COKE COUNTY UNDERGROUND WATER CONSERVATION DISTRICT

Groundwater Management Plan

2024-2029

P.O. Box 1110
Robert Lee. Texas 76945
Ph: 325-453-2232
E-mail: ccuwcd@wcc.net

Table of Contents

District Mission	4
Purpose of Management Plan	4
Regional Cooperation and Coordination	5
Time Period for this Plan	5
Statement of Guiding Principles	6
General Description	6
Location and Extent	6
Topography and Drainage	7
Groundwater Resources	7
Desired Future Conditions	8
Required District Specific Information	
Management of Groundwater Supplies and Actions, Procedures, Performanc Avoidance for Plan Implementation	
Methodology for Tracking Progress	8
Goals: Management Objectives and Performance Standards	10
1.0 Provide for Efficient Use of Groundwater within the District	10 11 11 11
Management Plans Determined Not Applicable	13
Control and Prevention of Subsidence	13

the control of the second of t

Summary Definitions

Appendix A- Estimated Historical Use and 2017 Texas Stale Water Plan Datasets

Appendix B - GAM Run 23-021: Coke County Underground Water Conservation District Management Plan

Appendix C - GAM Run I 6-026 MAG Modeled Available Groundwater

Appendix D - District Rules

COKE COUNTY UNDERGROUND WATER CONSERVATION DISTRICT

DISTRICT MISSION

and a well-and the same of

and the first transfer of the contract of the

a gyvendus is expaint atem Al elikis Pais e teaemige Hayla gereame Pratest e maa velkin Blat ei Monete e contaitis

nd sky mestydd allda leady pyfghallol o'r yllafyd o'r engyr pygyc o ei by y gyglaeth a ch

ar uda kadiba bakuwa si

- THURTUITER YTHEOL BLOO TOR THE HOUSE WESTER IN 1811

HOLESE YOUR DESCRIPTION

The overall objective of the Coke County Underground Water Conservation District (District) is to preserve the integrity of the groundwater in the aquifer over which the land in the District is located. This objective may be accomplished as the District provides for the conservation, preservation, protection, recharge, and prevention of waste of the groundwater reservoirs. This groundwater management plan will help provide guidance to accomplish the overall objective of the District. The plan is an open-ended document and can be revised or updated as needed to help meet the District goals and objectives.

PURPOSE OF MANAGEMENT PLAN

The 75th Texas Legislative in 1997 enacted Senate Bill 1 ("SB I") to establish a comprehensive statewide water planning process. SB I contained provisions that required groundwater conservation districts to prepare management plan to identify the water supply resources and water demands that will shape the decisions of each district. SB I designed the plans to include management goals for each district to manage and conserve the groundwater resources within their boundaries. In 200 I, the Texas Legislature enacted Senate Bill 2 ("SB2") to build on the planning requirements of SB I and to future clarify the actions necessary for districts to manage and conserve the groundwater resources of the state of Texas.

The Texas Legislative enacted significant changes to the management of groundwater resources in Texas with the passage of House Bill 1763 (HB 1763) in 2005. HB 1763 created a long-term planning process in which groundwater conservative districts (GCDs) in each Groundwater Management Area (GMA) are required to meet and determine the Desired Future Conditions (DFCs) for the groundwater resources within their boundaries by September J, 2010. In addition, HB 1763 required GCDs. to share management plans with the other GCDs in the GMA for review by the other GCDs.

The Coke County Underground Water Conservation District's groundwater management plan satisfies the statutory requirements of Chapter 36 of the Texas Water Code, and the administrative requirements of the Texas Water Development Board's (TWDB) rules.

REGIONAL COOPERATION AND COORDINATION

The District is a member of the West Texas Regional Groundwater Alliance (WTRGA). This WTRGA consists of eighteen (18) locally created and locally funded districts that encompass

The greenst objections of its characters by Modern plant of states Constant about 17 and profit in a greenst of the ground of the control of

the first terms large serve in 1994 change if the color of the first increases at the exemption of the exemp

The Tracer Legisland Colorations significancy countries for the management of the Tracer and the State of the Coloration of the property of the construction of the Coloration of the Coloration

The Court County Undaugramed Current Conserver on Timbic's glacefortism made purtured. I see to Asias I no tests to y sequit transmis of Maples Sib of the Terror Weits 1904 of 1912 and Ser Francisco for tagger and other of the Terror Wiston On Island and Depart of Terror of the

FOR AMBRICA CHA HOLLANIEDO LIGATORIA

For Detrict is a magness of the West Cause Reduced Cancerby his Alice of 1999 Ribby, This WARRIA consists of eighteur (US) for illy present and least a funded Johnstother encorpass approximately eighteen (18.2) million acres or twenty-eight thousand three hundred sixty-eight (28,368) square miles of West Texas.

In May of 1988 four (4) groundwater districts; Coke County UWCD, Glasscock County UWCD, Irion County WCD, and Sterling County UWCD adopted the original Cooperative Agreement.

As new districts were created, they too adopted the Cooperative Agreement. In the fall of 1996, the original Cooperative Agreement was redrafted, and the West Texas Regional Groundwater Alliance was created. The current member districts are:

Coke County (1988)	Crockett County GCD (1992)
Glasscock County GCD (1988)	Hickory UWCD No 1(1997)
Hill Country UWCD (2005)	Irion County WCD (1988)
Kimble County GCD (2004)	Lipan-Kickapoo GCD (1989)
Lone Wolf GCD (2002)	Menard County UWD (2000)
Middle Pecos GCD (2005)	Permian Basin UWCD (2006)
Plateau UWCSD (1991)	Santa Rita UWCD (1990)
Sterling County UWCD (1988)	Sutton County UWCD (1991)
Wes-Tex GCD (2005)	

This Alliance was created because the local districts have a common objective to facilitate the conservation, preservation, and beneficial use of water and related resources. Local districts monitor the water-related activities of the State's largest industries such as farming and ranching, oil and gas and municipalities. The alliance provides coordination essential to the activities of these member districts as they monitor these activities to accomplish their objectives.

TIME PERIOD FOR THIS PLAN

This amended plan becomes effective upon adoption by the Board of Directors and reapproved by the Texas Water Development Board executive. The plan remains in effect for five years with the required review and re-adoption, with or without revisions, every five years.

STATEMENT OF GUIDING PRINCIPLE

The District recognizes that the groundwater resources of the region are of vital importance. The preservation of this most valuable resource can be managed in a prudent and cost-effective manner through regulation and permitting. The greatest threat to prevent the District from achieving the stated mission *is* inappropriate management. based in part on a lack of understanding of local conditions. A basic

understanding of the aquifers and their hydrogeologic properties, as well as a quantification of resources is the foundation from which to build prudent planning measures. This management document is intended as a tool to focus the thoughts and actions of those given the responsibility for the execution of District activities.

GENERAL DESCRIPTION

The Coke County Underground Water District was created by Acts of 69th Legislature (1985). p. 6960. Ch. 950. H.B. 2418 under authority y of Articles XVI, Section 59 of the Constitution of Texas.

The residents confirmed the District and voted to fund the District operations through local property taxes. It became an active district on April 5. 1986.

On April 5. 1986. the District adopted rules and by-laws which became effective immediately and on this date the District adopted a management plan. With the adoption of these rules, the District implemented a well permitting and registration program. The current members of the Board of Directors are: President Wes Washam, Vice-President Mike Arrott, Secretary Jimmie Byrne and members Mike Pinard, Tim Smith. The District General Manager is Jnae Walls.

The Coke County UWCD covers all of Coke County. Recreational areas include golf, hunting and fishing.

LOCATION AND EXTENT

The District has an area extent of 911 square miles located approximately 32 miles north of San Angelo and 65 miles southwest of Abilene. The population of the District was about 3,285 in 2020. Two incorporated cities lie within the boundaries of the District: Robert Lee, the county seat and Bronte.

The economy of Coke County is based on ranching. Farming, oil and gas production. The annual income from agriculture is derived from: cattle. sheep and goats' sales. The water used in Coke County comes from both groundwater and surface water sources. The District has one small lake: Mountain Creek and two major reservoirs in the county impounding surface water runoff. The largest reservoir is E.V. Spence Reservoir which is formed on the Colorado River near Robert Lee. Oak Creek Reservoir is in the northeast corner of the county and furnishes water to the towns of Sweetwater, Bronte, Robert Lee and Blackwell. Bronte's water well field supplements Oak Creek water. Water for livestock needs is furnished by either small surface water catchment tanks or by wells.

TOPOGRAPHY AND DRAINAGE

undig standing of the oppyrace to object hydrogonests over edes, as well as it in the edge of the oppyrace is the foundation of the contract of the foundation of the contract of the foundation of the contract of the oppyrace of the contract of the contra

[2012] 역 2일 : 10 전 : 1

The Cultural action is the magnetic of Maker Bermiss and a state for the Salas of 1996. Interpretation of 1995, to 1996, in the 1996, in the 1996 and the state of 1997, year Arthridge 1991. Section to be of the standard on the colours of

The any supply to the Confidence in the book of the confidence of

Excludes to 1998 or Destroy adopted rules and by tows who'd bedeep a disclose intensity and on the choral tree is what adopted in comparations to with the adoption of the sea rules the format adjunctivitied a seal paration of the sea rules the format and the Ecura of Freekons are the produce to the contract real the Ecura of Freekons are and the sea the format and members this Paration Freekons and the search manufacture for the Ecural Contract is alread and members this Paration Contract is shown that and members this expense.

Phy Categorithmer 1917; Dicontropping Colm County in maniform installmeter influde quif, numiera and farm q

DESCRIPTION OF THE PROPERTY OF

The Directions on since extent of 0.15 square united a 68but 40° out offery do policy north of two Angele and 65 inces worthwest of Abde of Too point about of the Direction of a specification of the Color Two roders established as the Police courses of the 1° out of Harrie Lee Toe directions of the Color of the Colo

The economic of Color County is because a caractery barreery in a fide part of the production of the entraction of the e

함께 보고 있는 사이를 가고 있다. 그들다가 그 나가는 어떻게 한다.

The southwestern part of Coke County is in the Edwards Plateau section of the Great Plains physiographical province; the northwestern part of the county is in the Central Texas section which includes the Callahan Divide. The county is bisected diagonally by the southeastward flowing Colorado River. Altitudes range from about 1,700 feet above mean sea level in the river valley to more than 2.600 feet on the Edwards Plateau.

Except for the rugged and dissected escarpment, the Edwards Plateau is relatively flat. The soils are mostly thin, dark-colored, calcareous loams. The Central Texas sect

ion is characterized by a rolling topography and deep red-brown loam soils. Much of the area, however. is capped with caliche.

Surface drainage on the plateau is mostly internal but during periods of heavy rainfall some intermittent low-gradient streams flow southward to the North Concho River. Intermittent streams in canyons along the escarpment flow to the Colorado River. The Central Texas section is drained by the Colorado River and its intermittent tributaries, many of which enter Robert Lee Reservoir.

GROUNDWATER RESOURCES OF THE COKE COUNTY UWCD

The oldest geologic units cropping out in the county are the westward-dipping Permian "red beds". These rocks are composed mainly of shale and fine-grained sandstone and scattered beds, lenses and stringers of gypsum, anhydrite and dolomite. In the western and southern plateau areas, the Permian rocks are overlain by eastward-dipping sand, clay and limestone of Cretaceous age. Alluvial deposits of Quaternary age occur in the Valleys of the Colorado River and its tributaries.

Water in the alluvium and in the Cretaceous rocks (Fredericksburg and Trinity Groups) occurs under water table conditions. Water in the Permian rocks (Clear Fork, Pease River and Artesian Groups and Ochoa Series) occurs under both water tables and artesian conditions. The water producing zones in the geological units are (1) sand and gravel in the alluvium. (2) fine sands or fractures and solution openings in limestone beds of the Fredericksburg and Trinity Groups and

(3) sand, gypsum and dolomite strings or lenses in the Permian rocks.

The Edwards-Trinity (Plateau) Aquifer enters Coke County on the West and progresses to the southeast. Wells in the southeast corner of the county produce

The southweatern part of Coles County is in the Edwards Fisteral section of the Great Fistern part of the Great Fistern part of the county is sume Contest fester from which is sume contest for the county is businessed disgonally by the southeactiver of every. Coloredo River Althudes carge from about 1,700 feet about 1000 are formally as more care from the Edwards Fisterial.

Skoept for the auggest and dispeded escarpment, the Ecitation Platoeurs minimals. Red. The seits are mostly to in, dark-colored, calcanous ideams. The Central Texas and non-a characterist for the area to the group to be an accumulation of the area, however, is capped with colored.

Surface displayed on the placeous mostly intental holds and periods of heavy calched some intentions from a mostly intential some intentions of heavy calched some flowers and streams flowers and some flowers interpretations of the contract of the contrac

In a obtast quotogue under elegana autor biscourb, des libervissivants deputing Permission find bedaff. These hocks are compared many production and shelpfunds and glassical analysis of bada liberast of the configuration of gracum and confiderate documents. In the anstruction and societies positive account to a set of the configuration of the confideration of the configuration of the

More and the allument one in the Cretarious reaks (Frader), Automore in the Politica and Exemple of the Color of the appropriate open of the Politica and the Politica (Clear Apply Found State State) and the political and the political and the political and the political and application of the political and the politi

and cyssion and delicate strings or kniller in the littler state.

