SAN PATRICIO COUNTY

Amended

Groundwater Management Plan

Prepared by

San Patricio County Groundwater Conservation District

February 7, 2019

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 the district 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 Robert Gonzalez, 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, and Refugio counties. GCDs neighboring the District are: Corpus Christi Aquifer Storage and Recovery CD, Bee GCD, Live Oak GCD, and Refugio GCD (Figure 1).

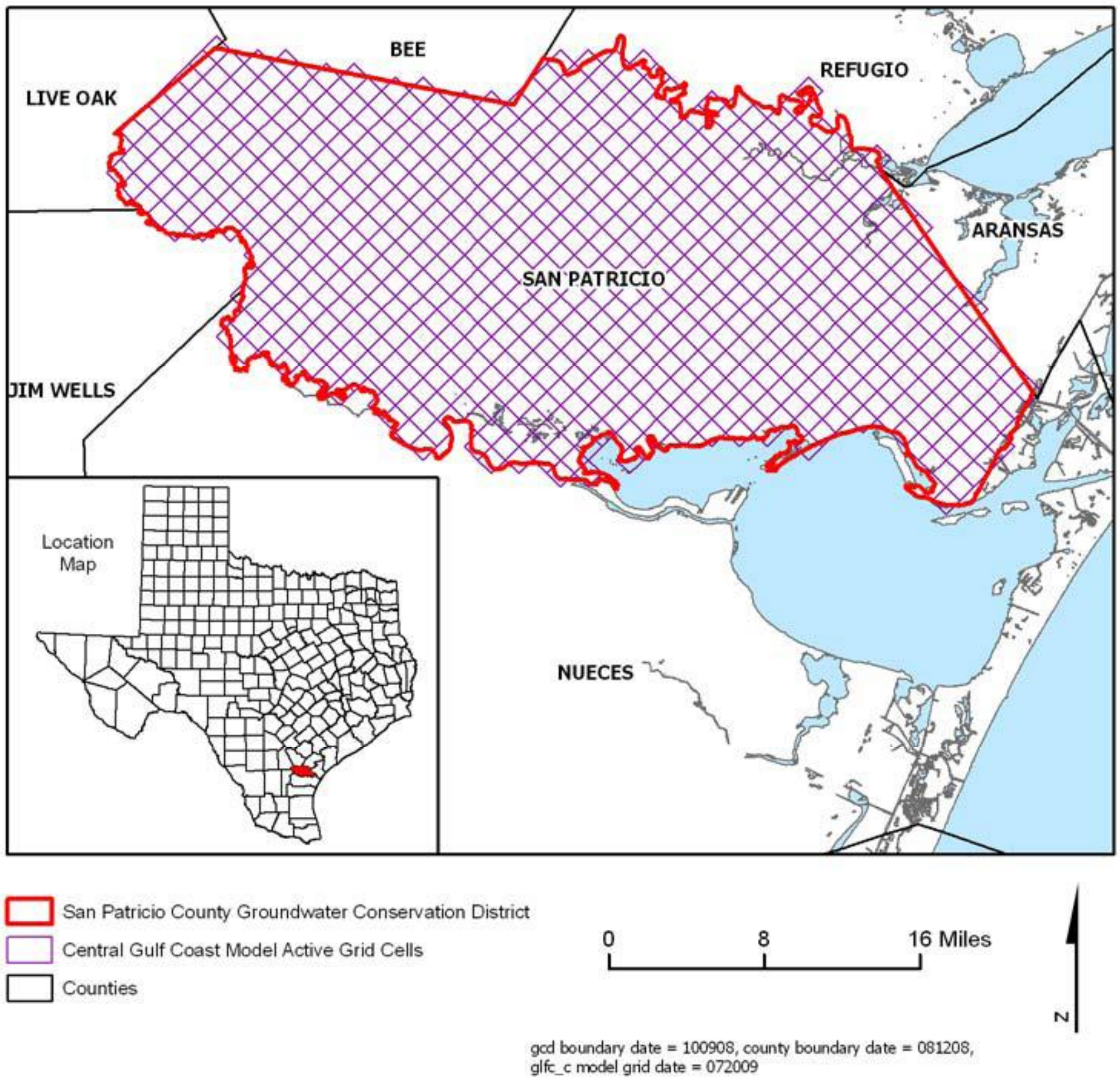

Figure 1: Area of the groundwater availability model for the central portion of the Gulf Coast Aquifer (San Patricio County Groundwater Conservation District boundary).

