nueces, West Nueces and South Llano rivers vary in width and thickness. The thickness is thought not to exceed 35 feet. There appears to be some hydraulic connection between the alluvial formations and the rivers and streams that meander through them. For the most part, wells in the alluvial formations within the District are generally shallow and provide water in small quantities for domestic and livestock purposes. The Barksdale Water Supply Corporation (serving the community of Barksdale), has its well field completed within the alluvium approximately one-half mile from the Nueces River. Estimates indicate there is approximately 3,574 acre-feet/year available within this aquifer. Plateau Region Water Plan 2015 Appendix 5

Estimated Available Groundwater

All estimates of groundwater availability, usage, supply, recharge, storage and future demands are from data supplied by the Texas Water Development Board, unless otherwise noted. Tables 1 thru 5 herein are taken from the TWDB GAM Run 13-023, December 18th, 2013. Appendix 1 The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. While the District is required to use these estimates, it is hoped that the TWDB will continue to improve the models and the data used herein. The District contends that the methodology used by the TWDB to project current and future water use is flawed in that it fails to consider factors including but not limited to: absentee landowners, vacationers, hunters, wildlife management, and exotic game. Appendix 4

Desired Future Conditions (DFC) and Modeled Available Groundwater (MAG)

House Bill (HB) 1763 passed by the 79th Legislature became effective and incorporated into Chapter 36 of the Texas Water Code. This bill regionalizes decisions of groundwater availability, requires regional water planning groups to use groundwater availability numbers, DFC, from groundwater conservation districts, and defines a permitting target for groundwater production modeled available groundwater (MAG). Groundwater conservation districts, in accordance with HB-1763 must establish their respective DFCs of how their aquifer will be managed for the period 2010 through 2070.

TWC § 36.001 defines modeled available groundwater as "the amount of water that the executive administrator determines may be produced on an average annual basis to achieve a desired future condition established under Section 36.108". The joint planning process set forth in TWC § 36.108 must be collectively conducted by all groundwater conservation districts within the same GMA. The District is a member of GMA 7, which along with the other districts in the GMA did establish a comprehensive DFC. Appendix 3 contains the GAM run (GAM Run: 16-026 MAG (Version 2)) [Appendix 3] whose results are based on a DFC of 2 to 4 feet of drawdown across the District from 2010 to 2070.

Natural and/or Artificial Recharge

Recharge is the addition of water to an aquifer. The principal source of groundwater recharge in Edwards and Real counties is precipitation that falls on the outcrop of the various aquifers. In addition, seepage from streams located on the outcrop and, possibly, interformational leakage are sources of groundwater recharge. Recharge is a limiting factor in the amount of water that can be developed from an aquifer, as it must balance discharge over a long period of time or the water in storage in the aquifer will eventually be depleted. Among the factors that influence the amount of recharge received by an aquifer are: the amount and frequency of precipitation; the extent of the outcrop or intake area; topography, type and amount of vegetation, the condition of soil cover in the outcrop area; and the ability of the aquifer to accept recharge and transmit it to areas of discharge. On aquifer outcrops where vegetation is dense, the removal of underbrush and non-beneficial plants will reduce evaporation and transpiration losses, making more water available for groundwater recharge. According to estimates from the TWDB GAM Run 13-023, December 18th, 2013, [Appendix 1] the District receives approximately 76,462 acre-feet/year of recharge annually from precipitation. See Table 1.

Table 1: ESTIMATED ANNUAL AMOUNT OF RECHARGE FROM PRECIPITATION TO THE DISTRICT. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT AS NOTED IN GAM RUN 13-023, DECEMBER 18TH, 2013.

Aquifers or Confining Units	Results (acre-feet/year)
Edwards-Trinity (Plateau) Aquifer	75,382
Trinity Aquifer	1,080
Total	76,462

In the Edwards Plateau region, the annual rate of evaporation is three times greater than the annual rate of precipitation, thus creating perpetual low soil moisture content that retards percolation except under the most ideal conditions. Percolation usually occurs during relatively short periods after rainfall. Soil permeability is an expression of the ability of water to pass through pore spaces of the soil and varies throughout the Edwards Plateau from less than 0.06 to 0.63 inches per hour. This information is derived from a 1979 report by Lloyd Walker titled "Occurrence, Availability, and Chemical Quality of Ground Water in the Edwards Plateau Region of Texas, Report 235, Texas Department of Water Resources."

Additional Recharge

The estimate of the annual amount of additional natural or artificial recharge of groundwater within the District that could result from implementation of feasible methods for increasing the natural or artificial recharge is difficult to determine due to the direct correlation to rainfall. There are several feasible methods of additional recharge:

Flood Prevention Sites: Along the headwaters of the Frio and Nueces River there are numerous privately-owned dams that catch and retain water. On the Nueces, there is a public dam along the Uvalde and Real County line. There are a few privately owned dams on the Llano River as well. Construction of small dams to slow down runoff may be beneficial to the recharge of the aquifers within the District.

Range Management through Brush Control: Real and Edwards counties have a coverage of approximately 65% ash juniper or cedar. Brush control can be accomplished by mechanical control, prescribed burning, a combination of mechanical and burn, or chemical application. Brush control may be considered more of a conservation method than an additional recharge method. Recent studies indicate in certain instances over certain terrain and with proper techniques, brush control may enhance recharge as well as serve as a water conservation measure.

Natural and Artificial Discharge

Discharge is the loss of water from an aquifer. The discharge may be either artificial or natural. Artificial discharge takes place from flowing and pumped water wells, drainage ditches, gravel pits, and other excavations that intersect the water table. Natural discharge occurs as seepage, springs, evaporation, transpiration, and intraformational leakage. Groundwater moves from areas of recharge to areas of discharge, or from points of higher hydraulic head to points of lower hydraulic head. Movement is in the direction of the hydraulic gradient just as in the case of surface water flow. Under normal artesian conditions, movement of groundwater usually is in the direction of the aquifer's regional dip. The slope of the water-table, and consequently, the direction of groundwater movement, is closely related to the slope of the land surface. However, for both artesian and water-table conditions, local anomalies are developed in areas of pumping and some water moves toward the point of artificial discharge. The rate of groundwater movement in an aquifer is usually very slow, being in the magnitude of a few feet to a few hundred feet per year. While it appears that substantial recharge occurs via precipitation, approximately 41,232 acre-feet/year of water per year is discharged from the aquifer to springs, streams and rivers within the District. [Appendix 1] See Table 2.

TABLE 2: ESTIMATED ANNUAL VOLUME OF WATER THAT DISCHARGES FROM THE AQUIFER TO SPRINGS, STREAMS, AND RIVERS. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT AS NOTED IN GAM RUN 13-023, DECEMBER 18TH, 2013.

Aquifers or Confining Units	Results (acre-feet/year)
Edwards-Trinity (Plateau) Aquifer	41,232
Trinity Aquifer	0
Total	41,232

In planning for future use and availability, it is necessary to look at the amount of water coming into the District from each aquifer. The TWDB estimates that there is a total of 25,653 acre-feet/year flowing into the District. Appendix 1 See Table 3.

TABLE 3: ESTIMATED ANNUAL VOLUME OF FLOW INTO THE DISTRICT WITHIN EACH AQUIFER IN THE DISTRICT. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT AS NOTED IN GAM RUN 13-023, DECEMBER 18TH, 2013.

Aquifers or Confining Units	Results (acre-feet/year)
Edwards-Trinity (Plateau) Aquifer	25,004
Trinity Aquifer	649
Total	25,653

Likewise, it is equally important to know how much water is leaving the District and how much flow there is between the different aquifers. The section above addressed the issue relating to discharges to springs, streams and rivers. However, if there is water entering the District through the aquifers, there is also water leaving the District via the aquifers. According to the TWDB, there is 80,462 acre-feet/year flowing out of the District annually. Appendix 1 See Table 4. There also appears to be a limited amount of flow between the Edwards formation and the Trinity units. This amounts to about 272 acre-feet/year. Appendix 1 See Table 5.

TABLE 4: ESTIMATED ANNUAL VOLUME OF FLOW OUT OF THE DISTRICT WITHIN EACH AQUIFER IN THE DISTRICT. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT AS NOTED IN GAM RUN 13-023, DECEMBER 18TH, 2013.

Aquifers or Confining Units	Results (acre-feet/year)
Edwards-Trinity (Plateau) Aquifer	79,007
Trinity Aquifer	1,455
Total	80,462

TABLE 5: ESTIMATED NET ANNUAL VOLUME OF FLOW BETWEEN EACH AQUIFER IN THE DISTRICT. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT AS NOTED IN GAM RUN 13-023, DECEMBER 18TH, 2013.

Aquifers or Confining Units	Results (acre-feet/year)
Volume of flow between the Edwards-Trinity (Plateau) Aquifer and the Trinity Aquifer	272
Total	272

Surface Water Resources and Availability

Surface water sources within the District include the Nueces River, the Frio River, and the Llano River, along with numerous small streams and hundreds of springs. Major springs include: Seven Hundred Springs, Evans Springs, and Old Faithful Springs. The City of Camp Wood, in Real County, uses Old Faithful Springs as its sole source of municipal water. During the Drought of Record in the 1950's Old Faithful Spring still flowed at a rate that was adequate for the City of Camp Wood's municipal use. According to projections, the City of Camp Wood may be short as much as 172 acre-feet of water per year thru 2060. Appendix 2 The District asked the Plateau Planning Group (Region J) to include a strategy relating to the City of Camp Wood drilling one or more wells to supplement the community's water supply.

Water Supply Needs and Water Management Strategies

District water supply needs exist for the following groups indicating a shortfall for each group by 2070:

- Municipal
  - Camp Wood - 172AF shortfall,
  - Rocksprings - 121AF shortfall,
  - Leakey - 91AF shortfall
  - Barksdale - 54AF shortfall
- Livestock
  - Edwards county - 40AF shortfall
  - Real county - 20AF shortfall
- Mining
  - Edwards county - 30AF shortfall

These shortfalls can be mitigated by management strategies that include drilling of additional groundwater wells into the Edwards-Trinity (Plateau) Aquifer. There are water management strategies (drilling of additional wells) to develop additional aquifer supplies from the Nueces River Alluvium Aquifer for Barksdale WSC and from the Frio River

Alluvium for the City of Leakey. The Edwards-Trinity (Plateau) Aquifer can supply additional water for the Oakmont Saddle Mountain WSC. The City of Leakey can also interconnect the current system wells and increase frequency of water loss audits and repairs to benefit local water availability. The City of Rocksprings, Barksdale WSC, and the Real WSC need to also increase frequency of water loss audits and line repairs to benefit water availability issues.

Surface water from the Frio, Nueces, and South Llano Rivers, as well as springs, contribute 2,520 acre-feet/year. Appendix 2 However, this cannot be considered available as surface water as it does not fall under the jurisdiction of the District. Flow data on most of the springs is sparse. The District has been monitoring the flow of the Nueces, Frio, and South Llano Rivers gathering data to be utilized to set future conditions, as well as use for specific drought triggers when combined with other data. As mentioned above, the aquifers discharge approximately 41,232 acre-feet/year to numerous springs, streams and rivers within the District. See Table 2 Above.

Current and Projected Use

As previously mentioned, artificial discharge is considered the amount of water from flowing and pumped water wells, drainage ditches, gravel pits, and other excavations that intersect the water table. According to the TWDB, the projected total water demand in 2010 was estimated to be 2,422 acre-feet Appendix 2 and estimates from the Plateau Region Water Plan indicate a decline in water use in the District through the year 2060. These figures are based primarily upon population through census and livestock use. The District feels these figures do not take into consideration the large number of absentee landowners in the Real and Edwards counties (approximately 65-70%), nor do the figures consider the rapid change from normal livestock to Game Management and Exotic Game ranches. Other factors the District feels were not considered in these estimates are the abundance of wild game such as hog, axis deer, blackbuck antelope, mouflon sheep and aoudad, nor do these figures account for the large amount of tourism and summer homes. The TWDB estimated historical water use values are found in Appendix 2.

Projected Water Supply

According to data from the Plateau Region Water Plan (May 2015), there are approximately 21,405 acre-feet/year of water available for District use. Appendix 5 However, since a part of this water is surface water, and, for the most part, is permitted by TCEQ and not under District control, that number should be lowered to 19,057 acre-feet /year. According to the Estimated Historical Water Use and 2017 State Water Plan Datasets: Real-Edwards Conservation and Reclamation District Appendix 2 the District has an estimated 2,464 acre-feet of surface water supply. Appendix 2

TABLE 6: PROJECTED SURFACE WATER SUPPLIES, TWDB 2017 STATE WATER PLAN DATA, AS NOTED IN ESTIMATED HISTORICAL WATER USE AND 2017 STATE WATER PLAN DATASETS: REAL-EDWARDS CONSERVATION AND RECLAMATION DISTRICT

EDWARDS COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
J	IRRIGATION, EDWARDS	COLORADO	COLORADO RUN-OF RIVER	43	43	43	43	43	43
J	IRRIGATION, EDWARDS	NUECES	NUECES RUN-OF RIVER	143	143	143	143	143	143
J	LIVESTOCK, EDWARDS	COLORADO	COLORADO OTHER LOCAL SUPPLY	5	5	5	5	5	5
J	LIVESTOCK, EDWARDS	NUECES	NUECES LIVESTOCK LOCAL SUPPLY	47	47	47	47	47	47
J	MINING, EDWARDS	NUECES	NUECES OTHER LOCAL SUPPLY	11	11	11	11	11	11
Sum of Projected Surface Water Supplies (acre-feet)				249	249	249	249	249	249

REAL COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
J	CAMP WOOD	NUECES	NUECES OTHER LOCAL SUPPLY	0	0	0	0	0	0
J	COUNTY-OTHER, REAL	NUECES	NUECES RUN-OF-RIVER	0	0	0	0	0	0
J	IRRIGATION, REAL	NUECES	NUECES RUN-OF-RIVER	2,162	2,162	2,162	2,162	2,162	2,162
J	LIVESTOCK, REAL	COLORADO	COLORADO OTHER LOCAL SUPPLY	3	3	3	3	3	3
J	LIVESTOCK, REAL	NUECES	NUECES LIVESTOCK LOCAL SUPPLY	50	50	50	50	50	50
Sum of Projected Surface Water Supplies (acre-feet)				2,215	2,215	2,215	2,215	2,215	2,215

Management of Groundwater Supplies

The District will work with other agencies and entities including but not limited to the Texas Water Development Board, The Plateau Region (Region J) Planning Group and the Groundwater Management Area 7 (GMA 7) to establish and monitor the Modeled Available Groundwater within the District. On an annual basis, the District will assess water supply and groundwater storage conditions and will report those conditions to the Board of Directors and to the public through the District website and news articles.

The District has, or will, amend as necessary, rules to regulate 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 but not be limited to:

- The equitable conservation and preservation of the resource;
- The economic hardship resulting from granting or denying a permit or the terms prescribed by the rules;
- The modeled available groundwater (MAG) for use in the District; and
- The desired future conditions (DFC) of the Aquifer.

In pursuit of the District's mission of protecting the resource, the District may require reduction of groundwater withdrawals to amounts which will not cause harm to the aquifer. To achieve this purpose, the District may, at the Board of Directors' discretion, amend or revoke any permits after notice and public hearing. The determination to seek the amendment or revocation of a permit by the District will be based on aquifer conditions observed by the District. The District will enforce the terms and conditions of permits and the rules of the District by enjoining the permit holder in a court of competent jurisdiction as provided for in TWC 36.102.

Actions, Procedures, Performance and Avoidance for Plan Implementation

The District will implement this plan and will utilize this plan as a guidepost for determining the direction or priority for all District activities. All operations of the District, all agreements entered by the District, and any additional planning efforts in which the District may participate will be consistent with this plan. The District has adopted and will amend, as necessary, rules relating to the implementation of this plan. The rules adopted by the District shall be pursuant to TWC Chapter 36, the District's enabling act, applicable law, and this plan. All rules will be adhered to and enforced. The promulgation and enforcement of the rules will be based on the best technical evidence available. The District shall treat all citizens fairly, in a nondiscriminatory manner, and with due process in accordance with the District's enabling act, TWC Chapter 36, and applicable law. Current District rules may be found on the District website at http://recrd.org/wp-content/uploads/2018/10/Rule-Revision-2016-Final.pdf.

Methodology for Tracking Progress

Prior to the first quarterly Board of Directors meeting of the fiscal year, the District Manager will prepare an annual report on District performance in achieving the management goals for the preceding year. This report will be presented to the Board of Directors during the first quarterly Board of Directors meeting annually. The report will include the number of instances in which each of the activities specified in the Districts management objectives was engaged in during the fiscal year. The Board of Directors will maintain the report on file, for public inspection, at the District's offices upon adoption. This methodology will apply to all management goals contained within this plan.

Goals, Management Objectives and Performance Standards

Goal 1 – Providing the most Efficient Use of Groundwater (36.1071(a)(1))

Management Objective
1.1: Registration of Wells - The District will review all new well applications and may conduct site visits prior to any new well construction. The District will encourage the registration of existing well through news articles and other means.

Performance Standards
1.1 (a): Within five days of the receipt of an application for a new well, staff will review the application and may contact the applicant to arrange for a site visit.

1.1 (b): Staff may conduct an onsite inspection of the well location prior to any new construction.

1.1 (c): Data will be entered into the District's computer system and a well number will be issued within five days of the receipt of the well log/report from the Driller.

1.1 (d): Staff will furnish a report to the Board of Directors on the number of wells currently listed in the District's computer system on a quarterly basis. The report will include at a minimum; the total number of wells in the data base, the completed number of wells, and the number of pending well files.

1.1 (e): At least 2 times per year, the District will publish an article on the need to register existing wells.

Management Objective
1.2: Operating Permits, Transport Permits, and Other Permits - The District will review and act upon all requests for all permits as outlined in the District's Rules.

Performance Standards
1.2 (a): The District will follow procedures as outlined in District rules for permitting.

1.2 (b): On a quarterly basis, the staff will furnish the Board of Directors with the number of active permits and the number of permits pending.

Management Objective
1.3: Improve/Enhance Water Level Monitoring Program - The District will improve its water level monitoring network by identifying additional wells to be monitored, and by annually measuring the depth to water in those wells; record all measurements and/or observations; enter all measurements into District's

computer data base. Establish a baseline by using existing wells, preferably those for which the District already has some historical data, in all major and minor aquifers where wells are available.

Performance Standards
1.3 (a): Annually report to the Board of Directors on the percent of water level monitoring wells for which measurements were recorded each year; the number of data records cataloged in the District's data base each year; the number of wells in the water level measurement network each year; the number of wells added to the network each year.

Goal 2 - Controlling and Preventing Waste of Groundwater (36.1071(a)(2))

Management Objective
2.1: Control and Prevention of Water Waste - The District will investigate all identified wasteful practices within a reasonable number of working days of identification or complaint received. The District will publish at least three (3) articles per year via the local newspapers regarding the prevention of waste.

Performance Standards
2.1 (a): Annually report to the Board of Directors on the number of wasteful practices identified and the average number of days District personnel took to respond or investigate after identification or complaint received. Report to Board of Directors the actions taken to resolve the identification or complaint received.

2.1 (b): Annually report to the Board of Directors on the number of news articles published.

Goal 4 - Addressing Conjunctive Surface Water Management Issues (36.1071(a)(4))

Except as provided in Chapter 36 of the Texas Water Code, the District has no jurisdiction over surface water. The District shall consider the effects of surface water resources as required by Section 36.113 and other state law. However, the Headwaters to the Nueces, Frio, and to some extent the South Llano Rivers, initiate in the District and the District is fully aware of the ecological and economic impact of these rivers. The Nueces River Authority is the predominant agency in dealing with the Nueces River and Frio River, and the District works with that entity in promoting water conservation and the prevention of waste and contamination of ground and surface water. The District also promotes the Clean Rivers Program initiated by the Nueces River Authority.

Management Objective
4.1: The District will work in conjunction with the Nueces River Authority and other stakeholder groups to promote the Clean Rivers Program and will include information about that program.

Performance Standards
4.1 (a): Annually report the number of programs, meetings etc. participated in.

4.1 (b): Annually report the number of articles relating to the Clean Rivers program.

Management Objective
4.2: The District will include information regarding the need to prevent contamination of the springs, streams, and rivers within the District.

Performance Standards
4.2 (a): Annually report the number of news articles relating to contamination.

Management Objective
4.3: Upon request and in conjunction with the Nueces River Authority, the District will conduct school and/or public presentations relating to the impact of contamination on the Nueces River Basin Watershed.

Performance Standards
4.3 (a): Annually report the number of requests and number of programs participated in.

Goal 5 – Addressing Natural Resource Issues that Impact the Use and Availability of Groundwater and Which are Impacted by the Use of Groundwater (36.1071(a)(5))

Management Objective
5.1: The District will investigate any reported contamination and work with the Railroad Commission, the Texas Commission on Environmental Quality, and/or other entities/agencies to ensure that any contamination is minimized or eliminated.

Performance Standards
5.1 (a): Investigate any report of potential contamination.

5.1 (b): Annually report the number of potential contamination incidents and the location of such incidents to the Board of Directors.

Management Objective
5.2: During the next round of Regional Planning, the District will again work to include Strategies relating to the investigation and/or impact of the contamination of wells in the District.

Performance Standards
5.2 (a): Annually report to the Board of Directors on the progress and/or the success of the objective.

Goal 6 –Addressing Drought Conditions (36.1071(a)(6))

Management Objective

6.1: Curtailment of Groundwater Withdrawal - The annual amount of groundwater permitted by the District for withdrawal from the portion of the aquifers located within the District may be curtailed during periods of extreme drought in the recharge zones of the aquifers or because of other conditions that cause significant declines in groundwater surface elevations. Such curtailment may be triggered by the District's Board of Directors based on the groundwater elevation measured in the District's monitoring well(s) and/or stream flow measurements along with other indices such as rainfall and soil moisture. District staff currently monitors five locations along the Frio River and its tributaries, two locations on the Nueces River, and two locations on the South Llano River.

Performance Standards

6.1 (a): Flow measurements will be taken monthly on the Frio, Nueces and South Llano Rivers. The information will be published on the District's webpage for public viewing and in local papers.

6.1 (b): Upon declaration of a change in drought stage, all permit holders will be notified of the need to curtail production.

6.1 (c): Upon declaration of a change in drought stage, staff will submit an article to the local papers. The article will describe the drought stage and the conditions and request that the public initiate conservation measures.

6.1. (d): The District will annually review its drought contingency plan to see what, if any, changes need to be made.

6.1. (e): District staff will report quarterly to the Board of Directors on local drought conditions. Such reports may be oral or written and presented at Board of Directors Meetings. Data for this report may be drawn from information contained on the TWDB web site: https://waterdatafortexas.org/drought or from other sites as deemed relevant by District staff.

Goal 7 – Addressing: a) Conservation, b) Rainwater Harvesting, and c) Brush Control Where Appropriate and Cost Effective (36.1071(a)(7))

Management Objective

7.1: Emphasize Water Conservation through Public Education - The District will sponsor the "Water Wise" conservation education curriculum, available upon request, for all 5th Grade Classrooms within the District.

Performance Standards

7.1(a): Annually report to the Board of Directors on the number of school districts and number of students instructed in the "Water Wise" conservation education curriculum, and the number of water conservation articles presented to the public.

Management Objective

7.2: Public Education – Provide and distribute literature on water conservation by publishing news articles.

Performance Standards

7.2 (a): Annually document number of news articles published.

7.2 (b): Promote rainwater harvesting, xeriscaping and brush control where appropriate and cost-effective. Promotion of these projects may be accomplished through news articles and/or the District's webpage.

7.2 (c): Update District Webpage with informative links that relate to conservation, waste prevention and enhancement of groundwater. The District web page is a direct link to numerous individuals who reside in or own property within the District. Links on the District webpage will be reviewed regularly to insure they are current and that the linked information reflects the management objective. Annually document that the District webpage was reviewed and/or updated.

Management Objective

7.3: Addressing Rainwater Harvesting - The District believes that the harvesting of rainwater is a viable way to both conserve groundwater and to supplement domestic supply in areas within the District where groundwater is in sparse supply. The District will promote rainwater harvesting through news articles and through the District's website.

Performance Standards

7.3 (a): Information regarding rainwater harvesting will be included in news articles.

7.3 (b): On at least a quarterly basis the District web page will be reviewed to ensure that links to information on rainwater harvesting are current.

Management Objective
7.4: Addressing Brush and Invasive plant control - The District is supportive of activities related to brush and invasive plant control as it relates to the recharge of the aquifers. The District will promote brush and invasive plant control through newspaper articles and through links on the District's webpage.