The belowed at 1 hours (Plateau). As the electric Coto Course an the Wast and grapters of the the southeast. Walls in the coutheast non-conditions and the county around

large volumes of water. The northeast part of the county lies over the Trinity Aquifer.

Chemical quality of the Edwards-Trinity (Plateau) groundwater ranges from fresh to slightly saline. The water is typically hard and may vary widely in concentrations of dissolved solids made up mostly of calcium and bicarbonate. The principal sources of recharge to the aquifers of Coke County are (1) direct precipitation on the outcrops: (2) infiltration of water from surface reservoirs, rivers, and numerous intermittent streams: and (3) subsurface inflow from adjoining counties.

DESIRED FUTURE CONDITIONS

On August 19, 2021 upon completion of the second cycle of joint planning among districts in Groundwater Management Area 7 mandated by section 36.108 of the Texas Water Code. GMA 7 adopted the following Desired Future Conditions for aguifers of the Coke County Underground

Water District as an average drawdown of 0 feet.

Groundwater Management Area (GMA) 7

Modeled Available Groundwater for Relevant Aquifers by Groundwater Conservation District (GCD)

2021 Joint Planning

	Colle Col	inty COOCD							
GCD	Requittes	County	Modeled Available Groundmater (acre-feet per year)						
			2020	2030	2040	2050	2060	2070	
Coke County UWCD	Edwards-Trinity (Plateau), Pecos Valley, and Trinity	Cole	997	997	997	397	397	399	

REQUIRED DISTRICT SPECIFIC INFORMATION

Modeled Available Groundwater in the District

argu kalumak of welar The Welterak uartent of it county less does to Terrig was its

Ominical coaling of the Edwards Trigity (Plateon) groundwater ranges from free or segment and the construction of the construc

한번에 발표되었다. 교육하게 경우 선택했다고 보다

On suspess of 2000 again completion within second cybic of part planning among distincts in Scoundwicker Management was a membered by several 36-106 of the tighty by Marin Caca (SWM) is adopted to etchwing the sea Fatare Conditions for spatisher of the Coka County Stades ground

tech dile tan invest one en more es cereili perm

All March Control of the Section of th



Triatic tait rimme consort, stablevi jodenalij

The modeled available groundwater report (GAM Run 21-012 MAG) is provided in Appendix C.

Amount of Groundwater Being Used Within the District

The estimated historical groundwater use from the TWDB Historical Water Use Survey is provided in Appendix A.

Projected Surface Water Supply within the District

There are 3 surface water lakes in Coke County UWCD. Lake Spence, Mountain Creek Lake located at Robert Lee and Oak Creek Lake located near Blackwell. The projected surface water supply within the District can be found in Appendix A.

Projected Total Demand for Water within the District

The projected total demand for water within the district is provided in Appendix A.

Current sources of supply are shown to be adequate to meet demands for all users throughout the planning horizon, except for irrigation and mining.

Water Supply Needs within the District

Within Coke County UWCD there are projected water supply needs identified in the 2022 State Water Plan. Needs are identified for the cities of Bronte and Robert Lee. Details on these projected water supply needs are listed in Appendix A.

Water Management Strategies within the District

Water management strategies identified in the 2017 State Water Plan that impact Coke County UWCD are development of groundwater supplies from the Edwards-Trinity (Plateau) Aquifer for mining and the City of Bronte. Details on the water management strategies are listed in Appendix.

Estimates of aquifer recharge, discharge, and flows

The required estimates from GAM Run 23-021 of annual amount of recharge from precipitation, discharge from the aquifer to springs and any surface water bodies. and annual flow into the district, out of the district, and between aquifers are included in Appendix B.

GOALS, MANAGEMENT OBJECTIVES AND PERFORMANCE STANDARDS

Goal 1.0 Providing the most efficient use of groundwater

fina hindaleo avadobis grounivratri, rapdiri (d.1414 Puin 21-0112 MAG) is provided a Apusadix C

Ancorn of Groundwalls Boing Osse Willin inc Institu

The mineral bistor of granded to use the 19703 Majorial Maleila Disk Standard provided to Aspendence

क्षेत्रकुर स्थान है. _{जिस्सी} कर हो स्थान के स्थान है । जिस्सी स्थान के कि कि स्थान

These and 3 sucked water levinging following to VACE in deciding the Montest and the Montest and Continues and Continues to the Montest and the Montest and Continues and

Presented Solal Daymon Joseph Georginin, de District

The projected on a near and for a memoritim the distinct is provided in cooperfus A Surrant summers of a sopily grant have adaptived no refer formands for all users mesugnent the purching hour on excent for impairs word maing

Thirtie Supply Westle william has District

"Miljar Loter County Avitud more for movement vans sangt, meets Mentifes in the 2002 stants start Files (Loter County Starts and Robert Loter County starts and Robert Loter County and Robert Loter County and Instrument value of the county of the start is the county of the county of

130000 administration of the majority of the consequences and the consequences and the consequences are also as a consequence of the consequences are a consequences and the consequences are a consequence are a consequences are a consequences are a consequences are a consequence are a consequen

Vister merogement independent intrilled in the Pork Slard Water Plant Internacial Court Start Materials in the clawards for the Clawards and policy in the Clawards for the Material character in strongers entitle court and Augustalian.

standing of aquilier is conga, varinarge, and flower

The regular advisorables to the Count Part of a normal amount of sectioning from procedingles the charge here the arguments countries and any social exister and or a and amplies how our the distriction of the Carder and between against are included in Appendix its

용근용소에게 A T 및 역가(4 M) 20의 1일 및 기계 및 20일 경기 (2 P) 기계 20일 및 20일 및 20일 기계 (2 P) 시계 (2 P) 시계 (2 P) 시계 (2 P) 시계 (2 P

dos: 110 Providing me mast efficient see of groundwater

Management Objective

Each year the District will locate at least one or more water wells for map location, check water levels and chemical analysis.

Performance Standards

1.1a Annual report to the Board of Directors will include: the number of wells located, number of wells measured for water levels and the number of wells sampled for chemical analysis.

Controlling and preventing waste of groundwater Goal 2.0 Management Objective

Annually investigate every wasteful practice reported by the public or identified by District personnel within the District.

Performance Standards

Annual report to Board of Directors will include the number of wasteful practices identified and a summary of action taken to resolve the waste of groundwater in each identified case.

Addressing conjunctive surface water management issues Goal 3.0

Management Objective

Monitor rainfall events on the watersheds within the District that will impact surface water runoff and groundwater recharge.

Performance Standards

District will maintain files on rainfall events to monitor surface water runoff and underground recharge within the District through a voluntary rainfall network. These rainfall totals will be reported annually to the Board.

Addressing natural resource issues that impact the use and availability of groundwater and which are impacted by the use of groundwater

Management Objective

To measure, record and accumulate a historic record of static water levels in monitor network wells on a periodic basis.

Performance Standards

The District will establish a water level monitoring network and annually measure at least five wells in the network. The number of wells in the monitor network will be reported to the board annually.

Addressing drought conditions Goal 5.0

Management Objective

writue;dC to prespandif

ig für desemble Signaderen inaate et lesete nuid inaate water wells für mag. Idaarion, desemble setale setale and disemble at 2000.

sins would a marrie to

s de sierale regentre de Bauré et Directois velt melle e dise eu nass af welle lactorel aux des els els merdetels foi water laveis poù de ne courret wells sampled for et en le chros

Dow 2.0 controlling and graveniting waste of groundstates.

enging and the continue of the control of the provider monorized by the public or control by the public or the control of the first first form.

ar argala contenut sõ

Addression for expension of the Colonia the Colonia the Colonia of the Colonia the Colonia of the Colonia Colonia of the Colon

THE COST PROTECTION OF THE PROPERTY OF THE PRO

- o double Green and we want

Park and acceptance of the control o

f ditte til mållim ender flags av miljafde sed måle endere endere semeste materiken. Uppreter pelaser edener de en flag med fillation i mindeliger av sedde til sinkell habst ditt. Flagse manfall telstate avlikt men av stodes hitchelig til tilst 180 mil.

Cool a.G. . Adareming meason resduct Engage the Jewannia sevent evaluability of group meason and which or a impacret by the cost of groundwars:

South Company Company

Pigensaucone e e el el entre a communité e en el el entre de districtió vise e la bivisió en Permittir debete el exelle en apprendir l'este

The District will examine a valence and relative mediators and interesting the control of the co

Gest 5.0 Addressing desught conditions density and the second sec

District will monitor the Palmer Drought Severity Index (PDSI) by Texas Climate Divisions. If PDSI indicates that the District will experience severe drought conditions, the District will provide information concerning the drought index upon request.

Performance Standard

The District staff will monitor the PDSI and report to the District Board of Directors annually the number of times information about the PDSI was requested.

Goal 6.0 Conservation, Recharge E11ha11ceme11t, Rainwater-Harvesting, Precipitation Enhancement and Brush Control where appropriate and cost effective

Management Objective

Each year the District will provide and distribute literature on water conservation to promote conservation and efficient use of water.

Performance Standard

Annual report to Board of Directors on the number of times literature on water conservation was provided to the public.

Management Objective: Recharge Enhancement

District staff will provide information, upon request, to area residents about recharge enhancement.

Performance Standard

An annual report to the Board of Directors on the number of times information on the recharge enhancement was provided to the area residents.

Management Objective: Rainwater Harvesting

Provide information to area residents about rainwater harvesting.

Performance Standard

An annual report to the Board of Directors on the number of times information on rainwater harvesting was provided to area residents.

Management Objective: Precipitation Enhancement

Provide information to area residents about precipitation enhancement.

Performance Standard

District will nonliter the Palmer Drough' Seventy Index (PUSI) by Taxes Operate Divisions (PUSI) by Taxes on Operate Divisions if PDSI and cates that the District will appear as severe Justific and provide information concentracy the droughs andex upon requess.

Periormande Stringerti

The bisetics and withmonizer the PDSs and report to the DARRO Scart of Objections amountly the number of times information about the PDSI was requisation.

Goal 6.0 Conservation, Rachargo Efficience is Rainvater-Harvesling. Precipiesies Entercoment and Brosh Centrel where appropriate and cost efective

e nagy de la company de la Mila de

Fair your the District will provide and distribute from the 20 water. Acceptable to 50 to 50 more conservation and infinitely to 50 water.

hallmak append of

Administragion to Boyco of Dependes on the number of times literature on water and restant water.

Henstein den vorstung de som Ginera von Militaria

bish sinstall and provide in ornition, upon request to preside that a substitution is a continued to the con

An as must report to the Secret Directors on Andrew Andrew Secret Properties. The Companies of the Companies

n Nice o to chantile i ancheng l'engre con Ni

Promocynian and religious to such statistics or securing the company

Pale Std and Empire

Acquerqui region to the Spantint Directors on the number of times affirmation or carry discriber that extensives provided to area residents.

11.20121.0011.3.114.8.14.0.19. (September 1.1012)

Provide information to area or adenty much preducation embryement.

Perconductor september

An annual report to the Board of Directors on the number of times information on precipitation enhancement was provided to area residents.

Management Objective Brush Control

Provide information to area residents about brush control.

Performance Standard

An annual report to the Board of Directors on the number of times information on brush control was provided to the area residents.

Goal 7.0 Addressing the Desired Future Conditions Adopted by the District

Management Objective

Each year the District will measure the water levels in at least five monitoring and determine the five year water level averages based on the measures taken. The district will compare the five year water level averages to the corresponding five year increments of its desired future conditions in order to track its progress in achieving the desired future conditions.

Performance Standard

The districts' annual report will include the water level measurements taken each year to address the districts progress towards achieving its desired future conditions. Once the district has obtained water level measurements for five consecutive years and is able to calculate water level averages over five year periods, the district will include a discussion of its comparison of water level averages to the corresponding five year increment of its desired future conditions in order to track its progress in achieving the desired future conditions.

Management Goal Determined Not-Applicable

Goal - Controlling and preventing subsidence

There is no history of subsidence of aquifer formations within the district upon water level depletion and available scientific information is that the formations are of sufficient rigidity that subsidence will not occur.

jagigarroma pessal, ja fro japano at Brestram undak muhuk duhilar at Manneksa ya gogi pitak ta lahijar tapaken muramayidan nu sehit at kishik.

gith, Durand avecade in preparate

lotinus de un incula signiere, parte e la servicia amai del

successful and arrest of the

e personale expert to the final financial description and the expert of the careformation on the careformation

deletel and yel collected acres one is charge builded a displicamental for the

and and Charles named

Each year the comment and will inexamble the water smearin of labet two hundring and determine the five year water level or progress in section if a messures intended the district will compare into the compare

estratic enternal eff

The digments' and country with noted the water towal managements taken and reading to address the destination of the state of the water and at the state of the destination of the state of the destination of the state of the contribute water eval mean, unaments for five considering water to all average of the destination of the comparison of the destination of the conditions in the conditions.