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

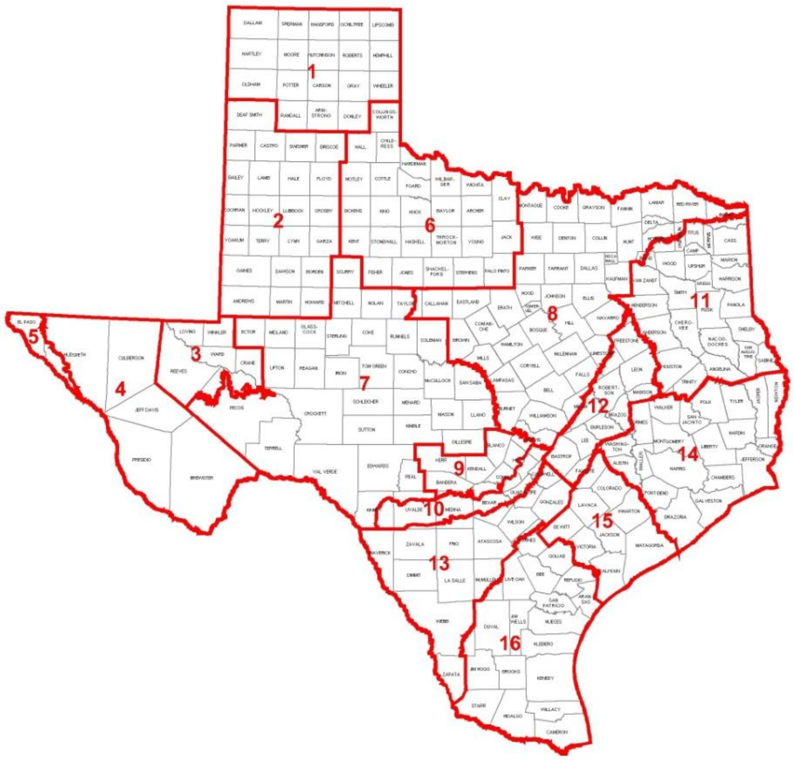

Figure 2. Groundwater Management Areas in Texas.

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, 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 inter-bedded 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 down-dip 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="5">Tertiary</td><td>Pliocene</td><td colspan="2">Goliad Sand</td><td rowspan="2">Evangeline aquifer</td></tr>
<tr><td rowspan="4">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 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 17-025MAG by the TWDB the Modeled Available Groundwater is available in the index.

X. Down-Gradient Movement (Lateral Underflow) in the Aquifer

The District recognizes annual groundwater availability in the portion of the Gulf Coast Aquifer underlying the County is the sum of:

1. Recharge (amount of water annually entering the aquifer through infiltration of rainfall);
2. Net lateral underflow (amount of water annually entering the district through underground migration of water moving down-gradient in the aquifer after being recharged in aquifer outcrops lying beyond the district boundaries less the amount of water that may migrate in a similar fashion out of the district boundaries); and
3. Amount of water (if any) annually taken from storage in the aquifer within the district boundaries.

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.

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

The estimates of annual natural and artificial recharge are available in Appendix A under GAM Run 16-003

XII. Water Management Strategies to Meet Water User Group Needs

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

XIII. Projected Water Supply Needs

The estimated projected water supply needs is 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 17-025 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. An observation network will be established and maintained to monitor changing storage conditions of groundwater supplies in The District. The District will make a regular assessment of water supply and groundwater storage conditions and will report those conditions to the board and the public. 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 has adopted rules to regulate groundwater withdrawals by means of well spacing and production limits. 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.

Relevant factors to be considered in making a determination to issue a permit or groundwater withdrawal limitations or spacing limitations will include:

1) purpose of the District Rules
2) distribution of groundwater resources
3) economic hardship resulting from approval or denial of a permit or terms prescribed by the permit

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.

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:

The board will establish a water well monitor network to ensure compliance with the DFC.

Performance Standard:

The board will establish a monitor well network and conduct regular measurements of water levels on, at least, 3 wells within the District. A report on water levels of the District's aquifers will be included in annual report to the board.

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.

Management Objective:

The District will provide information to the public on eliminating and reducing wasteful groundwater use practices.