Performance Standards
7.4 (a): The control of brush and/or other invasive plants will be included in news articles.

7.4 (b): On at least a quarterly basis the District web page will be reviewed to ensure that links to information on brush control are current.

Goal 8 – Addressing the Desired Future Conditions (36.1071(a)(8))

Management Objective
8.1: The desired future condition established for the District is for average drawdown not to exceed 2 feet of drawdown from 2010 to 2070. The GAM Run 16-026 MAG Version 2 model results include estimates of groundwater elevations and drawdown for each year of the predictive period (2010 to 2070). In order to assess the desired future condition, each year the District will measure water levels of at least three wells within the District. These measurements, and others in the area taken by the TWDB, will be used over five years to determine average drawdown over that time period.

Performance Standard
8.1: The District will report to the Board of Directors the results of the monitoring the sample wells each year, as well as report on downloaded groundwater data for Real and Edwards counties from the TWDB. After five years, the averages will be used to determine if the District is on track to meet the DFC projections from 2010 to 2070.

8.2: The District actively participates in developing the desired future conditions for the aquifers within the District's boundaries and within the boundaries of Groundwater Management Area (GMA) 7.

Management Goals Not Applicable to the District

Goal 7 – Addressing: a) Recharge Enhancement and b) Precipitation Enhancement (36.1071(a)(7))

Addressing Recharge Enhancement: This management goal is not applicable to the operations of the District as it is cost prohibitive at this time therefore it is not cost effective.

While the District is supportive of Precipitation Enhancement, such a program is costly, thus making it prohibitive. This portion of Management Goal 7 is currently not applicable to the operations of the District.

Goal 3 - Controlling and Preventing Subsidence (36.1071(a)(3))

Tables 1.3 and 1.4 in the LRE Water report *Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping* – TWDB Contract Number 1648302062, by LRE Water (http://www.twdb.texas.gov/groundwater/models/research/subsidence/subsidence.asp) indicate that the risk of subsidence in the District ranges from low (Edwards-Trinity (Plateau) Aquifer) to medium (Trinity Aquifer). Therefore, controlling and preventing subsidence are not applicable to the District.

Definitions and Concepts

In the administration of its duties, the Real-Edwards Conservation & Reclamation District follows the definitions of terms set forth in the District Enabling Act, Chapter 36 of the Texas Water Code, and other definitions as follows:

"Acre" means the unit of measure used to calculate the total land surface area. One acre is equal to 42,560 square-feet.

"Acre-foot" means the amount of water necessary to cover one acre of land one foot deep, or about 325,851 gallons of water.

Agricultural Use or Purpose" means any use or activity involving agriculture, including irrigation.

"Alluvial" means a geological deposit composed of sediment deposited by a stream or river and may be in direct hydraulic connection with the rivers and streams that meander through the area.

"Alluvium Aquifer" means a minor aquifer(s) in the District that is mostly composed of gravel and sands eroded from the surrounding limestone hills and deposited along the flood plains near rivers and streams.

"Aquifer" means a geologic formation, group of formations, or part of a formation that can yield a sufficient amount of groundwater to make the production from this formation feasible for beneficial use.

"Board" means the Board of Directors of the District.

"Conservation" means those water saving practices, techniques, and technologies that will reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses.

"Desired Future Conditions" (DFC's) means a quantitative description, adopted in accordance with Section 36.108 of the Texas Water Code, of the desired condition of the groundwater resources in a management area at one or more specified future times.

"Discharge" means the amount of water that leaves an aquifer by natural or artificial means.

"Director" means a person elected or appointed to serve on the Board of Directors of the District.

"District" means the Real-Edwards Conservation and Reclamation District.

"District Act" means Chapter 341, Acts of the 56th Legislature, Regular Session, 1959 (Article 8280-233, Vernon's Texas Civil Statutes), including all amendments thereto, and the non-conflicting provisions of Chapter 36, Texas Water Code.

"District boundaries" means the boundaries of the District, and such boundaries that are coexisting with the outside boundary lines of Edwards and Real counties.

"District Official" means District Directors and Officers.

"District Office" means the office of the District as established by the Board.

"Drought" means that term as defined in the District's Drought Contingency Plan.

"Drought Contingency Plan" (DCP) means a plan by the District that is designed to reduce demand on the available water supply through a process that becomes more restrictive as drought conditions worsen.

"Drought Stage" means one of the designated drought conditions listed in the District's Drought Contingency Plan.

"Edwards Trinity (Plateau) Aquifer" means the major aquifer within the District. The Edwards Trinity Aquifer extends from the Texas Hill Country to the Trans-Pecos area of West Texas.

"Frio River Alluvium Aquifer" means the minor aquifer in central Real County that extends over an area of approximately 9,530 acres and is mostly composed of gravel and sands eroded from the surrounding limestone hills and deposited along the floodplain of the Frio River.

"Groundwater" means water percolating beneath the surface of the earth.

"Modeled Available Groundwater" (MAG) means the amount of water that the executive administrator determines may be produced on an average annual basis to achieve a desired future condition established under Section 36.108 of the Texas Water Code.

"Municipal or Public Water Supply Use" means the use of groundwater through public water systems that are authorized for providing potable water to the public by the State of Texas.

"Nueces River Alluvium Aquifer" means the minor aquifer within the District extending into both Edwards and Real counties that extends over an area of approximately 24,450 acres and is mostly composed of gravel and sands eroded from the surrounding limestone hills and deposited along the floodplain of the Nueces River.

"Pollution" means the alteration of the physical, thermal, chemical, or biological quality of, or the contamination of any water in the District that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property or to public health, safety, or welfare, or impairs the usefulness or public enjoyment of the water for any lawful or reasonable purpose including the alteration of groundwater by saltwater or other deleterious matter admitted from another stratum or from the surface of the ground.

"Recharge" means the amount of water that infiltrates into the water table of an aquifer from the surface of the ground or from other underground formations.

"Registration" means a certificate issued by the District for an exempt or excluded well, or the initial registration of a well that upon completion is to be determined by the District to be non-exempt.

"Rules" means the rules of the District compiled in this document and as may be supplemented, repealed or amended from time to time.

"Spring" means a point of natural discharge from an aquifer.

"Waste" means any one or more of the following:

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

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

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

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

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

(f) groundwater pumped for irrigation that escapes as irrigation tail water onto land other than that of the owner of the well, unless the occupant of the land receiving the discharge has granted permission;

(g) for water produced from an artesian well, "waste" has the meaning assigned by Section 11.205 of the Texas Water Code.

In event of a conflict between "Beneficial Use" or "Beneficial Purposes" and "Waste", "Beneficial Use" or "Beneficial Purposes" shall be subordinate to "Waste".

"Water Table" means the upper boundary of the saturated zone in an unconfined aquifer.

"Well" means any facility, device, or method used to withdraw groundwater; or any artificial excavation or borehole constructed for the purposes of exploring for or producing groundwater, or for injection, monitoring, or dewatering purposes, or a leachate or remediation well.

"Well Registration" means the creation of a record of a well, as determined by its use, and a well identification number for purposes of registering the well as to its geographic location, and for notification to the well owner in cases of spills or accidents, data collection, record keeping, or future planning purposes.

"Xeriscape" means a landscape practice combining the use of low water use plants, design, conservation, and other landscaping principles to conserve water and energy.

Appendix 1

GAM Run 13-023:
Real-Edwards Conservation and Reclamation District Management Plan

GAM Run 13-023: Real-Edwards Conservation and Reclamation District Management Plan

by Radu Boghici, P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-5808
December 18, 2013

STATE OF TEXAS
RADU BOGHICI
GEOLOGY
No. 482
LICENSED
PROFESSIONAL GEOSCIENTIST

12/18/2013

The seal appearing on this document was authorized by Radu Boghici, P.G. 482 on December 18, 2013.

GAM Run 13-023: Real-Edwards Conservation and Reclamation District Management Plan

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Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
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December 18, 2013

EXECUTIVE SUMMARY:

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

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

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

The groundwater management plan for the Real-Edwards Conservation and Reclamation District should be adopted by the district on or before May 12, 2014 and submitted to the executive administrator of the TWDB on or before June 11, 2014. The current management plan for Real-Edwards Conservation and Reclamation District expires on August 10, 2014. This report discusses the methods, assumptions, and results from model runs using the groundwater availability model (version 1.01) for the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Anaya and Jones, 2009). Tables 1 and 2 summarize the groundwater availability model data required by the statute, and Figure 1 shows the area of the model from which the values in the tables were extracted. GAM Run 13-023 meets current standards. If after review of the figures, the Real-Edwards Conservation and Reclamation District determines that the district boundaries used in the assessment do not reflect current conditions, the District should notify the Texas Water Development Board immediately. Per statute, TWDB is required to provide the districts with data from the official groundwater availability models; however, the TWDB has also approved, for planning purposes, an alternative model that can have water budget information extracted for the district. The alternative model is the 1-layer alternative model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Hutchison and others, 2011). Please contact the author of this report if a comparison table using this model is desired.

METHODS:

In accordance with the provisions of the Texas Water Code, Section 36.1071, Subsection (h), the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers was run for this analysis. Real-Edwards Conservation and Reclamation District water budgets for the historical model periods were extracted using ZONEBUDGET Version 3.01 (Harbaugh, 2009) The average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow (upper), and net inter-aquifer flow (lower) for the portions of the aquifers located 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 groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers. The Pecos Valley Aquifer does not occur within the Real-Edwards Conservation and Reclamation District and, therefore, no groundwater budget values are included for it in this report.
- This groundwater availability model includes two layers within Real-Edwards Conservation and Reclamation District, which generally represent the Edwards Group (Layer 1) and the Trinity Group (Layer 2) of the Edwards-Trinity (Plateau) Aquifer. Individual water budgets for the District were determined for the Edwards-Trinity (Plateau) Aquifer (Layer 1 and Layer 2 combined).
- Water budgets for the Trinity Aquifer (Hill Country portion) were determined from layer 2.
- Within the Real-Edwards Conservation and Reclamation District, groundwater in the Edwards-Trinity (Plateau) Aquifer is fresh, with total dissolved solids of less than 500 milligrams per liter in all wells sampled by the TWDB from 2005 onwards. (TWDB Groundwater Database, queried in November 2013).
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the model results for the aquifers located within the district and averaged over the duration of the calibration and verification portion of the model runs in the district, as shown in Tables 1 and 2.

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

- Surface water outflow—The total water discharging from the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).
- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent counties.
- Flow between aquifers—The net vertical flow between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer or confining unit and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer.

The information needed for the District's management plan is summarized in Tables 1 and 2. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located (Figure 1). Also, due to differences in water budget-computing methodologies, certain budget components such as recharge and aquifer leakage to streams are now different from those reported to the Real-Edwards Conservation and Reclamation District in the past.

TABLE 1: SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER THAT IS NEEDED FOR THE REAL-EDWARDS CONSERVATION AND RECLAMATION 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	75,382
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	41,232
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	25,004
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	79,007
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer into the Edwards-Trinity (Plateau) Aquifer	272

TABLE 2: SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER THAT IS NEEDED FOR THE REAL-EDWARDS CONSERVATION AND RECLAMATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	1,080
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	649
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	1,455
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer into the Edwards-Trinity (Plateau) Aquifer	272

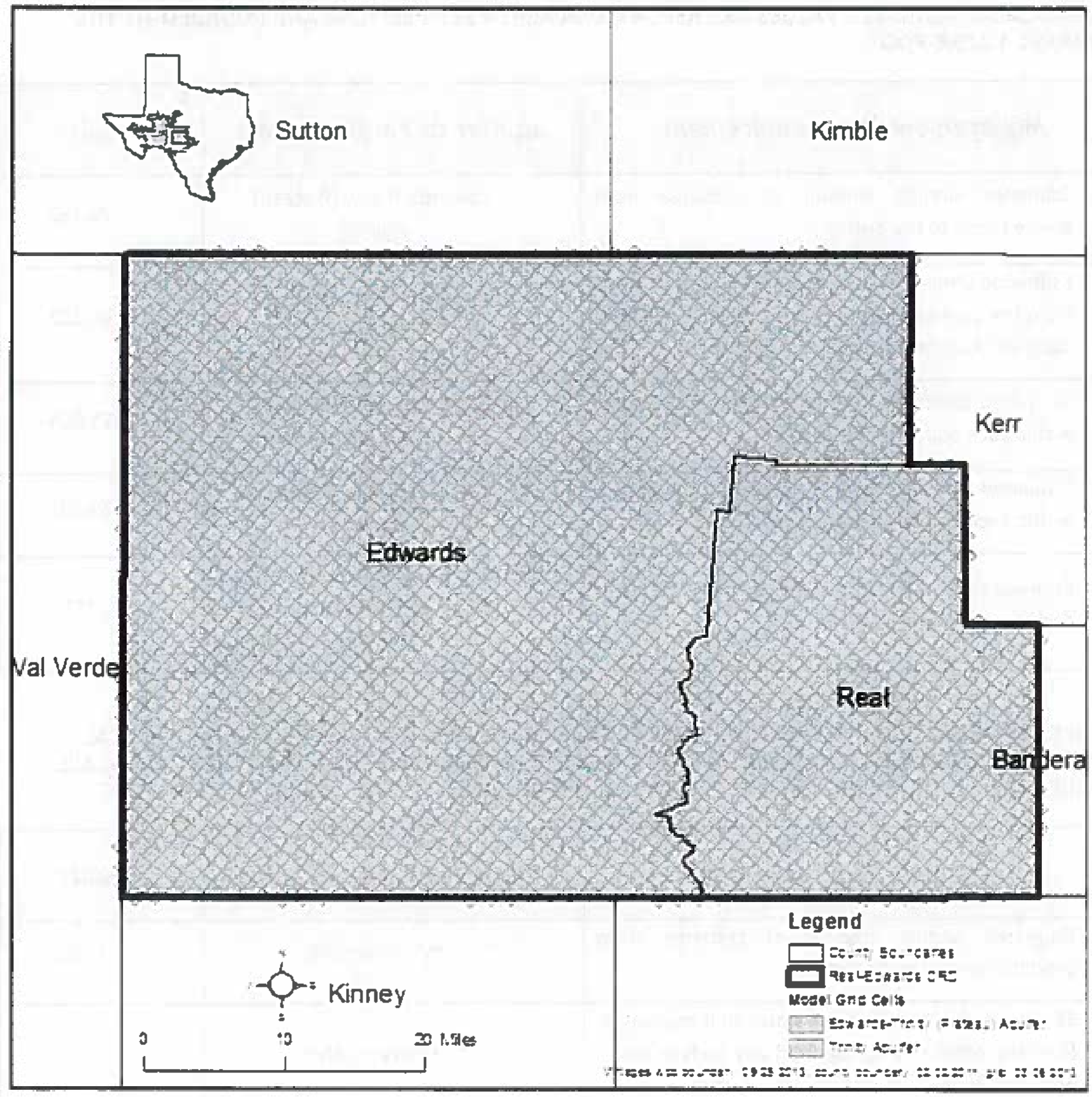

FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL (GAM) FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED FOR THE EXTENT OF THE EDWARDS-TRINITY (PLATEAU) AQUIFER. DATA FOR THE TRINITY (HILL COUNTRY PORTION) AQUIFER WITHIN THE DISTRICT BOUNDARY IS FOUND IN TABLE 2.

LIMITATIONS

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

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

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

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

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

REFERENCES:

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

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

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

Hutchison, W. R., Jones, I., and Anaya, R., 2011, Update of the Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas, 60 p., http://www.twdb.texas.gov/groundwater/models/alt/eddt_p_2011/alt1_eddt_p.asp

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.

TWDB Groundwater Database, 2013, Texas Water Development Board, http://www.twdb.texas.gov/groundwater/data/index.asp, queried November 2013.

Appendix 2

Estimated Historical Water Use
And 2017 State Water Plan Datasets:
Real-Edwards Conservation and Reclamation District
January 15, 2020

Estimated Historical Water Use And 2017 State Water Plan Datasets:

Real-Edwards Conservation and Reclamation District

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
January 15, 2020

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 1/15/2020. 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.

EDWARDS COUNTY

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2017	GW	265	0	0	0	180	288	733
	SW	0	0	0	0	41	32	73
2016	GW	286	0	0	0	240	271	797
	SW	0	0	0	0	22	30	52
2015	GW	282	0	0	0	43	269	594
	SW	0	0	0	0	76	30	106
2014	GW	292	0	0	0	234	267	793
	SW	0	0	0	0	8	30	38
2013	GW	295	0	0	0	127	288	710
	SW	0	0	0	0	63	32	95
2012	GW	339	0	0	0	97	372	808
	SW	0	0	0	0	63	41	104
2011	GW	397	0	0	0	257	426	1,080
	SW	0	0	0	0	61	48	109
2010	GW	269	0	30	0	33	433	765
	SW	0	0	4	0	133	48	185
2009	GW	334	0	27	0	0	469	830
	SW	0	0	4	0	121	52	177
2008	GW	355	0	24	0	57	471	907
	SW	0	0	4	0	60	52	116
2007	GW	291	0	0	0	104	281	676
	SW	0	0	0	0	23	31	54
2006	GW	352	0	0	0	359	353	1,064
	SW	0	0	0	0	58	39	97
2005	GW	352	0	0	0	347	417	1,116
	SW	0	0	0	0	53	47	100
2004	GW	310	0	0	0	315	121	746
	SW	0	0	0	0	63	318	381
2003	GW	292	0	0	0	137	122	551
	SW	0	0	0	0	188	324	512
2002	GW	341	0	0	0	202	126	669
	SW	0	0	0	0	0	334	334

REAL COUNTY

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2017	GW	460	0	0	0	165	38	663
	SW	103	0	0	0	81	10	194
2016	GW	471	0	0	0	146	50	667
	SW	143	0	0	0	71	13	227
2015	GW	436	0	0	0	120	48	604
	SW	143	0	0	0	83	12	238
2014	GW	465	0	0	0	176	48	689
	SW	107	0	0	0	108	12	227
2013	GW	470	0	0	0	149	62	681
	SW	107	0	0	0	119	15	241
2012	GW	494	0	0	0	107	85	686
	SW	136	0	0	0	122	21	279
2011	GW	575	0	0	0	203	209	987
	SW	136	0	0	0	122	52	310
2010	GW	529	0	0	0	95	203	827
	SW	136	0	0	0	148	50	334
2009	GW	515	0	1	0	0	106	622
	SW	136	0	0	0	166	27	329
2008	GW	513	0	1	0	54	101	669
	SW	0	0	1	0	348	25	374
2007	GW	442	0	0	0	0	114	556
	SW	0	0	0	0	160	29	189
2006	GW	498	0	0	0	308	101	907
	SW	0	0	0	0	0	25	25
2005	GW	466	0	0	0	100	128	694
	SW	0	0	0	0	100	32	132
2004	GW	413	0	0	0	78	80	571
	SW	0	0	0	0	97	56	153
2003	GW	418	0	0	0	18	82	518
	SW	0	0	0	0	282	59	341
2002	GW	409	0	0	0	24	93	526
	SW	0	0	0	0	144	67	211

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

EDWARDS COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
J	IRRIGATION, EDWARDS	COLORADO	COLORADO RUN-OF-RIVER	43	43	43	43	43	43
J	IRRIGATION, EDWARDS	NUECES	NUECES RUN-OF-RIVER	143	143	143	143	143	143
J	LIVESTOCK, EDWARDS	COLORADO	COLORADO OTHER LOCAL SUPPLY	5	5	5	5	5	5
J	LIVESTOCK, EDWARDS	NUECES	NUECES LIVESTOCK LOCAL SUPPLY	47	47	47	47	47	47
J	MINING, EDWARDS	NUECES	NUECES OTHER LOCAL SUPPLY	11	11	11	11	11	11
	Sum of Projected Surface Water Supplies (acre-feet)			**249**	**249**	**249**	**249**	**249**	**249**

REAL COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
J	CAMP WOOD	NUECES	NUECES OTHER LOCAL SUPPLY	0	0	0	0	0	0
J	COUNTY-OTHER, REAL	NUECES	NUECES RUN-OF-RIVER	0	0	0	0	0	0
J	IRRIGATION, REAL	NUECES	NUECES RUN-OF-RIVER	2,162	2,162	2,162	2,162	2,162	2,162
J	LIVESTOCK, REAL	COLORADO	COLORADO OTHER LOCAL SUPPLY	3	3	3	3	3	3
J	LIVESTOCK, REAL	NUECES	NUECES LIVESTOCK LOCAL SUPPLY	50	50	50	50	50	50
	Sum of Projected Surface Water Supplies (acre-feet)			**2,215**	**2,215**	**2,215**	**2,215**	**2,215**	**2,215**

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.

EDWARDS COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
J	COUNTY-OTHER, EDWARDS	COLORADO	22	20	20	20	19	19
J	COUNTY-OTHER, EDWARDS	NUECES	62	60	57	57	57	57
J	COUNTY-OTHER, EDWARDS	RIO GRANDE	12	12	11	11	11	11
J	IRRIGATION, EDWARDS	COLORADO	76	73	70	67	64	62
J	IRRIGATION, EDWARDS	NUECES	89	85	82	78	75	72
J	IRRIGATION, EDWARDS	RIO GRANDE	62	60	57	55	52	50
J	LIVESTOCK, EDWARDS	COLORADO	140	140	140	140	140	140
J	LIVESTOCK, EDWARDS	NUECES	252	252	252	252	252	252
J	LIVESTOCK, EDWARDS	RIO GRANDE	131	131	131	131	131	131
J	MINING, EDWARDS	COLORADO	19	19	19	19	19	19
J	MINING, EDWARDS	NUECES	25	25	25	25	25	25
J	MINING, EDWARDS	RIO GRANDE	45	45	45	45	45	45
J	ROCKSPRINGS	COLORADO	197	193	190	190	189	189
J	ROCKSPRINGS	NUECES	98	96	94	94	94	94
		Sum of Projected Water Demands (acre-feet)	**1,230**	**1,211**	**1,193**	**1,184**	**1,173**	**1,166**

REAL COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
J	CAMP WOOD	NUECES	134	131	128	127	126	126
J	COUNTY-OTHER, REAL	COLORADO	4	4	4	4	4	4
J	COUNTY-OTHER, REAL	NUECES	276	266	258	254	253	253
J	IRRIGATION, REAL	COLORADO	13	12	12	11	11	10
J	IRRIGATION, REAL	NUECES	225	216	207	198	188	181
J	LIVESTOCK, REAL	COLORADO	22	22	22	22	22	22
J	LIVESTOCK, REAL	NUECES	239	239	239	239	239	239
		Sum of Projected Water Demands (acre-feet)	**913**	**890**	**870**	**855**	**843**	**835**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

EDWARDS COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
J	COUNTY-OTHER, EDWARDS	COLORADO	61	63	63	63	64	64
J	COUNTY-OTHER, EDWARDS	NUECES	173	175	178	178	178	178
J	COUNTY-OTHER, EDWARDS	RIO GRANDE	32	32	33	33	33	33
J	IRRIGATION, EDWARDS	COLORADO	44	47	50	53	56	58
J	IRRIGATION, EDWARDS	NUECES	157	161	164	168	171	174
J	IRRIGATION, EDWARDS	RIO GRANDE	15	17	20	22	25	27
J	LIVESTOCK, EDWARDS	COLORADO	6	6	6	6	6	6
J	LIVESTOCK, EDWARDS	NUECES	-16	-16	-16	-16	-16	-16
J	LIVESTOCK, EDWARDS	RIO GRANDE	10	10	10	10	10	10
J	MINING, EDWARDS	COLORADO	4	4	4	4	4	4
J	MINING, EDWARDS	NUECES	18	18	18	18	18	18
J	MINING, EDWARDS	RIO GRANDE	-22	-22	-22	-22	-22	-22
J	ROCKSPRINGS	COLORADO	722	726	729	729	730	730
J	ROCKSPRINGS	NUECES	-98	-96	-94	-94	-94	-94
	Sum of Projected Water Supply Needs (acre-feet)		**-136**	**-134**	**-132**	**-132**	**-132**	**-132**

REAL COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
J	CAMP WOOD	NUECES	-134	-131	-128	-127	-126	-126
J	COUNTY-OTHER, REAL	COLORADO	11	11	11	11	11	11
J	COUNTY-OTHER, REAL	NUECES	817	827	835	839	840	840
J	IRRIGATION, REAL	COLORADO	37	38	38	39	39	40
J	IRRIGATION, REAL	NUECES	2,090	2,099	2,108	2,117	2,127	2,134
J	LIVESTOCK, REAL	COLORADO	33	33	33	33	33	33
J	LIVESTOCK, REAL	NUECES	-33	-33	-33	-33	-33	-33
	Sum of Projected Water Supply Needs (acre-feet)		**-167**	**-164**	**-161**	**-160**	**-159**	**-159**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

