SAN PATRICIO COUNTY

Groundwater Management Plan

Prepared by

San Patricio County Groundwater Conservation District

Amended on May 16, 2023

San Patricio County Groundwater Conservation District

Groundwater Management Plan

I. Mission Statement

The San Patricio County Groundwater Conservation District (the district) is committed to management and protection of the groundwater resources of San Patricio County. The District is committed to maintaining a sustainable, adequate, reliable, cost effective, high quality source of groundwater to promote the vitality, economy, and environment of the County. The District will work with and for the citizens and landowners of the County and cooperate with other local, regional, and state agencies involved in study and management of groundwater. The District will not take any action without the full consideration of the groundwater needs of the citizens of the County.

II. Purpose

In 1997 the 75th Texas Legislature established a statewide comprehensive regional water planning initiative with enactment of Senate Bill 1 (SB1). Among the provisions of SB1 were amendments to Chapter 36 of the Texas Water Code (TWC) requiring groundwater conservation districts (GCDs) to develop groundwater management plans to be submitted to the Texas Water Development Board (TWDB) for approval as administratively complete. The management plan must contain estimates of groundwater availability in San Patricio GCD, details of how the district will manage groundwater and management goals for the district. In 2001 the 77th Texas Legislature further clarified water planning and management provisions of SB1 through Senate Bill 2 (SB2).

Administrative requirements of Chapter 36 TWC provisions for groundwater management plan development are specified in 31 Texas Administrative Code (TAC) Chapter 356 of TWDB Rules. The following plan fulfills all requirements for groundwater management plans in SB1, SB2, Chapter 36 TWC, and the administrative rules of TWDB.

III. Time Period of Plan

This plan shall be in effect for a period of five (5) years from date of approval by TWDB unless a new or amended management plan is adopted by the district Board of Directors (board) and approved by TWDB. This management plan will be readopted with or without changes by the board and submitted to the TWDB for approval every 5 years.

IV. San Patricio County Groundwater Conservation District (The District)

The District was created in 2005 by the 79th Texas Legislature enacting HB 3568 creating Chapter 8817, Special District Local Laws Code. This act is recorded in Chapter 1178, General Laws, Acts of the 79th Legislature, Regular Session, 2005. The District was confirmed by local election held in San Patricio County on May 12, 2007 with 60% of the voters in favor.

The District Board of Directors (board) is comprised of seven (7) members elected to staggered four-year terms. Six directors are elected from county justice-of-the-peace precincts and one director is elected at-large. The current Board of Directors (board) consists of Clarence Chopelas, Stephen Thomas, Vernon Kramer, Joe Pullin, Jr., Charles Ring, Matt Setliff and Richard Dupriest. The election process for the district directors was clarified by the Texas Legislature in 2007. The board holds regular meetings at the County Extension Office at 219 N.

Vineyard Avenue in Sinton, Texas quarterly unless otherwise posted. All official meetings of the board of directors are public meetings noticed and held in accordance with all public meeting requirements.

The District is located in San Patricio County, Texas. The boundaries are the same as the political boundaries of San Patricio County, Texas. The District is bounded by Nueces, Jim Wells, Live Oak, Bee, Refugio, Nueces, and Aransas counties. As of the plan date, confirmed GCDs exist in Bee, Live Oak, Jim Wells, and Refugio counties. GCDs neighboring the District are: Corpus Christi Aquifer Storage and Recovery CD, Bee GCD, Live Oak GCD, Brush Country GCD, and Refugio GCD (Figure 1).

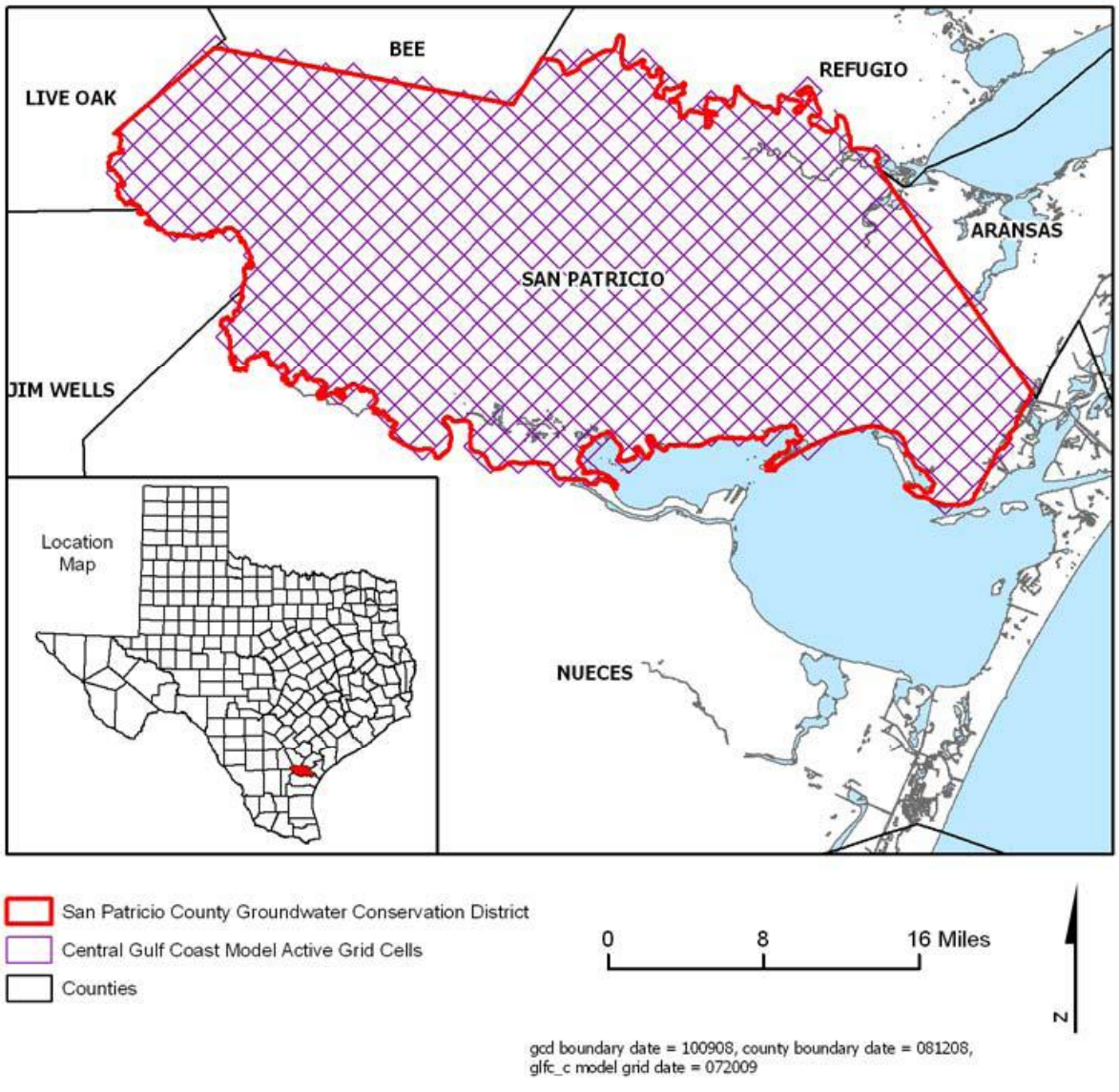

Figure 1: Area of the groundwater availability model for the central portion of the Gulf Coast Aquifer System (San Patricio County Groundwater Conservation District boundary).

The District is located in Groundwater Management Area (GMA) 16 (Figure 2). Chapter 36 TWC authorizes the district to coordinate its management of groundwater with other GCDs in GMA 16. Other confirmed GCDs in GMA 16 are:

- Bee Groundwater Conservation District
- Brush Country Groundwater Conservation District
- Corpus Christi ASR Conservation District
- Duval County Groundwater Conservation District
- Kenedy County Groundwater Conservation District
- Live Oak Underground Water Conservation District
- McMullen Groundwater Conservation District
- Red Sands Groundwater Conservation District
- Starr County Groundwater Conservation District

V. Authority of San Patricio County Groundwater Conservation District

The District derives its authority to manage groundwater through powers granted in Chapter 8817, Special District Local Laws Code. The District, acting under authority of the enabling legislation, assumes all rights and responsibilities of a groundwater conservation district specified in Chapter 36, Water Code. The rules are available on the District's website: www.spcgcd.org under the rules tab.

VI. Geology & Hydrologic Units of San Patricio County

The aquifer layers described below (Jasper, Evangeline, and Chicot) are all part of the Gulf Coast Aquifer System, which is recognized by the TWDB as a major aquifer.

Except for the Quaternary alluvium, the geologic formations crop out in belts nearly parallel to the Gulf of Mexico. Younger formations crop out nearer the Gulf and older formations crop out inland. The formations dip toward the coast and thicken causing the older formations to dip more steeply. Faults are common and some of them have displacements of up to several hundred feet. The displacements tend to decrease upward and may not appear at the surface. Faulting generally does not disrupt regional hydraulic continuity (Loskot et. al, 1982).

Jasper Aquifer - The Jasper aquifer is a minor source of water that may be slightly or moderately saline (Figure 3). It consists mainly of the Oakville Sandstone, but may include the upper part of the Catahoula Sandstone. The Oakville Sandstone contains laterally discontinuous sand and gravel lenses interbedded with shale and clay. Massive sandstone beds at the base of the formation thin upward with greater amounts of shale and clay. The Jasper aquifer ranges in thickness from about 200 to 800 feet where fresh to slightly saline water is present, but may reach 2,500 feet of thickness downdip in San Patricio County (adapted from Loskot et. al, 1982).