Magazgarea o Graf Batermiaeri Na o Fapi dakiti

Com - Creministy and newspling arbsidence

inger e patre cary elle de l'ambigness el squitze détimations set el the dest el aque municipal set et ever deglective des avendeble duantid détait nation es line de le four déces des el sufférence àglecte de la passéance del est coule. "Abandoned Well" - shall mean:

- a well or borehole the condition of which is causing or is likely Lo cause pollution of groundwater in the District. A well is considered to be in use in the following cases:
 - (A) a well which contains the casing. pump and pump column in good

condition: or

- (B) a well in good condition which has been capped.
- a well or borehole which is not in compliance with applicable law, including the Rules and Regulations of the District. the Texas Water well Drillers' Act, Texas Natural Resource Conservation Commission, or any other state or federal agency or political subdivision having jurisdiction, if presumed to be an abandoned or deteriorated well.

"Board" - the Board of Directors of the Coke County Underground Water Conservation District

"District" - the Coke County Underground Water Conservation District "TCEQ" - Texas Commission on Environmental Quality.

"TWDB" - Texas Water Development Board

"Waste" as defined by Chapter 36 of the Texas Water Code means any one or more of the following:

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

the flowing or producing of wells from a groundwater reservoir if the water produced

is not used for a beneficial purpose;

- (3) escape of groundwater from a groundwater reservoir to any other reservoir or geologic strata that does not contain groundwater:
- (4) pollution or harmful alteration of groundwater in a groundwater reservoir by saltwater or by other deleterious matter admitted from another stratum or from the surface of the ground;
- (5) willfully or negligently causing. suffering, or allowing groundwater to escape into any river. natural watercourse, depression, lake. reservoir. drain, sewer, street, highway, road or creek, ditch. or onto any land other than that of the owner of the well unless such discharge is authorized by permit, rule or order issued by the commission under Chapter 26:

nsoon lede - "leW belonedA"

a well deborradio the condition of which is causing or is essly Louring or like the Louring or selection of granter in the District. A widt is considered to be in use in the following cases:

care a wall which doctors the couling purity and plant to column in good

to minibago

baqqaa naad can dotdy, neddened boog on llexi a i 🗀

p well or borehold which is not in carrollance with applicable law including the Hules and Regulations of the District the Total Water well Driver Act, Fercus Maturel Resource Construction Commission, or any cities state or feperal agency or postest cubo ensign having juramented or figure arred to be an apartument or installed will.

"Board" - Inc Board of Disserting of the Case Covery Underground Whiter Conservation Discret

Casted Administration Calce County Underground Wilder Conservation District 17 CEO 1 - Median Material Los Friedrich (1975) 19 ville - Mexick Wilder Cavelour and Boston

"Vyga e" 4- de inad by Chapter 26 of the Texas Waler Cook means any coe or hotel of the taidword

eathus swall of group header from a group dynamic ros enton. Stic 1513 and in an sendont time, a season of a consideration for common the control of the con

- rii) jõur tavarg or praduarig at ivents retra ii grunntvater respayati il taa weltti peadinissa
 - . January Manfartha e rai bega fature
- Specialité of graupovilles i om a graduoissi et resendre in environtine confider (seep veit or geologie enstainhait does duit contain groupoviller.
- par application of high rith a closed on a growed water as a gradual section of the second section of the section of the
 - Sy wilfully or profugionus caucind subering or about a group breath of the page of the substitute of the page of t

- (6) groundwater pumped for irrigation that escapes as irrigation tail water onto land other than that of the owner of the well unless permission has been granted by the occupant of the land receiving the discharge; or
- (7) for water produced from an artesian well," waste" has the meaning assigned by Section 11.205.

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

- proceedwinter purpose for introducen that assumed as integets of lart weter onto land other than that of the represent face will oness permission here been practed by the people of the land received the discharge, or
 - for visited produced from on unasperavall factor of hor facilities during pastured by Scotton 15 20th.

yüşti"- inğans ap zirificki excayabon ihat is sun ör dinler iki ihe üürpüse of: prouding proundwalki.



Appendix A

Appendix A

TWDB Estimated Historical Groundwater Use and 2022 State Water Plan Datasets

Coke County Underground Water Conservation District

Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Department
stephen.allen@twdb.texas.gov
(512) 463-7317
October 17, 2024

GROUNDWATER MANAGEMENT PLAN DATA

This set of water data tables (part one of a two-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 table addresses a specific numbered requirement in the Texas Water Development Board's groundwater management plan review checklist. The checklist can be found at this web address:

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

The five tables included in part one of this data package are:

TWDB Historical Water Use Survey (WUS)

• Estimated Historical Water Use (checklist item 2)

State Water Plan (SWP)

- Projected Surface Water Supplies (checklist item 6),
- Projected Water Demands (checklist item 7),
- Projected Water Supply Needs (checklist item 8),
- Projected Water Management Strategies (checklist item 9)

Part two of the two-part package is the groundwater availability model (GAM) run report for the district (checklist items 3 through 5). The district should have received, or will receive, this report from the TWDB Groundwater Modeling Department. Questions about the GAM can be directed to Grayson Dowlearn, grayson.dowlearn@twdb.texas.gov, (512) 475-1552.

DISCLAIMER:

Data presented in these tables are the most up to date WUS and SWP data available as of 10/17/2024. Although it does not happen often, these data are subject to change pending the availability of more accurate WUS data or an amendment to the 2022 SWP. District personnel should review the data table values and correct any discrepancies to ensure approval of their groundwater management plan.

The WUS data can be verified at this web address:

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

The 2022 SWP data can be verified by contacting Sabrina Anderson, (sabrina.anderson@twdb.texas.gov or 512-936-0886).

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

The county values in two of the SWP tables (Projected Water Supply Needs and Projected Water Management Strategies) are not apportioned because district-specific values are not required to be presented in the groundwater management plan. However, a district is required to "consider" the county values in these two tables by drafting a short summary of the needs and strategies values in the groundwater management plan.

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

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

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

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

in acre-	alues are in	All	r) special sections	(multiplie	9705 10		COKE COUNTY			
· 1	Livestock	Irrigation	Steam Electric	Mining	ng	Manufacturing	Municipal	е	Source	Year
3 1	213	750	0	3	0	0	182		GW	2021
)	60	0	0	60	0	0	404		SW	
) 1	220	984	0	3	0	0	180		GW	2020
2	62	0	0	47	0	0	386		SW	
)	219	647	0	3	0	0	101		GW	2019
5 387 262	62	0	0	37	0	0	332		SW	
9	219	553	0	6	0	0	109		GW	2018
2	62	0	0	16	0	0	424		SW	
2	212	572	0	9	0	0	117		GW	2017
)	60	0	0	6	0	0	389		SW	
3	193	511	0	31	0	0	92		GW	2016
4	54	0	0	8	0	0	396		SW	
1	191	429	0	0	0	0	81		GW	2015
4	54	0	0	1	0	0	234		SW	
7	167	580	0	10	0	0	91		GW	2014
7	47	0	0	0	0	0	175		SW	
8 1	168	567	0	54	0	0	255		GW	2013
В	48	0	0	11	0	0	166		SW	
7	267	522	0	1	0	0	170		GW	2012
5	75	0	0	45	0	0	373		sw	

Projected Surface Water Supplies TWDB 2022 State Water Plan Data

COKE COUNTY			100%		All values are in acre-feet						
RWPG	WUG	WUG Basin	Source Name	20	020	2030	2040	2050	20	060	2070
F=	Bronte	Colorado	Oak Creek Lake/Reservoir	Edow	0	0	0	0	eartros	0	18m V 0
F	County-Other, Coke	Colorado	Oak Creek Lake/Reservoir		0	0	0	0		0	0
F	Irrigation, Coke	Colorado	Colorado Run-of- River		11	11	11	11	No.	11	11
F	Livestock, Coke	Colorado	Colorado Livestock Local Supply		84	84	84	84		84	84
F	Robert Lee	Colorado	EV Spence Lake/Reservoir Non System Portion	-	0	0	0	0		0	0
F	Robert Lee	Colorado	Oak Creek Lake/Reservoir	91	0	0	0	0		0	0
Sum of Projected Surface Water Supplies (acre-feet)					95	95	95	95	1/2/10	95	95

Projected Water Demands TWDB 2022 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.

COK	E COUNTY	100% (multi	plier)			All value	es are in a	cre-feet
RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	Bronte	Colorado	273	269	265	262	262	262
F	County-Other, Co	oke Colorado	118	112	107	105	105	105
F	Irrigation, Coke	Colorado	689	689	689	689	689	689
F	Livestock, Coke	Colorado	306	306	306	306	306	306
F	Mining, Coke	Colorado	488	482	430	376	328	286
F	Robert Lee	Colorado	295	290	286	286	285	285
		Sum of Projected Water Demands (acre-feet)	2,169	2,148	2,083	2,024	1,975	1,933

Projected Water Supply Needs TWDB 2022 State Water Plan Data

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

COKI	COUNTY					All value	es are in a	icre-feet
RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	Bronte	Colorado	-212	-210	-209	-207	-207	-207
F	County-Other, Coke	Colorado	0	0	0	0	0	0
F	Irrigation, Coke	Colorado	0	0	0	0	0	0
F	Livestock, Coke	Colorado	0	0	0	0	0	0
F	Mining, Coke	Colorado	0	0	0	0	0	0
F	Robert Lee	Colorado	-237	-234	-231	-231	-230	-230
	Sum of Proje	cted Water Supply Needs (acre-feet)	-449	-444	-440	-438	-437	-437

Projected Water Management Strategies TWDB 2022 State Water Plan Data

COKE COUNTY

WUG, Basin (RWPG)					All value	es are in a	cre-feet
Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
Bronte, Colorado (F)							
Develop Other Aquifer Supplies in Southwest Coke County - Bronte	Other Aquifer [Coke]	561	800	800	800	800	800
Municipal Conservation - Bronte	DEMAND REDUCTION [Coke]	3	3	3	3	3	3
Subordination - Oak Creek Reservoir	Oak Creek Lake/Reservoir [Reservoir]	0	210	209	207	207	207
		564	1,013	1,012	1,010	1,010	1,010
rrigation, Coke, Colorado (F)							
Irrigation Conservation - Coke County	DEMAND REDUCTION [Coke]	34	69	83	83	83	83
,		34	69	83	83	83	83
Mining, Coke, Colorado (F)				a win win all with the			****
Mining Conservation - Coke County	DEMAND REDUCTION [Coke]	20	20	18	16	14	12
		20	20	18	16	14	12
Robert Lee, Colorado (F)							
Develop Other Aquifer Supplies in Southwest Coke County - Bronte	Other Aquifer [Coke]	239	0	0	0	0	0
Municipal Conservation - Robert Lee	DEMAND REDUCTION [Coke]	3	3	3	3	3	3
Subordination - Oak Creek Reservoir	Oak Creek Lake/Reservoir [Reservoir]	0	238	239	239	239	239
		242	241	242	242	242	242
Sum of Projected Water Manag	ement Strategies (acre-feet)	860	1,343	1,355	1,351	1,349	1,347

Projected Water Management Strategres TWDB 2022 State Water Plan Data

Appendix B

Appendix B

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan

Tim Cawthon, GIT and Grayson Dowlearn, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-463-5076
September 22, 2023



GAM RUN 23-624: Core County Underground Water Conservation District Wareham Pean

Tra Carella e, of Tanu Teeyson Dewinara P.C.
Ceese Water Development naard
Groundseder Division
Groundseding Department
\$12.46 t 1078

This page is intentionally blank

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan

Tim Cawthon, GIT and Grayson Dowlearn, P.G.

Texas Water Development Board

Groundwater Division

Groundwater Modeling Department

512-463-5076

September 22, 2023

EXECUTIVE SUMMARY:

Texas Water Code § 36.1071(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.

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

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

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan September 22, 2023
Page 4 of 18

The groundwater management plan for the Coke County Underground Water Conservation District should be adopted by the district on or before December 20, 2023 and submitted to the TWDB Executive Administrator on or before January 19, 2024. The current management plan for the Coke County Underground Water Conservation District expires on March 19, 2024.

This analysis used version 1.01 of the groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015), version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer (Anaya and Jones, 2009), and version 1.01 of the groundwater availability model for the Lipan Aquifer (Beach and others, 2004), to estimate the management plan information for the aquifers within the Coke County Underground Water Conservation District.

This report replaces the results of GAM Run 17-014 (Anaya, 2018). Values may differ from the previous report as a result of routine updates to the spatial grid files used to define county, groundwater conservation district, and aquifer boundaries, which can impact the calculated water budget values. Additionally, the approach used for analyzing model results is reviewed during each update and may have been refined to better delineate groundwater flows. Tables 1, 2, and 3 summarize the groundwater availability model data required by statute. Figures 1, 3, and 5 show the areas of the respective models from which the values in Tables 1, 2, and 3 were extracted. Figures 2, 4, and 6 provide generalized diagrams of the groundwater flow components provided in Tables 1, 2, and 3. If, after review of the figures, the Coke County Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

The flow components presented in this report do not represent the full groundwater budget. If additional inflow and outflow information would be helpful for planning purposes, the district may submit a request in writing to the TWDB Groundwater Modeling Department for the full groundwater budget.