Performance Standard:

A copy of information provided on the District's website regarding groundwater waste reduction will be included in Annual Report to the District.

Goal 3.0: Controlling and preventing subsidence

The geologic framework of the District Area precludes any significant subsidence from occurring. This management goal is not applicable to the operations of the District.

Goal 4.0: Addressing Conjunctive surface water management issues

Except as provided in Chapter 36 of the Texas Water Code, the District does not have any jurisdiction over surface water. The District shall consider the effects of surface water resources as required by Section 36.113 and other state law. This goal is not applicable at this time.

Goal 5.0: Addressing Natural Resource Issues

Management Objective:

A District representative will participate in the regional planning process by attending at least 50% of the Region N Water Planning Group meetings to encourage development of surface water supplies to meet the needs of water user groups in the District.

Performance Standard:

The attendance of a District representative at Region N Water Planning Group meetings will be noted in the Annual 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 Palmer Drought Severity Index will be presented to the District board on an annual basis.

Goal 7.0: Addressing Conservation

Management Objective:

The District will provide an article discussing water conservation in, at least, one newspaper of general circulation within the County.

Performance Standard:

A copy of the article submitted for publication to a newspaper of general circulation in the County discussing water conservation will be included in the Annual Report to the board.

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.

<u>Performance Standard:</u>

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 Water Use And 2017 State Water Plan Datasets:

San Patricio County Groundwater Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
January 11, 2017

GROUNDWATER MANAGEMENT PLAN DATA:

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

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

The five reports included in this part are:

1. Estimated Historical Water Use (checklist item 2)

   from the TWDB Historical Water Use Survey (WUS)

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

   from the 2017 Texas State Water Plan (SWP)

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

DISCLAIMER:

The data presented in this report represents the most up-to-date WUS and 2017 SWP data available as of 1/11/2017. Although it does not happen frequently, either of these datasets are subject to change pending the availability of more accurate WUS data or an amendment to the 2017 SWP. District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The WUS dataset can be verified at this web address:

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

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

For additional questions regarding this data, please contact Stephen Allen (stephen.allen@twdb.texas.gov or 512-463-7317) or Rima Petrossian (rima.petrossian@twdb.texas.gov or 512-936-2420).

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

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2015. 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
2014	GW	1,822	25	1	0	7,626	174	9,648
	SW	7,038	10,465	0	0	159	174	17,836
2013	GW	2,091	3	1	0	6,267	167	8,529
	SW	8,321	10,255	0	0	236	167	18,979
2012	GW	2,232	1	12	0	11,447	192	13,884
	SW	8,569	10,347	1	0	226	191	19,334
2011	GW	2,473	3	120	0	14,441	234	17,271
	SW	7,685	8,928	154	0	204	233	17,204
2010	GW	2,691	2	135	0	7,175	225	10,228
	SW	6,927	9,492	173	0	0	224	16,816
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
2003	GW	2,159	10	3	0	7,891	20	10,083
	SW	7,114	7,657	0	0	128	340	15,239
2002	GW	2,367	4	0	0	4,492	26	6,889
	SW	7,691	8,058	0	0	0	448	16,197
2001	GW	2,393	9	0	0	4,389	26	6,817
	SW	12,177	5,741	0	0	0	450	18,368
2000	GW	2,396	12	0	0	4,565	57	7,030
	SW	9,358	8,961	0	0	0	508	18,827

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	565	574	574	577	583	588
N	ARANSAS PASS	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	566	574	575	578	584	588
N	COUNTY-OTHER, SAN PATRICIO	NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	105	118	137	150	159	166
N	COUNTY-OTHER, SAN PATRICIO	NUECES	TEXANA LAKE/RESERVOIR	51	63	82	96	104	111
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	179	181
N	INGLESIDE	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	526	531	530	532	537	542
N	INGLESIDE	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	525	531	530	532	537	541
N	INGLESIDE ON THE BAY	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	38	39	39	39	39	39
N	INGLESIDE ON THE BAY	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	39	39	39	39	40	40
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	102	102	102	102	102	102
N	LIVESTOCK, SAN PATRICIO	SAN ANTONIO-NUECES	SAN ANTONIO-NUECES LIVESTOCK LOCAL SUPPLY	13	13	13	13	13	13
N	MANUFACTURING, SAN PATRICIO	NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	12,983	13,493	13,958	14,382	14,916	15,483
N	MANUFACTURING, SAN PATRICIO	NUECES	TEXANA LAKE/RESERVOIR	2,117	2,071	2,064	2,042	2,018	1,998