EDWARDS COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, EDWARDS, NUECES (J)							
BARKSDALE WSC - ADDITIONAL GROUNDWATER WELL	NUECES RIVER ALLUVIUM AQUIFER [EDWARDS]	54	54	54	54	54	54
BARKSDALE WSC - WATER LOSS AUDIT AND MAIN-LINE REPAIR	DEMAND REDUCTION [EDWARDS]	1	1	1	1	1	1
EDWARDS COUNTY OTHER - VEGETATIVE MANAGEMENT - ARUNDO DONAX	NUECES RUN-OF-RIVER [EDWARDS]	0	0	0	0	0	0
		55	**55**	**55**	**55**	**55**	**55**
LIVESTOCK, EDWARDS, NUECES (J)							
EDWARDS COUNTY LIVESTOCK - ADDITIONAL GROUNDWATER WELLS	EDWARDS-TRINITY-PLATEAU AQUIFER [EDWARDS]	20	20	20	20	20	20
		20	**20**	**20**	**20**	**20**	**20**
MINING, EDWARDS, RIO GRANDE (J)							
EDWARDS COUNTY MINING - ADDITIONAL GROUNDWATER WELLS	EDWARDS-TRINITY-PLATEAU AQUIFER [EDWARDS]	30	30	30	30	30	30
		30	**30**	**30**	**30**	**30**	**30**
ROCKSPRINGS, COLORADO (J)							
CITY OF ROCKSPRINGS - WATER LOSS AUDIT AND MAIN-LINE REPAIR	DEMAND REDUCTION [EDWARDS]	1	1	1	1	1	1
		1	**1**	**1**	**1**	**1**	**1**
ROCKSPRINGS, NUECES (J)							
CITY OF ROCKSPRINGS - ADDITIONAL GROUNDWATER WELL	EDWARDS-TRINITY-PLATEAU AQUIFER [EDWARDS]	121	121	121	121	121	121
		121	**121**	**121**	**121**	**121**	**121**
Sum of Projected Water Management Strategies (acre-feet)		**227**	**227**	**227**	**227**	**227**	**227**

REAL COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
CAMP WOOD, NUECES (J)							
CITY OF CAMP WOOD - ADDITIONAL GROUNDWATER WELLS	EDWARDS-TRINITY-PLATEAU AQUIFER [REAL]	172	172	172	172	172	172
CITY OF CAMP WOOD - CONSERVATION PUBLIC INFORMATION	DEMAND REDUCTION [REAL]	1	1	1	1	1	1

COUNTY-OTHER, REAL, NUECES (J)		**173**	**173**	**173**	**173**	**173**	**173**
CITY OF LEAKEY - ADDITIONAL GROUNDWATER WELL	NUECES RIVER ALLUVIUM AQUIFER [REAL]	91	91	91	91	91	91
CITY OF LEAKEY - INTERCONNECTIONS BETWEEN WELLS	NUECES RIVER ALLUVIUM AQUIFER [REAL]	81	81	81	81	81	81
CITY OF LEAKEY - WATER LOSS AUDIT AND MAIN-LINE REPAIR	DEMAND REDUCTION [REAL]	1	1	1	1	1	1
OAKMONT SADDLE WSC - ADDITIONAL GROUNDWATER WELL	NUECES RIVER ALLUVIUM AQUIFER [REAL]	54	54	54	54	54	54
REAL COUNTY OTHER - VEGETATIVE MANAGMENT (ARUNDO DONAX)	NUECES RUN-OF-RIVER [REAL]	0	0	0	0	0	0
REAL WSC - WATER LOSS AUDIT AND MAIN-LINE REPAIR	DEMAND REDUCTION [REAL]	2	2	2	2	2	2
		229	**229**	**229**	**229**	**229**	**229**
LIVESTOCK, REAL, NUECES (J)							
REAL COUNTY LIVESTOCK - ADDITIONAL GROUNDWATER WELLS	EDWARDS-TRINITY-PLATEAU AQUIFER [REAL]	40	40	40	40	40	40
		40	**40**	**40**	**40**	**40**	**40**
Sum of Projected Water Management Strategies (acre-feet)		**442**	**442**	**442**	**442**	**442**	**442**

Appendix 3

GAM Run 16-026 MAG (Version 2): Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7, September 21, 2018

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

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

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

9/24/2018

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

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

EXECUTIVE SUMMARY:

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

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

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

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

REQUESTOR:

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

DESCRIPTION OF REQUEST:

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

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

Capitan Reef [Complex] Aquifer

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

Dockum Aquifer

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

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

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

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

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

Taylor	0
Terrell	2
Upton	20
Uvalde	2

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

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

Minor Aquifers of the Llano Uplift Area

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

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

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

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

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

Ogallala Aquifer

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

Rustler Aquifer

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

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

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

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

Capitan Reef Complex Aquifer

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

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

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

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

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

Kinney County

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

Val Verde County

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

Minor Aquifers of the Llano Uplift Area

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

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

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

Dockum Aquifer

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

Modeled available groundwater analysis excludes pass-through cells.

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

Ogallala Aquifer

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

Modeled available groundwater analysis excludes pass-through cells.

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

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

Rustler Aquifer

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

Use 2008 recharge conditions throughout the predictive period.

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

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

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

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

METHODS:

As defined in Chapter 36 of the Texas Water Code (TWC, 2011), "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits.

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

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

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

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

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

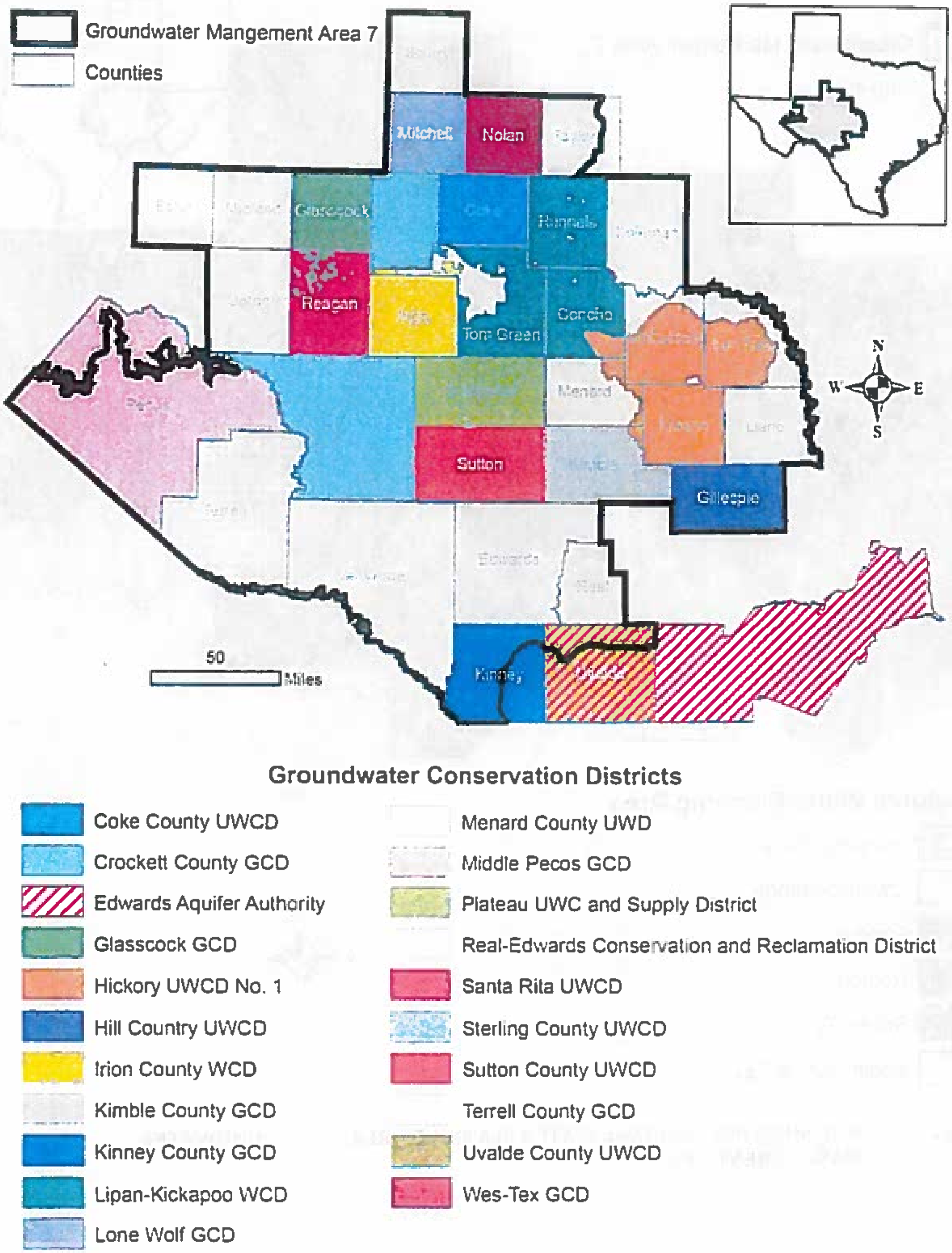

FIGURE 1. **MAP SHOWING THE GROUNDWATER CONSERVATION DISTRICTS (GCD) IN GROUNDWATER MANAGEMENT AREA 7. NOTE: THE BOUNDARIES OF THE EDWARDS AQUIFER AUTHORITY OVERLAP WITH THE UVALDE COUNTY UNDERGROUND WATER CONSERVATION DISTRICT (UWCD).**

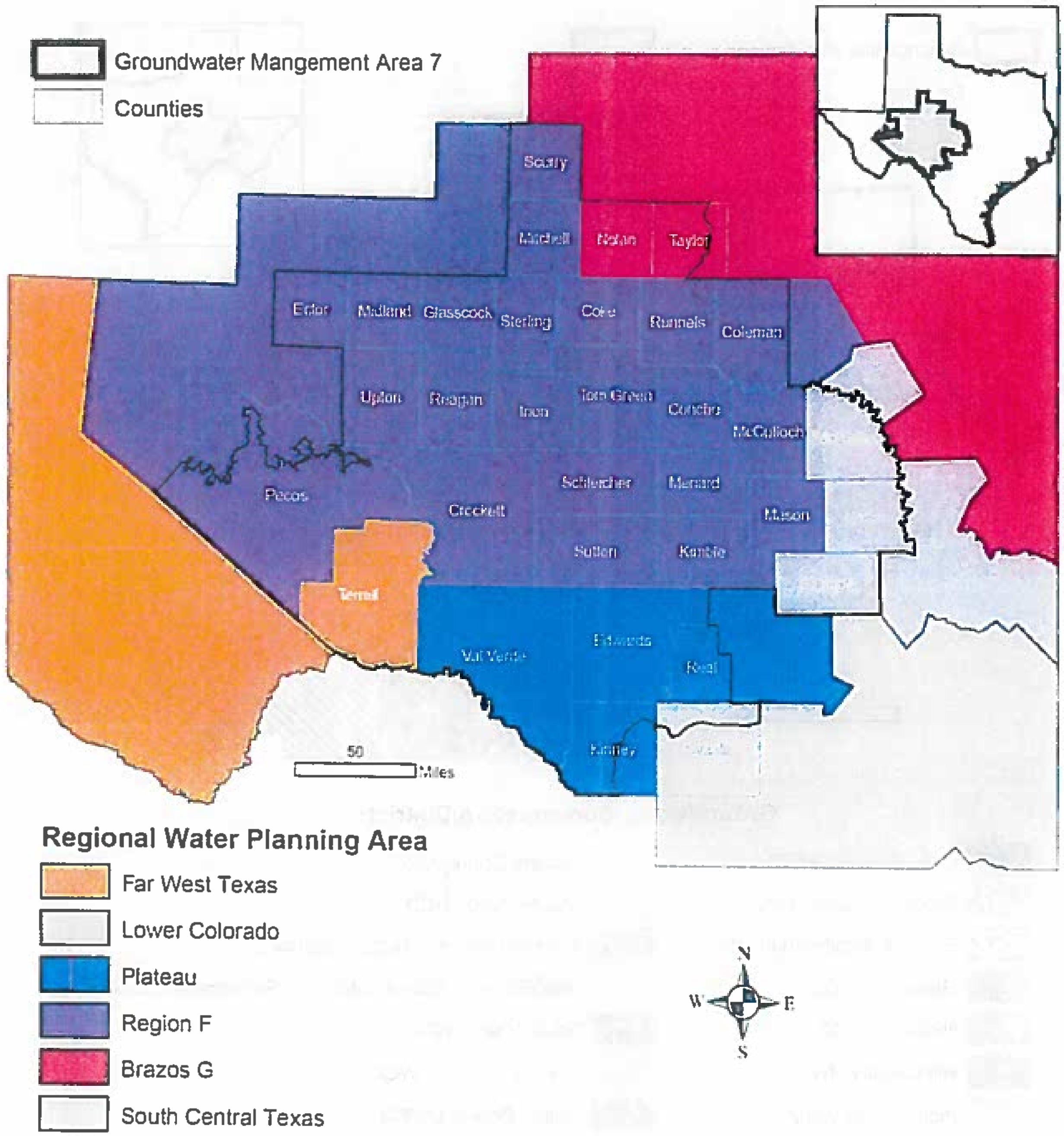

FIGURE 2. MAP SHOWING REGIONAL WATER PLANNING AREAS IN GROUNDWATER MANAGEMENT AREA 7.

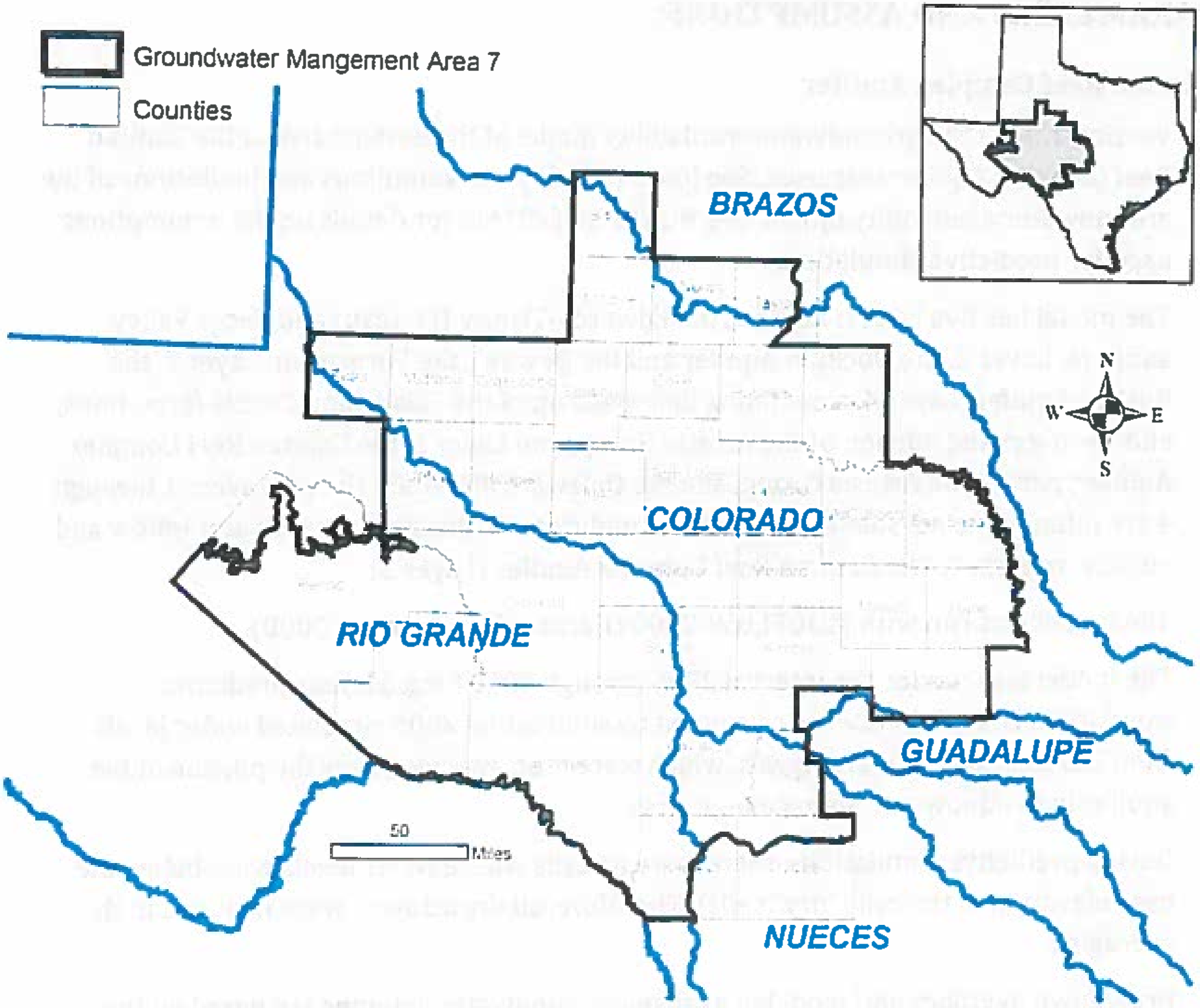

FIGURE 3. **MAP SHOWING RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 7. THESE INCLUDE PARTS OF THE BRAZOS, COLORADO, GUADALUPE, NUECES, AND RIO GRANDE RIVER BASINS.**

PARAMETERS AND ASSUMPTIONS:

Capitan Reef Complex Aquifer

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

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

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

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

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

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

Dockum and Ogallala Aquifers

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

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

The model was run with MODFLOW-NWT (Niswonger and others, 2011). The model uses the Newton formulation and the upstream weighting package, which automatically reduces pumping as heads drop in a particular cell, as defined by the user. This feature may simulate the declining production of a well as saturated thickness decreases. Deeds and Jigmond (2015) modified the MODFLOW-NWT code to use a saturated thickness of 30 feet as the threshold—instead of percent of the saturated thickness—when pumping reductions occur during a simulation. It is important for groundwater management areas to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

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

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

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

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

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

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

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

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

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

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

Edwards-Trinity (Plateau) Aquifer of Kinney County

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

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

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

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

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

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

Edwards-Trinity (Plateau) Aquifer of Val Verde County

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

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

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

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

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

Rustler Aquifer

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

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

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

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

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

Minor aquifers of the Llano Uplift Area

We used version 1.01 of the groundwater availability model for the minor aquifers in the Llano Uplift Area. See Shi and others (2016) for assumptions and limitations of the model. See Hutchison (2016g) for details of the initial assumptions.

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

The model was run with MODFLOW-USG beta (development) version (Panday and others, 2013). Perennial rivers and reservoirs were simulated using the MODFLOW-USG river package. Springs were simulated using the MODFLOW-USG drain package.

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

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

RESULTS:

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

The modeled available groundwater for the respective aquifers has been summarized by aquifer, county, and groundwater conservation district (Tables 1, 3, 5, 7, 9, 11, and 13). The modeled available groundwater is also summarized by county, regional water planning area, river basin, and aquifer for use in the regional water planning process (Tables 2, 4, 6, 8, 10, 12, and 14). The modeled available groundwater for the Ogallala Aquifer that achieves the desired future conditions adopted by districts in Groundwater Management Area 7 decreases from 7,925 to 6,570 acre-feet per year between 2020 and 2070 (Tables 9 and 10). This decline is attributable to the occurrence of increasing numbers of cells where water levels were below the base elevation of the cell ("dry" cells) in parts of Glasscock County. Please note that MODFLOW-NWT automatically reduces pumping as water levels decline.

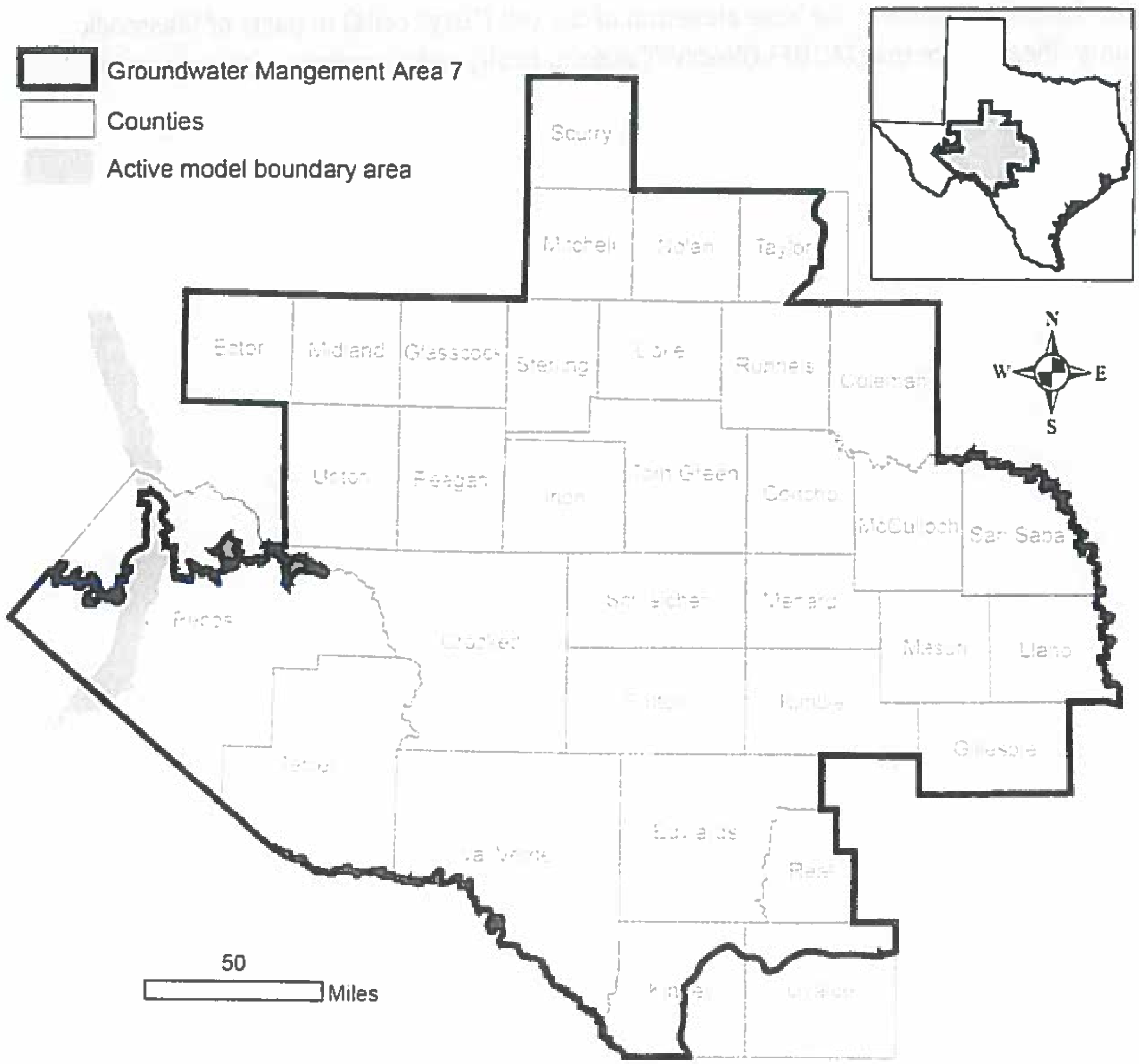

FIGURE 4. MAP SHOWING THE AREAS COVERED BY THE CAPITAN REEF COMPLEX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EASTERN ARM OF THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

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

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

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

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

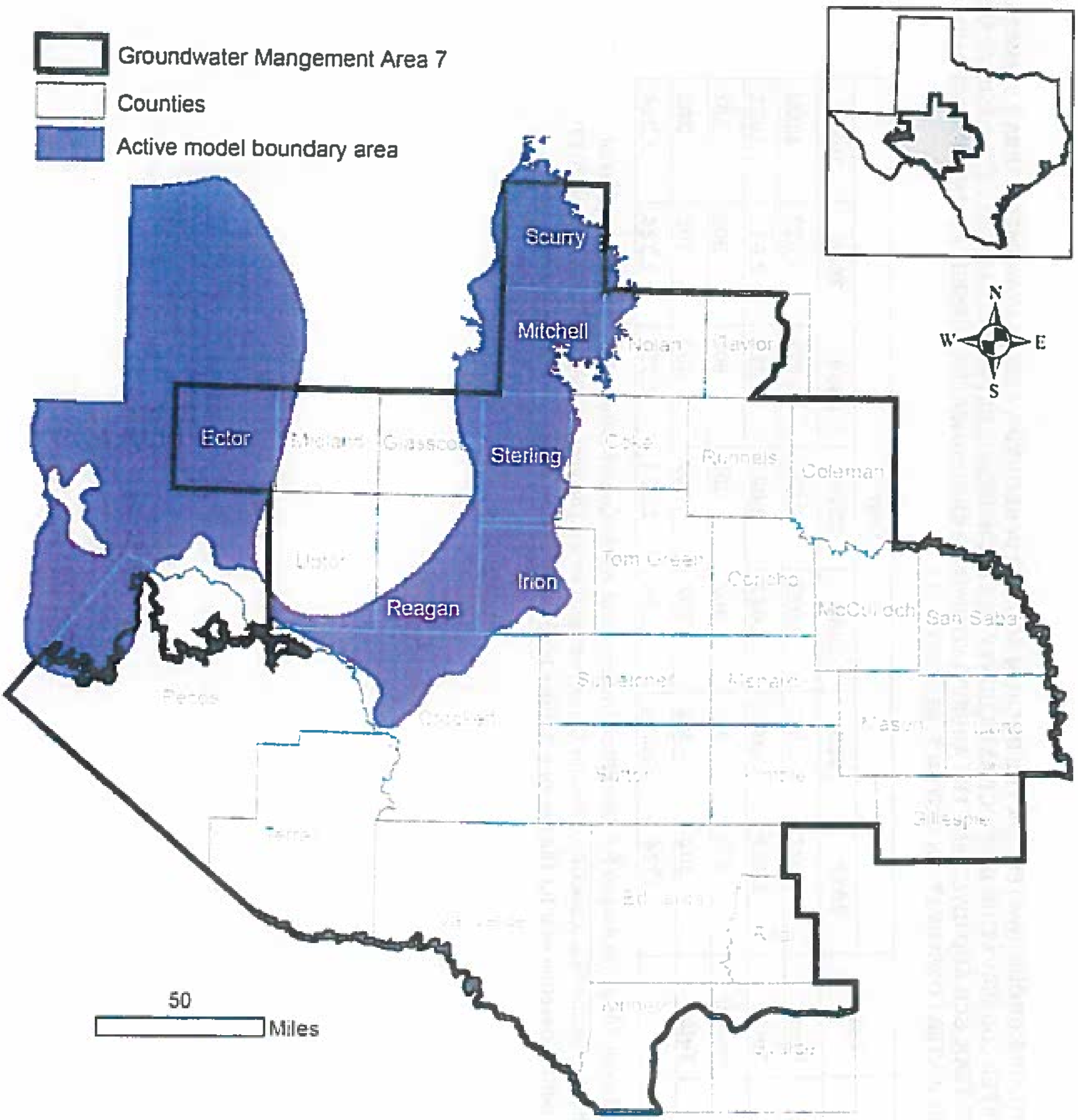

FIGURE 5. MAP SHOWING AREAS COVERED BY THE DOCKUM AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.