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan September 22, 2023 Page 5 of 18

METHODS:

In accordance with Texas Water Code § 36.1071(h), the groundwater availability models mentioned above were used to estimate information for the Coke County Underground Water Conservation District management plan. Water budgets were extracted for the historical model periods for the Dockum Aquifer (1980 through 2012), Edwards-Trinity (Plateau) Aquifer (1981 through 2000), and Lipan Aquifer (1980 through 1998) 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, and the flow between aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Groundwater availability model for the High Plains Aquifer System

- We used version 1.01 of the groundwater availability model for the High Plains Aquifer System to analyze the Dockum Aquifer. See Deeds and others (2015) and Deeds and Jigmond (2015) for assumptions and limitations of the model.
- The groundwater availability model for the High Plains Aquifer System contains the following four layers:
 - Layer 1 represents the Ogallala and Pecos Valley aquifers
 - Layer 2 represents the Rita Blanca, Edwards-Trinity (High Plains), and Edwards-Trinity (Plateau) aquifers
 - Layer 3 represents the upper portion of the Dockum Aquifer and equivalent units
 - Layer 4 represents the lower portion of the Dockum Aquifer and equivalent units
- Water budget values for the district were determined for the Dockum Aquifer (Layers 3 and 4). Interaction between the Edwards-Trinity (Plateau) and Dockum aquifers was determined using water budget information for layers 2, 3, and 4.
- The MODFLOW-NWT River package was used to simulate rivers and general head boundaries within the district.
- Water budget terms were averaged for the historical calibration period 1980 through 2012 (stress periods 52 through 84).
- The model was run with MODFLOW-NWT (Niswonger and others, 2011).

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan September 22, 2023 Page 6 of 18

Groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers to analyze the Edwards-Trinity (Plateau) Aquifer. See Anaya and Jones (2009) for assumptions and limitations of the model. The Pecos Valley Aquifer does not occur within the Coke County Underground Water Conservation District and therefore no groundwater budget values are included for it in this report.
- Within Coke County Underground Water Conservation District only layer two of the groundwater availability model is active and generally represents the Edwards Group and the Trinity Group of the Edwards-Trinity (Plateau) Aquifer.
- Seeps and springs were simulated with the MODFLOW Drain package and streams were simulated with the MODFLOW Streamflow-Routing package.
- Water budget terms were averaged for the period 1981 through 2000 (stress periods 2 through 21).
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

Groundwater availability model for the Lipan Aquifer

- We used version 1.01 of the groundwater availability model for the Lipan Aquifer to analyze the Lipan Aquifer. See Beach and others (2004) for assumptions and limitations of the model.
- The groundwater availability model contains one layer with a constant thickness of 400 feet. The layer represents portions of the Quaternary Leona Formation, underlying Permian units, adjacent Permian units, and the Edwards-Trinity (Plateau) Aquifer.
- Water budgets terms were averaged for the period of 1980 through 1998 (stress periods 2 through 20). The last stress period representing the year 1999 was not included because of incorrect pumping values.
- The model does not cover the entire Lipan Aquifer (Figure 5). Consequently, please contact Mr. Stephen Allen with the TWDB at (512) 463-7317 or stephen.allen@twdb.texas.gov for additional information on the aquifer in areas not covered by the groundwater availability model in the Coke County Underground Water Conservation District.
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan September 22, 2023 Page 7 of 18

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving an aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the aquifers located within the Coke County Underground Water Conservation District and averaged over the historical calibration periods, as shown in Tables 1, 2, and 3.

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

The information needed for the district's management plan is summarized in Tables 1, 2, and 3. Figures 1, 3, and 5 show the area of the model from which the values in Tables 1, 2, and 3 were extracted. Figures 2, 4, and 6 provide generalized diagrams of the groundwater flow components provided in Tables 1, 2, and 3. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan September 22, 2023 Page 8 of 18

Table 1: Summarized information for the Dockum Aquifer for the Coke County
Underground Water Conservation District groundwater management plan.
All values are reported in acre-feet per year and rounded to the nearest 1 acre-foot.

Management plan requirement	Aquifer or confining unit	Results	
Estimated annual amount of recharge from precipitation to the district	Dockum Aquifer	133	
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	295	
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	79	
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	estable cos od: 35	
Estimated net annual volume of flow	To Dockum Aquifer from Dockum equivalent units	15	
between each aquifer in the district	To Dockum Aquifer from Edwards-Trinity (Plateau) Aquifer	63	

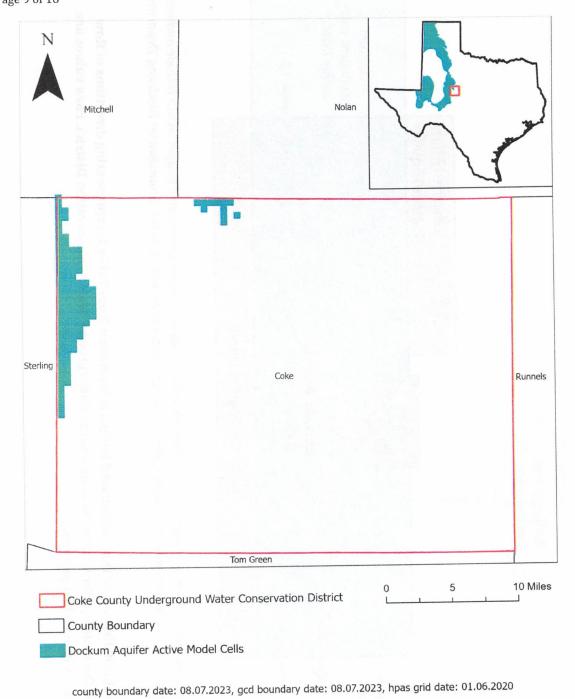
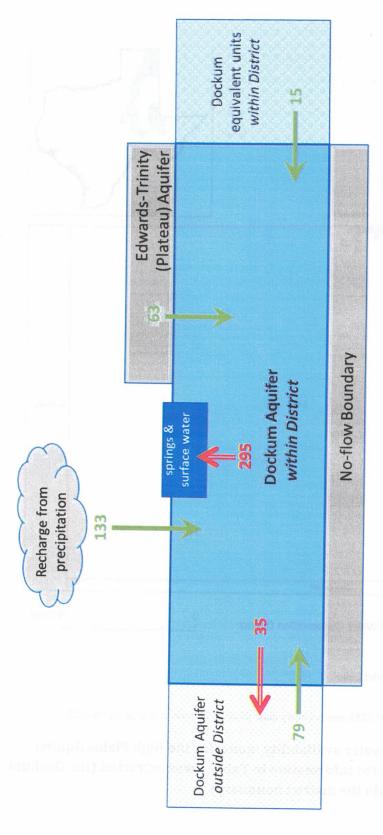


Figure 1: Area of the groundwater availability model for the High Plains Aquifer System from which the information in Table 1 was extracted (the Dockum Aquifer extent within the district boundary).

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan September 22, 2023 Page 10 of 18



inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department. Caveat: This diagram only includes the water budget items provided in Table 1. A complete water budget would include additional

for the Dockum Aquifer within the Coke County Underground Water Conservation District. Flow values are Figure 2: Generalized diagram of the summarized budget information from Table 1, representing directions of flow expressed in acre-feet per year.

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan September 22, 2023 Page 11 of 18

Table 2: Summarized information for the Edwards-Trinity (Plateau) Aquifer for the Coke County Underground Water Conservation District 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	5,832	
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	6,693	
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	1,235	
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	545	
Estimated net annual volume of flow between each aquifer in the district	From Edwards-Trinity (Plateau) Aquifer to Dockum Aquifer	63*	

^{*}Flow from the Edwards-Trinity (Plateau) Aquifer to the Dockum Aquifer is provided by the High Plains Aquifer System groundwater availability model.

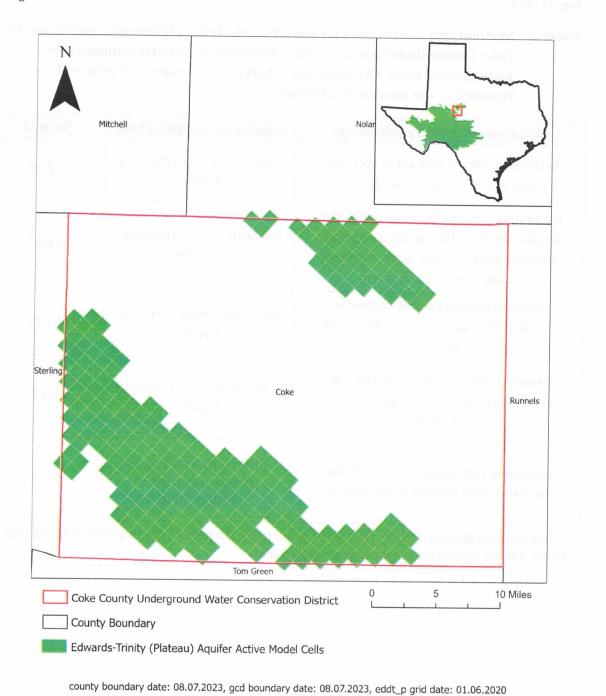
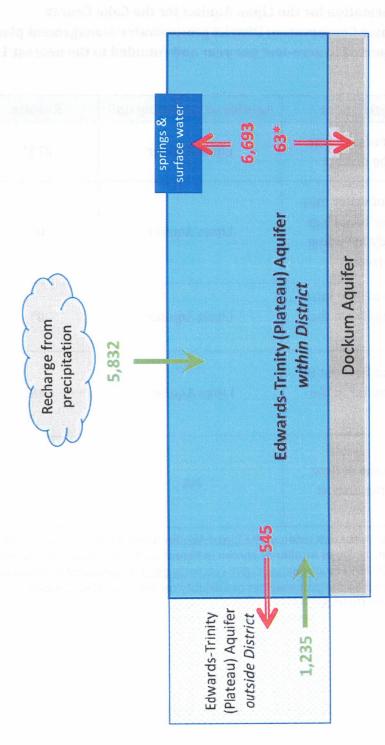


Figure 3: Area of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers from which the information in Table 2 was extracted (the Edwards-Trinity [Plateau] Aquifer extent within the

district boundary).



* Flow from the Edwards-Trinity (Plateau) Aquifer to the Dockum Aquifer is provided by the High Plains Aquifer System groundwater availability model.

inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department. Caveat: This diagram only includes the water budget items provided in Table 2. A complete water budget would include additional

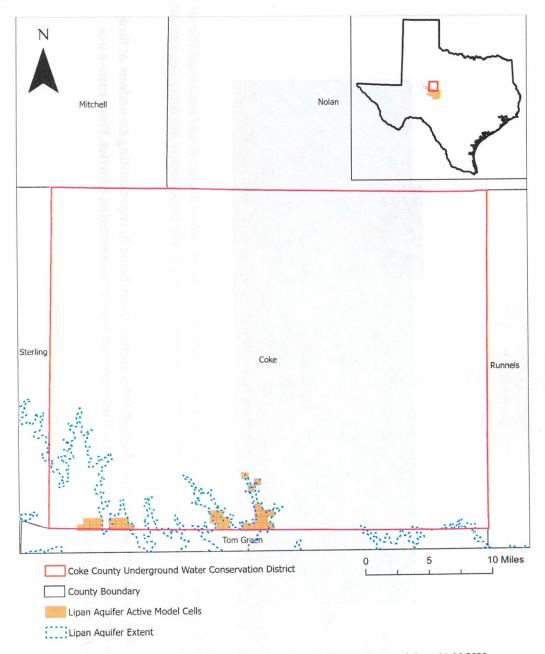
Figure 4: Generalized diagram of the summarized budget information from Table 2, representing directions of flow for the Edwards-Trinity (Plateau) Aquifer within the Coke County Underground Water Conservation District. Flow values expressed in acre-feet per year.

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan September 22, 2023 Page 14 of 18

Table 3: Summarized information for the Lipan Aquifer for the Coke County
Underground Water Conservation District 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	Lipan Aquifer	271*	
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Lipan Aquifer	0*	
Estimated annual volume of flow into the district within each aquifer in the district	Lipan Aquifer	0*	
Estimated annual volume of flow out of the district within each aquifer in the district	Lipan Aquifer	648*	
Estimated net annual volume of flow between each aquifer in the district	NA	NA *	

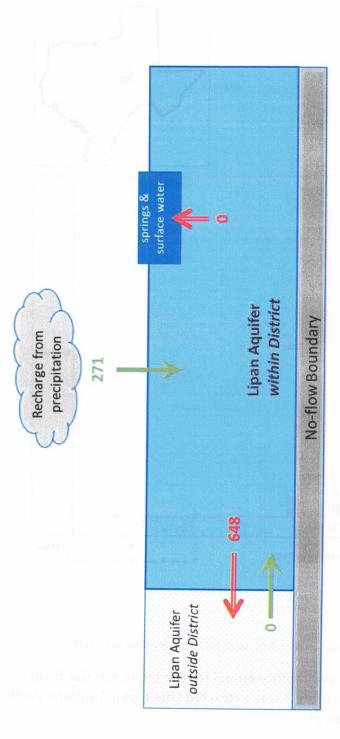
^{*}The model was developed prior to the extension of the Lipan Aquifer along the North Concho River. The model does not cover the entire Lipan Aquifer as shown in Figure 5. Please contact Mr. Stephen Allen with the TWDB at 512-463-7317 or stephen.allen@twdb.texas.gov for additional information on the aquifer in areas not covered by the groundwater availability model in the Coke County Underground Water Conservation District.



county boundary date: 08.07.2023, gcd boundary date: 08.07.2023, lipan grid date: 01.06.2020

Figure 5: Area of the groundwater availability model for the Lipan Aquifer from which the information in Table 3 was extracted (the Lipan Aquifer extent within the district boundary).