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
N	MANUFACTURING, SAN PATRICIO	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	15,241	15,839	16,385	16,884	17,511	18,175
N	MANUFACTURING, SAN PATRICIO	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	2,485	2,431	2,423	2,398	2,368	2,346
N	MATHIS	NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	335	338	336	339	342	345
N	MATHIS	NUECES	TEXANA LAKE/RESERVOIR	335	338	336	340	343	346
N	ODEM	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	189	192	192	193	195	198
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	1,315	1,342	1,349	1,359	1,373	1,385
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	173	177	179	181	183	184
N	RINCON WSC	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	173	178	180	182	183	185
N	TAFT	SAN ANTONIO-NUECES	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	232	235	235	238	240	242
N	TAFT	SAN ANTONIO-NUECES	TEXANA LAKE/RESERVOIR	232	235	234	237	240	242
	Sum of Projected Surface Water Supplies (acre-feet)			**40,185**	**41,331**	**42,381**	**43,340**	**44,538**	**45,801**

Projected Water Demands
TWDB 2017 State Water Plan Data

Please note that the demand numbers presented here include the plumbing code savings found in the Regional and State Water Plans.

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	1,131	1,148	1,149	1,155	1,167	1,176
N	COUNTY-OTHER, SAN PATRICIO	NUECES	473	480	492	500	505	509
N	COUNTY-OTHER, SAN PATRICIO	SAN ANTONIO-NUECES	1,111	1,129	1,155	1,174	1,186	1,196
N	GREGORY	SAN ANTONIO-NUECES	339	344	348	354	358	361
N	INGLESIDE	SAN ANTONIO-NUECES	1,051	1,062	1,060	1,064	1,074	1,083
N	INGLESIDE ON THE BAY	SAN ANTONIO-NUECES	77	78	78	78	79	79
N	IRRIGATION, SAN PATRICIO	NUECES	1,109	1,224	1,353	1,494	1,650	1,863
N	IRRIGATION, SAN PATRICIO	SAN ANTONIO-NUECES	9,976	11,020	12,172	13,446	14,854	16,769
N	LAKE CITY	NUECES	64	65	64	64	65	66
N	LIVESTOCK, SAN PATRICIO	NUECES	205	205	205	205	205	205
N	LIVESTOCK, SAN PATRICIO	SAN ANTONIO-NUECES	201	201	201	201	201	201
N	MANUFACTURING, SAN PATRICIO	NUECES	18,279	19,825	21,351	22,695	24,392	26,216
N	MANUFACTURING, SAN PATRICIO	SAN ANTONIO-NUECES	21,458	23,273	25,065	26,643	28,635	30,775
N	MATHIS	NUECES	670	676	672	679	685	691
N	MINING, SAN PATRICIO	NUECES	78	88	92	97	103	112
N	MINING, SAN PATRICIO	SAN ANTONIO-NUECES	294	333	348	363	389	421
N	ODEM	SAN ANTONIO-NUECES	379	384	384	387	391	394
N	PORTLAND	SAN ANTONIO-NUECES	2,631	2,684	2,698	2,718	2,747	2,770
N	RINCON WSC	SAN ANTONIO-NUECES	346	355	359	363	366	369
N	SINTON	SAN ANTONIO-NUECES	1,409	1,448	1,463	1,478	1,495	1,507
N	TAFT	SAN ANTONIO-NUECES	464	470	469	475	480	484
		Sum of Projected Water Demands (acre-feet)	**61,745**	**66,492**	**71,178**	**75,633**	**81,027**	**87,247**