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

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

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

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

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Pecos	F	Rio Grande	2,022	2,022	2,022	2,022	2,022	2,022
		Total	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**
Reagan	F	Colorado	302	302	302	302	302	302
		Rio Grande	0	0	0	0	0	0
		Total	**962**	**962**	**962**	**962**	**962**	**962**
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.

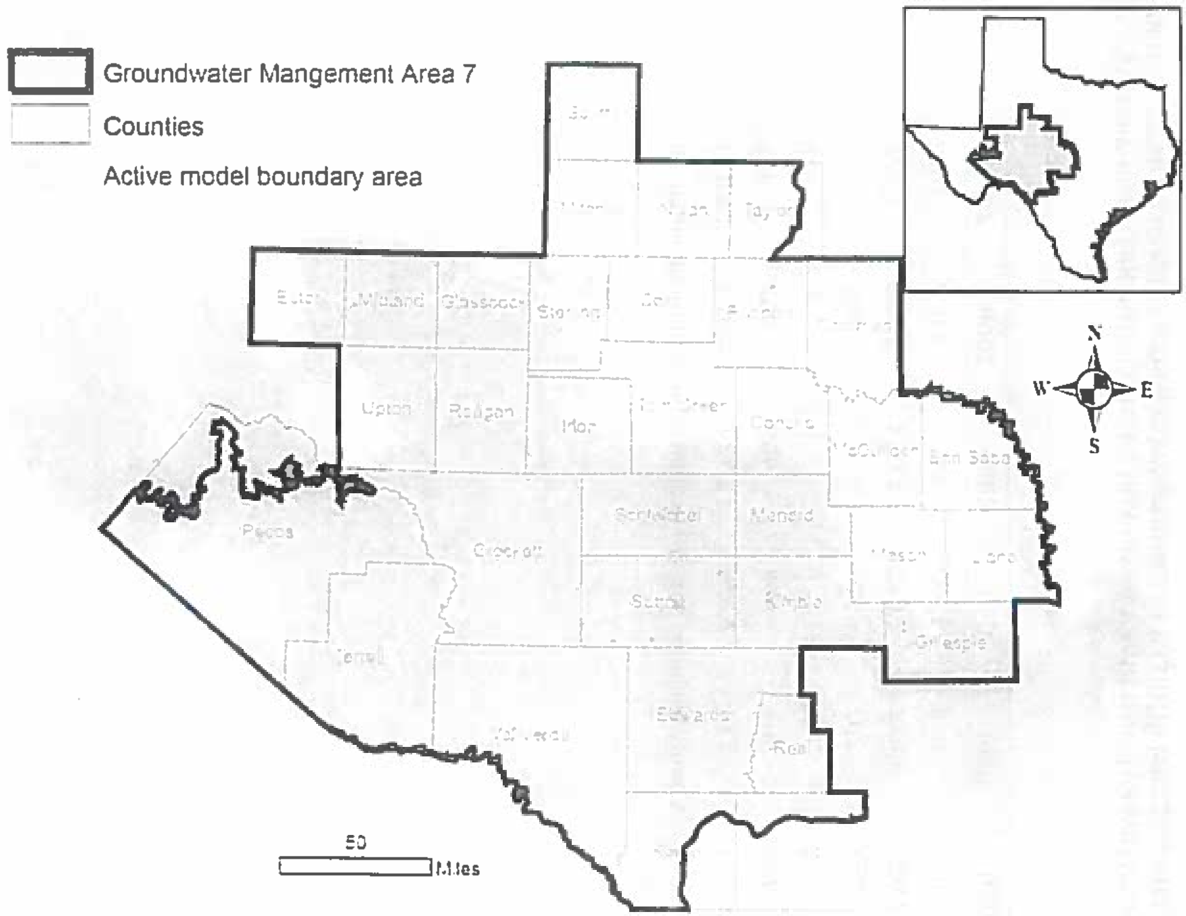

FIGURE 6. MAP SHOWING THE AREAS COVERED BY THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7.

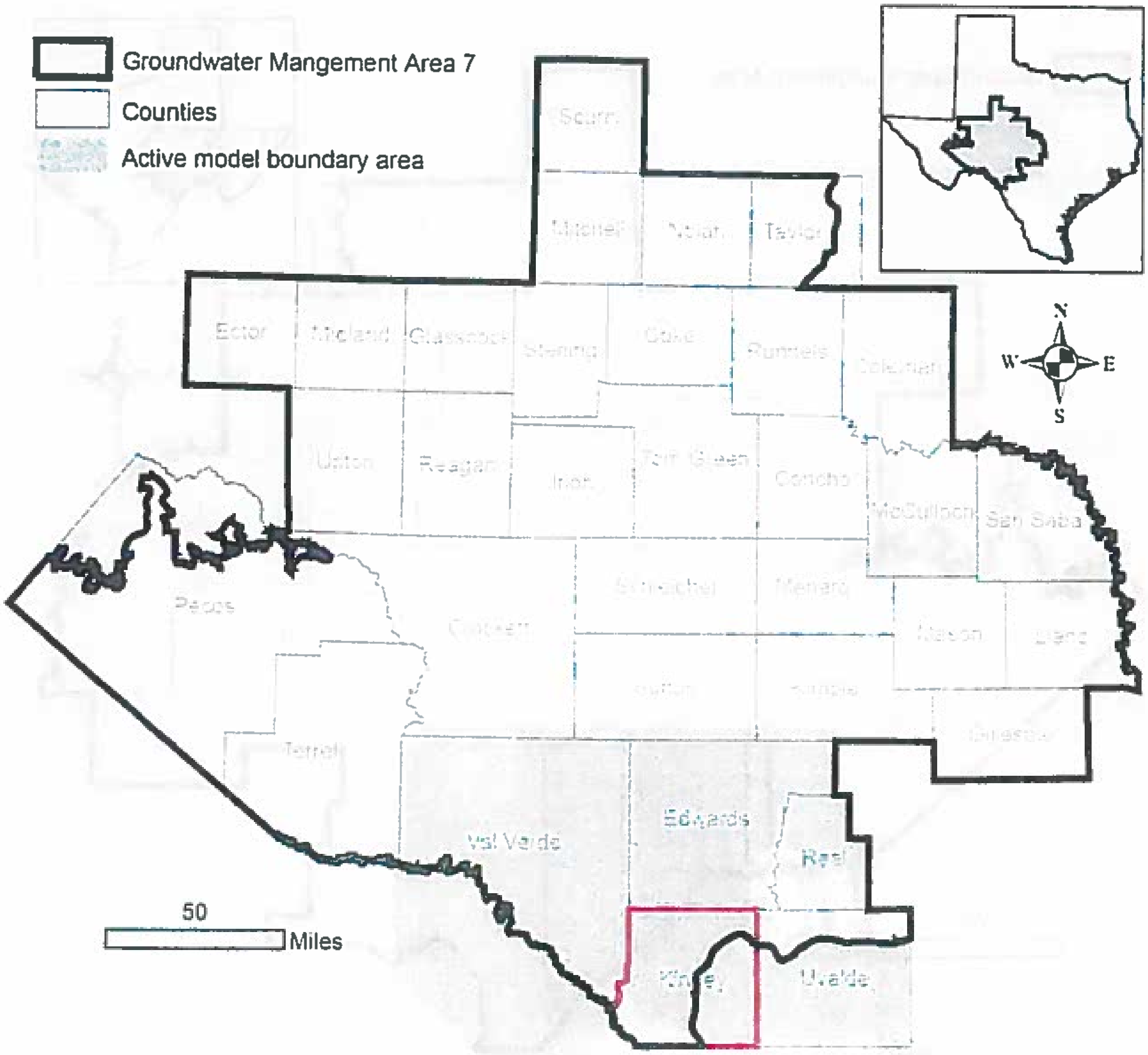

FIGURE 7. MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE ALTERNATIVE MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN KINNEY COUNTY.

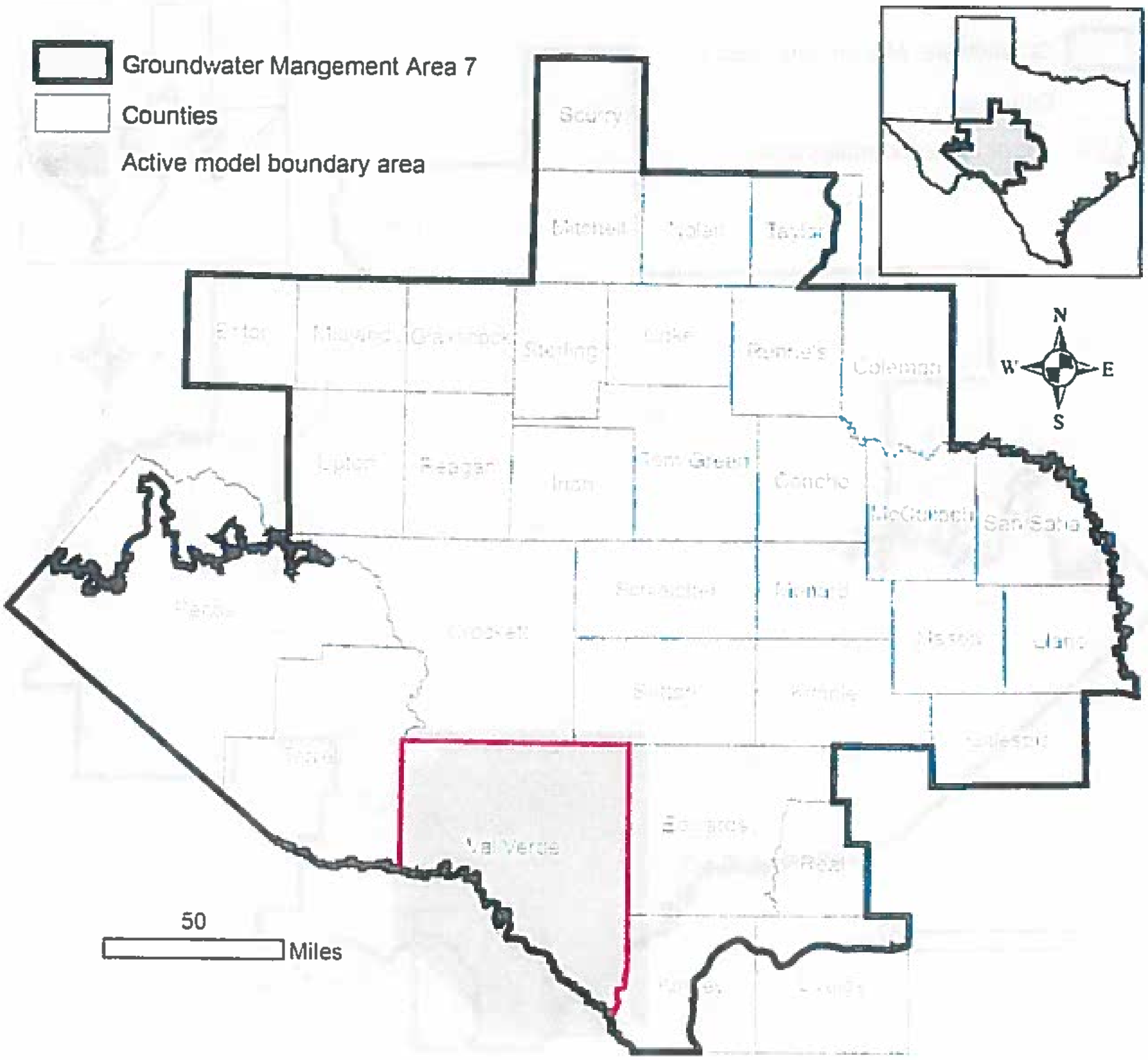

FIGURE 8. MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE GROUNDWATER FLOW MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN VAL VERDE COUNTY.

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.

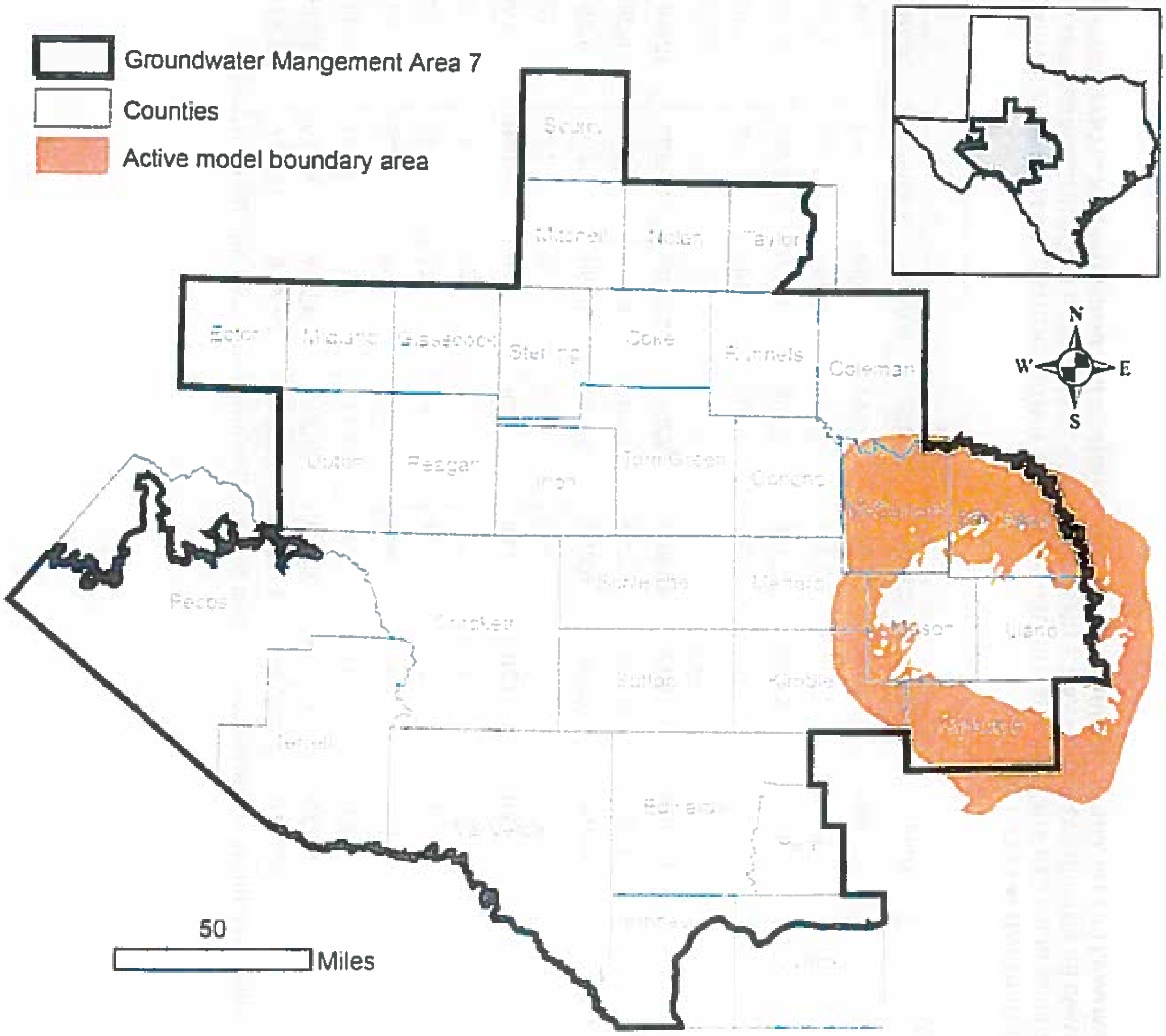

FIGURE 9. MAP SHOWING THE AREAS COVERED BY THE ELLENBURGER-SAN SABA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.

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

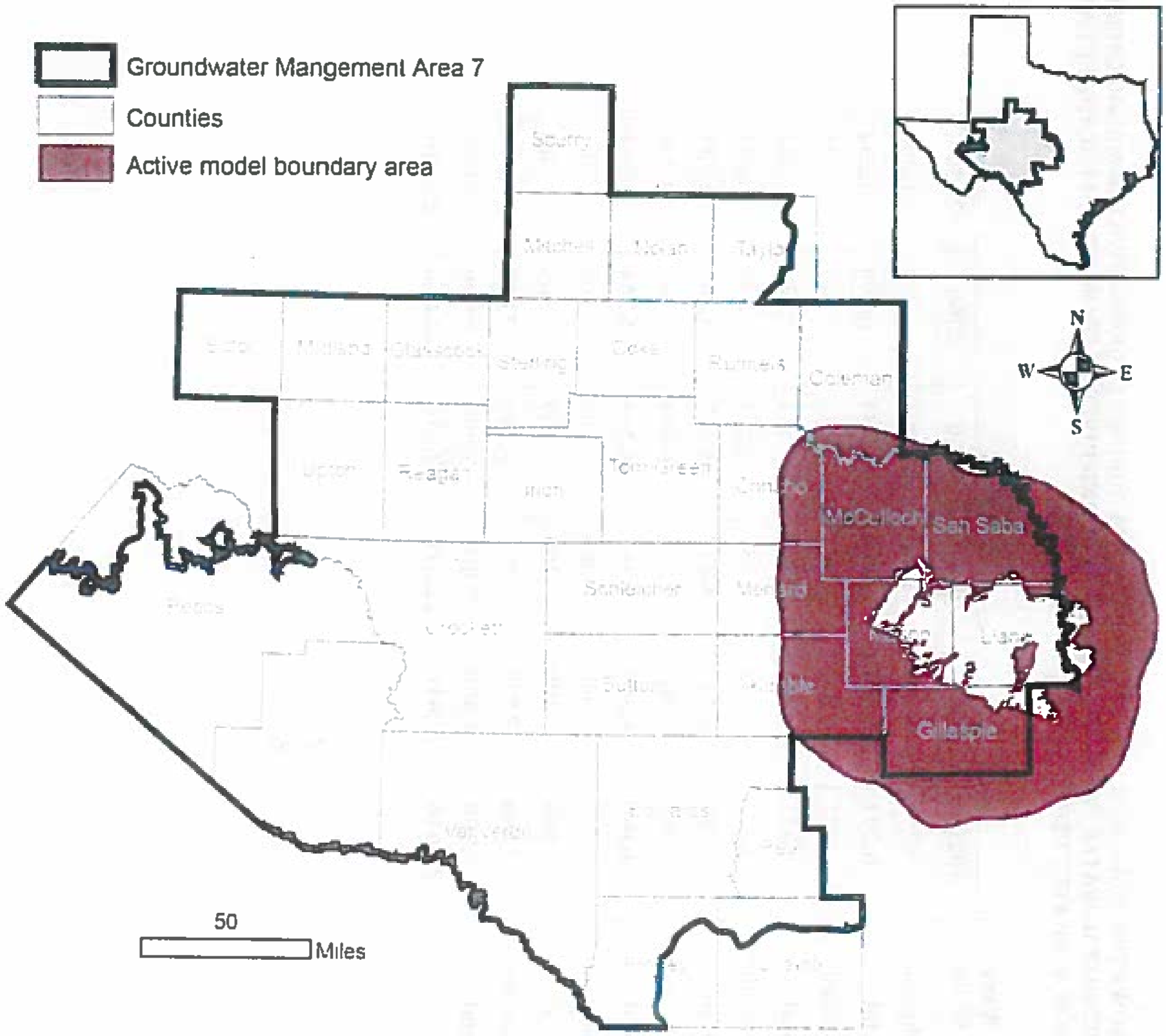

FIGURE 10. MAP SHOWING AREAS COVERED BY THE HICKORY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.

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

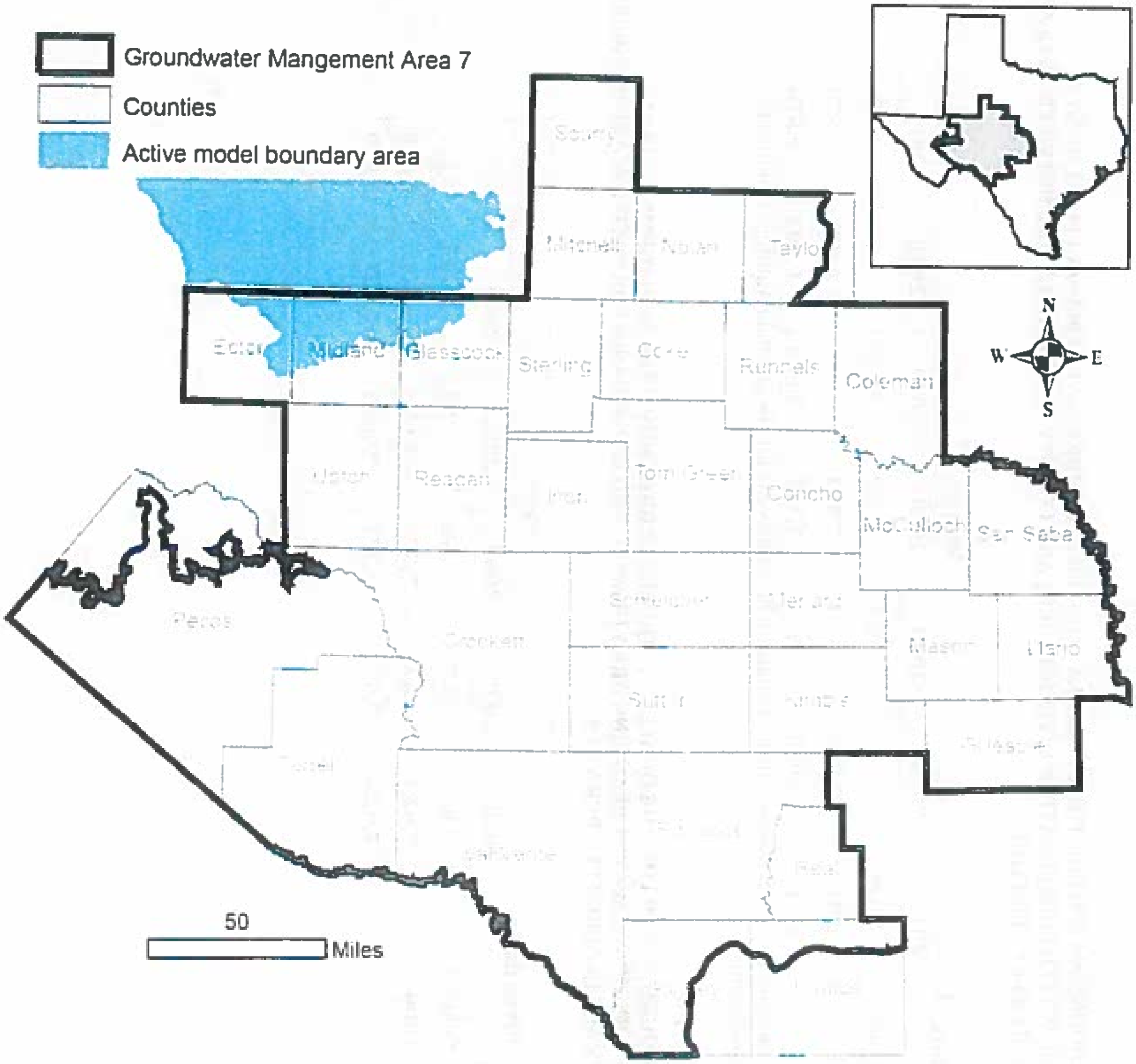

FIGURE 11. MAP SHOWING THE AREAS COVERED BY THE OGALLALA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.