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan September 22, 2023 Page 16 of 18



inflows and outflows. For a full groundwater budget, please submit a request in writing to the Groundwater Modeling Department. Caveat: This diagram only includes the water budget items provided in Table 3. A complete water budget would include additional

Figure 6: Generalized diagram of the summarized budget information from Table 3, representing directions of flow for the Lipan Aquifer within the Coke County Underground Water Conservation District. Flow values are expressed in acre-feet per year.

GAM Run 23-021: Coke County Underground Water Conservation District Management Plan
September 22, 2023
Page 17 of 18

LIMITATIONS:

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

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

A key aspect of using the groundwater model to evaluate historic 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 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., 2018, GAM Run 17-014: Texas Water Development Board, GAM Run 17-014 Report, 12 p., https://www.twdb.texas.gov/groundwater/docs/GAMruns/GR17-014.pdf.

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

Beach, J.A., Burton, S., and Kolarik, B., 2004, Groundwater availability model for the Lipan Aquifer in Texas: Final report prepared for the Texas Water Development Board by LBG-Guyton Associates, 246 p.,

https://www.twdb.texas.gov/groundwater/models/gam/lipn/LIPN Model Report.pdf.

Deeds, N. E., Harding, J. J., Jones, T. L., Singh, A., Hamlin, S. and Reedy, R. C., 2015, Final Conceptual Model Report for the High Plains Aquifer System Groundwater Availability Model, 590 p.,

https://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS GAM Conceptual Report.pdf

Deeds, N. E. and Jigmond, M., 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model, 640 p.,

https://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS GAM Numerical Report.pdf?d=4324

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.

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

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

Texas Water Code § 36.1071



APPENDIX C

GAM Run 21-012 MAG: 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 Modeling Department
512-463-6641
August 12, 2022



GAM RUN 21-012 MAG:
MODELED AVAILABLE GROUNDWATER FOR
THE AQUIFERS IN GROUNDWATER

MANAGEMENT AREA

(**sec***Claret Development Board
Commitween Division
Commitween Modeling Department
S12-461-4641

This page is intentionally left blank.



GAM Run 21-012 MAG: 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 Modeling Department
512-463-6641
August 12, 2022

EXECUTIVE SUMMARY:

The Texas Water Development Board (TWDB) has 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 August 19, 2021. The explanatory reports and other materials submitted to the TWDB were determined to be administratively complete on February 23, 2022.

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 for each decade from 2020 through 2070 are:

- 26,164 acre-feet per year in the Capitan Reef Complex Aquifer,
- 2,324 acre-feet per year in the Dockum Aquifer,
- 6,570 to 7,925 acre-feet per year in the Ogallala Aquifer,
- 479,063 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, 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 [Version

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 4 of 52

1.01] (Jones, 2016) for the Capitan Reef Complex Aquifer; the High Plains Aquifer System [Version 1.01] (Deeds and Jigmond, 2015) for the Dockum and Ogallala aquifers; the minor aquifers of the Llano Uplift Area [Version 1.01] (Shi and others, 2016) for the Ellenburger-San Saba and Hickory aquifers, and the Rustler Aquifer [Version 1.01] (Ewing and others, 2012) for the Rustler Aquifer. In addition, the alternative 1-layer model for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers (Hutchison and others, 2011a) 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, 2011b) and the model associated with a hydrogeological study for Val Verde County and the City of Del Rio (EcoKai and Hutchison, 2014), respectively, were used to estimate modeled available groundwater.

REQUESTOR:

Ms. Meredith Allen, coordinator of Groundwater Management Area 7 districts.

DESCRIPTION OF REQUEST:

In an email dated August 28, 2021, Dr. William Hutchison on behalf of Groundwater Management Area 7 provided the TWDB with the desired future conditions for the Capitan, Dockum, Ellenburger-San Saba, Hickory, Ogallala, and Rustler aquifers, as well as for the undifferentiated Edwards-Trinity (Plateau), Pecos Valley and Trinity aquifers, in Groundwater Management Area 7. Groundwater Management Area 7 provided additional clarifications through an email to the TWDB on November 12, 2021, for the assumptions and model files to be used to calculate modeled available groundwater.

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

Capitan Reef Complex Aquifer (Resolution #08-19-2021-2)

- a) Total net drawdown of the Capitan Reef Complex Aquifer not to exceed 56 feet in Pecos County (Middle Pecos GCD) in 2070 as compared with 2006 aquifer levels.
 *(Reference: Scenario 4, GMA 7 Technical Memorandum 16-03)
- b) The Capitan Reef Complex Aquifer is not relevant for joint planning purposes in all other areas of GMA 7.

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 5 of 52

Dockum and Ogallala aquifers (Resolution #08-19-2021-5)

Ogallala Aquifer:

a) Total net drawdown of the Ogallala Aquifer not to exceed 6 feet in Glasscock County in 2070 as compared with 2010 aquifer levels.

Dockum Aquifer:

- b) Total net drawdown of the Dockum Aquifer not to exceed **52 feet in Pecos County** in 2070 as compared with 2010 aquifer levels.
- c) Total net drawdown of the Dockum Aquifer not to exceed **14 feet in Reagan County** in 2070 as compared with 2010 aquifer levels.
- *(Reference items a) through c): Scenario 17, GMA 7 Technical Memorandum 16-01)
- d) The Ogallala and Dockum Aquifers are not relevant for joint planning purposes in all other areas of GMA 7.

Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers (Resolution #08-19-2021-3)

- a) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed **0 feet in Coke County** in 2070 as compared with 2010 aquifer levels.
- b) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 10 feet in Crockett County in 2070 as compared with 2010 aquifer levels.
- c) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 4 feet in Ector County in 2070 as compared with 2010 aquifer levels.
- d) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 2 feet in Edwards County in 2070 as compared with 2010 aquifer levels.
- e) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 5 feet in Gillespie County in 2070 as compared with 2010 aquifer levels.
- f) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 42 feet in Glasscock County in 2070 as compared with 2010 aquifer levels.
- g) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 10 feet in Irion County in 2070 as compared with 2010 aquifer levels.
- h) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 1 foot in Kimble County in 2070 as compared with 2010 aquifer levels.
- i) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 1 foot in Menard County in 2070 as compared with 2010 aquifer levels.
- j) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 12 feet in Midland County in 2070 as compared with 2010 aquifer levels.
- k) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 14 feet in Pecos County in 2070 as compared with 2010 aquifer levels.
- 1) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 42 feet in Reagan County in 2070 as compared with 2010 aquifer levels.
- m) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 4 feet in Real County in 2070 as compared with 2010 aquifer levels.
- n) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed **8 feet in Schleicher County** in 2070 as compared with 2010 aquifer levels.
- o) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 7 feet in Sterling County in 2070 as compared with 2010 aquifer levels.
- p) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 6 feet in Sutton County in 2070 as compared with 2010 aquifer levels.
- q) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed **0 feet in Taylor County** in 2070 as compared with 2010 aquifer levels.
- r) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed **2 feet in Terrell County** in 2070 as compared with 2010 aquifer levels.
- s) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 20 feet in Upton County in 2070 as compared with 2010 aquifer levels.
- t) Total net drawdown of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers not to exceed 2 feet in Uvalde County in 2070 as compared with 2010 aquifer levels.
 *(Reference items a) through t): GMA 7 Technical Memorandum 18-01)

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 7 of 52

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

- u) Total net drawdown in **Kinney County** in 2070, as compared with 2010 aquifer levels, shall be consistent with maintenance of an annual average flow of 23.9 cfs and an annual median flow of 23.9 cfs at Las Moras Springs.
 - *(Reference: Groundwater Flow Model of the Kinney County Area by W.R. Hutchison and others, 2011).
- v) Total net drawdown 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 mgd at San Felipe Springs.

*(Reference: EcoKai, 2014)

w) The Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers are not relevant for joint planning purposes in all other areas of GMA 7.

Minor Aquifers of the Llano Uplift Area (Resolution #08-19-2021-4)

Ellenburger-San Saba Aquifer:

- a) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed 8 feet in Gillespie County in 2070 as compared with 2010 aquifer levels.
- b) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed 18 foot in Kimble County in 2070 as compared with 2010 aquifer levels.
- c) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed 14 foot in Mason County in 2070 as compared with 2010 aquifer levels.
- d) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed 29 feet in McCulloch County in 2070 as compared with 2010 aquifer levels.
- e) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed 46 feet in Menard County in 2070 as compared with 2010 aquifer levels.
- f) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed 5 feet in San Saba County in 2070 as compared with 2010 aquifer levels.

Hickory Aquifer:

- g) Total net drawdown of the Hickory Aquifer not to exceed 53 feet in Concho County in 2070 as compared with 2010 aquifer levels.
- h) Total net drawdown of the Hickory Aquifer not to exceed 9 feet in Gillespie County in 2070 as compared with 2010 aquifer levels.
- Total net drawdown of the Hickory Aquifer not to exceed 18 feet in Kimble County in 2070 as compared with 2010 aquifer levels.
- j) Total net drawdown of the Hickory Aquifer not to exceed 17 feet in Mason County in 2070 as compared with 2010 aquifer levels.

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 8 of 52

Minor Aquifers of the Llano Uplift Area (continued)

- k) Total net drawdown of the Hickory Aquifer not to exceed **29 feet in McColloch** County in 2070 as compared with 2010 aquifer levels.
- 1) Total net drawdown of the Hickory Aquifer not to exceed 46 feet in Menard County in 2070 as compared with 2010 aquifer levels.
- m) Total net drawdown of the Hickory Aquifer not to exceed 6 feet in San Saba County in 2070 as compared with 2010 aquifer levels.

 *(Reference items a) through m): Scenario 3, GMA 7 Technical Memorandum 16-02)
- n) The Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls) Aquifers are not relevant for joint planning purposes in all other areas of GMA 7.

Rustler Aquifer (Resolution #08-19-2021-6)

- a) Total net drawdown of the Rustler Aquifer not to exceed 94 feet in Pecos County in 2070 as compared with 2010 aquifer levels.
 *(Reference: Scenario 4, GMA 7 Technical Memorandum 15-05)
- b) The Rustler Aquifer not relevant for joint planning purposes in all other areas of GMA 7.

In addition to the non-relevant statements provided above in the individual resolutions, Groundwater Management Area 7 also provided additional non-relevant documentation dated August 27, 2021 and January 20, 2022 as part of their submittal to TWDB. The following aquifers or parts of aquifers are non-relevant for the purposes of joint planning:

- The entirety of the Blaine, Cross Timbers, Igneous, Lipan, Marble Falls, and Seymour aquifers.
- The Capitan Reef Complex Aquifer outside of the boundaries of the Middle Pecos Groundwater Conservation District.
- The Edwards-Trinity (Plateau) Aquifer in Concho, Mason, McCulloch, Nolan, and Tom Green counties.
- The Ellenburger-San Saba Aquifer in Coleman, Concho, and Mason counties.
- The Hickory Aquifer in Coleman and Llano counties.
 - The Dockum Aquifer outside of Reagan and Pecos counties.
 - The Ogallala Aquifer outside of Glasscock County.

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 9 of 52

CLARIFICATIONS:

In response to a request for clarifications from the TWDB in 2021, the Groundwater Management Area 7 Chair, Ms. Meredith Allen, and Groundwater Management Area 7 consultant, Dr. William R. Hutchison, provided the following clarifications regarding the definition of the desired future conditions. These clarifications were necessary for verifying that the desired future conditions of the aquifers were attainable and for confirming approval of the TWDB methodology to calculate modeled available groundwater volumes in Groundwater Management Area 7:

Capitan Reef Complex Aquifer

- The calculated modeled available groundwater values are based on the official TWDB aquifer boundary.
- The modeled available groundwater calculations are based on the desired future conditions with a one-foot tolerance (that is, modeled drawdown verifications within one foot of the desired future conditions are acceptable).
- Drawdown calculations used to define the desired future conditions value take into consideration the occurrence of "dry" cells, where water levels are below the base of the aquifer.

Dockum Aquifer

- The calculated modeled available groundwater values are based on the spatial extent of the Dockum Formation, as represented in the groundwater availability model for the High Plains Aquifer System, rather than the official TWDB aquifer boundary.
- Modeled available groundwater analysis excludes model pass-through cells.
- The modeled available groundwater calculations are based on the desired future conditions with a one-foot tolerance (that is, modeled drawdown verifications within one foot of the desired future conditions are acceptable).

Ogallala Aquifer

- The calculated modeled available groundwater values are based on the official TWDB aquifer boundary and use the same model assumptions used in Groundwater Management Area 7 Technical Memorandum 16-01 (Hutchison, 2016c).
- Drawdown calculations used to define the desired future conditions do not take into consideration the occurrence of "dry" cells, where water levels are below the base of the aquifer.

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 10 of 52

• The modeled available groundwater calculations are based on the desired future conditions with a one-foot tolerance (that is, modeled drawdown verifications within one foot of the desired future conditions are acceptable).

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

- The calculated modeled available groundwater values are based on the official TWDB aquifer boundaries.
- The modeled available groundwater calculations are based on the desired future conditions with a one-foot tolerance (that is, modeled drawdown verifications within one foot of the desired future conditions value are acceptable).
- Drawdown calculations used to define the desired future conditions include drawdowns for cells with water levels below the base elevation of the cell ("dry" cells).