Burkeville Confining Layer - The Burkeville confining layer is mostly clay but contains some sand layers (Figure 3). Burkeville clay sequences are identified in the subsurface by electric logs and act as a regional impediment to vertical water flow. The Burkeville ranges from 300 to 500 feet in thickness (adapted from Loskot et. al, 1982).

Evangeline Aquifer - The Evangeline Aquifer consists of sand and clay of the Goliad Sands and the upper part of the Fleming Formation (Figure 3). The Evangeline Aquifer

generally contains more sand than clay. Some of the sands and clays are continuous throughout much of the area. Individual sands may reach 100 feet in thickness in the area containing fresh to slightly saline water. Maximum thickness of the Evangeline Aquifer is 1,380 feet and may have up to 470 feet of sand in aggregate thickness. Fresh water may occur as deep as 2,000 feet in east-central San Patricio County (adapted from Loskot et. al, 1982).

Chicot Aquifer - The Chicot Aquifer is the main source of groundwater in San Patricio County and consists of discontinuous layers of sand and clay of about equal thickness. It is composed of water bearing units of the Willis Sand, Lissie Formation, Beaumont Clay, and Quaternary alluvium, which include all deposits from land surface to the top of the Evangeline Aquifer. The Chicot Aquifer contains all fresh water in San Patricio County. Individual sands may reach 500 feet in thickness. It is in hydrologic continuity with the Evangeline Aquifer and the two units can be difficult to distinguish. The Chicot is delineated from the Evangeline in the subsurface mainly on higher sand to clay ratios that give the Chicot higher hydraulic conductivity (adapted from Loskot et. al, 1982).

<table>
<tr><th>System</th><th>Series</th><th colspan="2">Geologic Unit</th><th>Hydrologic Unit</th></tr>
<tr><td rowspan="5">Quaternary</td><td>Holocene</td><td colspan="2">Alluvium</td><td rowspan="5">Chicot Aquifer</td></tr>
<tr><td rowspan="4">Pleistocene</td><td colspan="2">Beaumont Clay</td></tr>
<tr><td>Montgomery Formation</td><td rowspan="2">Lissie Formation</td></tr>
<tr><td>Bentley Formation</td></tr>
<tr><td colspan="2">Willis Sand</td></tr>
<tr><td rowspan="4">Tertiary</td><td>Pliocene</td><td colspan="2">Goliad Sand</td><td rowspan="2">Evangeline Aquifer</td></tr>
<tr><td rowspan="3">Miocene</td><td colspan="2" rowspan="2">Fleming Formation</td></tr>
<tr><td>Burkeville Confining Zone</td></tr>
<tr><td colspan="2">Oakville Sandstone</td><td rowspan="2">Jasper Aquifer</td></tr>
<tr><td colspan="2">Catahoula Sandstone (Tuff)</td></tr>
</table>

Figure 3. Geologic and Hydrologic Units of the Gulf Coast Aquifer System in San Patricio County (modified from Loskot et al. 1982).

VII. Geography of San Patricio County GCD

The District is located in the Gulf Coastal Plains region of Texas. Topography ranges from gently rolling in the northwestern part of the County to flatlands in the eastern portion. Three major drainages occur in the county: the Nueces River drains the southern part, Chiltipin Creek drains the central part, and the Aransas River drains the northern part of the County.

Major north-south highways of the County are U.S. Highways 77 and 181, and IH 37. Major east-west routes include parts of U.S. 181 and all of State Highway 188.

Major population centers in the district occur in Sinton, Portland, Mathis, Odem, Taft, and Ingleside. Other population centers of the County are Edroy, Gregory, and St. Paul.

Agriculture is one of the principal economic activities in the County. Major crops produced in the County by acreage include grain sorghum (45%), cotton (45%), and corn (10%), with minor amounts of canola, sesame, sunflowers, and wheat. Beef cattle production is also a significant agricultural activity. Other economic activities in the County include production and refining of oil and gas, mining of caliche and gravel, waterfowl and big-game hunting, salt water fishing and shrimping, and various types of manufacturing.

VIII. Estimated Historical Water Use

Estimates of the amount of groundwater and surface water used annually are in Appendix A.

IX. Modeled Available Groundwater

GAM run 21-021MAG by the TWDB the Modeled Available Groundwater is available in the Appendix A.

X. Surface Water Resource and total demand of San Patricio County

This data is available to view in the Estimated Historical Water Use/2022 State Water Plan report in Appendix A.

XI. Estimates of annual natural and artificial recharge to groundwater for San Patricio County

Estimates of the annual volume of water that discharges from the aquifer, the annual volume of flow into the district within each aquifer, the annual volume of flow out of the aquifer within each aquifer, and the annual volume of flow between aquifers in the district are available in Appendix A under GAM Run 21-022.

Net annual amount of lateral underflow received by the aquifer underlying the District and annual amount of water taken from storage in the aquifer in the County are available in Appendix A under GAM Run 21-022.

The estimates of annual natural and artificial recharge is available in Appendix A under GAM Run 21-022

XII. Water Management Strategies to Meet Water User Group Needs

The District considered the water management strategies included in the state water plan. The District considered the management strategies identified in the State Water Plan including development of supplies from the Gulf Coast Aquifer System, the Gulf of Mexico, direct reuse, demand reduction, and treatment plant improvement for irrigation, mining, and manufacturing.

The estimated projected water management strategies are available in Appendix A.

XIII. Projected Water Supply Needs

The projected water supply needs identified for San Patricio County are in the following categories: irrigation, mining, and manufacturing. The needs are estimated to be 1,920 acre-feet/year in 2020 increasing to 18,165 acre-feet/year in 2070. The District has considered the projected water supply needs identified.

The estimated projected water supply needs are available in Appendix A.

XIV. Desired Future Conditions

The desired future condition (DFC) of the groundwater within the District has been established in accordance with Chapter 36.108 of the Texas Water Code. The District actively participated in the joint planning process with GMA 16 and development of a DFC for the portion of the aquifer(s) in the District.

The modeled available groundwater is available in Appendix A as GAM Run 21-021 MAG.

XV. How the District Will Manage Groundwater

The District will manage groundwater in the County to conserve the resource while seeking to maintain economic viability of all resource user groups, both public and private. In consideration of economic and cultural activities in the County, the District will identify and engage in activities and practices that if implemented would result in more efficient groundwater use. The District will undertake and cooperate with investigations of groundwater resources in the County and make results of investigations available to the public upon adoption by the board. All actions and rules of The District will adhere to TWC, Chapter 36.

The District will issue permits and set production and spacing limitations in accordance with guidelines stated in the District rules. A copy of the District's rules is available on the District website: www.spcgcd.org under the Rules tab.

The District is committed to maintaining a sustainable, adequate, reliable, cost effective, high quality source of groundwater to promote the vitality, economy, and environment of the County. In pursuit of The District's mission of protecting the resource, The District may require reduction of groundwater withdrawals to amounts that will not cause harm to the aquifer.

The District will enforce the terms and conditions of permits and rules by enjoining the permit holder in a court of competent jurisdiction as provided for in TWC, Chapter 36.102.

The District will employ technical resources at its disposal to evaluate resources available in the County and determine the effectiveness of regulatory or conservation measures. A public or private user may appeal to the board for discretion in enforcement of provisions of the water supply deficit contingency plan on grounds of adverse economic hardship or unique local conditions. Exercise of this discretion by the board shall not be construed as limiting the board's power.

The District considered the water supply needs and water management strategies included in the state water plan. The water supply needs could be met with either surface water supplies, or desalinization of sea water by the City of Corpus Christi. The City of Corpus Christi supplies most of southern San Patricio county manufacturing and cities with water, which, mainly, is surface water currently.

XVI. Actions, Procedures, Performance, & Avoidance Necessary to Put Plan into Effect

The District will implement provisions of this management plan and will utilize plan objectives as a guide for board actions, operations, and decision-making. The District will ensure its planning efforts, activities, and operations are consistent with plan provisions.

The District has adopted rules in accordance with TWC, Chapter 36 and all rules will be followed and enforced. Rules development will be based on the best scientific information and technical evidence available. The rules are available on the District website: www.spcgcd.org under the rules tab.

The District will encourage cooperation and coordination in plan implementation. All operations and activities will be performed to encourage citizen cooperation in the County and with appropriate water management entities at state, regional, and local levels.

XVII. Methodology for Tracking Progress in Achieving Management Goals

The District will prepare and submit an annual report (Annual Report) to the board. The Annual Report will include an update on the District's performance in achieving management goals contained in this plan. The Annual Report will be presented to the board within ninety (90) days following completion of the District's Fiscal Year, beginning in the fiscal year starting 2010. A copy of the annual audit of the District's financial records will be included in the Annual Report.

Literature Cited

Dutton, A. R. and B. C. Richter. 1990. *Regional Geohydrology of the Gulf Coast Aquifer in Matagorda and Wharton Counties, TX*. University of Texas, Austin. Bureau of Economic Geology Final Report for Lower Colorado River Authority.