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

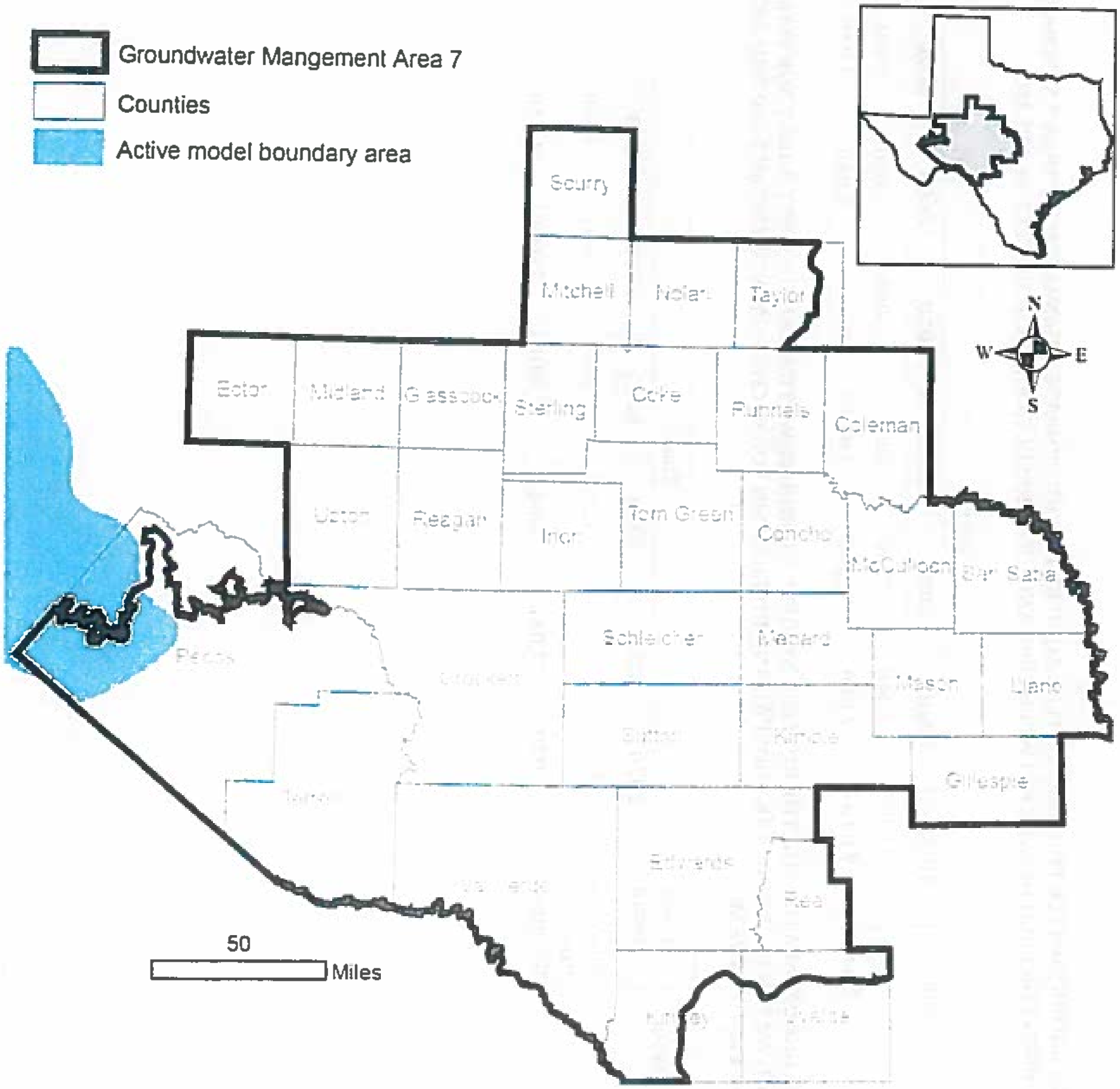

FIGURE 12. MAP SHOWING AREAS COVERED BY THE RUSTLER AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

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.

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Appendix 4

Water Use by Livestock and Game Animals in the Plateau Regional Planning Area, Plateau Region Water Plan, January 2011

Water Use by Livestock and Game Animals in the Plateau Regional Water Planning Area

Jeremy Rice & Jon Albright – Freese and Nichols

April 28, 2010

Introduction

Hunting is a large part of the economy in the Plateau Region. In some cases hunting has replaced traditional livestock as the primary source of income for ranches. In addition to native species, some ranches have imported exotic game animals for their hunting clients. These exotic species are usually confined by high fencing. The high fencing limits access by both the native and non-native animals to natural sources of water, creating greater reliance on pumped groundwater to support these species. In addition, some of these exotic game animals, most notably axis deer, have escaped and established large free-roaming populations throughout the area. Feral hogs, which have originated either as escaped domestic hogs or European wild hogs imported for hunting, have large populations in the region as well.

The Plateau Regional Water Planning group is concerned that the water use for game species is not included in the regional plan. These species are similar to livestock in that they provide considerable economic benefit to the region. Ranchers develop groundwater supplies to provide water for confined exotic species as well as to attract native species. Preliminary estimates of water use by exotic animals show that these animals use about the same amount of water as more conventional livestock species.

This memorandum describes:

- Methods used by the Texas Water Development Board (TWDB) to determine water use and projected demands for traditional livestock
- Trends in water use for traditional livestock
- Available data on the population and water use by game species in the Plateau Region

Changes to the livestock demand projections for the region are not recommended at this time. However, the Plateau Regional Water Planning Group may wish to consider revisions in the next round of regional water planning. More complete data on animal populations in each county will be needed to develop these projections.

Historical and Projected Livestock Water Use in the Plateau Region

Table 1 shows the historical and projected use for livestock in the Plateau Region from the Texas Water Development Board (TWDB). The projected water demands are equal to the year 2000 historical use and remain the same throughout the planning period. Livestock water use was about 6 percent of the total historical water use in the Plateau Region in 2007. (At this time, 2007 is the last year of complete historical water use available for the Plateau Region.)

Table 1
Historical and Projected Livestock Use in the Plateau Region from the Texas Water Development Board
(Values in Acre-Feet per Year)

Historical							
Year	Bandera County	Edwards County	Kerr County	Kinney County	Real County	Val Verde County	Region Total
1974	427	1,311	1,012	780	329	1,223	5,082
1980	376	1,011	535	518	267	1,053	3,860
1984	319	510	442	482	227	471	2,451
1985	284	513	407	468	210	495	2,377
1986	265	443	306	567	226	545	2,352
1987	233	436	337	632	225	596	2,559
1988	331	552	390	680	235	687	2,875
1989	327	549	384	620	234	678	2,792
1990	325	552	382	624	232	691	2,806
1991	333	600	399	648	244	749	2,973
1992	333	615	326	675	174	563	2,986
1993	312	595	488	592	139	676	2,802
1994	361	603	492	553	182	592	2,783
1995	362	596	473	536	190	555	2,712
1996	294	426	432	465	128	534	2,279
1997	275	424	448	391	144	465	2,147
1998	288	473	428	346	143	599	2,277
1999	346	568	501	404	156	733	2,708
2000	315	562	487	445	176	767	2,752
2001	314	520	450	419	158	773	2,634
2002	278	450	415	387	160	687	2,387
2003	241	446	415	285	141	590	2,118
2004	253	439	414	309	136	533	2,084
2005	263	463	369	331	160	516	2,102
2006	263	391	385	298	127	497	1,961
2007	279	312	385	272	143	437	1,828

Projected							
Year	Bandera County	Edwards County	Kerr County	Kinney County	Real County	Val Verde County	Region Total
2000	315	562	487	445	176	767	2,752
2010	315	562	487	445	176	767	2,752
2020	315	562	487	445	176	767	2,752
2030	315	562	487	445	176	767	2,752
2040	315	562	487	445	176	767	2,752
2050	315	562	487	445	176	767	2,752
2060	315	562	487	445	176	767	2,752

TWDB calculates historical livestock water use by multiplying the number of livestock animal units by the estimated water needs for each type of animal. The Natural Resources Conservation Service *National Range and Pasture Handbook* defines an animal unit as "one mature cow of approximately 1,000 pounds and a calf up to weaning, usually 6 months of age, or their equivalent." Animal units can be used to estimate the amount of water or feed needed in livestock operations. One animal unit can represent many individual animals. For example, 1,000 hens is one animal unit.

Table 2 shows the historical animal units from 2003 to 2007, as provided by TWDB. TWDB obtains the number of animal units from the United States Department of Agriculture (USDA). Cattle, sheep, goats and horses are the dominant types of livestock in the Plateau Region. Table 3 shows the water use factors used by TWDB to develop historical water use data.

Trends in Livestock Water Use

Figure 1 compares the historical to projected livestock water use for the region. There is a significant decline in water use between 1974 and 1984, and a slight downward trend since 1984. The estimated year 2007 livestock water use is about 37 percent of the 1974 water use and about 66 percent of the projected livestock water used for planning. This trend is probably the result of the reduction of traditional ranching as a source of income in the region.

Exotic Game Animal Water Use

Numerous exotic game species have been introduced into the Plateau Region. These species were primarily introduced for hunting, which has become a significant source of income in the region. Many of these species are confined in high fenced areas. These animals are essentially equivalent to other types of livestock kept on ranches for commercial purposes. Some of these species have escaped confined operations and have become established throughout the region. Species such as axis deer can out-compete native deer for food. As a result there are now large free-roaming populations of axis deer in addition to the confined populations.

Because many of these species are kept in confined areas, access to natural sources of water may be limited. As a result, groundwater is used as a water source for the commercial herds. Other ranches that are not confined may supplement natural water sources with groundwater to attract game species and improve hunting. The Plateau Regional Water Planning Group believes that, because hunting is a major commercial activity in the area, water use by game species should be considered in regional water planning.

Although not considered a game species, feral hogs have also established significant populations in the region. These hogs originated as domestic hogs or imported European wild hogs. Because there are so many of these animals, water use by feral hogs is significant as well.

Table 2
Historical Livestock Animal Units in the Plateau Region Years 2003 to 2007

Year	County	Cattle	Hogs	Sheep	Goats	Broilers	Horses	County Total
2003	Bandera	11,000	0	8,100	11,000	0	2,465	*32,565*
	Edwards	16,000	438	37,000	67,000	0	3,797	*124,235*
	Kerr	20,000	0	13,000	21,000	0	2,828	*56,828*
	Kinney	11,000	0	23,000	22,000	249	2,491	*58,740*
	Real	7,000	0	4,200	10,000	0	534	*21,734*
	Val Verde	15,000	0	108,000	42,000	0	5,396	*170,396*
	Category Total	*80,000*	*438*	*193,300*	*173,000*	*249*	*17,511*	*464,498*
2004	Bandera	12,000	0	5,500	11,000	0	2,465	*30,965*
	Edwards	16,000	0	35,000	73,000	0	3,797	*127,797*
	Kerr	20,000	0	12,000	21,000	0	2,828	*55,828*
	Kinney	13,000	0	18,000	21,000	257	2,491	*54,748*
	Real	7,000	0	2,100	9,000	0	534	*18,634*
	Val Verde	14,000	0	90,000	41,000	0	5,396	*150,396*
	Category Total	*82,000*	*0*	*162,600*	*175,000*	*257*	*17,511*	*438,368*
2005	Bandera	12,000	0	5,000	11,000	0	3,252	*31,252*
	Edwards	17,000	0	36,000	77,000	0	4,022	*134,022*
	Kerr	15,000	0	12,000	22,000	0	2,054	*54,054*
	Kinney	15,000	0	17,000	24,000	0	2,054	*58,054*
	Real	7,000	0	2,300	8,000	3	2,396	*19,699*
	Val Verde	11,000	0	91,000	43,000	0	7,702	*152,702*
	Category Total	*80,000*	*0*	*153,300*	*185,000*	*3*	*21,480*	*449,783*
2006	Bandera	12,000	0	4,900	12,000	0	3,252	*32,152*
	Edwards	13,000	0	34,000	75,000	0	4,022	*126,022*
	Kerr	19,000	0	12,000	21,000	0	2,054	*54,054*
	Kinney	13,000	0	17,000	24,000	0	2,054	*56,054*
	Real	5,000	0	2,500	8,500	3	2,396	*18,399*
	Val Verde	10,000	0	89,000	46,000	0	7,702	*152,702*
	Category Total	*72,000*	*0*	*159,400*	*186,500*	*3*	*21,480*	*439,383*
2007	*Bandera*	*13,000*	*0*	*4,600*	*11,000*	*0*	*3,252*	*31,852*
	Edwards	9,000	0	30,000	70,000	0	4,022	113,022
	Kerr	19,000	0	12,000	20,000	0	2,054	53,054
	Kinney	12,000	0	13,000	24,000	0	2,054	51,054
	Real	6,000	0	2,200	8,500	14	2,396	19,110
	Val Verde	7,000	0	35,000	45,000	0	7,702	144,702
	Category Total	66,000	0	146,300	178,500	14	21,480	412,794

* Data are from the Texas Water Development Board

Table 6
RECRD Exotic Species Estimates for Real County

Real County	Estimated Number	Gallons per Day	Gallons per Year	Acre Feet per Year
White Tail	44 800	44 800	16 363 200	50
Axis	29 867	61 073	22 306 913	58
Feral Hog	44 800	92 876	33 922 955	104
Black Buck	2,500	2 045	746 983	2
Elk	500	4 499	1,643 143	5
Other	2 000	2 454	896 260	3
Totals	*124 467*	*207,746*	*75 879 354*	233

Conclusions

- The water use projections for traditional livestock may be higher than the actual livestock needs in the region. The Plateau Region may wish to monitor livestock population data to see if the downward trend in livestock populations continues.
- Water use by game species can be estimated using techniques similar to those employed by TWDB in estimating traditional livestock water use. However, at this time there are insufficient data on the number of animals in the region to make these estimates. Additional information on exotic game populations will be required if the Plateau Region wishes to include this water use in regional planning.

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Appendix 5

Occurrence of Significant River Alluvium Aquifers in the Plateau Region, Plateau Region Water Plan, May 2015

3 REGIONAL WATER SUPPLY SOURCES

From the semi-arid Hill Country to the arid Rio Grande Basin, both groundwater and surface water are critical resources for the livelihood of the citizens of the Plateau Region and the environment in which they reside. Chapter 3 explores the current and future availability of all water supply resources in the Region including surface water, groundwater and reuse. The water demand and supply availability analysis developed in Chapters 2 and 3, respectively, form the basis for identifying in Chapter 4 the areas within the Plateau Region that potentially could experience supply shortages in future years.

The City of Kerrville currently uses surface water from the Guadalupe River in conjunction with their groundwater supply. Kerrville also injects excess treated surface water into the Trinity Aquifer through an aquifer storage and recovery (ASR) system. The City of Del Rio obtains their water from San Felipe Springs, which issues from the Edwards limestone. The spring water is treated to surface water standards in a new microfiltration plant prior to distribution. Camp Wood in Real County is supplied from Old Faithful Springs on a tributary of the Nueces River. All other communities in the Region are totally dependent on groundwater sources for their supplies.

Water supplies available to meet the demands reported in Chapter 2 are shown in Table 3-1 and Table 3-2. Table 3-1 lists groundwater and surface water availability by county and river basin. Water source availability analyses, including water-quality concerns, are discussed in more detail in Section 3.2 (groundwater) and Section 3.3 (surface water). Table 3-2 lists water supplies available to cities and general water use categories based on the current infrastructure ability of each to obtain water supplies. These abilities primarily include existing infrastructure, water-rights limitations, and Groundwater Conservation District permit limitations. All water supplies based upon contracts are assumed to be renewed.

Table 3-1. Water Source Availability (Acre Feet per Year)

Groundwater	County	Basin	Salinity	2020	2030	2040	2050	2060	2070
Austin Chalk	Kinney	Rio Grande	Brackish	4,928	4,928	4,928	4,928	4,928	4,928
Edwards-BFZ Aquifer	Kinney	Nueces	Fresh	6,319	6,319	6,319	6,319	6,319	6,319
Edwards-BFZ Aquifer	Kinney	Rio Grande	Fresh	2	2	2	2	2	2
Edwards-Trinity (Plateau) Aquifer	Kerr	Colorado	Fresh	245	245	245	245	245	245
Edwards-Trinity (Plateau) Aquifer	Kerr	Guadalupe	Fresh	1,015	1,015	1,015	1,015	1,015	1,015
Edwards-Trinity (Plateau) Aquifer	Kerr	Nueces	Fresh	5	5	5	5	5	5
Edwards-Trinity (Plateau) Aquifer	Kerr	San Antonio	Fresh	3	3	3	3	3	3
Edwards-Trinity (Plateau) Aquifer	Bandera	Guadalupe	Fresh	21	21	21	21	21	21
Edwards-Trinity (Plateau) Aquifer	Bandera	Nueces	Fresh	101	101	101	101	101	101
Edwards-Trinity (Plateau) Aquifer	Bandera	San Antonio	Fresh	561	561	561	561	561	561
Edwards-Trinity (Plateau) Aquifer	Edwards	Colorado	Fresh	2,306	2,306	2,306	2,306	2,306	2,306
Edwards-Trinity (Plateau) Aquifer	Edwards	Nueces	Fresh	1,632	1,632	1,632	1,632	1,632	1,632
Edwards-Trinity (Plateau) Aquifer	Edwards	Rio Grande	Fresh	1,700	1,700	1,700	1,700	1,700	1,700
Edwards-Trinity (Plateau) Aquifer	Kinney	Nueces	Fresh	12	12	12	12	12	12
Edwards-Trinity (Plateau) Aquifer	Kinney	Rio Grande	Fresh	70,326	70,326	70,326	70,326	70,326	70,326
Edwards-Trinity (Plateau) Aquifer	Real	Colorado	Fresh	278	278	278	278	278	278
Edwards-Trinity (Plateau) Aquifer	Real	Guadalupe	Fresh	3	3	3	3	3	3
Edwards-Trinity (Plateau) Aquifer	Real	Nueces	Fresh	7,196	7,196	7,196	7,196	7,196	7,196
Edwards-Trinity (Plateau) Aquifer	Val Verde	Rio Grande	Fresh	24,988	24,988	24,988	24,988	24,988	24,988
Nueces River Alluvium Aquifer	Edwards	Nueces	Fresh	1,787	1,787	1,787	1,787	1,787	1,787
Nueces River Alluvium Aquifer	Real	Nueces	Fresh	1,787	1,787	1,787	1,787	1,787	1,787
Nueces River Alluvium Aquifer | Frio River	Real	Nueces	Fresh	2,145	2,145	2,145	2,145	2,145	2,145
Trinity Aquifer	Bandera	Guadalupe	Fresh	76	76	76	76	76	76
Trinity Aquifer	Bandera	Nueces	Fresh/Brackish	903	903	903	903	903	903
Trinity Aquifer	Bandera	San Antonio	Fresh/Brackish	6,305	6,305	6,305	6,305	6,305	6,305
Trinity Aquifer	Kerr	Colorado	Fresh	318	318	318	318	318	318
Trinity Aquifer	Kerr	Guadalupe	Fresh/Brackish	14,129	14,056	13,767	13,450	13,434	13,434
Trinity Aquifer	Kerr	Nueces	Fresh	0	0	0	0	0	0
Trinity Aquifer	Kerr	San Antonio	Fresh	471	471	471	471	471	471
Trinity Aquifer	Real	Nueces	Fresh	52	52	52	52	52	52
Colorado Other Local Supply	Edwards	Colorado	Fresh	13	13	13	13	13	13
Colorado Other Local Supply	Kerr	Colorado	Fresh	46	46	46	46	46	46
Colorado Other Local Supply	Real	Colorado	Fresh	3	3	3	3	3	3
Colorado Run-Of-River	Edwards	Colorado	Fresh	43	43	43	43	43	43
Guadalupe Other Local Supply	Kerr	Guadalupe	Fresh	393	393	393	393	393	393
Guadalupe Run-Of-River	Bandera	Guadalupe	Fresh	3	3	3	3	3	3
Colorado Other Local Supply	Kerr	Colorado	Fresh	46	46	46	46	46	46

Table 3-1 (Continued). Water Source Availability (Acre Feet per Year)

Groundwater	County	Basin	Salinity	2020	2030	2040	2050	2060	2070
Medina Lake/Reservoir	Bandera	San Antonio	Fresh	0	0	0	0	0	0
Nueces Livestock Local Supply | Surface Water	Edwards	Nueces	Fresh	47	47	47	47	47	47
Nueces Livestock Local Supply | Surface Water	Real	Nueces	Fresh	50	50	50	50	50	50
Nueces Other Local Supply	Edwards	Nueces	Fresh	11	11	11	11	11	11
Nueces Other Local Supply	Kinney	Nueces	Fresh	42	42	42	42	42	42
Nueces Other Local Supply | Old Faithful Springs	Real	Nueces	Fresh	0	0	0	0	0	0
Nueces Run-Of-River	Bandera	Nueces	Fresh	27	27	27	27	27	27
Nueces Run-Of-River	Edwards	Nueces	Fresh	143	143	143	143	143	143
Nueces Run-Of-River	Real	Nueces	Fresh	2,162	2,162	2,162	2,162	2,162	2,162
Rio Grande Livestock Local Supply | Surface Water	Edwards	Rio Grande	Fresh	47	47	47	47	47	47
Rio Grande Livestock Local Supply | Surface Water	Val Verde	Rio Grande	Fresh	27	27	27	27	27	27
Rio Grande Other Local Supply	Kinney	Rio Grande	Fresh	42	42	42	42	42	42
Rio Grande Other Local Supply	Val Verde	Rio Grande	Fresh	149	149	149	149	149	149
Rio Grande Run-Of-River	Kinney	Rio Grande	Fresh	1,103	1,103	1,103	1,103	1,103	1,103
Rio Grande Run-Of-River	Val Verde	Rio Grande	Fresh	13,935	13,935	13,935	13,935	13,935	13,935
San Antonio Other Local Supply	Bandera	San Antonio	Fresh	74	74	74	74	74	74
San Antonio Other Local Supply	Kerr	San Antonio	Fresh	23	23	23	23	23	23
San Antonio Run-Of-River | Medina River Combined	Bandera	San Antonio	Fresh	0	0	0	0	0	0
Trinity ASR	Kerr	Guadalupe	Fresh	390	390	390	390	390	390
Region J Total Source Availability				**169,608**	**169,535**	**169,246**	**168,929**	**168,913**	**168,913**

Table 3-2. Existing Supply (Acre-Feet per Year)