Kinney County

• The modeled available groundwater values, model assumptions, and simulated springflow are from GAM Run 10-043 MAG Version 2 (Shi, 2012).

Val Verde County

• There is no associated drawdown as a desired future condition. The desired future condition is based solely on simulated spring flow 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 2021).

Minor Aquifers of the Llano Uplift Area

- The calculated modeled available groundwater values are based on the full spatial extent of the Ellenburger-San Saba and Hickory formations in the groundwater availability model for the aquifers of the Llano Uplift Area rather than the official TWDB aquifer boundaries and use the same model assumptions used in Groundwater Management Area 7 Technical Memorandum 16-02 (Hutchison 2016b).
- The modeled available groundwater calculations are based on the desired future conditions with a one-foot tolerance (that is, modeled drawdown verifications within one foot of the desired future conditions value are acceptable).

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 11 of 52

• The drawdown calculations used to define desired future conditions did not include "dry" cells, where water levels are below the base of the aquifer.

Rustler Aquifer

- The model used to define desired future conditions and calculate modeled available groundwater assumes that the initial model heads represent the heads at the end of 2008 (the baseline for calculating desired future conditions drawdown values).
- Calculated modeled available groundwater values are based on the full spatial extent of the Rustler Formation, as represented in the groundwater availability model for the Rustler Aquifer, rather than the official TWDB aquifer boundary.
- The predictive model used to define desired future conditions and calculate modeled available groundwater uses the same model assumptions used in Groundwater Management Area 7 Technical Memorandum 15-05 (Hutchison, 2016d).
- The modeled available groundwater calculations are based on the desired future conditions with a one-foot tolerance (that is, modeled drawdown verifications within one foot of the desired future conditions value are acceptable).

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 12 of 52

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 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 the water levels in the baseline year. These baseline years are 2005 in the groundwater availability model for the Capitan Reef Complex Aquifer and the alternative model for the Edwards-Trinity (Plateau) and Pecos Valley 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 2008 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. In most cases, these model runs were supplied by Groundwater Management Area 7 for review by TWDB staff before they were used to calculate the modeled available groundwater. 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 for all aquifers were compared with the desired future conditions to verify that the pumping scenario achieved the desired future conditions.

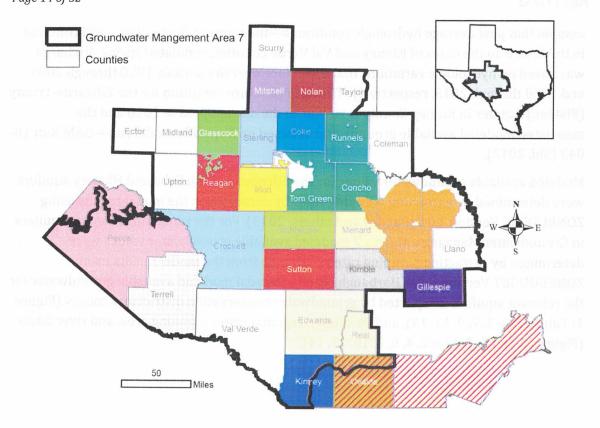
In Kinney and Val Verde counties, the desired future conditions are based on discharge from selected springs. In these cases, spring discharge was estimated based on simulated average spring discharge over a historical period, maintaining all historical hydrologic conditions—such as recharge and river stage—except pumping. In other words, we

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 13 of 52

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 was 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 is 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).

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 14 of 52



Groundwater Conservation Districts



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).

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 15 of 52

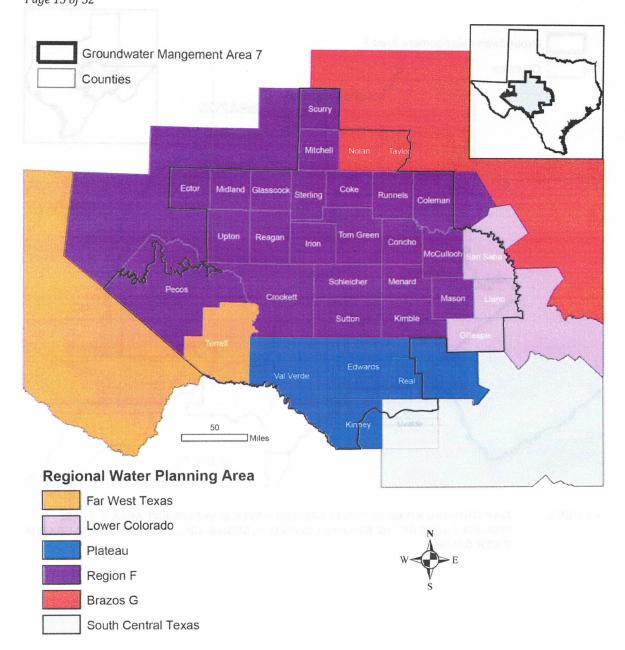


FIGURE 2. MAP SHOWING REGIONAL WATER PLANNING AREAS IN GROUNDWATER MANAGEMENT AREA 7.

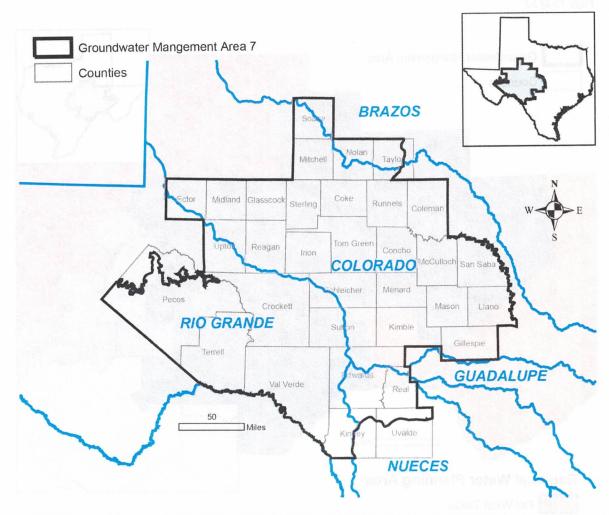


FIGURE 3. MAP SHOWING RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 7. THESE INCLUDE PARTS OF THE BRAZOS, COLORADO, GUADALUPE, NUECES, AND RIO GRANDE RIVER BASINS.

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 (2016a) 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 TWDB 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 (2016c) 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 to hydraulically connect the Ogallala Aquifer to the Lower Dockum where the Edwards-Trinity (High Plains)

and Upper Dockum aquifers are absent. 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. Therefore, the groundwater management area should be aware that the modeled available groundwater values will be less than pumping input values if the modeled saturated thickness drops below that threshold.
- The model was run for the interval 2013 through 2070 for a 58-year predictive simulation. Drawdowns were calculated by subtracting initial 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 in the Dockum Aquifer where
 water levels were below the base elevation of the cell ("dry" cells). Therefore, all
 drawdowns were included in the averaging. However, in the Ogallala Aquifer, dry
 cells occurred during the predictive simulation. These dry cells were excluded from
 the modeled available groundwater calculations.
- Drawdown averages and modeled available groundwater volumes are based on the model boundary within Groundwater Management Area 7 for the Dockum Aquifer and the official TWDB aquifer boundary 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 was 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; 2018) 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).

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7

August 12, 2022

Page 19 of 52

- 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.
- Because simulated water levels for the baseline year (2010) are not included in the original calibrated historical model, these water levels had to be verified against measured water levels to confirm that the predictive model satisfactorily matched real-world conditions. Comparison of 2010 simulated and measured water levels indicated a root mean squared error of 100 feet or 4 percent of the range in water-level elevations, which is within acceptable limits. Based on these results, we consider the predictive model an appropriate tool for evaluating the attainability of desired future conditions and for calculating modeled available groundwater.
- 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 TWDB 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 56 annual stress periods under the conditions set in Scenario 3 in Task 10-027 (Hutchison, 2011).
- Modeled available groundwater volumes are based on the official TWDB aquifer boundary 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 and Hutchison
 (2014) for assumptions and limitations of the model. See Hutchison (2016e; 2021)
 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 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 TWDB aquifer boundary within Groundwater Management Area 7 in Val Verde County.

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 (2016b) 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.
- The model was run for the interval 2011 through 2070 for a 60-year predictive simulation. Drawdowns were calculated by subtracting initial water levels from 2070 simulated water levels, which were then averaged over the portion of the

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 21 of 52

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.

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.
- The predictive model used to define desired future conditions uses 2008 recharge conditions throughout the predictive period.
- The predictive model used to define desired future conditions has general-head boundary heads that decline at a rate of 1.5 feet per year.
- 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.

RESULTS:

The modeled available groundwater estimates for each decade from 2020 through 2070 are:

- 26,164 acre-feet per year in the Capitan Reef Complex Aquifer,
- 2,324 acre-feet per year in the Dockum Aquifer,
- 6,570 to 7,925 acre-feet per year in the Ogallala Aquifer,

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 22 of 52

- 479,063 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, 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 5 and 6). 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.

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 23 of 52

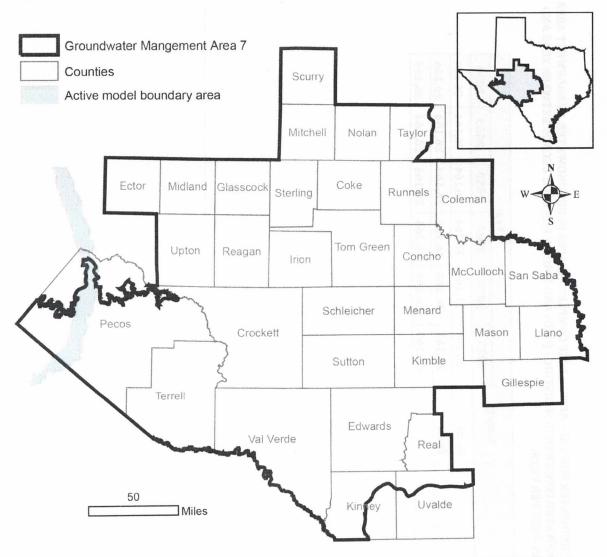


FIGURE 4. MAP SHOWING THE AREAS COVERED BY THE CAPITAN REEF COMPLEX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EASTERN ARM OF THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 24 of 52

TABLE 1. MODEL

MODELED AVAILABLE GROUNDWATER FOR THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

District	June			Year	r		
	County	2020	2030	2040	2050	2060	2070
Middle Pecos GCD	Pecos	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

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 25 of 52

TABLE 2. N

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 2030 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

					Year		
County	RWPA	River Basın	2030	2040	2050	2060	2070
		Rio Grande	26,164	26,164	26,164	26,164	26,164 26,164
Pecos	Ľ,	Total	26,164	26,164	26,164	26,164	26,164
GMA 7			26,164	26,164	26,164	26,164	26,164

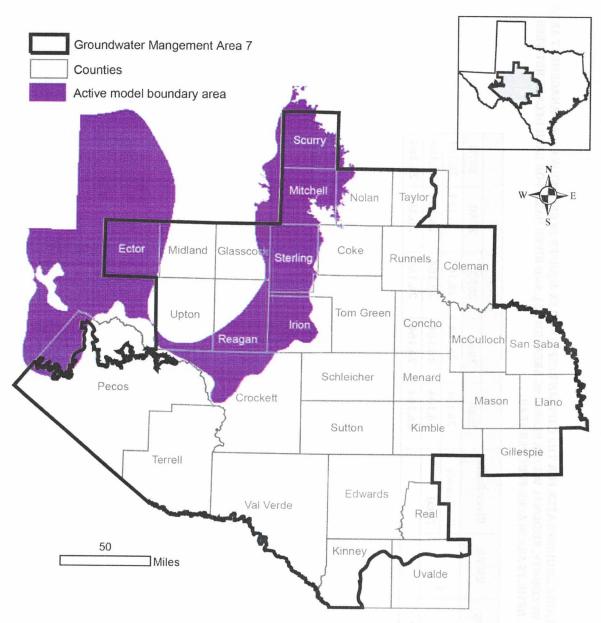


FIGURE 5. MAP SHOWING AREAS COVERED BY THE DOCKUM AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.

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 2020 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.

i				Year	r		
District	County	2020	2030	2040	2050	2060	2070
400	Pecos	2,022	2,022	2,022	2,022	2,022	2,022
Middle Pecos GUD	Total	2,022	2,022	2,022	2,022	2,022	2,022
GOYANT	Reagan	302	302	302	302	302	302
Santa Kita UWCD	Total	302	302	302	302	302	302
GMA 7		2,324	2,324	2,324	2,324	2,324	2,324
			Dit. II.	1 14			1 1

Note: The modeled available groundwater for Santa Rita Underground Water Conservation District excludes parts of Reagan County that fall within Glasscock Groundwater Conservation District. GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 28 of 52

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 2030 AND 2070. TABLE 4.

RESULTS ARE IN ACRE-FEET PER YEAR.

County NWIA NIVE	Divon Dagin			Year		
	IVEL DASIII	2030	2040	2050	2060	2070
Pecos F Rio C	Rio Grande	2,022	2,022	2,022	2,022	2,022
	ıtal	2,022	2,022	2,022	2,022	2,022
Colo	Colorado	302	302	302	302	302
Reagan F Rio C	Rio Grande	0	0	0	0	0
Total	tal	302	302	302	302	302
GMA 7		2,324	2,324	2,324	2,324	2,324

fall outside of Santa Rita Underground Water Conservation District.