Loskot, Carole L., William M. Sandeen, and C. R. Follett. 1982. *Texas Water Development Board Report 270: Ground-water Resources of Colorado, Lavaca, & Wharton Counties, Texas*. 1982.

Ryder, P. D. 1988. *Hydrogeology and Predevelopment Flow in the Texas Gulf Coast Aquifer System*. USGS Water Resources Investigations Report 87-4248.

Scanlon, B. R., R. W. Healy, and P.G. Cook, Choosing appropriate techniques for quantifying groundwater recharge, *Hydrogeology J.*, 2002.

XVIII. Management Goals, Objectives, and Performance Standards

Resource Goals

Goal 1.0: Providing the most efficient use of groundwater

Management Objective:

Each year the District will provide education materials concerning the efficient use of groundwater.

Performance standard:

Provide educational materials to at least one school annually.

Goal 2.0: Controlling and preventing waste of groundwater

Management Objective:

The management will report any waste to the District Board.

Performance standard:

The District will investigate all reports of waste within 7 working days. The number of reports of waste as well as the investigation findings will be reported to the District Board annually.

Goal 3.0: Controlling and preventing subsidence

The District has reviewed the report: Identification of the Vulnerability of the Major and Minor Aquifers in Texas to Subsidence with regard to Groundwater Pumping – TWDB Contract Number 1648302062 by LRE Water: http://www.twdb.texas.gov/groundwater/models/research/subsidence/subsidence.asp. Figure 4.23 of the subsidence report illustrates that the major aquifer subsidence risk within the District boundaries ranges from medium to the high range. Due to the amount of current pumping, subsidence is not expected to occur, but the District will monitor any potential pumping that may affect subsidence. This goal is currently not applicable

Goal 4.0: Addressing Conjunctive surface water management issues

Management Objective:

The District will participate in the regional planning process by attending the Region N regional water planning group meetings to encourage the development of surface water supplies to meet the needs of water user groups within the District. A representative of the District will attend, at least, one meeting of the Region N regional water planning group.

Performance Standard:

The District will attend, at least, one meeting of the Region N regional water planning group and include the attendee's name in the Annual Report to the Board.

Goal 5.0: Addressing Natural Resource Issues

Management Objective:

The District will investigate issues related to environmental and other concerns that may be affected by a district's groundwater management plan and rules, such as impacts on endangered species, soils, oil and gas production, mining, air and water quality degradation, agriculture, and plant and animal life.

Performance Standard:

The District will investigate reports of any issues related to environmental and other concerns that may be affected by a district's groundwater management plan and rules, such as impacts on endangered species, soils, oil and gas production, mining, air and water quality degradation, agriculture, and plant and animal life within 120 days of receiving the report.

Goal 6.0: Addressing Drought Conditions

Management Objective:

The District will monitor the Palmer Drought Severity Index (PDSI). The link to the Drought index is www.waterdatafortexas.org/drought

Performance Standard:

A report of the U S Drought Monitor will be presented to the District board on an annual basis: https://droughtmonitor.unl.edu . This link and additional links to important information on drought can be accessed at the TWDB's Water Data for Texas website: www.waterdatafortexas.org/drought

Goal 7.0: Addressing Conservation

Management Objective:

Each year the District will provide educational material to the public promoting conservation methods and concepts.

Performance Standard:

The District will provide educational materials to at least one school annually.

Goal 8.0: Addressing Precipitation Enhancement

The District has determined that this goal is not financially feasible at this time so it is not applicable.

Goal 9.0: Recharge Enhancement

This goal is not applicable to the District because, at the current time, it is cost prohibitive.

Goal 10.0: Addressing Rainwater Harvesting

This goal is not applicable to the District because, at the current time, it is cost prohibitive.

Goal 11.0: Addressing Brush Control

This goal is not applicable to the District because, at the current time, it is cost prohibitive.

Goal 12.0: Addressing the desired future conditions of the groundwater resource in the District.

Management Objective:

The District will review and calculate its permit and well registration totals in light of the Desired Future Conditions of the groundwater resources within the boundaries of the District to assess whether the District is on target to meet the Desired Future Conditions estimates submitted to the TWDB.

Performance Standard:

The District's Annual Report will include a discussion of the District's permit and well registration totals and will evaluate the District's progress in achieving the Desired Future Conditions of the groundwater resources within the boundaries of the District and whether the District is on track to maintain the Desired Future Conditions estimates over the 50-year planning period.

Management Objective:

The District will annually measure the water levels in at least three monitoring wells within the District and will determine the five-year water level averages based on the samples taken. The District will compare the five-year 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.

Performance Standard:

The District's Annual Report will include the water level measurements taken each year for the purpose of measuring water levels to assess the District's 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 thereafter, 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 its Desired Future Conditions. Any water measurements taken by TWDB or USGS will also be considered.

APPENDIX A

Estimated Historical Groundwater Use And 2022 State Water Plan Datasets:

San Patricio County Groundwater Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
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February 3, 2022

GROUNDWATER MANAGEMENT PLAN DATA:

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

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

The five reports included in this part are:

1. Estimated Historical Groundwater Use (checklist item 2)
   from the TWDB Historical Water Use Survey (WUS)
2. Projected Surface Water Supplies (checklist item 6)
3. Projected Water Demands (checklist item 7)
4. Projected Water Supply Needs (checklist item 8)
5. Projected Water Management Strategies (checklist item 9)
   from the 2022 Texas State Water Plan (SWP)

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

DISCLAIMER:

The data presented in this report represents the most up-to-date WUS and 2022 SWP data available as of 2/3/2022. Although it does not happen frequently, either of these datasets are subject to change pending the availability of more accurate WUS data or an amendment to the 2022 SWP. District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The WUS dataset can be verified at this web address:

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

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

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

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

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2020. TWDB staff anticipates the calculation and posting of these estimates at a later date.

SAN PATRICIO COUNTY

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2019	GW	1,338	0	0	0	3,607	143	5,088
	SW	7,049	12,313	0	2,391	157	143	22,053
2018	GW	1,240	0	0	0	5,661	143	7,044
	SW	7,211	11,185	0	0	133	143	18,672
2017	GW	1,241	0	0	0	5,704	138	7,083
	SW	8,846	10,237	0	0	172	138	19,393
2016	GW	1,591	0	0	0	5,506	136	7,233
	SW	6,877	9,377	0	0	183	136	16,573
2015	GW	1,857	1	2	0	6,255	134	8,249
	SW	10,529	9,142	0	0	109	134	19,914
2014	GW	1,822	25	1	0	7,626	174	9,648
	SW	7,618	10,698	0	0	159	174	18,649
2013	GW	2,091	3	2	0	6,267	168	8,531
	SW	8,700	10,255	0	0	236	168	19,359
2012	GW	2,232	1	4	0	11,447	192	13,876
	SW	7,472	11,848	1	0	226	192	19,739
2011	GW	2,473	3	0	0	14,441	233	17,150
	SW	7,685	11,874	0	0	204	233	19,996
2010	GW	2,691	2	135	0	7,175	224	10,227
	SW	7,001	11,777	173	0	0	224	19,175
2009	GW	2,628	2	121	0	10,277	153	13,181
	SW	7,339	7,785	156	0	0	152	15,432
2008	GW	2,451	2	107	0	13,921	237	16,718
	SW	11,767	4,796	138	0	0	237	16,938
2007	GW	2,245	3	0	0	5,838	136	8,222
	SW	6,330	7,880	0	0	557	135	14,902
2006	GW	2,471	1	0	0	9,968	280	12,720
	SW	7,315	8,004	0	0	0	280	15,599
2005	GW	2,398	1	0	0	9,413	211	12,023
	SW	10,309	7,617	0	0	200	211	18,337
2004	GW	2,126	2	0	0	8,936	24	11,088
	SW	7,577	7,617	0	0	223	403	15,820

Projected Surface Water Supplies
TWDB 2022 State Water Plan Data

SAN PATRICIO COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
N	ARANSAS PASS	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	685	696	696	700	707	713
N	ARANSAS PASS	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	685	695	696	699	707	712
N	COUNTY-OTHER, SAN PATRICIO	NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	330	324	315	307	303	300
N	COUNTY-OTHER, SAN PATRICIO	NUECES	TEXANA LAKE/RESERVOIR	51	63	82	96	104	111
N	COUNTY-OTHER, SAN PATRICIO	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	258	262	269	274	276	279
N	GREGORY	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	169	172	174	177	179	180
N	GREGORY	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	170	172	174	177	178	180
N	INGLESIDE	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	507	512	512	513	518	522
N	INGLESIDE	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	506	512	511	513	518	522
N	IRRIGATION, SAN PATRICIO	SAN ANTONIO-NUECES	SAN ANTONIO-NUECES RUN-OF-RIVER	0	0	0	0	0	0
N	LIVESTOCK, SAN PATRICIO	NUECES	NUECES LIVESTOCK LOCAL SUPPLY	83	83	83	83	83	83
N	LIVESTOCK, SAN PATRICIO	SAN ANTONIO-NUECES	SAN ANTONIO-NUECES LIVESTOCK LOCAL SUPPLY	80	80	80	80	80	80
N	MANUFACTURING, SAN PATRICIO	NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	22,844	19,825	18,292	16,712	15,124	13,361
N	MANUFACTURING, SAN PATRICIO	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	11,560	11,833	10,919	9,976	9,028	7,975
N	MANUFACTURING, SAN PATRICIO	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	4,154	4,033	4,006	3,951	3,895	3,851
N	MATHIS	NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	326	329	327	330	334	336

N	MATHIS	NUECES	TEXANA LAKE/RESERVOIR	327	329	328	331	334	337
N	ODEM	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	205	209	209	210	212	215
N	ODEM	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	190	192	192	194	196	196
N	PORTLAND	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	2,073	2,116	2,128	2,144	2,165	2,184
N	PORTLAND	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	1,316	1,342	1,349	1,359	1,374	1,385
N	RINCON WSC	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	184	188	190	192	194	196
N	RINCON WSC	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	184	189	191	193	195	196
N	STEAM ELECTRIC POWER, SAN PATRICIO	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	1,919	1,919	1,919	1,919	1,919	1,919
N	TAFT	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	319	322	322	326	330	332
N	TAFT	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	221	224	223	226	228	231
	Sum of Projected Surface Water Supplies (acre-feet)			**49,346**	**46,621**	**44,187**	**41,682**	**39,181**	**36,396**

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.