		2020	2030	2040	2050	2060	2070
Bandera County							
Guadalupe Basin							
County-Other	Edwards-Trinity Plateau Aquifer	20	20	20	20	20	20
Livestock	Edwards-Trinity Plateau Aquifer	1	1	1	1	1	1
Guadalupe Basin Total Existing Supply		21	21	21	21	21	21
Nueces Basin							
County-Other	Edwards-Trinity Plateau Aquifer	39	39	39	39	39	39
County-Other	Nueces Run-of-River	2	2	2	2	2	2
County-Other	Trinity Aquifer Fresh/Brackish	230	230	230	230	230	230
Livestock	Edwards-Trinity Plateau Aquifer	24	24	24	24	24	24
Livestock	Trinity Aquifer Fresh/Brackish	48	48	48	48	48	48
Irrigation	Nueces Run-of-River	25	25	25	25	25	25
Irrigation	Trinity Aquifer Fresh/Brackish	461	461	461	461	461	461
Nueces Basic Total Existing Supply		829	829	829	829	829	829
San Antonio Basin							
Bandera	Trinity Aquifer Fresh/Brackish	1,319	1,319	1,319	1,319	1,319	1,319
County-Other	Edwards-Trinity Plateau Aquifer	411	411	411	411	411	411
County-Other	San Antonio Run-Of-River	0	0	0	0	0	0
County-Other	Trinity Aquifer Fresh/Brackish	4,670	4,670	4,670	4,670	4,670	4,670
Livestock	Edwards-Trinity Plateau Aquifer	52	52	52	52	52	52
Livestock	San Antonio Other Local Supply	74	74	74	74	74	74
Livestock	Trinity Aquifer Fresh/Brackish	99	99	99	99	99	99
Irrigation	San Antonio Run-Of-River	0	0	0	0	0	0
Irrigation	Trinity Aquifer Fresh/Brackish	217	217	217	217	217	217
San Antonio Basin Total Existing Supply		6,842	6,842	6,842	6,842	6,842	6,842
Bandera County Total Existing Supply		7,692	7,692	7,692	7,692	7,692	7,692
Edwards County							
Colorado Basin							
Rocksprings	Edwards-Trinity Plateau Aquifer	919	919	919	919	919	919
County-Other	Edwards-Trinity Plateau Aquifer	83	83	83	83	83	83
Mining	Edwards-Trinity Plateau Aquifer	23	23	23	23	23	23
Livestock	Colorado Other Local Supply	5	5	5	5	5	5
Livestock	Edwards-Trinity Plateau Aquifer	141	141	141	141	141	141
Irrigation	Colorado Run-Of-River	43	43	43	43	43	43
Irrigation	Edwards-Trinity Plateau Aquifer	77	77	77	77	77	77
Colorado Basin Total Existing Supply		1,291	1,291	1,291	1,291	1,291	1,291
Nueces Basin							
Rocksprings		0	0	0	0	0	0
County-Other	Edwards-Trinity Plateau Aquifer	223	223	223	223	223	223
County-Other	Nueces River Alluvium Aquifer	12	12	12	12	12	12
Mining	Edwards-Trinity Plateau Aquifer	32	32	32	32	32	32
Mining	Nueces Other Local Supply	11	11	11	11	11	11
Livestock	Edwards-Trinity Plateau Aquifer	189	189	189	189	189	189
Livestock	Nueces Livestock Local Supply	47	47	47	47	47	47
Irrigation	Edwards-Trinity Plateau Aquifer	103	103	103	103	103	103
Irrigation	Nueces Run-of-River	143	143	143	143	143	143
Nueces Basin Total Existing Supply		760	760	760	760	760	760
Rio Grande Basin							
County-Other	Edwards-Trinity Plateau Aquifer	44	44	44	44	44	44
Mining	Edwards-Trinity Plateau Aquifer	23	23	23	23	23	23
Livestock	Edwards-Trinity Plateau Aquifer	141	141	141	141	141	141
Irrigation	Edwards-Trinity Plateau Aquifer	77	77	77	77	77	77
Rio Grande Basin Total Existing Supply		285	285	285	285	285	285
Edwards County Total Existing Supply		2,336	2,336	2,336	2,336	2,336	2,336

Table 3-2 (Continued). Existing Supply (Acre-Feet per Year)

		2020	2030	2040	2050	2060	2070
Kerr County							
Colorado Basin							
County-Other	Edwards-Trinity Plateau Aquifer	48	48	48	48	48	48
Mining	Edwards-Trinity Plateau Aquifer	2	2	2	2	2	2
Livestock	Colorado Other Local Supply	46	46	46	46	46	46
Livestock	Edwards-Trinity Plateau Aquifer	43	43	43	43	43	43
Irrigation	Edwards-Trinity Plateau Aquifer	44	44	44	44	44	44
Colorado Basin Total Existing Supply		183	183	183	183	183	183
Guadalupe Basin							
Ingram	Trinity Aquifer Fresh/Brackish	552	552	552	552	552	552
Kerrville	Guadalupe Run-Of-River	150	150	150	150	150	150
Kerrville	Trinity Aquifer Fresh/Brackish	885	885	885	885	885	885
Kerrville	Trinity ASR	390	390	390	390	390	390
Loma Vista Water System	Trinity Aquifer Fresh/Brackish	387	387	387	387	387	387
County-Other	Edwards-Trinity Plateau Aquifer	457	457	457	457	457	457
County-Other	Guadalupe Run-Of-River	15	15	15	15	15	15
County-Other	Trinity Aquifer Fresh/Brackish	4,716	4,716	4,716	4,716	4,716	4,716
Manufacturing	Guadalupe Run-Of-River	9	9	9	9	9	9
Manufacturing	Trinity Aquifer Fresh/Brackish	25	25	25	25	25	25
Mining	Edwards-Trinity Plateau Aquifer	10	10	10	10	10	10
Mining	Guadalupe Run-Of-River	89	89	89	89	89	89
Mining	Trinity Aquifer Fresh/Brackish	5	5	5	5	5	5
Livestock	Edwards-Trinity Plateau Aquifer	133	133	133	133	133	133
Livestock	Guadalupe Other Local Supply	393	393	393	393	393	393
Livestock	Trinity Aquifer Fresh/Brackish	247	247	247	247	247	247
Irrigation	Guadalupe Run-Of-River	958	958	958	958	958	958
Irrigation	Trinity Aquifer Fresh/Brackish	402	402	402	402	402	402
Guadalupe Basin Total Existing Supply		9,823	9,823	9,823	9,823	9,823	9,823
Nueces Basin							
County-Other	Edwards-Trinity Plateau Aquifer	0	0	0	0	0	0
Livestock	Edwards-Trinity Plateau Aquifer	5	5	5	5	5	5
Nueces Basin Total Existing Supply		5	5	5	5	5	5
San Antonio Basin							
County-Other	Edwards-Trinity Plateau Aquifer	1	1	1	1	1	1
County-Other	Trinity Aquifer	112	112	112	112	112	112
Livestock	Edwards-Trinity Plateau Aquifer	1	1	1	1	1	1
Livestock	San Antonio Other Local Supply	23	23	23	23	23	23
Irrigation	Edwards-Trinity Plateau Aquifer	1	1	1	1	1	1
San Antonio Basin Total Existing Supply		138	138	138	138	138	138
Kerr County Total Existing Supply		10,149	10,149	10,149	10,149	10,149	10,149
Kinney County							
Nueces Basin							
County-Other	Edwards-BFZ Aquifer	29	29	29	29	29	29
County-Other	Edwards-Trinity Plateau Aquifer	5	5	5	5	5	5
Livestock	Edwards-BFZ Aquifer	162	162	162	162	162	162
Livestock	Edwards-Trinity Plateau Aquifer	7	7	7	7	7	7
Livestock	Nueces Other Local Supply	42	42	42	42	42	42
Irrigation	Edwards-BFZ Aquifer	2,694	2,694	2,694	2,694	2,694	2,694
Nueces Basin Total Existing Supply		2,939	2,939	2,939	2,939	2,939	2,939
Rio Grande Basin							
Brackettville	Edwards-Trinity Plateau Aquifer	645	645	645	645	645	645
Brackettville	Rio Grande Run-Of-River	0	0	0	0	0	0
Fort Clark Springs MUD	Edwards-Trinity Plateau Aquifer	1,371	1,371	1,371	1,371	1,371	1,371

Table 3-2 (Continued). Existing Supply

		2020	2030	2040	2050	2060	2070
Rio Grande Basin (Continued)							
County-Other	Austin Chalk Aquifer Brackish	125	125	125	125	125	125
County-Other	Edwards-Trinity Plateau Aquifer	132	132	132	132	132	132
Livestock	Austin Chalk Aquifer Brackish	85	85	85	85	85	85
Livestock	Edwards-Trinity Plateau Aquifer	84	84	84	84	84	84
Livestock	Rio Grande Other Local Supply	42	42	42	42	42	42
Irrigation	Austin Chalk Aquifer Brackish	673	673	673	673	673	673
Irrigation	Edwards-Trinity Plateau Aquifer	3,367	3,367	3,367	3,367	3,367	3,367
Irrigation	Rio Grande Run-Of-River	1,099	1,099	1,099	1,099	1,099	1,099
Rio Grande Basin Total Existing Supply		7,623	7,623	7,623	7,623	7,623	7,623
Kinney County Total Existing Supply		10,562	10,562	10,562	10,562	10,562	10,562
Real County							
Colorado Basin							
County-Other	Edwards-Trinity Plateau Aquifer	15	15	15	15	15	15
Livestock	Colorado Other Local Supply	3	3	3	3	3	3
Livestock	Edwards-Trinity Plateau Aquifer	52	52	52	52	52	52
Irrigation	Edwards-Trinity Plateau Aquifer	50	50	50	50	50	50
Colorado Basin Total Existing Supply		120	120	120	120	120	120
Nueces Basin							
Camp Wood	Nueces Other Local Supply	0	0	0	0	0	0
County-Other	Edwards-Trinity Plateau Aquifer	357	357	357	357	357	357
County-Other	Nueces River Alluvium Aquifer	736	736	736	736	736	736
County-Other	Nueces Run-of-River	0	0	0	0	0	0
Livestock	Edwards-Trinity Plateau Aquifer	156	156	156	156	156	156
Livestock	Nueces Livestock Local Supply	50	50	50	50	50	50
Irrigation	Edwards-Trinity Plateau Aquifer	153	153	153	153	153	153
Irrigation	Nueces Run-of-River	2,162	2,162	2,162	2,162	2,162	2,162
Nueces Basin Total Existing Supply		3,614	3,614	3,614	3,614	3,614	3,614
Real County Total Existing Supply		3,734	3,734	3,734	3,734	3,734	3,734
Val Verde County							
Rio Grande Basin							
Del Rio	Edwards-Trinity Plateau Aquifer	15,484	15,484	15,484	15,484	15,484	15,484
Del Rio	Rio Grande Run-Of-River	11,416	11,416	11,416	11,416	11,416	11,416
Laughlin AFB	Edwards-Trinity Plateau Aquifer	2,299	2,299	2,299	2,299	2,299	2,299
County-Other	Edwards-Trinity Plateau Aquifer	4,513	4,513	4,513	4,513	4,513	4,513
Mining	Edwards-Trinity Plateau Aquifer	37	37	37	37	37	37
Mining	Rio Grande Other Local Supply	149	149	149	149	149	149
Livestock	Edwards-Trinity Plateau Aquifer	506	506	506	506	506	506
Livestock	Rio Grande Livestock Local Supply	27	27	27	27	27	27
Irrigation	Edwards-Trinity Plateau Aquifer	276	276	276	276	276	276
Irrigation	Rio Grande Run-Of-River	2,519	2,519	2,519	2,519	2,519	2,519
Rio Grande Basin Total Existing Supply		37,226	37,226	37,226	37,226	37,226	37,226
Val Verde County Total Existing Supply		37,226	37,226	37,226	37,226	37,226	37,226
Region J Total Existing Supply		71,699	71,699	71,699	71,699	71,699	71,699

3.1 GROUNDWATER RESOURCES

The principal aquifers in the Plateau Region are the Trinity, Edwards-Trinity (Plateau), Edwards (Balcones Fault Zone), Austin Chalk, and the Frio and Nueces River Alluviums (Figure 3-1). Aquifer descriptions provided in this chapter are relatively limited; more detailed hydrogeological characterization of the aquifers may be obtained from reports published by the TWDB, USGS, UTBEG, and other agencies and universities. The water quality of aquifers is relatively good and a detailed discussion on water-quality characteristics and issues is provided in Chapter 1, Section 1.4.5.

Two water-source characterization studies were conducted during the previous planning period. The first study (Occurrence of Significant River Alluvium Aquifers in the Plateau Region) identifies and quantifies viable groundwater sources in shallow alluvial aquifers that parallel many of the major streams in the Region. As a result of the study, substantial volumes were estimated for the Frio and Nueces River Alluvium Aquifers in Real and Edwards Counties. These new sources are identified as "other-aquifer" sources in this *Plan*.

The second study (Groundwater Data Acquisition in Edwards, Kinney and Val Verde Counties, Texas) was performed to assist in the further characterization of the Edwards and associated aquifers in the western part of the Plateau Region. The project included four general tasks: (1) review of existing aquifer evaluations, field studies and new well data; (2) performance of dye tracer tests to analyze groundwater flow direction and speed; (3) measurement of water levels in wells during two seasonal periods; and (4) review of recent water quality sampling projects. These two reports can be viewed at (www.ugra.org/waterdevelopment.html).

Over much of the Region, water levels generally fluctuate with seasonal precipitation and are highly susceptible to declines during drought conditions. Discharge from the aquifers occurs naturally through springs and artificially by pumping from wells. Some discharge also occurs through leakage from one water-bearing unit to another and through natural down-gradient flow out of the Region.

3.1.1 Groundwater Availability

Base flow to the many rivers and streams that flow through the Plateau Region is principally generated from the numerous springs that issue from rock formations that form the major aquifers in the Region. The Plateau Region contains the headwaters of the Guadalupe, San Antonio, Medina, Sabinal, Frio, Nueces, and West Nueces Rivers; and tributaries to the Colorado River and Rio Grande such as the Pecos, Devils, and South Llano Rivers. Flow in these rivers and streams is critical to the Plateau Region in that it provides municipal drinking water, supplies irrigation and livestock needs, maintains environmental habitat, and supports a thriving ecological and recreational tourist economy. Water users downstream of the Plateau Region (Regions K, L, and M) likewise have a stake in maintaining and protecting river flows that originate in the Plateau Region.

It is thus recognized that sustaining flow in these important rivers and streams is highly dependent on maintaining an appropriate water level in the aquifer systems that feed the supporting springs. With the sustainability of local water supplies and the economic welfare of the Region in mind, the PWPG in the previous *2011 Plan* defined groundwater availability as a maximum level of aquifer withdrawal that results in an acceptable level of long-term aquifer impact such that the base flow in rivers and streams is not significantly affected beyond a level that would be anticipated due to naturally occurring conditions.

In so defining groundwater availability, the planning group established a policy decision to protect the long-term water supply and related economic needs of the Plateau Region. The PWPG acknowledges that Groundwater Conservation Districts have regulatory authority over permitted withdrawals from aquifers within their respective boundaries.

Groundwater availability as listed in Table 3-1 in this *2016 Plateau Region Water Plan* is based on the Modeled Available Groundwater (MAG) volumes that may be produced on an average annual basis to achieve a Desired Future Condition (DFC) as adopted by Groundwater Management Areas (GMAs) (per Texas Water Code 36.001). The GMA process is explained in more detail in Chapter 1- Section 1.1.5. Groundwater availability volumes for parts of the Region where MAGs are not determined by the TWDB are retained from the previous *2011 Plan*.

3.1.2 Trinity Aquifer

Located mostly in the Hill Country counties of Bandera and Kerr, the Trinity Aquifer system is composed of deposits of sand, clay and limestone of the Glen Rose and Travis Peak formations of the Lower Cretaceous Trinity Group. The water-bearing units include, in descending order, the Glen Rose Limestone, Hensell Sand, Cow Creek Limestone, Sligo Limestone and Hosston Sand (Table 3-3). The Glen Rose formation is divided informally into upper and lower members. Based on their hydrologic relationships, the water-bearing rocks of the Trinity Group, collectively referred to as the Trinity Aquifer system, are organized into the following aquifer units.

Table 3-3. Water-Bearing Rocks of the Trinity Group

Aquifer	Formations
Upper Trinity	Upper Glen Rose Limestone
Middle Trinity	Lower Member of the Glen Rose Limestone, Hensell Sand and Cow Creek Limestone
	Pine Island/Hammet Shale (confining bed)
Lower Trinity	Sligo Limestone and Hosston Sand

Because of fractures, faults and other hydrogeological factors, the Upper, Middle and Lower Trinity Aquifer units often are in hydraulic communication with one another and collectively should be considered a leaky-aquifer system.

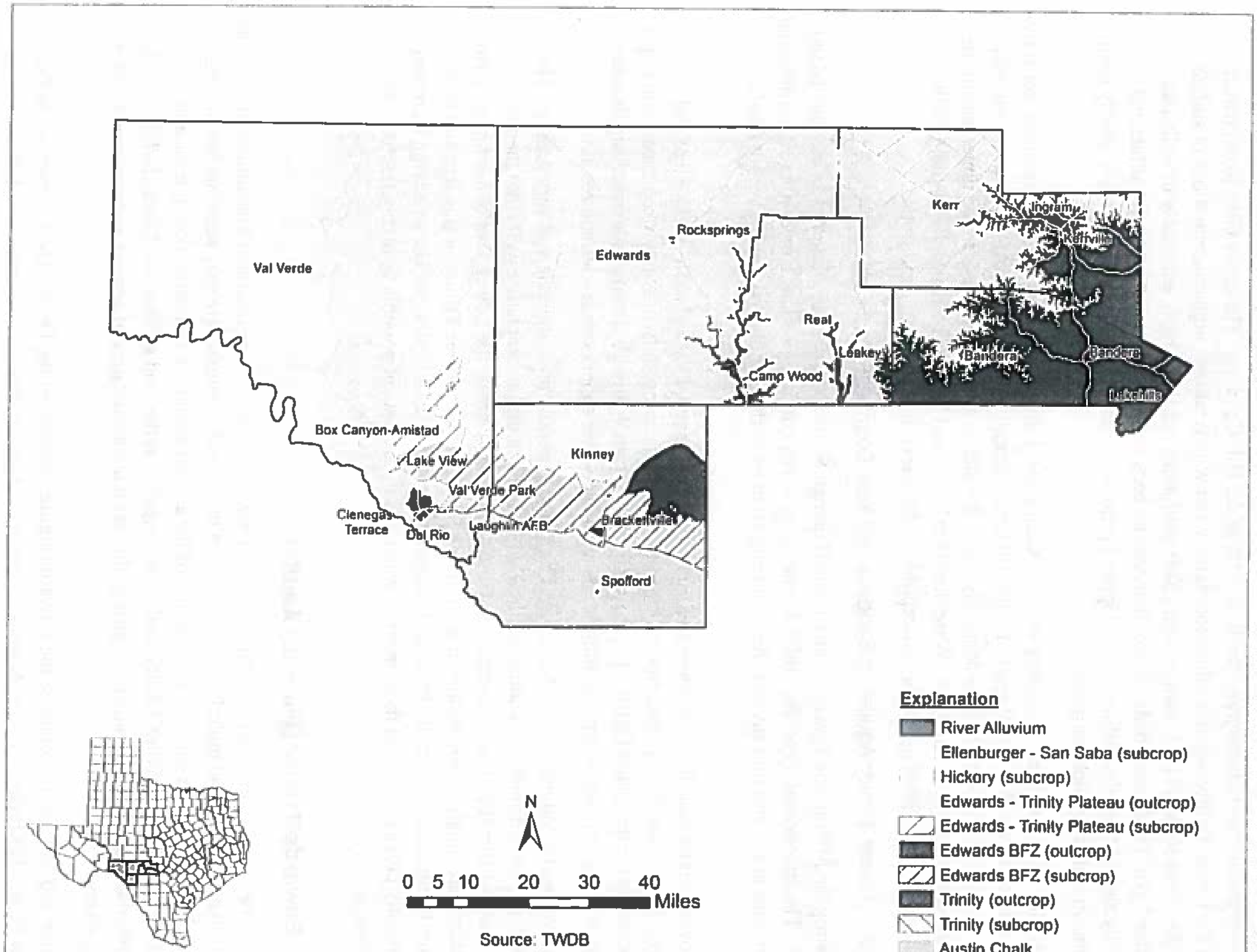

Figure 3-1. Groundwater Sources

3.1.2.1 Upper and Middle Trinity Aquifer

The upper member of the Glen Rose, when weath¬ered on the land surface, creates the dis¬tinctive "stair-step" topography found throughout the hilly train of the Hill Coun¬try. The upper Glen Rose, which forms the Upper Trinity Aquifer, often con¬tains water with relatively high concentrations of sulfate. Total dissolved solids (TDS) often exceed 1,000 milligrams per liter (mg/l), especially in wells that penetrate "gyp" (evaporite) beds. Water in evaporite beds has a tendency to be high in sulfate and generally should be sealed off in a well. Upper Trinity wells are generally shallow and are mostly used for domestic and livestock purposes.

The Middle Trinity aquifer, consisting of lower Glen Rose, Hensell, and Cow Creek formations, generally contains TDS of less than 1,000 mg/l. In the Hill Country region, the primary contribution to poor water-quality occurs in wells that do not adequately case off water from evaporite beds in the upper part of the Glen Rose (Upper Trinity Aquifer). Water levels in Upper and Middle Trinity wells fluctuate with seasonal precipitation and are highly susceptible to declines during drought conditions.

3.1.2.2 Lower Trinity Aquifer in Bandera and Kerr Counties

Separating the Middle and Lower Trinity is the Hammett Shale (sometimes referred to as the Pine Island Shale). The approximately 60-foot thick formation acts as a confining bed, or barrier to cross-formational flow in most areas, and thus divides the producing sections of the Middle and Lower Trinity Aquifer units.

The Lower Trinity Aquifer is composed of sandy limestone, sand, clay and shale of the Sligo and Hosston. The Lower Trinity thins toward the northeast and is completely missing or coalesces with upper Trinity units near the Llano Uplift. The Lower Trinity is principally used to provide water supplies for the Cities of Bandera and Kerrville and for a few private water-supply companies and resorts.

Yields from wells completed into the Lower Trinity are generally unpredictable and vary greatly. The greater depth and difficulty of sealing off the Hammett Shale make completing wells into the Lower Trinity more difficult and more expensive. However, in some areas, the Lower Trinity has higher yields and better water quality than shallower aquifers. Recharge to the Lower Trinity in Bandera and Kerr Counties likely occurs primarily by lateral underflow from the north and west. The overlying Hammett Shale mostly prevents vertical movement of water downward except possibly in highly fractured or faulted areas.

3.1.3 Edwards-Trinity (Plateau) Aquifer

The Edwards-Trinity (Plateau) Aquifer consists of lower Cretaceous age saturated limestone and dolomite of the Edwards Group and underlying sediments of the Trinity Group where they occur underlying the Edwards Plateau. The upper Edwards portion of the aquifer system is generally more porous and permeable than the underlying Trinity, and where exposed at the land surface, the Edwards-Trinity (Glen Rose) interface gives rise to numerous springs that form the headwaters of several eastward and southerly flowing rivers.

In Kinney and Val Verde Counties, the Edwards aquifer consists of the Devils River Limestone or the Salmon Peak, McKnight and West Nueces Limestone. Aquifer thickness is as much as 1,000 feet. All known water wells produce water from the Salmon Peak and McKnight formations. San Felipe Springs in Val Verde County issues from the Edwards and is the primary municipal supply source for Del Rio.

Recharge to the aquifer occurs primarily by the downward percolation of surface water from streams draining off the Edwards Plateau to the north and west and by direct infiltration of precipitation on the outcrop. Some water enters the region in the aquifer as underflow from counties up gradient (generally north).

The Glen Rose Limestone is the primary unit in the Trinity in the southern part of the Plateau. The aquifer generally exists under water-table conditions; however, where the Glen Rose is fully saturated and a zone of low permeability occurs near the base of the overlying Edwards, artesian conditions exist.

Reported well yields commonly range from less than 50 gallons per minute (gpm) where saturated thickness is thin to more than 1,000 gpm where large-capacity wells are completed in jointed and cavernous limestone. There is little pumping withdrawals from the aquifer over most of its extent, and water levels have generally fluctuated only with seasonal precipitation. In some instances, water levels have declined as a result of increased pumping. Del Rio, Brackettville, Fort Clark, and Rocksprings have municipal wells that produce from this aquifer.

3.1.4 Edwards (BFZ) Aquifer

In the Plateau Region, the Edwards-Balcones Fault Zone (BFZ) Aquifer is designated only in eastern Kinney County at its westernmost extent. The Edwards portion of the Edwards-Trinity (Plateau) Aquifer and the Edwards of the Edwards (BFZ) Aquifer are the same geologic formation and their boundary is arbitrarily established by the TWDB. There is no significant hydrologic boundary between the outcrops of these two aquifer systems, thus groundwater in the Edwards-Trinity freely moves down gradient into the Edwards (BFZ).