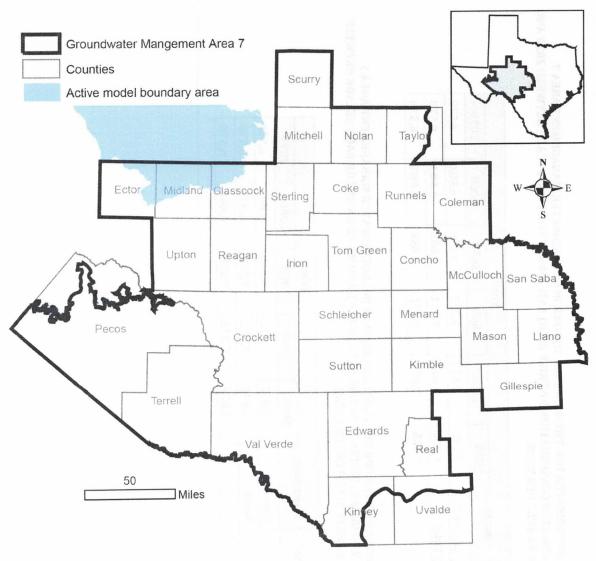


FIGURE 6. MAP SHOWING THE AREAS COVERED BY THE OGALLALA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 30 of 52

TABLE 5.

SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

District	Country			Year			
TO THE COLOR	County	2020	2030	2040	2050	2060	2070
Glasscock GCD	Glasscock	7,925	7,673	7,372	7,058	6,803	6.570
diasscore deb	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

TABLE 6.

SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 2030 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWDA	Divor Bacin			Year		
6		MIVEL DASIII	2030	2040	2050	2060	2070
Glasscock	[I	Colorado	7,673	7,372	7,058	6,803	6,570
100000000000000000000000000000000000000	13	Total	7,673	7,372	7.058	6.803	6.570
GMA 7	SEAS-	2 %	7,673	7,372	7.058	6.803	6.570

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 31 of 52

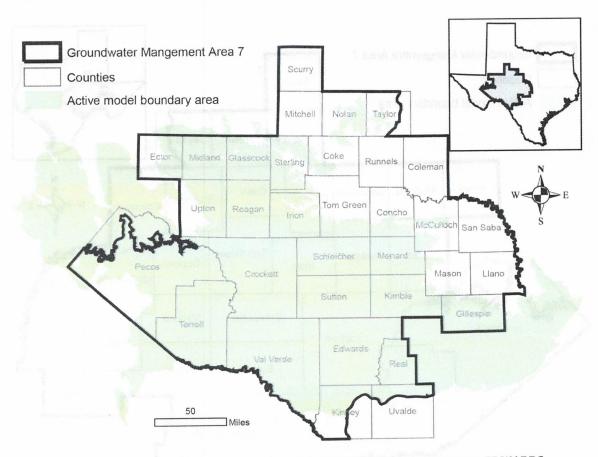


FIGURE 7. MAP SHOWING THE AREAS COVERED BY THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7.

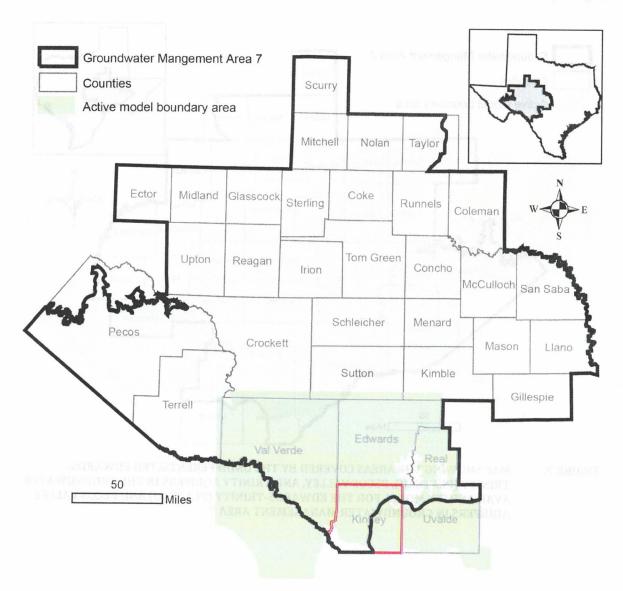


FIGURE 8. MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU)
AQUIFER IN THE ALTERNATIVE MODEL FOR THE EDWARDS-TRINITY (PLATEAU)
AQUIFER IN KINNEY COUNTY [HIGHLIGHTED IN RED].

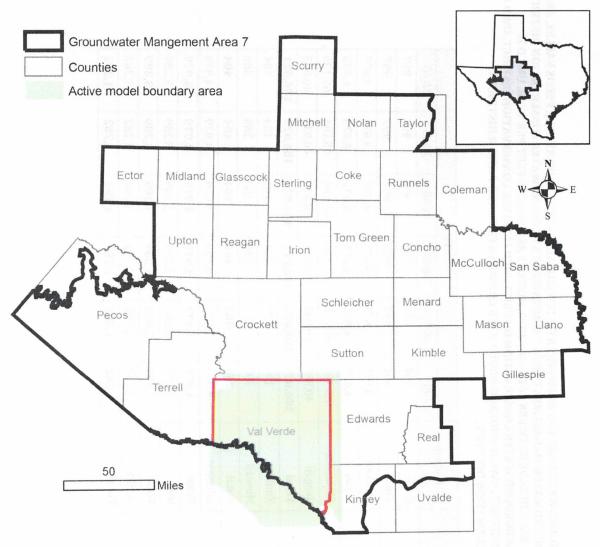


FIGURE 9. MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE GROUNDWATER FLOW MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN VAL VERDE COUNTY [HIGHLIGHTED IN RED].

TABLE 7.

TRINITY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT ABBREVIATION FOR UNDERGROUND WATER CONSERVATION DISTRICT, WCD IS WATER CONSERVATION DISTRICT, UWD IS MODELED AVAILABLE GROUNDWATER FOR THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND (GCD) AND COUNTY, FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. UWCD IS UNDERGROUND WATER DISTRICT, UWC IS UNDERGROUND WATER CONSERVATION, AND CAND R DISTRICT IS CONSERVATION AND RECLAMATION DISTRICT.

District	Competer			Ye	Year		
	County	2020	2030	2040	2050	2060	2070
Coke County HWCD	Coke	466	266	466	266	466	466
	Total	466	266	266	466	466	266
Crockett County GCD	Crockett	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
	Glasscock	65,186	65,186	65,186	65,186	65,186	65,186
Glasscock GCD	Reagan	40,835	40,835	40,835	40,835	40,835	40,835
INS FILE	Total	106,021	106,021	106,021	106,021	106,021	106,021
	Kimble	104	104	104	104	104	104
Hickory UWCD No. 1	Menard	380	380	380	380	380	380
NO.	Total	484	484	484	484	484	484
Hill Country UWCD	Gillespie	4,979	4,979	4,979	4,979	4,979	4,979
37	Total	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
	Total	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
	Total	1,282	1,282	1.282	1.282	1.282	1.282

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 35 of 52

TABLE 7. (CONTINUED).

District				rear	ar		
	County	2020	2030	2040	2050	2060	2070
	Kinney	70,341	70,341	70,341	70,341	70,341	70,341
Kinney County GCD To	Total	70,341	70,341	70,341	70,341	70,341	70,341
	Menard	2,217	2,217	2,217	2,217	2,217	2,217
Menard County UWD	Total	2,217	2,217	2,217	2,217	2,217	2,217
	Pecos	117,309	117,309	117,309	117,309	117,309	117,309
Middle Pecos GCD To	Total	117,309	117,309	117,309	117,309	117,309	117,309
	Schleicher	8,034	8,034	8,034	8,034	8,034	8,034
Plateau UWC and Supply District To	Total	8,034	8,034	8,034	8,034	8,034	8,034
EC	Edwards	5,676	5,676	5,676	5,676	5,676	2,676
Real-Edwards C and R District Re	Real	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

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 36 of 52

TABLE 7. (CONTINUED).

District	County			Ye	Year		
	Commis	2020	2030	2040	2050	2060	2070
Santa Rita IIWCD	Reagan	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
Sterling County IIWCD	Sterling	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 County IIWCD	Sutton	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
Terrell County GCD	Terrell	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
Uvalde Compty HWCD	Uvalde	1,993	1,993	1,993	1,993	1,993	1.993
and demonstrated	Total	1,993	1,993	1,993	1,993	1.993	1.993
No district		102,703	102,703	102,703	102.703	102.703	102 703
GMA 7		475,236	475,236	475,236	475,236	475,236	475,236

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 37 of 52

TABLE 8.

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 2030 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

					Year		
County	RWPA	River Basın	2030	2040	2050	2060	2070
-	ŗ.	Colorado	766	266	266	266	466
Coke	L,	Total	266	466	266	266	466
		Colorado	20	20	20	20	20
Crockett	ĮĮ,	Rio Grande	5,427	5,427	5,427	5,427	5,427
		Total	5,447	5,447	5,447	5,447	5,447
		Colorado	4,925	4,925	4,925	4,925	4,925
Ector	[II,	Rio Grande	617	617	617	617	617
		Total	5,542	5,542	5,542	5,542	5,542
		Colorado	2,305	2,305	2,305	2,305	2,305
-		Nueces	1,631	1,631	1,631	1,631	1,631
Edwards	_	Rio Grande	1,740	1,740	1,740	1,740	1,740
		Total	5,676	2,676	5,676	5,676	5,676
		Colorado	4,843	4,843	4,843	4,843	4,843
Gillespie	X	Guadalupe	136	136	136	136	136
		Total	4,979	4,979	4,979	4,979	4,979
-	E	Colorado	65,186	65,186	65,186	65,186	65,186
GIASSCOCK	L,	Total	65,186	65,186	65,186	65,186	65,186

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 38 of 52

TABLE 8. (CONTINUED).

County	PWDA	Diron Docin			Year		
fammon	VIMU	MIVEL DASIII	2030	2040	2050	2060	2070
Irion	[I	Colorado	3,289	3,289	3,289	3,289	3,289
		Total	3,289	3,289	3,289	3,289	3,289
Kimble	[T	Colorado	1,386	1,386	1,386	1,386	1,386
	,	Total	1,386	1,386	1,386	1,386	1,386
	300	Nueces	12	12	12	12	12
Kinney	_	Rio Grande	70,329	70,329	70,329	70,329	70,329
		Total	70,341	70,341	70,341	70,341	70,341
Menard	ŢŢ	Colorado	2,597	2,597	2,597	2,597	2,597
		Total	2,597	2,597	2,597	2,597	2,597
Midland	[T	Colorado	23,233	23,233	23,233	23,233	23,233
		Total	23,233	23,233	23,233	23,233	23,233
Pecos	ĹT.	Rio Grande	117,309	117,309	117,309	117,309	117,309
		Total	117,309	117,309	117,309	117,309	117,309

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 39 of 52

TABLE 8. (CONTINUED).

					Year		
County	RWPA	River Basin	2030	2040	2050	2060	2070
		Colorado	68,202	68,205	68,205	68,205	68,205
Reagan	ഥ	Rio Grande	28	28	28	28	28
		Total	68,233	68,233	68,233	68,233	68,233
		Colorado	277	277	277	277	277
	-	Guadalupe	3	3	3	3	3
Keal	_	Nueces	7,243	7,243	7,243	7,243	7,243
		Total	7,523	7,523	7,523	7,523	7,523
		Colorado	6,403	6,403	6,403	6,403	6,403
Schleicher	ഥ	Rio Grande	1,631	1,631	1,631	1,631	1,631
		Total	8,034	8,034	8,034	8,034	8,034
0.40	ū	Colorado	2,495	2,495	2,495	2,495	2,495
giiii aic	Į.	Total	2,495	2,495	2,495	2,495	2,495
		Colorado	388	388	388	388	388
Sutton	Ţ	Rio Grande	6,022	6,022	6,022	6,022	6,022
		Total	6,410	6,410	6,410	6,410	6,410
		Brazos	331	331	331	331	331
Taylor	5	Colorado	158	158	158	158	158
,		Total	489	489	489	489	489
Torroll	Ĺ	Rio Grande	1,420	1,420	1,420	1,420	1,420
ובוובוו	ū	Total	1,420	1,420	1,420	1,420	1,420

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 40 of 52

TABLE 8. (CONTINUED).