SAN PATRICIO COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
N	ARANSAS PASS	SAN ANTONIO-NUECES	1,370	1,391	1,392	1,399	1,414	1,425
N	COUNTY-OTHER, SAN PATRICIO	NUECES	567	576	590	600	606	611
N	COUNTY-OTHER, SAN PATRICIO	SAN ANTONIO-NUECES	276	280	287	292	294	297
N	GREGORY	SAN ANTONIO-NUECES	339	344	348	354	357	360
N	INGLESIDE	SAN ANTONIO-NUECES	1,013	1,024	1,023	1,026	1,036	1,044
N	IRRIGATION, SAN PATRICIO	NUECES	1,464	1,464	1,464	1,464	1,464	1,464
N	IRRIGATION, SAN PATRICIO	SAN ANTONIO-NUECES	13,181	13,181	13,181	13,181	13,181	13,181
N	LIVESTOCK, SAN PATRICIO	NUECES	200	200	200	200	200	200
N	LIVESTOCK, SAN PATRICIO	SAN ANTONIO-NUECES	196	196	196	196	196	196
N	MANUFACTURING, SAN PATRICIO	NUECES	24,323	27,067	27,067	27,067	27,067	27,067
N	MANUFACTURING, SAN PATRICIO	SAN ANTONIO-NUECES	14,518	16,156	16,156	16,156	16,156	16,156
N	MATHIS	NUECES	653	658	655	661	668	673
N	MINING, SAN PATRICIO	NUECES	78	88	92	96	103	112
N	MINING, SAN PATRICIO	SAN ANTONIO-NUECES	294	333	348	364	389	421
N	ODEM	SAN ANTONIO-NUECES	395	401	401	404	408	411
N	PORTLAND	SAN ANTONIO-NUECES	3,389	3,458	3,477	3,503	3,539	3,569
N	RINCON WSC	SAN ANTONIO-NUECES	368	377	381	385	389	392
N	SINTON	SAN ANTONIO-NUECES	1,345	1,382	1,396	1,411	1,427	1,438
N	STEAM ELECTRIC POWER, SAN PATRICIO	SAN ANTONIO-NUECES	1,919	1,919	1,919	1,919	1,919	1,919
N	TAFT	SAN ANTONIO-NUECES	540	546	545	552	558	563
	Sum of Projected Water Demands (acre-feet)		**66,428**	**71,041**	**71,118**	**71,230**	**71,371**	**71,499**

Projected Water Supply Needs
TWDB 2022 State Water Plan Data

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

SAN PATRICIO COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
N	ARANSAS PASS	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	COUNTY-OTHER, SAN PATRICIO	NUECES	0	0	0	0	0	0
N	COUNTY-OTHER, SAN PATRICIO	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	GREGORY	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	INGLESIDE	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	IRRIGATION, SAN PATRICIO	NUECES	-20	-20	-20	-20	-20	-20
N	IRRIGATION, SAN PATRICIO	SAN ANTONIO-NUECES	-184	-184	-184	-184	-184	-184
N	LIVESTOCK, SAN PATRICIO	NUECES	0	0	0	0	0	0
N	LIVESTOCK, SAN PATRICIO	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	MANUFACTURING, SAN PATRICIO	NUECES	-1,479	-7,242	-8,775	-10,355	-11,943	-13,706
N	MANUFACTURING, SAN PATRICIO	SAN ANTONIO-NUECES	1,669	183	-758	-1,756	-2,760	-3,857
N	MATHIS	NUECES	0	0	0	0	0	0
N	MINING, SAN PATRICIO	NUECES	-50	-60	-64	-68	-75	-84
N	MINING, SAN PATRICIO	SAN ANTONIO-NUECES	-187	-226	-241	-257	-282	-314
N	ODEM	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	PORTLAND	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	RINCON WSC	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	SINTON	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	STEAM ELECTRIC POWER, SAN PATRICIO	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	TAFT	SAN ANTONIO-NUECES	0	0	0	0	0	0
	Sum of Projected Water Supply Needs (acre-feet)		**-1,920**	**-7,732**	**-10,042**	**-12,640**	**-15,264**	**-18,165**

Projected Water Management Strategies
TWDB 2022 State Water Plan Data

SAN PATRICIO COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
GREGORY, SAN ANTONIO-NUECES (N)							
MUNICIPAL CONSERVATION - GREGORY	DEMAND REDUCTION [SAN PATRICIO]	0	11	6	6	4	4
		0	**11**	**6**	**6**	**4**	**4**
IRRIGATION, SAN PATRICIO, NUECES (N)							
GULF COAST SUPPLIES - SAN PATRICIO IRRIGATION	GULF COAST AQUIFER SYSTEM [SAN PATRICIO]	20	20	20	20	20	20
IRRIGATION CONSERVATION - SAN PATRICIO COUNTY	DEMAND REDUCTION [SAN PATRICIO]	37	73	110	146	183	220
		57	**93**	**130**	**166**	**203**	**240**
IRRIGATION, SAN PATRICIO, SAN ANTONIO-NUECES (N)							
GULF COAST SUPPLIES - SAN PATRICIO IRRIGATION	GULF COAST AQUIFER SYSTEM [SAN PATRICIO]	184	184	184	184	184	184
IRRIGATION CONSERVATION - SAN PATRICIO COUNTY	DEMAND REDUCTION [SAN PATRICIO]	329	659	988	1,319	1,648	1,977
		513	**843**	**1,172**	**1,503**	**1,832**	**2,161**
MANUFACTURING, SAN PATRICIO, NUECES (N)							
CITY OF CORPUS CHRISTI SEAWATER DESALINATION (LA QUINTA)	GULF OF MEXICO [GULF OF MEXICO]	0	14,029	14,029	14,029	14,029	14,029
EVANGELINE/LAGUNA TREATED GROUNDWATER PROJECT	GULF COAST AQUIFER SYSTEM [SAN PATRICIO]	0	6,230	6,230	6,230	7,135	7,135
MANUFACTURING WATER CONSERVATION	DEMAND REDUCTION [SAN PATRICIO]	608	1,353	2,030	2,707	3,383	4,060
O.N. STEVENS WATER TREATMENT PLANT IMPROVEMENTS	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM [RESERVOIR]	882	887	890	893	893	894
PORT OF CORPUS CHRISTI AUTHORITY SEAWATER DESALINATION - HARBOR ISLAND	GULF OF MEXICO [GULF OF MEXICO]	0	17,548	17,548	17,548	17,548	17,548
PORT OF CORPUS CHRISTI AUTHORITY SEAWATER DESALINATION - LA QUINTA CHANNEL	GULF OF MEXICO [GULF OF MEXICO]	0	21,043	21,043	21,043	21,043	21,043
POSEIDON REGIONAL SEAWATER DESALINATION PROJECT AT INGLESIDE	GULF OF MEXICO [GULF OF MEXICO]	0	35,096	35,096	35,096	35,096	35,096
REGIONAL INDUSTRIAL WASTEWATER REUSE PLAN (SPMWD)	DIRECT REUSE [SAN PATRICIO]	0	5,010	5,010	5,010	5,010	5,010
		1,490	**101,196**	**101,876**	**102,556**	**104,137**	**104,815**
MANUFACTURING, SAN PATRICIO, SAN ANTONIO-NUECES (N)							
CITY OF CORPUS CHRISTI SEAWATER DESALINATION (LA QUINTA)	GULF OF MEXICO [GULF OF MEXICO]	0	8,373	8,373	8,373	8,373	8,373