The Edwards (BFZ) Aquifer exists under water-table conditions in the outcrop and under artesian conditions where it is confined below the overlying Del Rio Clay in its downdip extent. Water in the aquifer generally moves from the recharge zone toward natural discharge points such as Las Moras Springs at Brackettville. Additional water is lost from the Kinney County area as underflow that leaves the County to the east into Uvalde County (Region L). Very little pumping has occurred from this aquifer in Kinney County, and therefore water levels have remained relatively constant with only minor changes over time.

3.1.5 Austin Chalk Aquifer

The Austin Chalk is located in the southern half of Kinney County and the southernmost part of Val Verde County. Many wells located south of Highway 90 obtain part or all of their water from the Austin Chalk. A veneer of gravel deposits covers much of the southwest portion of Kinney County; some wells penetrate both these gravels and the underlying Austin Chalk. Source of water in the Austin Chalk is from precipitation recharge and stream loss over the outcrop areas and probably from Edwards Aquifer underflow through faults located up-gradient.

A wide range of production rates exists for wells completed in the Austin Chalk. The best production from the aquifer occurs in areas that have been fractured or contain a number of solution openings. Most wells only discharge enough water for domestic or livestock use, but a few wells are large enough for irrigation purposes. The largest reported yield for an Austin Chalk well in Kinney County is 2,000 gpm (Bennett and Sayre, 1962). Most of the more productive wells completed in the Austin Chalk are located along Las Moras Creek. Much less production is apparent in the Nueces River Basin in the eastern part of the county.

3.1.6 Frio River Alluvium Aquifer

The Frio River Alluvium in central Real County extends over an area of approximately 9,530 acres. Recharge to the aquifer is from stream loss and direct infiltration of precipitation. Water supplies for the City of Leakey and other rural domestic homes are derived from this small aquifer. Because of the limited extent of this aquifer and its shallow water table, the aquifer system is readily susceptible to diminished supplies during drought conditions and potentially from over pumping. Also due to its shallow nature, the aquifer is susceptible to contamination from surface sources.

3.1.7 Nueces River Alluvium Aquifer

The Nueces River Alluvium between Edwards and Real Counties extends over an area of approximately 24,450 acres. Recharge to the aquifer is from stream loss and direct infiltration of precipitation. Water supplies for the Community of Barksdale and rural domestic homes are derived from this small aquifer. As with the Frio Alluvium, the Nueces River Alluvium Aquifer is readily susceptible to diminished supplies during drought conditions and potentially from over pumping, and to contamination from surface sources.

3.1.8 Other Aquifers

Located along many of the streams and rivers are shallow alluvial floodplains composed of sediments ranging from clay and silt to sand, gravel, cobbles and boulders. Wells completed in these deposits supply small to moderate quantities of water mostly for domestic and livestock purposes. However, because these wells are relatively shallow, many are prone to going dry during drought conditions. The alluvium is often in direct hydraulic connection with the rivers and streams that meander through them.

In addition, the TWDB has identified the downdip extents of the Ellenburger-San Saba and the Hickory Aquifers in northeast Kerr County. Because no known wells have penetrated these aquifers in Kerr County, very little is known about their water-bearing characteristics. These aquifers are mentioned as possible resources but are not currently included in the supply analysis for this *Plan.* There is strong interest in Kerr County to explore the potential for developing a new water supply from the Ellenburger.

3.1.9 Public Supply Use of Groundwater

All communities in the Plateau Region rely partially or completely on groundwater supply sources. Even the spring sources used by Del Rio and Camp Wood originate from aquifers. The higher concentration of wells in Kerr and Bandera Counties related to population growth may present water supply availability problems in the future. Public supply wells serving communities in Edwards, Kinney, Real and Val Verde Counties are not anticipated to have long-term declines due to the relatively smaller quantities of water that are needed to serve these communities. Also, no long-term water-quality deterioration has been detected in groundwater supplies for these communities. Long-term viability of the aquifers serving these other communities appears to be acceptable. However, new wells should be located outside the local areas of pumping influence of the existing wells. Although no evidence of contamination from surface sources have been detected in public-supply groundwater sources in the Plateau Region, a wellhead protection program should be considered by all communities.

3.1.9.1 City of Bandera

The City of Bandera is dependent on wells completed into the Lower Trinity Aquifer and must compete for this water with numerous private wells in the county. Long-term viability of the Trinity Aquifer as a supply source for Bandera and outlying areas will require implementation of management policies aimed at establishing withdrawals based on the sustainable yield of the aquifer.

City of Bandera Well No. 69-24-202 shows a consistent decline from the 1950s through the 1990s, with a total of approximately 400 feet of water level decline. Most of the water withdrawn by Bandera public supply wells is produced from the Lower Trinity (Hosston) which receives very little vertical recharge and an undetermined amount of lateral underflow from the north and west of the well fields. Because of the continuous water-level decline in these well fields, the City should monitor levels to anticipate production reductions.

3.1.9.2 City of Kerrville

The City of Kerrville is dependent on conjunctive use of surface water from the Guadalupe River and groundwater from Lower Trinity Aquifer wells. Kerrville Wells No. 4 and No. 11 experienced declines of as much as 200 feet through the early to mid-1980s. Between the early to mid-1980s and the early 1990s, water levels in these two wells increased by as much as 200 feet in response to the decreased pumpage by the City when surface water sources were brought on-line. Since 1998, water levels have remained relatively constant.

The only long-term water-quality degradation trend observed in Kerrville public-supply wells is noted in the increase in sodium, chloride and total dissolved solids in the City's Travis Well No. 14 during the late 1960s to mid-1970s. The well showed steady increases in sodium (18 to 72 mg/l), chloride (55 to 200 mg/l), and total dissolved solids (417 to 624 mg/l) between 1968 and 1976. This corresponded with the time period that large drawdowns in water levels were occurring in the Kerrville area. Today, the City mixes water from Well No. 14 with water from all other sources to maintain acceptable overall quality.

The City of Kerrville operates an aquifer storage and recovery (ASR) operation where treated surface water is injected into the Lower Trinity Aquifer to maintain aquifer pressure and provide a source for peak demand periods.

Specific strategies to meet Kerrville's future water needs are addressed in Chapter 5. If additional wells are needed for increasing supply needs, the City should consider locating new wells outside the local area of pumping influence. The City should also cooperate with efforts of the local Groundwater Conservation Districts to establish aquifer management policies.

3.1.9.3 City of Ingram

Ingram Water Supply Inc. provides water to the City of Ingram from wells completed in the Middle and Lower Trinity Aquifers. The supply source appears to be sufficient to meet future needs. However, these wells are completed in the same aquifer as many other wells in the area and thus may be somewhat impacted in the future.

3.1.9.4 City of Rocksprings

The City of Rocksprings obtains its water supply from wells completed in the Edwards Limestone of the Edwards-Trinity (Plateau) Aquifer. This rural community has little competition for groundwater and, thus, its supply is considered dependable. A new well has been drilled and is currently being connected to the City distribution system.

3.1.9.5 City of Brackettville and Fort Clark Springs MUD

Water wells completed in the Edwards portion of the Edwards-Trinity (Plateau) Aquifer produce water used for municipal supply in these two adjacent communities. Las Moras Springs, an identified major spring, also exists at the same location of the Fort Clark Springs wells. Under existing conditions, there appears to be sufficient supply to meet futures needs. The Kinney County Groundwater Conservation District is currently evaluating potential impacts that might result from increased future pumping within the District.

3.1.9.6 City of Camp Wood

Camp Wood located in southwestern Real County derives its water supply from Old Faithful Springs. The spring has reportedly always flowed. However, with increasing population and the drilling of additional wells in the area, the spring may experience decreasing flow during drought periods in the future.

3.1.9.7 City of Leakey

The City of Leakey obtains its water supply from four shallow wells ranging in depth from 34 to 42 feet in the Frio River Alluvium Aquifer. An additional well has recently been constructed and an application for an operation permit is being filed with the Real-Edwards Conservation and Reclamation District. The City must compete for groundwater from this small aquifer with numerous private domestic wells. Trinity Aquifer wells in the local area have proven to be unreliable and often contain poor-quality groundwater.

3.1.9.8 City of Del Rio

The City of Del Rio is supplied with water from San Felipe Springs, which issue from the Edwards portion of the Edwards-Trinity (Plateau) Aquifer. The water is collected through pumps set in the springs, treated with microfiltration and chlorine and then distributed to the City, Laughlin Air Force Base, and outlying neighborhoods.

The average discharge of San Felipe Springs since Lake Amistad was filled is about 110 cubic feet per second or about 80,000 acre-feet/yr. During recent droughts, the spring discharge has fallen below 50 cfs or, extrapolated over one year, about 36,000 acre-feet. Recent droughts as compared to the 1950s drought would be appropriate to use as a drought-condition gage because the filling of Amistad Lake has generally increased the springflow after the late 1960s. A minimum flow has not been determined for the threatened species living downstream of the springs and a study is needed to determine the actual amount that would have to be subtracted from the total spring flow to meet these environmental needs.

3.1.10 Agricultural Use of Groundwater

Because of the arid conditions and lack of well-developed soils over much of the Region, irrigated agricultural activities are generally limited in most of the counties. Low well yields common throughout much of the Region also limit the development of large-scale irrigation. Water quality, however, is not generally a limiting factor for irrigation in the Region. Kinney County has the greatest amount of agricultural use of water. The acreage of land irrigated by groundwater in the year 2000 in each county as reported in TWDB Report 347 is, from most to least, Kinney, 4,865 acres; Bandera, 173 acres; Val Verde, 145 acres; Kerr, 57 acres; Edwards, 40 acres; and Real, 15 acres. The PWPG is concerned about the accuracy of the irrigation surveys and believes that there is significantly more irrigation water use than is documented. For example, the Headwaters Groundwater Conservation District in Kerr County documents approximately 700 acres being irrigated just with groundwater.

A review of historical and current data suggests that there has been no long-term change in regional water levels or water quality as a result of agricultural pumping. Local water-level declines occur during the irrigation season but generally recover during the off- season. Although irrigation conservation efficiencies could be improved, currently used equipment and practices are not resulting in depletion of the aquifers. At the current rate of agricultural use, groundwater of sufficient quantity in the Edwards-Trinity (Plateau), Edwards (BFZ), and Austin Chalk Aquifers should remain available for future agricultural use. However, the competition for Trinity Aquifer water between municipal and agricultural needs in Bandera and Kerr Counties is increasing. The Bandera County River Authority and Groundwater District and the Headwaters Groundwater Conservation District are both actively involved in managing the use of groundwater in these counties.

3.1.11 Brackish Groundwater Desalination Sources

As expressed in Chapter 1, Section 1.4.5, most groundwater in the Plateau Region contains total dissolved-solids (TDS) concentrations of less than 1,000 mg/l and thus meets drinking water standards. Groundwater of slightly poorer quality (1,000 to 3,000 mg/l) occurs in the Trinity Aquifer in some areas. Elevated levels of calcium-sulfate resulting from the dissolution of evaporate beds in the upper Glen Rose is the primary source of higher TDS groundwater. Productivity from this aquifer source makes desalination a marginal option at this time.

3.2 SURFACE WATER SUPPLIES

The Plateau Region is unique within all planning regions in that it straddles several different river basins rather than generally following a single river basin or a large part of a single river basin (Figure 3-2). From west to east, these basins include the Rio Grande, Nueces, Colorado, San Antonio, and Guadalupe. The headwaters of three of these river basins (Nueces, San Antonio, and Guadalupe), as well as major tributaries of the Rio Grande and Colorado River, originate in this Region.

Available surface water supplies under drought-of-record conditions depend on two components: water that is physically present (usually substantially reduced during a drought-of-record since by definition it is the most severe) and the authorized amount per existing water right adjudications. The Texas Commission on Environmental Quality (TCEQ) Water Availability Models (WAMs) perform a simulation of availability and diversion for all water rights in a river basin based on naturalized flows over a specified hydrologic period. These models generally follow an appropriation of water in priority date order, but appropriation order from upstream to downstream may be simulated. The TCEQ WAMs of the five river basins were used to determine surface water availability during a drought-of-record. The simulations used to determine water availability assume that all water rights in each basin are allowed to divert the full authorized amount when water is available, following appropriation in priority date order. They also assume that no return flows are present. These assumptions are known as the "Run 3" scenario. Area-capacity of major reservoirs was adjusted to reflect sedimentation conditions for 2000 and 2060. Drought-of-record supply source amounts by county and river basin are provided in Table 3-1. A list of all authorized surface water rights in the Region is available in the *2011 Plateau Region Water Plan*, Chapter 3, Appendix 3A.

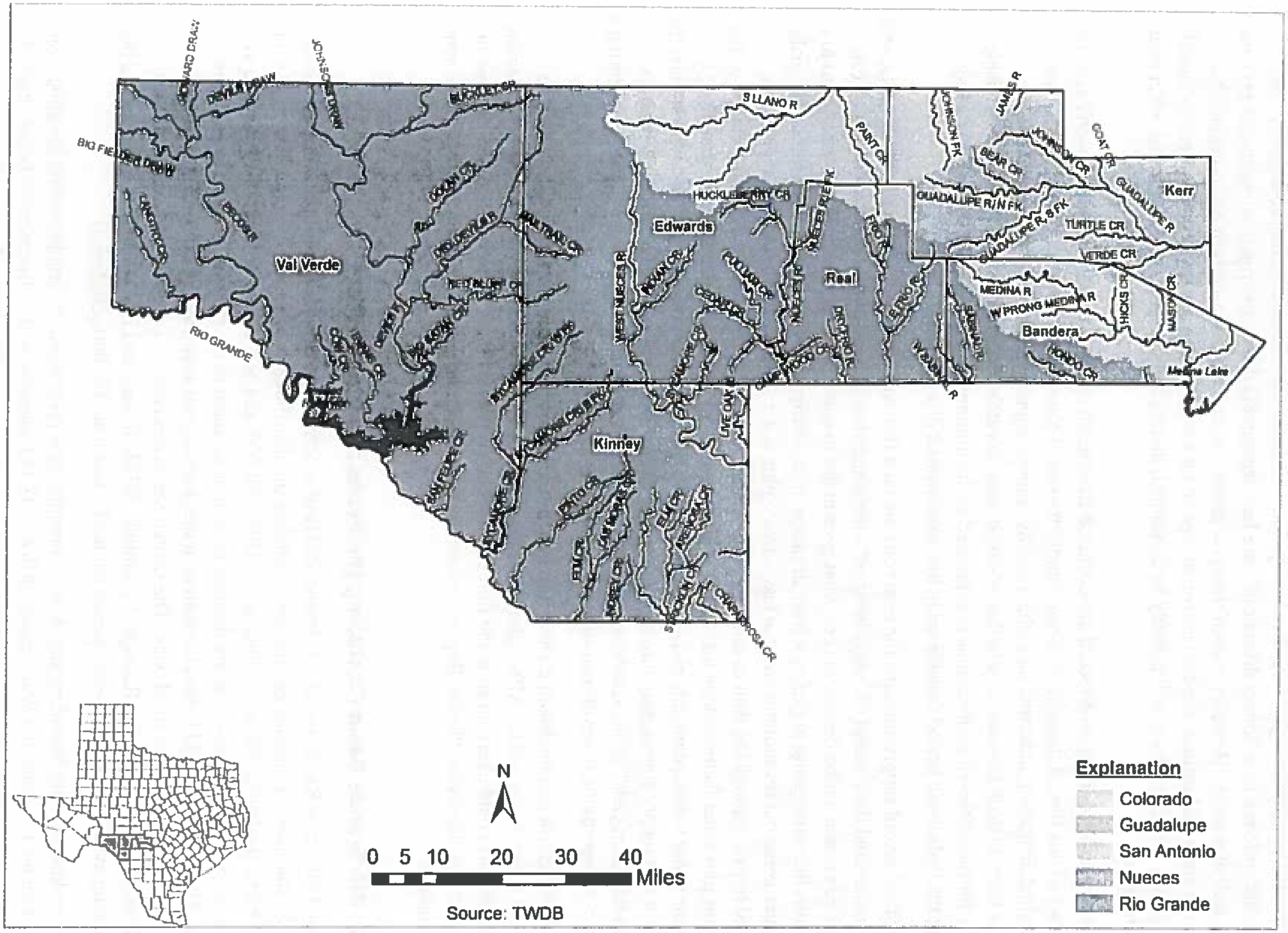

Figure 3-2. Surface Water Sources

The term "run-of-the-river" is used to distinguish water rights with diversion points directly on a watercourse from water rights with diversion points on a reservoir. Generally, run-of-the-river water rights, also referred to as "direct diversions", are less dependable than water rights on reservoirs because of the lack of storage. However, run-of-the-river diversions are often very convenient, especially for irrigators and small entities, because a diversion point on a watercourse can be located extremely close to the location where the water will actually be consumed, thereby negating the need to pipe the water over long distances.

Diversions under a drought-of-record are extracted from results of a WAM simulation for each basin. For purposes of this Plan, a drought-of-record supply for run-of-the-river diversions is categorized by use (municipal, irrigation, industrial and other) and by county. Supply amounts on river segments have always been difficult to assess due to the lack of storage to catch excess flows. In this Plan, the reliable supply for run-of-the-river diversions is expressed as the minimum annual diversion for each category during the hydrologic period considered in the water availability models.

Drought-of-record supply amounts for reservoirs are on a firm-yield basis. To understand firm yield, one must understand the concept of "mass balance" - the simple but true principle of physics that mass can neither be created nor be destroyed (i.e., what goes in has to come out). In practical terms as applied to a reservoir, the water going in (inflows from drainage areas of tributaries feeding the reservoir site) equals the water going out (evaporation off the lake surface plus water spilled over the dam plus any water allowed to pass through the dam to satisfy senior water rights downstream plus the demand placed on the reservoir plus other factors which may exist). Engineers and hydrologists simulate the operation of a reservoir under various demands placed on the reservoir, iterating the simulation to find a demand that the reservoir can supply consistently throughout a repeat of the historical hydrologic regime. Demand is termed the "firm yield" of the reservoir if for every year of the historical hydrologic regime (even during a drought-of-record) the reservoir can supply the demand placed on it.

Canyon Reservoir and the Medina/Diversion system are key water supply reservoirs for the Plateau Region's future water needs. Although neither reservoir currently serves a water need within the Region, both reservoirs could likely do so in the future. Although recreational use of streams and lakes serves an important function in the Plateau Region, its use has no impact on reservoir yields, as these uses are non-consumptive.

3.2.1 Rio Grande Basin (Including the Pecos and Devils River)

The Rio Grande, or Rio Bravo as it is known in Mexico, forms the border between the United States and Mexico. International treaties govern the ownership and distribution of the water in this river. Under The 1906 Treaty, the United States is obligated to deliver 60,000 acre-feet annually from the Rio Grande to Mexico, except in the cases of severe drought or serious accident to the irrigation system in the United States. The 1944 Treaty addresses the waters in the international segment of the Rio Grande from Fort Quitman, Texas to the Gulf of Mexico. The United States receives 1/3 of the flow from six tributaries (Rio Conchos, San Diego, San Rodrigo, Escondido, Salado Rivers, and Las Vacas Arroyo), provided that the running average over a five-year period cannot be less than 350,000 acre-feet/yr.

While the International Boundary and Water Commission is responsible for implementing the allocation of water on the U.S. side, the Watermaster office of TCEQ administers the allocation of Texas' share of the international waters. The two reservoirs located in the middle of the lower Rio Grande, the Amistad and Falcon, store the water regulated by the Watermaster. The Watermaster oversees Texas' share of water in the Rio Grande and its Texas tributaries from Fort Quitman to Amistad Dam, excluding drainage basins of the Pecos River and Devils River.

The Pecos River forms a portion of the boundary between Terrell County in the Far West Texas Region and Crockett County in Region F before reaching Langtry in Val Verde County in the Plateau Region. The Devils River originates in Sutton County and proceeds generally southward through Val Verde County before reaching Amistad International Reservoir. There are no surface-water rights on the Pecos and Devils Rivers within the Plateau Region.

Flow of the Pecos River within the Plateau Region is inconsistent, with livestock and wildlife watering apparently being the only use made of whatever water that may remain in the River. Independence Creek, a large spring-fed creek in northern Terrell County west of Val Verde County, is the most important of the few remaining freshwater tributaries to the lower Pecos River. Independence Creek's contribution increases the Pecos River water volume by 42 percent at the confluence and reduces the total suspended solids by 50 percent, thus improving both water quantity and quality (Nature Conservancy of Texas descriptive flier).

Flows of the Devils River are gaged at the Pafford Crossing near Comstock in Val Verde County. This gage (USGS 08449400) began recording in 1978 and was discontinued in 1985. Therefore, it does not record flows for the 1950s. However, from 1978 through 1985 the flows are consistently between approximately 100 and 300 cfs, with rare spikes ranging from 4,000 cfs up to 50,000 cfs. These spikes result from unusually intense but short rainfall events. In absence of data for the 1950s drought period, and considering the generally low and undependable flows within the Devils River, a realistic estimate of the drought-of-record amount of supply from the Devils River within the Plateau Region is zero.

3.2.2 Amistad International Reservoir on the Rio Grande

The Amistad International Reservoir is located on the border between the United States and Mexico near the City of Del Rio, was constructed jointly by the two nations. It was completed in 1968 with a maximum capacity of 5,250,000 acre-feet, 3,505,000 acre-feet of which are used for water conservation. The water is distributed among downstream users of Mexico and the United States. However, Amistad is not a source of supply for the Plateau Region, as the City of Del Rio and downstream irrigators in Val Verde County obtain their supply primarily from San Felipe Springs and Creek. Thus the constraints on Amistad Reservoir as a source of water supply for the Plateau Region are the existing water rights held by water rights holders and enforced by the Rio Grande Watermaster.

Good enough Spring is inundated by Lake Amistad and was at one time considered the third largest spring in Texas. The spring, which discharges from the Edwards-Trinity (Plateau) Aquifer, still provides a significant flow contribution to the Rio Grande.

3.2.3 The Nueces River Basin

The upper Nueces River Basin lies in Edwards, Real, Bandera, and Kinney Counties, with the main stem Nueces forming a portion of the border between Real County and Edwards County. Headwater tributaries of the Nueces River located in the Plateau Region include the Sabinal River and Hondo Creek in Bandera County, the West Nueces River in Edwards and Kinney Counties, and the Frio, East Frio, and Dry Frio

Rivers in Real County. Although undocumented, there appears to be a significant amount of underflow occurring through gravel beds that line long stretches of the river bottom.

Total authorized diversions by water rights on the Nueces River within the Plateau Region are 11,419 acre-feet/year. Most of this amount (10,116 acre-feet/year or 88 percent) is for irrigation use. Diversions for municipal use total 1,259 acre-feet/year. The City of Camp Wood holds the largest municipal right for 1,000 acre-feet/year. Small water rights for other uses have a total authorized diversion of 44 acre-feet/year.

The drought-of-record for the Nueces River Basin appears to have occurred not in the 1950s, but in 1996. USGS gages on the Sabinal River, Hondo Creek and West Nueces River seem to substantiate this assertion; flows at these gages during 1996 were significantly reduced from expected historical flows. The locations of gages USGS 08198500 (Sabinal River at Sabinal in eastern Uvalde County) and USGS 08200700 (Hondo Creek at King Waterhole near Hondo in central Medina County) are outside the Plateau Region, but the gages themselves measure flows from drainage areas lying within counties of the Plateau Region. The location of USGS gage 08190500 on the West Nueces River is near Brackettville in Kinney County.

An internal TWDB memorandum dated May 26, 1998 cites the Sabinal and Hondo gages as having experienced streamflows in calendar years 1994 through 1996 significantly reduced from expected historical flows, and cites the West Nueces gage as having experienced streamflow in calendar years 1994 and 1995 significantly reduced from expected historical flows. The memorandum defines "significantly reduced" as showing a 40 percent or more difference between the historical and the recent year non-exceedance probabilities. (It should be noted that for all three of these gages 1997, flows were higher than the 1994 through 1996 flows.)

Flows for the main stem Nueces River are gaged at USGS 08192000 near Uvalde in Uvalde County. These gaged flows for a period of record of 1939 through 1997 indicate a low annual flow of 3.63 cfs (approximately 2,650 acre-feet/year), occurring in 1956. Flows for the Frio River are gaged at USGS 08195000 at Concan in Uvalde County. These gaged flows for a period of record of 1930 through 1997 indicate a low annual flow of 8.8 cfs (approximately 6,424 acre-feet/year), occurring in 1956. For these areas, the 1950s drought was evidently the drought-of-record.