Country	DIA/DA	Divocabout			Year		
county	NWIA	NIVEI DASIII	2030	2040	2050	2060	2070
	l,	Colorado	21,243	21,243	21,243	21,243	21,243
Upton	ഥ	Rio Grande	1,126	1,126	1,126	1,126	1,126
		Total	22,369	22,369	22,369	22,369	22,369
Uvalde	_	Nueces	1,993	1,993	1,993	1,993	1,993
	1	Total	1,993	1,993	1,993	1,993	1,993
Val Verde	_	Rio Grande	20,000	50,000	20,000	20,000	50,000
	,	Total	20,000	20,000	20,000	20,000	20,000
GMA 7			479,063	479,063	479,063	479,063	479,063

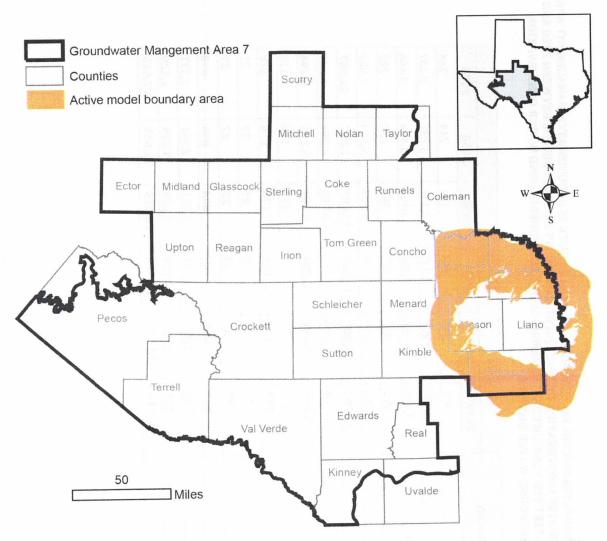


FIGURE 10. MAP SHOWING THE AREAS COVERED BY THE ELLENBURGER-SAN SABA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 42 of 52

TABLE 9.

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 2020 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	.		
		2020	2030	2030	2050	2060	2070
	Kimble	344	344	344	344	344	344
	Mason	3,237	3,237	3,237	3,237	3,237	3.237
Hickory UWCD No. 1	McCulloch	3,466	3,466	3,466	3,466	3,466	3.466
	Menard	282	282	282	282	282	282
	San Saba	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
Hill Country UWCD	Gillespie	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 County GCD	Kimble	178	178	178	178	178	178
	Total	178	178	178	178	178	178
Menard County UWD	Menard	27	27	27	27	27	27
	Total	27	27	27	27	27	27
	McCulloch	868	868	868	868	868	868
No District	San Saba	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
GMA 7		22,615	22,615	22.615	22.615	22.615	27 615

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 43 of 52 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 TABLE 10.

		River			Year		
County	RWPA	Basin	2030	2040	2050	2060	2070
	1	Colorado	6,294	6,294	6,294	6,294	6,294
ullespie		Total	6,294	6,294	6,294	6,294	6,294
11	E	Colorado	521	521	521	521	521
Kimble	L,	Total	521	521	521	521	521
1,4	E	Colorado	3,237	3,237	3,237	3,237	3,237
Mason	249 249	Total	3,237	3,237	3,237	3,237	3,237
M.Cllock	E	Colorado	4,364	4,364	4,364	4,364	4,364
McCullocn	ų	Total	4,364	4,364	4,364	4,364	4,364
7		Colorado	309	309	309	309	309
Menard		Total	309	309	309	309	309
2420	4	Colorado	7,890	7,890	7,890	7,890	7,890
San Saba	4	Total	7,890	7,890	7,890	7,890	7,890
CMA 7			27 615	27 615	27 615	27 615	27 615

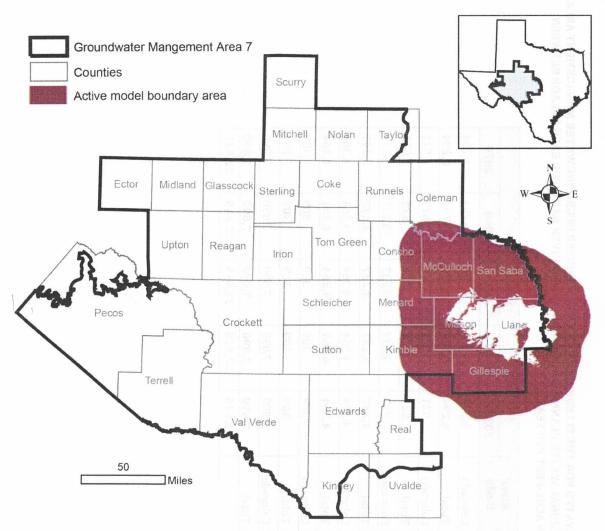


FIGURE 11. MAP SHOWING AREAS COVERED BY THE HICKORY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 11.

MODELED AVAILABLE GROUNDWATER FOR THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR, UWCD IS THE ABBREVÍATION FOR UNDERGROUND WATER CONSERVATION DISTRICT AND UWD IS UNDERGROUND WATER DISTRICT.

				Year			
District	County	2020	2030	2040	2050	2060	2070
	Concho	13	13	13	13	13	13
	Kimble	42	42	42	42	42	42
	Mason	13,212	13,212	13,212	13,212	13,212	13,212
Hickory UWCD No. 1	McCulloch	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
	San Saba	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
Colonia	Gillespie	1,751	1,751	1,751	1,751	1,751	1,751
Hill Country UWCD	Total	1,751	1,751	1,751	1,751	1,751	1,751
	Kimble	123	123	123	123	123	123
Kimble County GCD	Total	123	123	123	123	123	123
	Concho	13	13	13	13	13	13
Lipan-Kickapoo WCD	Total	13	13	13	13	13	13
	Menard	126	126	126	126	126	126
Menard County UWD	Total	126	126	126	126	126	126
a fuel i	McCulloch	2,427	2,427	2,427	2,427	2,427	2,427
No District	San Saba	652	652	652	652	652	652
	Total	3,080	3,080	3,080	3,080	3,080	3,080
CMA7		49,937	49,937	49,937	49,937	49,937	49,937

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 46 of 52

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 2030 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. TABLE 12.

Compty	DIA/DA	River			Year		
county	NWFA	Basin	2030	2040	2050	2060	2070
Concho	[T.	Colorado	27	27	27	27	27
		Total	27	27	27	27	27
Gillespie	Х	Colorado	1,751	1,751	1,751	1,751	1,751
1		Total	1,751	1,751	1,751	1,751	1,751
Kimble	[T	Colorado	165	165	165	165	165
		Total	165	165	165	165	165
Mason	[T	Colorado	13,212	13,212	13,212	13,212	13,212
		Total	13,212	13,212	13,212	13,212	13,212
McCulloch	[T.	Colorado	24,377	24,377	24,377	24,377	24,377
		Total	24,377	24,377	24,377	24,377	24,377
Menard	[T.	Colorado	2,725	2,725	2,725	2,725	2,725
		Total	2,725	2,725	2,725	2,725	2,725
San Saba	×	Colorado	7,680	7,680	7,680	7,680	7,680
		Total	7,680	7,680	7,680	7,680	7,680
GMA 7			49,937	49,937	49,937	49,937	49,937

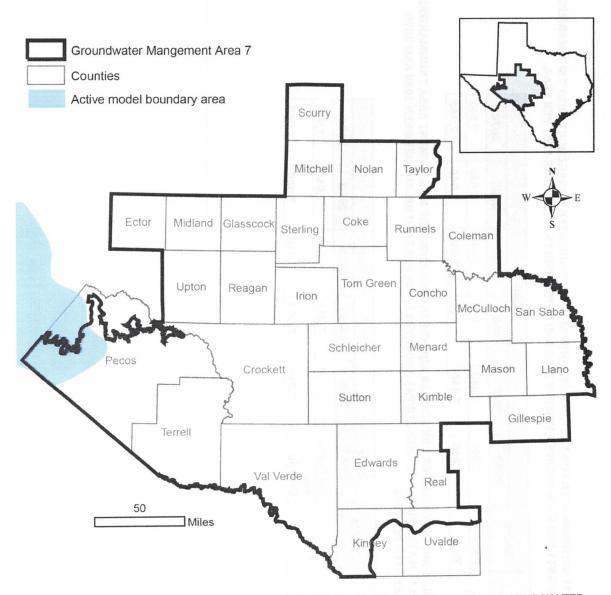


FIGURE 13. MAP SHOWING AREAS COVERED BY THE RUSTLER AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022 Page 48 of 52

TABLE 13.

DELED AVAILABLE GROUNDWATER FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.
--

Dietriot	Country			Year			
District	county	2020	2030	2040	2050	2060	2070
Middle Pecos GCD	Pecos	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

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 2030 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

Commty	DIAZDA	River			Year		
County	NWFA	Basin	2030	2040	2050	2060	2070
	فسي [Rio Grande	7,040	7,040	7,040	7,040	7,040
Pecos	Į,	Rio				al d	360
	partie.	Grande	7,040	7.040	7.040	7.040	7.040

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 49 of 52

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

In some cases, the predictive model run for this analysis could result 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. This would mean that the modeled available groundwater would include imaginary "pumping" values that are coming from cells that are actually dry.

REFERENCES:

- Anaya, R., and Jones, I. C., 2009, Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas: Texas Water Development Board Report 373, 103p.

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

 http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS GAM Numerical Report.pdf
- EcoKai Environmental, Inc. and Hutchison, W. R., 2014, Hydrogeological Study for Val Verde and Del Rio, Texas: Prep. For Val Verde County and City of Del Rio, 167 p.
- Ewing, J. E., Kelley, V. A., Jones, T. L., Yan, T., Singh, A., Powers, D. W., Holt, R. M., and Sharp, J. M., 2012, Final Groundwater Availability Model Report for the Rustler Aquifer, Prepared for the Texas Water Development Board, 460p.

 http://www.twdb.texas.gov/groundwater/models/gam/rslr/RSLR GAM Report.pd
 f
- Harbaugh, A. W., 2005, MODFLOW-2005, The US Geological Survey Modular Groundwater-Model the Ground-Water Flow Process. Chapter 16 of Book 6. Modeling techniques, Section A Ground Water: U.S. Geological Survey Techniques and Methods 6-A16. 253p.
- Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models: U.S. Geological Survey Groundwater Software.
- Harbaugh, A. W., Banta, E. R., Hill, M. C., 2000, MODFLOW-2000, the U.S. Geological Survey Modular Ground-Water Model User Guide to Modularization Concepts and the Ground-Water Flow Process: U.S. Geological Survey, Open-File Report 00-92, 121p.
- Hutchison, W. R., Jones, I. C, and Anaya, R., 2011a, Update of the Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas, Texas

- Water Development Board, 61 p. http://www.twdb.texas.gov/groundwater/models/alt/eddt p 2011/ETP PV One L aver Model.pdf
- Hutchison, W. R., Shi, J., and Jigmond, M., 2011b, Groundwater Flow Model of the Kinney County Area, Texas Water Development Board, 217 p.

 http://www.twdb.texas.gov/groundwater/models/alt/knny/Kinney County Model-Report.pdf
- Hutchison, W. R., 2011, Draft GAM Task 10-027 (revised), 8 p.
- Hutchison, W. R., 2016a, GMA 7 Technical Memorandum 16-03—Final, Capitan Reef Complex Aquifer: Initial Predictive Simulations with Draft GAM, 8 p.
- Hutchison, W. R., 2016b, GMA 7 Technical Memorandum 16-02—Final, Llano Uplift Aquifers: Initial Predictive Simulations with Draft GAM, 24 p.
- Hutchison, W. R., 2016c, GMA 7 Technical Memorandum 16-01—Final, Dockum and Ogallala Aquifers: Initial Predictive Simulations with HPAS, 29 p.
- Hutchison, W. R., 2016d, GMA 7 Technical Memorandum 15-05—Final, Rustler Aquifer: Nine Factor Documentation and Predictive Simulation with Rustler GAM, 27 p.
- Hutchison, W. R., 2016e, GMA 7 Technical Memorandum 15-06—Final, Edwards-Trinity (Plateau) and Pecos Valley Aquifers: Nine Factor Documentation and Predictive Simulation, 60 p.
- Hutchison, W. R., 2018, GMA 7 Technical Memorandum 18-01—Final, Edwards-Trinity (Plateau) and Pecos Valley Aquifers: Update of Average Drawdown Calculations, 10 p.
- Hutchison, W. R., 2021, GMA 7 Explanatory Report—Final, Edwards-Trinity, Pecos Valley and Trinity Aquifers: Prep. For Groundwater Management Area 7, 173 p.
- Jones, I. C., 2016, Groundwater Availability Model: Eastern Arm of the Capitan Reef Complex Aquifer of Texas. Texas Water Development Board, March 2016, 488p. http://www.twdb.texas.gov/groundwater/models/gam/crcx/CapitanModelReportFinal.pdf
- National Research Council, 2007, Models in Environmental Regulatory Decision-Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p., http://www.nap.edu/catalog.php?record id=11972.
- Niswonger, R.G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, a Newton formulation for MODFLOW-2005: United States Geological Survey, Techniques and Methods 6-A37, 44 p.
- Panday, S., Langevin, C. D., Niswonger, R. G., Ibaraki, M., and Hughes, J. D., 2013, MODFLOW–USG version 1: An unstructured grid version of MODFLOW for

GAM Run 21-012 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7 August 12, 2022
Page 52 of 52

simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p.

- Shi, J, 2012, GAM Run 10-043 MAG (Version 2): Modeled Available Groundwater for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers in Groundwater Management Area 7, Texas Water Development Board GAM Run Report 10-043, 15 p. www.twdb.texas.gov/groundwater/docs/GAMruns/GR10-043 MAG v2.pdf
- Shi, J., Boghici, R., Kohlrenken, W., and Hutchison, W., 2016, Numerical model report: minor aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory): Texas Water Development Board published report, 400 p. http://www.twdb.texas.gov/groundwater/models/gam/llano/Llano Uplift Numerical Model Report Final.pdf

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