EVANGELINE/LAGUNA TREATED GROUNDWATER PROJECT	GULF COAST AQUIFER SYSTEM [SAN PATRICIO]	0	3,719	3,719	3,719	4,259	4,259
MANUFACTURING WATER CONSERVATION	DEMAND REDUCTION [SAN PATRICIO]	363	808	1,212	1,615	2,020	2,423
O.N. STEVENS WATER TREATMENT PLANT IMPROVEMENTS	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM [RESERVOIR]	527	529	532	533	533	533
PORT OF CORPUS CHRISTI AUTHORITY SEAWATER DESALINATION - HARBOR ISLAND	GULF OF MEXICO [GULF OF MEXICO]	0	10,474	10,474	10,474	10,474	10,474
PORT OF CORPUS CHRISTI AUTHORITY SEAWATER DESALINATION - LA QUINTA CHANNEL	GULF OF MEXICO [GULF OF MEXICO]	0	12,561	12,561	12,561	12,561	12,561
POSEIDON REGIONAL SEAWATER DESALINATION PROJECT AT INGLESIDE	GULF OF MEXICO [GULF OF MEXICO]	0	20,948	20,948	20,948	20,948	20,948
		890	**57,412**	**57,819**	**58,223**	**59,168**	**59,571**
MINING, SAN PATRICIO, NUECES (N)							
GULF COAST SUPPLIES - SAN PATRICIO MINING	GULF COAST AQUIFER SYSTEM [SAN PATRICIO]	84	84	84	84	84	84
MINING WATER CONSERVATION	DEMAND REDUCTION [SAN PATRICIO]	1	4	5	8	10	13
		85	**88**	**89**	**92**	**94**	**97**
MINING, SAN PATRICIO, SAN ANTONIO-NUECES (N)							
GULF COAST SUPPLIES - SAN PATRICIO MINING	GULF COAST AQUIFER SYSTEM [SAN PATRICIO]	314	314	314	314	314	314
MINING WATER CONSERVATION	DEMAND REDUCTION [SAN PATRICIO]	6	13	21	28	39	50
		320	**327**	**335**	**342**	**353**	**364**
SINTON, SAN ANTONIO-NUECES (N)							
MUNICIPAL CONSERVATION - SINTON	DEMAND REDUCTION [SAN PATRICIO]	0	106	211	219	427	430
		0	**106**	**211**	**219**	**427**	**430**
Sum of Projected Water Management Strategies (acre-feet)		**3,355**	**160,076**	**161,638**	**163,107**	**166,218**	**167,682**

GAM Run 21-022: San Patricio County Groundwater Conservation District Management Plan

Shirley Wade, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
(512) 936-0883
January 19, 2022

Shirley C. Wade
1/19/22

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GAM RUN 21-022: SAN PATRICIO COUNTY GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

Shirley Wade, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
(512) 936-0883
January 19, 2022

EXECUTIVE SUMMARY:

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

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

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

The groundwater management plan for the San Patricio County Groundwater Conservation District should be adopted by the district on or before February 7, 2022 and submitted to the executive administrator of the TWDB on or before March 9, 2022. The current management plan for the San Patricio County Groundwater Conservation District expires on May 8, 2022.

We used the groundwater availability model for the central portion of the Gulf Coast Aquifer System version 1.01 (Chowdhury and others, 2004) to estimate the management plan information for the Gulf Coast Aquifer System within the San Patricio County Groundwater Conservation District. An updated groundwater availability model for the central portion of the Gulf Coast Aquifer System is currently under development and is expected to be completed in late 2022. San Patricio County Groundwater Conservation District can request a new GAM Run report to update their management plan information when the model is available.

This report replaces the results of GAM Run 16-003 (Goswami, 2016). In this report the approach used for analyzing model output has been refined to better delineate groundwater flows. Additionally, we updated the spatial grid file used to define county, groundwater conservation district, and aquifer boundaries, which also impacted the water budget values. Table 1 summarizes the groundwater availability model data required by statute and Figure 1 shows the area of the model from which the values in Table 1 were extracted. Figure 2 is a generalized diagram of the groundwater flow components provided in Table 1. If, after review of the figures, the San Patricio County Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability model mentioned above was used to estimate information for the San Patricio County Groundwater Conservation District management plan. Water budgets were extracted for the historical model period for the Gulf Coast Aquifer System (1981-1999) 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:

Gulf Coast Aquifer System

- We used version 1.01 of the groundwater availability model for the central portion of the Gulf Coast Aquifer for this analysis. See Chowdhury and others (2004) and Waterstone and others (2003) for assumptions and limitations of the groundwater availability model.
- The model for the central portion of the Gulf Coast Aquifer assumes partially penetrating wells in the Evangeline Aquifer due to a lack of data for aquifer properties in the deeper section of the aquifer located closer to the Gulf of Mexico.
- This groundwater availability model includes four layers, which generally represent the Chicot Aquifer (Layer 1), the Evangeline Aquifer (Layer 2), the Burkeville Confining Unit (Layer 3), and the Jasper Aquifer including parts of the Catahoula Formation (Layer 4).
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Gulf Coast Aquifer System located within the San Patricio County Groundwater Conservation District and averaged over the historical calibration periods, as shown in Table 1.

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

TABLE 1: SUMMARIZED INFORMATION FOR THE GULF COAST AQUIFER SYSTEM THAT IS NEEDED FOR THE SAN PATRICIO COUNTY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	10,022
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers.	Gulf Coast Aquifer System	10,262
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	8,855
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	3,230
Estimated net annual volume of flow between each aquifer in the district	From Gulf Coast Aquifer System to equivalent formations within the district	3,503
	Flow between the Gulf Coast Aquifer System and Underlying Units	Not Applicable[1]

[1] Not applicable because the model assumes a no flow barrier at the base of the Gulf Coast Aquifer System

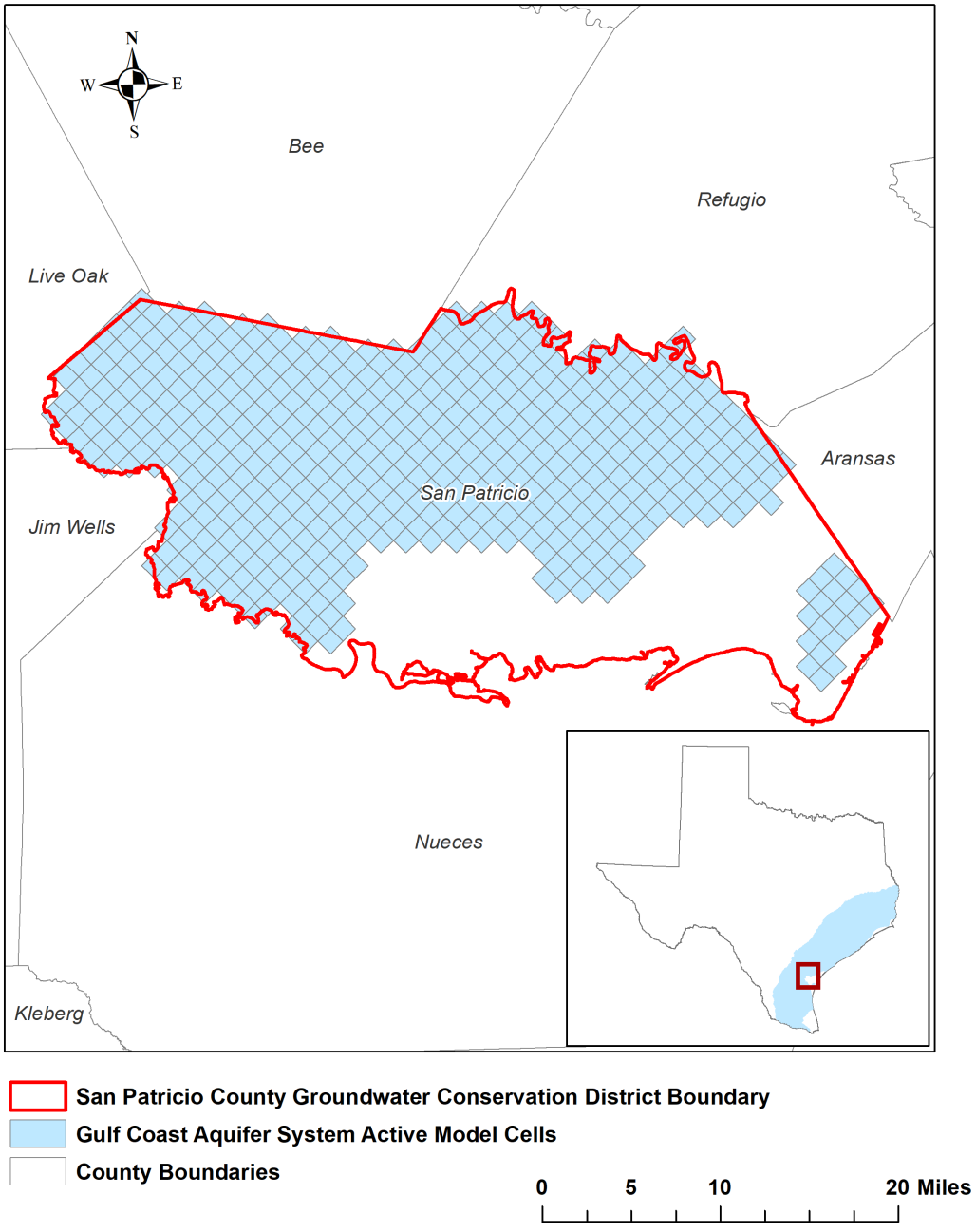
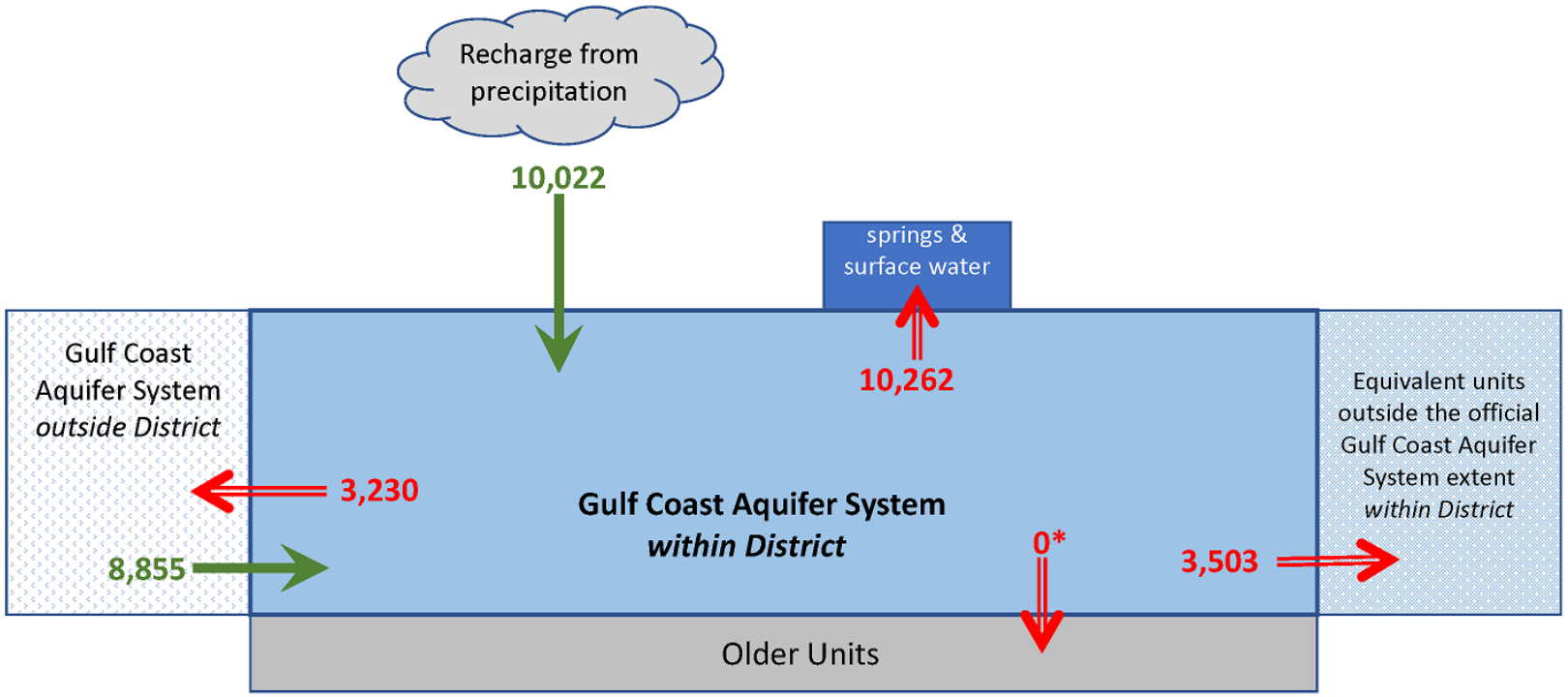


FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CENTRAL PORTION OF THE GULF COAST AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE GULF COAST AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).



* The groundwater availability model for the Gulf Coast Aquifer System assumes a no-flow condition at the base.

Caveat: This diagram only includes the water budget items provided in Table 1. A complete water budget would include additional inflows and outflows. If the District requires values for additional water budget items, please contact TWDB.

FIGURE 2: GENERALIZED DIAGRAM OF THE SUMMARIZED BUDGET INFORMATION FROM TABLE 1, REPRESENTING DIRECTIONS OF FLOW FOR THE GULF COAST AQUIFER SYSTEM WITHIN SAN PATRICIO COUNTY GROUNDWATER CONSERVATION DISTRICT. FLOW VALUES EXPRESSED IN ACRE-FEET PER YEAR (AFY).

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:

Chowdhury, Ali. H., Wade, S., Mace, R.E., and Ridgeway, C., 2004, Groundwater Availability Model of the Central Gulf Coast Aquifer System: Numerical Simulations through 1999- Model Report, 114 p., http://www.twdb.texas.gov/groundwater/models/gam/glfc_c/TWDB_Recalibration_Report.pdf.

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

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

Goswami, R. R., 2016, GAM Run 16-003: Texas Water Development Board, GAM Run 16-003 Report, 9 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR16-003.pdf

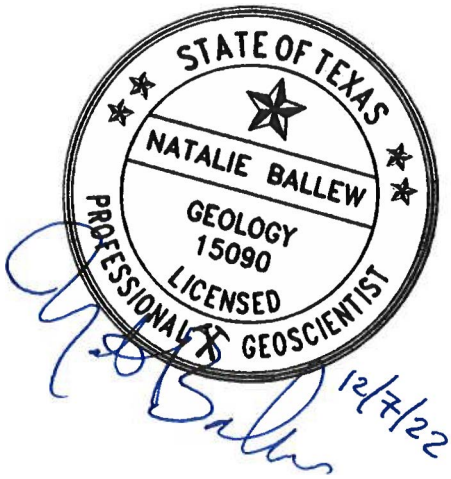
National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p., http://www.nap.edu/catalog.php?record_id=11972.

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

Waterstone Environmental Hydrology and Engineering Inc. and Parsons, 2003, Groundwater availability of the Central Gulf Coast Aquifer: Numerical Simulations to 2050, Central Gulf Coast, Texas Contract report to the Texas Water Development Board, 157 p., http://www.twdb.texas.gov/groundwater/models/gam/glfc_c/Waterstone_Conceptual_Report.pdf?

GAM RUN 21-021 MAG:
MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 16

Ki Cha, Ph.D., EIT
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-463-5604
October 31, 2022



Natalie Ballew, P.G. 15090, is the Director of the Groundwater Division and is responsible for oversight of work performed by Ki Cha under her supervision.

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GAM RUN 21-021 MAG: MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 16

Ki Cha, Ph.D., EIT
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-463-5604
October 31, 2022

EXECUTIVE SUMMARY:

The modeled available groundwater for Groundwater Management Area 16 for the Gulf Coast Aquifer System is summarized by decade by groundwater conservation district and county (Table 1) and for use in the regional water planning process by county, regional water planning area, and river basin (Table 2). The modeled available groundwater estimates range from approximately 229,000 acre-feet per year in 2020 to approximately 294,000 acre-feet per year in 2080 (Tables 1 and 2). The estimates are based on the desired future conditions for the Gulf Coast Aquifer System adopted by groundwater conservation districts in Groundwater Management Area 16 on November 23, 2021 and re-adopted with minor clerical corrections on June 28, 2022. The explanatory report and other materials submitted to the TWDB were determined to be administratively complete on August 26, 2022.

REQUESTOR:

Mr. Scott Bledsoe, III, coordinator for Groundwater Management Area 16.

DESCRIPTION OF REQUEST:

In a letter dated January 22, 2022, Dr. Steve C. Young, consultant for Groundwater Management Area 16, provided the TWDB with the desired future conditions of the Gulf Coast Aquifer System adopted by the groundwater conservation district representatives in Groundwater Management Area 16. The Carrizo-Wilcox and Yegua-Jackson aquifers were declared non-relevant for joint planning purposes by Groundwater Management Area 16.

On June 2, 2022, TWDB requested clarifications about the wording of the desired future conditions, as some were unachievable based on TWDB analysis of the submitted model files during administrative review. In response, the Groundwater Management Area 16 consultant and groundwater conservation district representatives submitted an amended explanatory report (Young, 2022) on July 4, 2022. Groundwater Management Area 16

adopted a revised version of the desired future conditions for the Gulf Coast Aquifer System. The final desired future conditions adopted by the groundwater conservation district representatives in Groundwater Management Area 16 as described in Resolution No. 2022-01, on June 28, 2022 (Young, 2022; Appendix C), are presented below:

> *"Groundwater Management Area 16 adopts Desired Future Conditions for each county within the groundwater management area (county-specific DFC's) and adopts a Desired Future Condition for the counties in the groundwater management area (gma-specific DFC's). The Desired Future Condition for the counties in the groundwater management area shall not exceed an average drawdown of 78 feet for the Gulf Coast Aquifer System at December 2080. Desired Future Conditions for each county within the groundwater management area (county-specific DFC's) shall not exceed the values specified in Scenario 2 at December 2080.*
>
> *Table A-1: Desired Future Conditions for GMA 16 expressed as an Average Drawdown between January 2010 and December 2079.*
>
> *Bee GCD: 93 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Live Oak UWCD: 45 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *McMullen GCD: 12 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Red Sands GCD: 60 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Kenedy County GCD: 27 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Brush Country GCD: 89 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Duval County GCD: 137 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *San Patricio County GCD: 69 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Starr County GCD: 94 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Cameron: 119 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Hidalgo: 138 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Kleberg: 21 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Nueces: 26 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Webb: 161 feet of drawdown of the Gulf Coast Aquifer System;*
>
> *Willacy: 44 feet of drawdown of the Gulf Coast Aquifer System."*

METHODS:

The alternative groundwater availability model for Groundwater Management Area 16 (version 1.01; Hutchison and others, 2011) was run using the predictive model files ("Pumping Scenario #2") submitted with the desired future condition explanatory report (Young, 2022). Model-calculated water levels were extracted for January 2010 (stress period 11) and December 2079 (stress period 81), and drawdown was calculated as the difference between these water levels. Drawdown averages were calculated for the Gulf Coast Aquifer System by county, groundwater conservation district, and the entire groundwater management area. The calculated drawdown averages were compared with the desired future conditions to verify that the submitted pumping scenario can achieve the desired future conditions within the three-foot tolerance specified by Groundwater Management Area 16.

The modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The modeled available groundwater can be presented by groundwater conservation district and county within Groundwater Management Area 16 (Figure 1) and by county, regional water planning area, and river basin within Groundwater Management Area 16 (Figure 2)

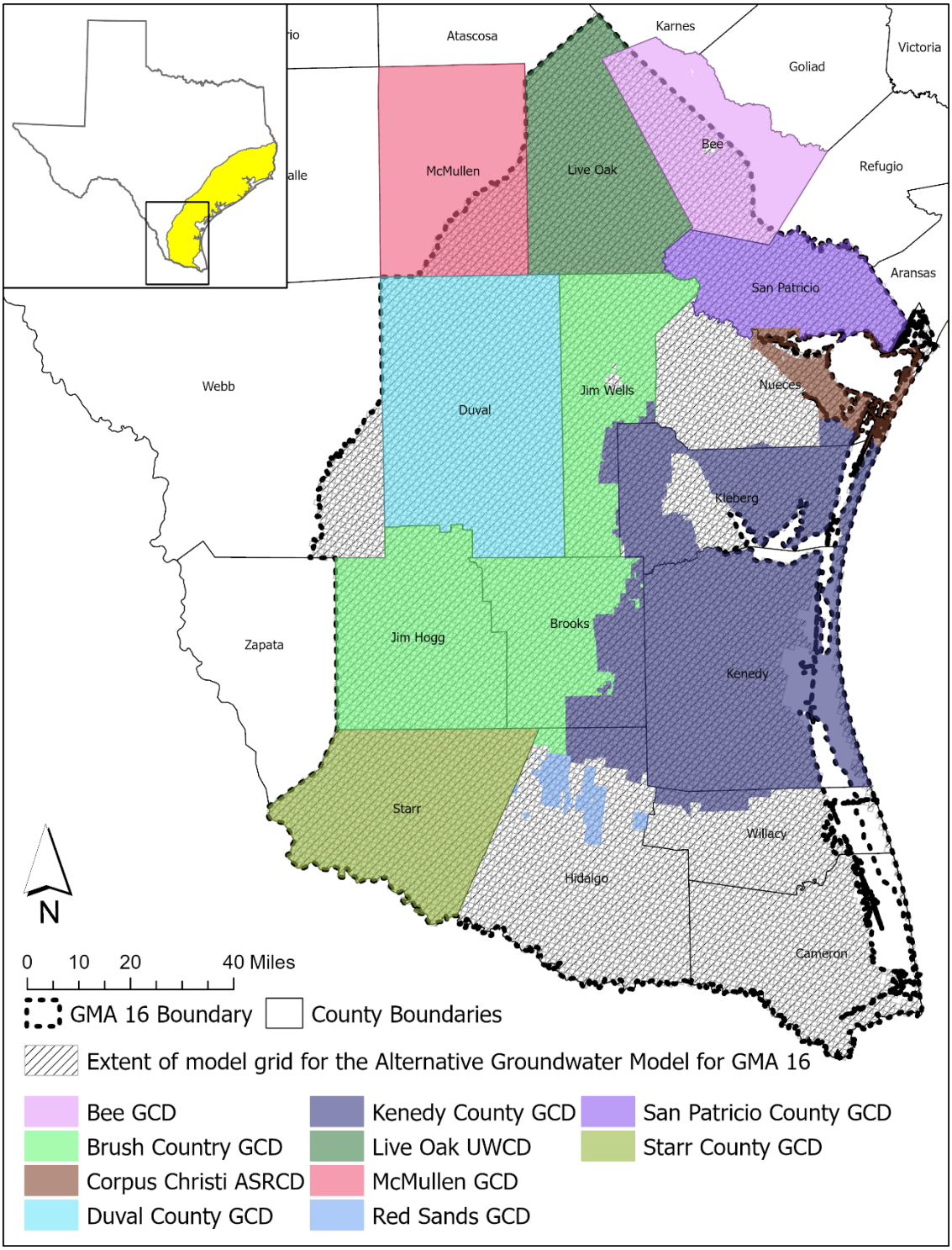

FIGURE 1. MAP SHOWING GROUNDWATER CONSERVATION DISTRICTS (GCDS) AND COUNTIES IN GROUNDWATER MANAGEMENT AREA 16, OVERLAIN ON THE EXTENT OF THE ALTERNATIVE GROUNDWATER AVAILABILITY MODEL FOR GROUNDWATER MANAGEMENT AREA 16.

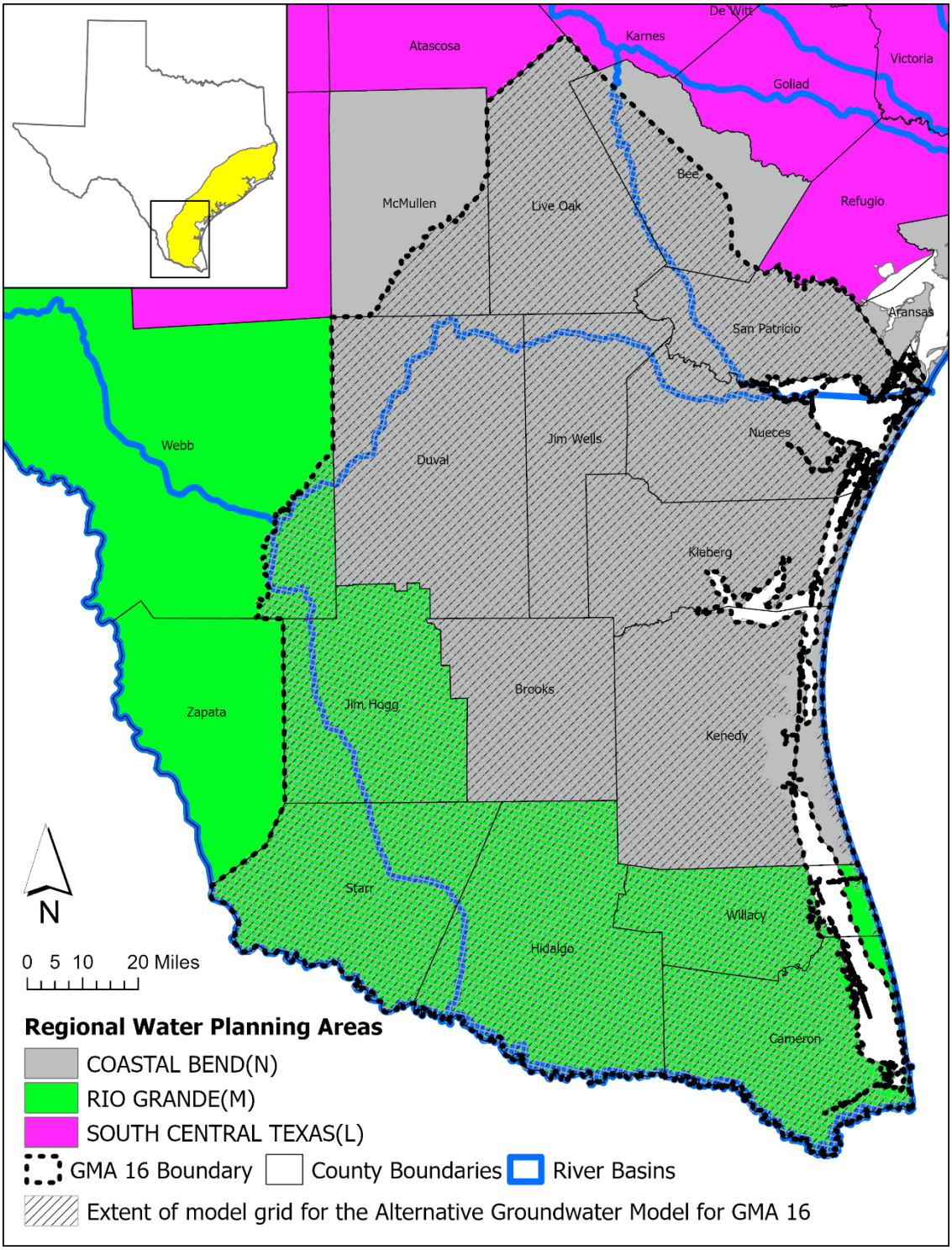

FIGURE 2. MAP SHOWING THE REGIONAL WATER PLANNING AREAS, COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 16, OVERLAIN ON THE EXTENT OF THE ALTERNATIVE GROUNDWATER AVAILABILITY MODEL FOR GROUNDWATER MANAGEMENT AREA 16.

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code (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 must consider modeled available groundwater when issuing permits in order to manage groundwater production to achieve the desired future condition(s). Districts must also consider 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.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the modeled available groundwater estimates are described below:

- Version 1.01 of the alternate groundwater availability model for Groundwater Management Area 16 was the base model for this analysis. See Hutchison and others (2011) for assumptions and limitations of the model. Groundwater Management Area 16 constructed a predictive model simulation to extend the base model to 2080 for planning purposes. See Young (2022) for the assumptions of this predictive model simulation.

- The model has six layers that represent the Chicot aquifer (Layer 1), the Evangeline aquifer (Layer 2), the Burkeville confining unit (Layer 3), the Jasper aquifer (Layer 4), the Yegua-Jackson Aquifer (Layer 5), and the Queen-City, Sparta and Carrizo-Wilcox Aquifer System (Layer 6). Layers 1 through 4 were lumped to calculate modeled available groundwater for the Gulf Coast Aquifer System.