The TCEQ Water Availability Model for the Nueces River Basin was used to evaluate surface water supplies. The model includes data through the year 1996, and therefore addresses the drought-of-record occurring in 1996 for the localized areas on the Sabinal River and Hondo Creek.

3.2.4 Colorado River Basin

The headwaters of the South Llano River, a tributary of the Colorado River, lie in Edwards County. There are three water rights on the South Llano River and Paint Creek within the Plateau Region for irrigation use. The combined authorized amount of these rights is 180 acre-feet/year.

The TCEQ Colorado River Basin WAM was used to evaluate the supply for these rights. This model covers the period 1940-1998. Hydrologic data for these streams suggest that the drought-of-record occurred during the 1950s. The minimum annual diversion for the three rights is 43 acre-ft/yr.

3.2.5 San Antonio River Basin

Headwaters of the San Antonio River lie in Bandera County. Most water right authorizations from the San Antonio Basin are run-of-the-river diversions for irrigation use. Run-of-the-river diversions exclude authorizations on Medina Lake. Eight authorized water rights on the Medina River main stem total 236 acre-feet/year. Of these eight water right holders on the River, six use the water for irrigation. The sum of these six irrigation rights totals 227 acre-feet/year. Of the remaining two water right holders, one is for 9 acre-feet of water per year used by an individual for municipal purposes, and the other is for a non-consumptive recreation reservoir owned by the City of Bandera. This recreation-only reservoir is for non-consumptive use only.

Since the Guadalupe-San Antonio WAM covers the period 1934-1989, it is appropriate to consider if the drought of 1996 exceeded the severity of the drought of the mid-1950s. USGS gage 08178880 on the Medina River at Bandera just downstream of State Highway 173 gives a lowest annual streamflow amount at 33.7 cubic feet per second (cfs) (approximately 24,600 acre-feet/year) in 1996. However, this gage did not begin recording until 1982, and therefore records from the 1950s drought are missing and cannot be compared directly to the low flows of 1996. Data for the 1950s at the Bandera gage as extracted from the Guadalupe-San Antonio River Basin WAM gives an annual naturalized flow of 10,500 acre-feet in 1956. Regulated flows would be even lower once upstream diversions and impoundments are accounted for. Therefore, based on estimates of the Guadalupe-San Antonio Basins WAM, the drought of the 1950s represents the drought-of-record conditions for the San Antonio Basin in the Plateau Region.

3.2.6 Medina Lake on the Medina River

Medina Lake was constructed in 1911 to provide irrigation water for farmers to the southwest of San Antonio. Although commonly referred to as Medina Lake, the lake is actually a system consisting of Medina Lake and Diversion Lake. Impounded in 1913,

Diversion Lake is approximately 4 miles downstream of Medina Lake.

Diversions from the dual-lake system are authorized only from Diversion Lake, as per the water right held by Bexar-Medina-Atascosa Water Control and Improvement District #1 (BMAWCID#1). BMAWCID#1's Adjudication Certificate No. 19-2130C authorizes the District to divert up to 65,830 acre-feet/year of water for irrigation, municipal and industrial use, up to 750 acre-feet/year specifically for domestic and livestock purposes, and up to 170 acre-feet/year specifically for municipal use.

BMAWCID#1 has signed contracts to supply several irrigators and a development corporation with water. In January 2000, BMAWCID#1 signed a contract with Bexar Metropolitan Water Authority indicating that BMAWCID#1 will sell 20,000 acre-feet/year to the Authority for municipal use.

Bandera County currently has a Water Supply Agreement with BMAWCID#1 for purchase of up to 5,000 acre-feet/year; however, this agreement is not currently associated with the infrastructure necessary to carry out the purchase and subsequent distribution of the water. Alternate Strategy J-1 discussed in Chapter 5 describes the potential use of this source.

Loss of impounded water from Medina Lake to the Trinity Aquifer and Diversion Lake to the Edwards Aquifer reduces the firm yield of the system. This loss has long been known to be substantial. Quantification of water recharging the aquifers has been elusive, as different estimates of recharge have resulted in different firm-yield estimates for the system. In 1957, a Bureau of Reclamation study estimated the firm annual yield of the Medina Lake/Diversion Lake system to be 27,500 acre-feet/year if the lake system were operated under an agricultural (irrigation) demand only scenario, but it estimated 29,700 acre-feet/year as the firm yield for municipal and industrial demand. Due to effects of seepage around the dam and of recharge to the underlying aquifers, Espey Huston estimated a firm yield of zero for Medina Lake in 1994, based on the relationship they found between the Lake stage and recharge. HDR Engineering modified the Espey Huston stage-recharge curves for its Trans-Texas report and cited 8,770 acre-feet/year as the firm yield. According to personal communication, HDR assumed diversions would be from Medina Lake rather than from Diversion Lake and that all irrigation use would be curtailed. This assumption does not comply with existing conditions as regards to water right authorizations.

The latest USGS report, "Assessment of Hydrogeology, Hydrologic Budget, and Water Chemistry of the Medina Lake Area, Medina and Bandera Counties, Texas," maintains that earlier methods of estimating recharge (Lowry, Espey Huston curves as modified by HDR for the Trans-Texas report) overestimate recharge. Overestimation of recharge would result in an underestimation of firm yield; however, the USGS report did not include a firm-yield estimate for the reservoir system.

The TCEQ Guadalupe-San Antonio River Basins WAM incorporates the HDR Trans-Texas method of estimating recharge and probably provides the best overall data (water rights, inflows determined by water rights) available at this time. The model was used to determine a firm yield of the Medina/Diversion system of zero acre-feet/year.

3.2.7 Guadalupe River Basin

Within the Plateau Region, the Guadalupe River Basin occurs almost exclusively within Kerr County. The Basin drains approximately 510 square miles at Kerrville, and approximately 839 square miles at Comfort near the eastern county line. The River originates almost entirely within western Kerr County as three branches (Johnson Creek, North Fork, and South Fork) merge west of Kerrville to form the main river course. A study report titled Spring Flow Contribution to the Headwaters of the Guadalupe River in Western Kerr County (2005) was prepared for the PWPG (www.ugra.org/waterdevelopment.html).

The total amount of authorized water rights for the Guadalupe River within the Plateau Region is 21,020 acre-feet/year. Municipal use accounts for the highest authorization at 8,076 acre-feet/year. Holders of these water rights include the City of Kerrville, the Upper Guadalupe River Authority (UGRA), and independent persons.

The City of Kerrville and the UGRA own the largest municipal water rights. Certificate of Adjudication 1996 and Permit 3505 are held solely by Kerrville. UGRA and Kerrville hold Permit 5394 jointly. Authorized diversions from the Guadalupe River associated with these water rights are taken from an 840-acre on-channel reservoir located in the City of Kerrville and are pumped from the reservoir to Kerrville's water treatment plant. A summary of the pertinent information for their water rights is shown in Table 3-4.

Texas Parks and Wildlife Department owns a continuous flow-through water right for 5,780 acre-feet/year used for the Heart of the Hills Fisheries Science Center, consumptive use is approximately 400 acre-feet/year. Industrial use permits are authorized for 17 acre-feet/year and irrigation rights for 6,904 acre-feet/year. The remaining water-rights holders use their water for mining, hydroelectric power, and recreation. One individual holds a water right (35,125 acre-feet/year) for hydroelectric use; however, this right has not been exercised. Kerr County holds the rights for three non-consumptive recreation-use reservoirs in and near Kerrville.

Table 3-4. Municipal Water Rights for Kerrville and UGRA

Water Rights Permit	Authorized Diversion (acre-ft/yr)	Permit Holder	Priority Data	Storage (ac-ft)	Restrictions
1996 (amended 4/10/98)	150 (mun) 75 (irr)	Kerrville	April 4, 1914		
3505	3,603	Kerrville	May 23, 1977	840	Max diversion rate = 9.7 cfs Divert only when reservoir is above 1,608 ft msl
5394 (amended 4/10/98)	2,169	Kerrville (Kerrville Municipal use)	January 6, 1992	Utilizes the storage authorized for Permit 3505	Max combined diversion rate for water rights #3505 and #5394 = 15.5 crfs. Minimum instream flow requirements vary from 30 to 50 cfs during year.
	2,000	UGRA (County Municipal use)			

Note: Permit 1996 authorizes a total diversion of 225 acre-feet/year, of which 150 acre-feet/year is designated for municipal use and 75 acre-feet/year for irrigation purposes.

During winter months when there is surplus surface water supply, a portion of the treated water is injected into the Lower Trinity Aquifer for subsequent use during the typically dry summer months. This aquifer storage and recovery (ASR) program has been in full operation since 1998.

Both the City of Kerrville and the UGRA have within their authorizations (Permits Nos. 5394B and 5394A respectively) a Special Condition addressing the seasonal distribution of allowed diversions. The Special Condition stipulates that during the months of October through May, the permittees may divert only when the flow of the Guadalupe River exceeds 40 cfs, and during the months of June through September, the permittees are authorized to divert only when the flow of the Guadalupe River exceeds 30 cfs. Another Special Condition common to both permittees is that, when inflows to Canyon Reservoir are less than 50 cfs, each permittee is to restrict diversions to allow a flow of at least 50 cfs to pass through. Yet another Special Condition imposed on both permittees is that diversions may be made only when the level of UGRA Lake is above 1,608 feet above mean sea level.

Pursuant to a Memorandum of Understanding (MOU) between the Guadalupe-Blanco River Authority (GBRA) and the Commissioner's Court of Kerr County, the South Central Texas Water Planning Group (Region L) recognizes a potential commitment of approximately 2,000 acre-feet/year from the firm yield of Canyon Reservoir for the calendar years 2021 through 2050. GBRA's hydrology studies indicate that a commitment of about 2,000 acre-feet/year would be necessary to allow permits for 6,000 acre-feet/year to be issued by TCEQ for diversions in Kerr County.

Data from the Corps of Engineers show a computed inflow into Lake Canyon of 132,900 acre-feet/year in 1996. The Guadalupe-San Antonio WAM estimates naturalized flows to be 27,800 acre-feet in 1956. The USGS gage 08167000 on the Guadalupe River at Comfort gives a lowest annual streamflow amount of 14.5 cfs (approximately 10,585 acre-feet/year) occurring in 1956. This gage has been recording since 1939. Interestingly, statistics for the gage include the fact that, for water years 1939 through 1997, the mean annual runoff was 157,800 acre-feet or approximately 216 cfs, and that 90 percent of these flows exceeded 25 cfs. This puts the 1956 occurrence of 14.5 cfs within the 0 to 10 percent non-exceedance category. In calendar year 1996, the annual mean was 151 cfs and the median was 85 cfs. The mean and median for 1997 exceeded the 1996 values. These facts seem to substantiate that the drought-of-record for Kerr County occurred in 1956, not in 1996, as consistent with most other areas of the State.

3.2.8 Canyon Reservoir

The construction of Canyon Reservoir was completed and impoundment commenced in June 1964. This reservoir controls approximately 1,425 square miles of drainage area and serves to impound water for various uses (mostly appropriated to the GBRA for use primarily in the South Central Texas Region). Canyon is also an Army Corps of Engineers (COE) Reservoir and as such operates under the Army COE Operations Manual as occasionally modified by request of GBRA (and agreed to by county judges of the downstream counties). Canyon Reservoir is also subject to the Federal Emergency Management Agency's (FEMA) requirements as to daily releases. The Army COE and FEMA operations and release requirements are incorporated into the updated TCEQ WAM for the Guadalupe-San Antonio River Basin. GBRA's TCEQ permit currently authorizes an average annual diversion from Canyon Reservoir of 90,000 acre-feet/year. The firm yield of Canyon Reservoir used in the Region L Plan ranges from 88,232 acre-feet/year to 87,484 acre-feet/year in years 2000 and 2060 respectively.

3.2.9 San Felipe Springs

The City of Del Rio has a water right authorizing it to divert 11,416 acre-feet/year from San Felipe Springs for municipal use. San Felipe Manufacturing and Irrigation Company has a water right authorizing it to divert 4,962 acre-feet/year for irrigation use and 50 acre-feet/year for industrial use. No data exists for flows during the drought of the 1950s. The only available records are from USGS gage 08452800 maintained by the IBWC at San Felipe Springs that covers the period of February 1961 to present. The minimum annual amount during this time period was 36,580 acre-feet/year (occurring in 1963).

3.2.10 Old Faithful Springs

Issuing from the upper Glen Rose Limestone portion of the Edwards-Trinity (Plateau) Aquifer and shallow creek alluvium, Old Faithful Springs is the sole-source water supply for the City of Camp Wood. The Spring has been a dependable source and was reported to have continuously flowed during the 1950s drought. There is current concern that the increase in the number of wells being drilled in the area may lower the local water table and thus negatively impact spring flow. The Spring is privately owned and may not be available for City use after the current contract expires.

3.2.11 Surface Water Rights

The right to use water from streams and lakes is permitted through the State of Texas. A list of all authorized surface water rights in the Region is available in the *2011 Plateau Region Water Plan*, Chapter 3, Appendix 3A.

Major downstream water rights include those in Region L supplied by the Guadalupe-Blanco River Authority out of Canyon Lake and by the Bexar-Medina-Atascosa WCID#1 out of the Medina/Diversion system. The firm yields of Canyon and Medina limit the amount of water available for appropriation in both the Plateau Region and Region L. Major downstream water rights in Region M (i.e., cities and irrigators on the Rio Grande downstream from Amistad Reservoir) do not limit the amount of water available for appropriation in the Plateau Region because currently the Plateau Region does not depend on the Falcon-Amistad system. TCEQ's Lower Rio Grande Watermaster allocates water rights on the Rio Grande according to the supply in the Amistad Reservoir and in accordance with the 1944 International Treaty with Mexico.

3.3 GROUNDWATER/SURFACE WATER RELATIONSHIP

In the natural environment, water is constantly in transition between the land surface and underground aquifers. Under certain conditions, stream losses percolate downward to underlying aquifers as recharge; while in other cases, aquifers give up water to the land surface in the form of springs and seeps.

Most of the Plateau Region occurs at higher elevations that constitute the headwaters of the numerous streams and tributaries that frequent this Region. At these elevations, significant quantities of water exit the aquifer systems through springs and form the base flow of the surface streams. Downstream, only a portion of that water may renter the underground system. For this reason, these streams are generally gaining throughout much of their extent within the Plateau Region. Spring flows are also environmentally important in that they are the primary source of water for wildlife in the area. These discharges from springs are thus the primary source of continuous flow to the rivers downstream and, therefore, their protection is warranted.

Some of the largest springs in the Region, such as San Felipe Springs (Val Verde County) and Las Moras Springs (Kinney County), issue from the Edwards limestone. However, numerous other springs issue from either the Edwards or Glen Rose Limestones. Many of the springs, such as Fessenden Spring (Kerr County), issue near the contact between the Edwards and the upper Glen Rose Limestones. Smaller springs are more prevalent where they issue from the Glen Rose, particularly in Bandera and Kerr Counties.

Most springs located in the headwaters of rivers that traverse the eastern part of the Region issue from the contact between the Edwards limestone and underlying upper Glen Rose limestone. Most well production in this area is from deeper aquifers and, therefore, little impact to spring flow from the pumping is anticipated. However, as new development expands to the west, care should be given to potential water level declines that could diminish spring flow and base flow to the rivers.

Springs located in the western part of the Region issue primarily from the Edwards Limestone. Because of limited pumping of groundwater from wells in the Del Rio area, San Felipe Springs has not had to compete for source water. A significant increase in groundwater pumpage immediate updip and to the east of the springs may lower the water table sufficiently to affect flow from the springs. Because much of the recharge areas for the contributing zones of these western springs occur in remote areas, very little information is available concerning the relationship between the springs and the underlying aquifers.

Gain/loss studies are needed to identify stream segments that are critical to aquifer recharge and spring discharge. The studies can be used to identify where recharge structures would be most efficient and where most river base-flow gain occurs. Specific candidate areas occur over the plateau area that is underlain by Edwards Limestone, especially in the upper tributaries of all the rivers. Gain/loss studies of tributaries in the vicinity of Del Rio would be beneficial in understanding the recharge areas that contribute to San Felipe Springs.

Two supplemental study reports were prepared for the *Plateau Region Water Plan* that address springs. The first report (Springs of Kinney and Val Verde counties, 2005) considers the location and geohydrology of springs in Kinney and Val Verde Counties, and the second report (Spring Flow Contribution to the Headwaters of the Guadalupe River in Western Kerr County, Texas, 2005) relates springflow in western Kerr County to base flow in the three branches of the upper Guadalupe River.

3.4 WATER REUSE

While recycling is a term generally applied to aluminum cans, glass bottles, and newspapers, water can be recycled as well. Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a groundwater aquifer (referred to as groundwater recharge or ASR for aquifer storage and recovery). Water is sometimes recycled and reused onsite; for example, when an industrial facility recycles water used for cooling processes. A common type of recycled water is water that has been reclaimed from municipal wastewater, or sewage. The term "water recycling" is generally used synonymously with water reclamation and water reuse.

Kerrville treats its wastewater to the strictest set of standards in the State of Texas, which nearly meets drinking water standards. The treated wastewater is pumped through a dedicated pipeline for reuse as irrigation water for the Scott Schreiner Municipal Golf Course, the Hill Country Youth Soccer Fields, and the golf course at Comanche Trace Ranch & Golf Club. Additional treated water is sold by the truckload for construction projects. The remaining wastewater is released into Third Creek, which flows into Flatrock Lake on the Guadalupe River. That water is then available for use downstream of Kerrville. Future expansion of Kerrville's reuse project is anticipated to yield approximately 1 million gallons per day. The current thinking within city leadership is that potable reuse is a better use for that water than irrigation. The Cities of Bandera and Camp Wood also provide treated wastewater for non-potable uses.

Real–Edwards Conservation & Reclamation District

P.O. Box 1208
234 Evergreen
Leakey, Texas 78873

Tel: 830-232-5733
Fax: 830-232-5734

April 29, 2020 – 6:00 p.m.
First United Methodist Church, 206 W. Austin, Rocksprings, Texas 78880

Additional, more detailed notice of the public hearings required by state law and the District's Rules was separately issued by the District. During the meeting, the Board reserves the right to go into executive session for any of the purposes authorized under the Texas Open Meetings Act, V.T.C.A., Government Code, Chapter 551, for any item on this agenda or as otherwise authorized by law. The Board may change the order in which one or more of the meeting items are considered.

NOTICE OF PUBLIC HEARING ON DISTRICT MANAGEMENT 2020-2025

1. Call to Order.
2. Public Hearing on Adoption of District Management Plan for 2020-2025.
3. Adjourn.

I hereby certify that this notice was posted at least 10 days prior to the Public Hearing in accordance with the Texas Open Meetings Act.

NOTICE OF REGULAR BOARD MEETING

This meeting is intended to commence immediately upon consideration of the hearings; however, the Board may change the order in which one or more of the hearings or meeting items are considered.

1. Call to Order, Determination of Quorum.
2. Pledge of Allegiance.
3. Welcome Visitors/Public Comment. (Note: Board may limit time.)
4. Consider for Approval Minutes from January 22, 2020, Regular Board Meeting.
5. Consider for Approval and Adoption of the District Management Plan for 2020-2025.
6. Consider for Approval and Acceptance of Resignation of Board Director.
7. Consider for Approval and Appointment of Board Director to Fill Unexpired Term.
8. Swear-In Newly Appointed Board Member
9. Reports:
    a. Financial Statements and Financial Reports.
    b. Well Report/Operating Permit Report/Water Quality Screening Report.
    c. River Flows Update.
    d. Rainfall Record and Drought Assessment of Real and Edwards counties.
10. Consider for Approval Opening a CD with First State Bank of Uvalde.
11. Discussion/Update on November 2020 Director Election.
12. Update on Water Leak, Damage, and Removal/Repair.
13. Discussion and Possible Action on Personnel/Budget Issues.
14. Set Time and Date for Next Meeting. (July 2020)
15. Adjourn.

I hereby certify that this notice was posted at least 72 hours prior to the Board meeting in accordance with the Texas Open Meetings Act.

Executive Session: At any time during the meeting and in compliance with the Texas Open Meeting Act, Chapter 551, Government Code, Vernon's Texas Codes, Annotated, the Real Edwards Conservation and Reclamation District Board of Directors may meet in Executive Session on any of the above agenda items for consultation concerning Attorney-client matters, (551:071; deliberation regarding real property (551:072); deliberation regarding prospective gifts (551:073); personnel matters (551:074); and deliberation regarding security devices (551:076). All final votes, action, or decisions will be taken in open meeting.

By: Grady Douglass /with permission by Ima Ashley
GRADY DOUGLASS, GENERAL MANAGER

RESOLUTION
OF
REAL-EDWARDS CONSERVATION AND RECLAMATION DISTRICT

RESOLUTION REGARDING THE ADOPTION OF THE REVISED DISTRICT MANAGEMENT PLAN REVISED & ADOPTED APRIL 2020

WHEREAS, The Real-Edwards Conservation and Reclamation District was created in 1959 and has operated under the requirements of Chapter 36 of the Texas Water Code or other chapters of the Texas Water Code or sections of the Texas Administrative Code since creation; and

WHEREAS, The District is required by SB1 through the Texas Water Code, Chapter §36.1071 to adopt a comprehensive management plan to address the following management goals as applicable: (I) providing the most efficient use of groundwater; (2) Controlling and preventing waste of groundwater; (3) controlling and preventing subsidence; (4) addressing conjunctive surface water management issues; (5) addressing natural resource issues that impact the use and availability of groundwater and which are impacted by the use of groundwater; (6) addressing drought conditions; (7) addressing conservation, recharge enhancement, rainwater harvesting, precipitation enhancement, or brush control, where appropriate and cost-effective; and (8) addressing the desired future conditions; and

WHEREAS, The District is required by SB1 to submit the adopted Management Plan to the Executive Director of the Texas Water Development Board for review and re-approval by April 2020; and

WHEREAS, The District's Management Plan shall be approved by the Executive Director if the plan is administratively complete; and

WHEREAS, The Real-Edwards Conservation and Reclamation District intends to continue to carry out the purpose for which the people created the District; and

WHEREAS, The Board of Directors of The Real-Edwards Conservation and Reclamation District believes that the 2020 Revised Management Plan of the District reflects the best management of the groundwater for the District and meets the requirements of §36.1071 as applicable; and

WHEREAS, The Board further believes that the description of activities, programs, procedures and rules of the District included in the plan provide performance standards and management objectives necessary in accordance with §36.1071; and

WHEREAS, The District is fully prepared to amend this Plan as determined by the Board of Directors as necessary and in accordance with applicable laws of this state;

NOW, THEREFORE BE IT RESOLVED, That the Board of Directors of the Real-Edwards Conservation and Reclamation District, following notice and hearing, does hereby adopt this revised Management Plan to replace the existing Management Plan.

The board officially finds, determines, and declares that this Resolution was reviewed, carefully considered, and adopted at a regular meeting of the board on the date set forth below and that a sufficient written notice of the date, hour, place, and subject of this meeting was posted at a place readily accessible and convenient to the public within the District and on a bulletin board located at a place convenient to the public in the Real and Edwards County Courthouses for the time required by law preceding this meeting, as required by the Open Meetings Act, Chapter 551,TEXAS GOV'T CODE, and that this meeting had been open to the public as required by law at all times during which this Resolution was discussed, considered, and acted upon. The board further ratifies, approves and confirms such written notice and the contents and posting thereof.

PASSED AND APPROVED THIS 29th DAY OF APRIL 2020.

REAL-EDWARDS CONSERVATION AND RECLAMATION DISTRICT

Roland Trees

PRESIDENT, Roland "Tooter" Trees

ATTEST:

Pablo "Beatsie" Rubio

SECRETARY, Pablo "Beatsie" Rubio

Real-Edwards Conservation & Reclamation District Management Plan

GD Grady Douglass <manager@recrd.org>
To jbyrum@nueces-ra.org

Reply | Reply All | Forw

Mon 5/18/

Retention Policy Default 2 Year permanent Delete (2 years) Expires 5/18/2022

Management Plan 2020 + Appendices.pdf
5 MB

External: Beware of links/attachments.

Mr. Byrum;

As the surface water management entity within our Groundwater Conservation District, I am sending you a copy of our Management Plan to inform you of what RECRD has submitted to the Texas Water Develop Board. It has been a pleasure working with Mr. Mims and your education team in the past and I hope to continue that effort as we move forward.

JP

Joel Pigg
Consulting Manager & CFO
Real-Edwards Conservation & Reclamation District
P. O. Box 1208
Leakey, TX 78873
830-232-5733 office
830-232-5734 fax
830-377-2631 cell