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

- To be consistent with Groundwater Management Area 16, the TWDB model grid file dated May 1, 2014 (alt1_gma16) was used to determine model cell entity assignment (county, groundwater management area, groundwater conservation district, river basin, regional water planning area).

- Although the original groundwater availability model was only calibrated to the end of 1999, an analysis during the previous round of joint planning verified that the measured water levels did not change significantly for the period from 2000 to 2010 (Goswami, 2017). For this reason, TWDB considers it acceptable to use 2010 as the reference year for drawdown calculations.

- Drawdown averages and modeled available groundwater values are based on the official TWDB boundary for the groundwater conservation district, county, regional water planning area, river basin, and Regional Water Planning Areas within Groundwater Management Area 16 (Figures 1 and 2).

- Drawdown values for cells with water levels below the base elevation of the cell ("dry" cells) were included in the average drawdown calculations. The groundwater availability model for Groundwater Management Area 16 was constructed using the confined aquifer assumption (and LAYCON=0 option), meaning the transmissivity of "dry" cells remains constant and pumping from those cells continues. The desired future conditions adopted by Groundwater Management Area 16 are based on the average drawdowns that include "dry" cells. Therefore, pumping values from "dry" cells were also included in the calculation of modeled available groundwater. Please note that the confined aquifer assumption may also lead to physically unrealistic conditions, with pumping in a model cell continuing even when water levels have dropped below the base of the model cell.

- Drawdown was calculated as the difference in modeled water levels between the baseline date January 2010 (stress period 11) and the final date December 2079 (stress period 81). Average drawdowns were calculated as the sum of drawdowns for all model cells within a specified area divided by the number of cells in that specified area.

- Estimates of modeled available groundwater from the model simulation were rounded to whole numbers.

RESULTS:

The modeled available groundwater for the Gulf Coast Aquifer System that achieves the desired future conditions adopted by Groundwater Management Area 16 increases from approximately 229,000 acre-feet per year in 2020 to 294,000 acre-feet per year in 2080. The modeled available groundwater is summarized by groundwater conservation district and county (Table 1) and by county, regional water planning area, and river basin (Table 2) for use in the regional water planning process.

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 16 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District (GCD)	County	2020	2030	2040	2050	2060	2070	2080
Bee GCD	**Bee**	10,338	11,849	12,593	12,944	13,146	13,146	13,146
Brush Country GCD	Brooks	3,660	3,660	3,660	3,660	3,660	4,205	4,205
Brush Country GCD	Hidalgo	131	131	131	131	131	150	150
Brush Country GCD	Jim Hogg	6,167	6,167	6,167	6,167	6,167	7,084	7,084
Brush Country GCD	Jim Wells	8,701	9,065	9,393	9,758	10,050	11,544	11,544
Brush Country GCD Total		**18,659**	**19,023**	**19,351**	**19,716**	**20,008**	**22,983**	**22,983**
Duval County GCD	**Duval**	**20,571**	**22,169**	**23,764**	**25,363**	**26,963**	**26,963**	**26,963**
Kenedy County GCD	Brooks	1,308	1,463	1,693	1,847	2,078	2,232	2,232
Kenedy County GCD	Hidalgo	412	460	534	582	654	703	703
Kenedy County GCD	Jim Wells	296	330	383	417	469	505	505
Kenedy County GCD	Kenedy	9,040	10,104	11,698	12,762	14,358	15,421	15,421
Kenedy County GCD	Kleberg	4,291	4,796	5,553	6,058	6,815	7,320	7,320
Kenedy County GCD	Nueces	171	191	221	241	271	291	291
Kenedy County GCD	Willacy	328	365	424	462	520	558	558
Kenedy County GCD Total		**15,846**	**17,709**	**20,506**	**22,369**	**25,165**	**27,030**	**27,030**
Live Oak UWCD	**Live Oak**	**10,169**	**11,394**	**10,444**	**10,294**	**10,294**	**10,294**	**10,294**
McMullen GCD	**McMullen**	**510**	**510**	**510**	**510**	**510**	**510**	**510**
Red Sands GCD	**Hidalgo**	**1,667**	**1,966**	**2,265**	**2,563**	**2,863**	**2,863**	**2,863**
San Patricio County GCD	**San Patricio**	**43,611**	**45,016**	**46,422**	**47,828**	**49,234**	**49,234**	**49,234**
Starr County GCD	**Starr**	**3,798**	**4,797**	**5,797**	**6,794**	**7,795**	**7,795**	**7,795**

TABLE 1. CONTINUED

Groundwater Conservation District (GCD)	County	2020	2030	2040	2050	2060	2070	2080
No District-Cameron	Cameron	6,688	7,999	9,311	10,620	11,932	11,932	11,932
No District-Hidalgo	Hidalgo	85,634	90,905	96,175	101,445	106,715	106,715	106,715
No District-Kleberg	Kleberg	4,051	4,243	4,436	4,629	4,822	4,822	4,822
No District-Nueces	Nueces	6,339	6,596	6,857	7,115	7,372	7,372	7,372
No District-Webb	Webb	620	789	959	1,129	1,299	1,299	1,299
No District-Willacy	Willacy	664	785	905	1,024	1,145	1,145	1,145
No District-Total		**103,996**	**111,317**	**118,643**	**125,962**	**133,285**	**133,285**	**133,285**
GMA 16 Total		**229,165**	**245,750**	**260,295**	**274,343**	**289,263**	**294,103**	**294,103**

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 16. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2030 AND 2080.

County	RWPA	River Basin	2030	2040	2050	2060	2070	2080
Bee	N	Nueces	981	1,043	1,072	1,089	1,089	1,089
Bee	N	San Antonio-Nueces	10,868	11,550	11,872	12,057	12,057	12,057
Brooks	N	Nueces-Rio Grande	5,123	5,353	5,507	5,738	6,437	6,437
Cameron	M	Nueces-Rio Grande	7,536	8,771	10,005	11,241	11,241	11,241
Cameron	M	Rio Grande	463	540	615	691	691	691
Duval	N	Nueces	351	376	401	428	428	428
Duval	N	Nueces-Rio Grande	21,818	23,388	24,962	26,535	26,535	26,535
Hidalgo	M	Nueces-Rio Grande	91,421	96,658	101,867	107,103	107,171	107,171
Hidalgo	M	Rio Grande	2,041	2,447	2,854	3,260	3,260	3,260
Jim Hogg	M	Nueces-Rio Grande	5,230	5,230	5,230	5,230	6,008	6,008
Jim Hogg	M	Rio Grande	937	937	937	937	1,076	1,076
Jim Wells	N	Nueces	593	593	593	593	681	681
Jim Wells	N	Nueces-Rio Grande	8,802	9,183	9,582	9,926	11,368	11,368
Kenedy	N	Nueces-Rio Grande	10,104	11,698	12,762	14,358	15,421	15,421
Kleberg	N	Nueces-Rio Grande	9,039	9,989	10,687	11,637	12,142	12,142
Live Oak	N	Nueces	11,326	10,382	10,233	10,233	10,233	10,233
Live Oak	N	San Antonio-Nueces	68	62	61	61	61	61
McMullen	N	Nueces	510	510	510	510	510	510
Nueces	N	Nueces	756	787	816	845	845	845
Nueces	N	Nueces-Rio Grande	6,031	6,291	6,540	6,798	6,818	6,818
San Patricio	N	Nueces	4,502	4,874	5,247	5,619	5,619	5,619
San Patricio	N	San Antonio-Nueces	40,514	41,548	42,581	43,615	43,615	43,615

TABLE 2. CONTINUED

County	RWPA	River Basin	2030	2040	2050	2060	2070	2080
Starr	M	Nueces-Rio Grande	1,958	2,366	2,772	3,180	3,180	3,180
Starr	M	Rio Grande	2,839	3,431	4,022	4,615	4,615	4,615
Webb	M	Nueces	22	27	32	37	37	37
Webb	M	Nueces-Rio Grande	642	780	918	1,056	1,056	1,056
Webb	M	Rio Grande	125	152	179	206	206	206
Willacy	M	Nueces-Rio Grande	1,150	1,329	1,486	1,665	1,703	1,703
GMA 16 Total			**245,750**	**260,295**	**274,343**	**289,263**	**294,103**	**294,103**

*GCAS: Gulf Coast Aquifer System

LIMITATIONS:

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

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

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

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

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

REFERENCES:

Goswami, R.R., 2017, GAM Run 17-025 MAG: Modeled Available Groundwater for the Gulf Coast Aquifer System in Groundwater Management Area 16. Texas Water Development Board. Ay 2017

Hutchison, W.R., Hill, M.E., Anaya, R., Hassan, M.M., Oliver, W., Jigmond, M., Wade, S., and Aschenbach, E. 2011. Groundwater Management Are 16 Groundwater Flow Model, Texas Water Development Board,306 p. https://www.twdb.texas.gov/groundwater/models/alt/gma16/GMA16_Model_Report_DRAFT.pdf?d=3579

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

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model- user guide to modularization concepts and the groundwater flow process: U.S. Geological Survey, Open-File Report 00-92.

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

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

Young, S., 2022. Desired Future Condition Explanatory Report for Groundwater Management Area 16. Prepared for Groundwater Management Area 16 Member Districts. July 2022.