Projected Water Supply Needs
TWDB 2017 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	INGLESIDE ON THE BAY	SAN ANTONIO-NUECES	0	0	0	0	0	0
N	IRRIGATION, SAN PATRICIO	NUECES	1,160	1,045	916	0	0	0
N	IRRIGATION, SAN PATRICIO	SAN ANTONIO-NUECES	2,196	1,152	0	-499	-2,063	-4,191
N	LAKE CITY	NUECES	6	5	6	6	5	4
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	-3,177	-4,259	-5,327	-6,269	-7,456	-8,733
N	MANUFACTURING, SAN PATRICIO	SAN ANTONIO-NUECES	-3,274	-4,545	-5,799	-6,903	-8,298	-9,796
N	MATHIS	NUECES	0	0	0	0	0	0
N	MINING, SAN PATRICIO	NUECES	37	27	23	18	12	3
N	MINING, SAN PATRICIO	SAN ANTONIO-NUECES	156	117	102	87	61	29
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	560	521	506	491	474	462
N	TAFT	SAN ANTONIO-NUECES	0	0	0	0	0	0
		Sum of Projected Water Supply Needs (acre-feet)	**-6,451**	**-8,804**	**-11,126**	**-13,671**	**-17,817**	**-22,720**

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 WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [SAN PATRICIO]	8	11	6	6	5	5
		8	**11**	**6**	**6**	**5**	**5**
IRRIGATION, SAN PATRICIO, NUECES (N)							
IRRIGATION WATER CONSERVATION	DEMAND REDUCTION [SAN PATRICIO]	0	0	0	149	206	279
		0	**0**	**0**	**149**	**206**	**279**
IRRIGATION, SAN PATRICIO, SAN ANTONIO-NUECES (N)							
GULF COAST AQUIFER - SAN PATRICIO IRRIGATION	GULF COAST AQUIFER [SAN PATRICIO]	0	0	0	237	237	237
IRRIGATION WATER CONSERVATION	DEMAND REDUCTION [SAN PATRICIO]	0	0	0	1,345	1,857	2,516
SUPPLY REDUCTION FOR SAN PATRICIO IRRIGATION	GULF COAST AQUIFER [SAN PATRICIO]	0	0	0	466	466	466
		0	**0**	**0**	**2,048**	**2,560**	**3,219**
MANUFACTURING, SAN PATRICIO, NUECES (N)							
GBRA LOWER BASIN OFF-CHANNEL RESERVOIR	GBRA LOWER BASIN OFF-CHANNEL LAKE/ RESERVOIR [RESERVOIR]	0	3,680	3,680	3,680	3,680	3,680
MANUFACTURING WATER CONSERVATION	DEMAND REDUCTION [SAN PATRICIO]	248	268	287	306	325	344
SEAWATER DESALINATION	GULF OF MEXICO [GULF OF MEXICO]	0	4,140	4,140	4,140	4,140	4,140
SPMWD INDUSTRIAL WTP IMPROVEMENTS	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM [RESERVOIR]	3,432	2,875	2,402	1,956	1,399	812
		3,680	**10,963**	**10,509**	**10,082**	**9,544**	**8,976**
MANUFACTURING, SAN PATRICIO, SAN ANTONIO-NUECES (N)							
GBRA LOWER BASIN OFF-CHANNEL RESERVOIR	GBRA LOWER BASIN OFF-CHANNEL LAKE/ RESERVOIR [RESERVOIR]	0	4,320	4,320	4,320	4,320	4,320
MANUFACTURING WATER CONSERVATION	DEMAND REDUCTION [SAN PATRICIO]	292	314	337	359	381	404
PORTLAND REUSE PIPELINE	DIRECT REUSE [SAN PATRICIO]	2,240	2,240	2,240	2,240	2,240	2,240
SEAWATER DESALINATION	GULF OF MEXICO [GULF OF MEXICO]	0	4,860	4,860	4,860	4,860	4,860

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
SPMWD INDUSTRIAL WTP IMPROVEMENTS	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM [RESERVOIR]	4,028	3,375	2,820	2,297	1,642	953
		6,560	**15,109**	**14,577**	**14,076**	**13,443**	**12,777**
PORTLAND, SAN ANTONIO-NUECES (N)							
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [SAN PATRICIO]	74	49	0	0	0	0
		74	**49**	**0**	**0**	**0**	**0**
SINTON, SAN ANTONIO-NUECES (N)							
MUNICIPAL WATER CONSERVATION (SUBURBAN)	DEMAND REDUCTION [SAN PATRICIO]	62	170	277	385	447	451
		62	**170**	**277**	**385**	**447**	**451**
Sum of Projected Water Management Strategies (acre-feet)		**10,384**	**26,302**	**25,369**	**26,746**	**26,205**	**25,707**

GAM Run 16-003: San Patricio County Groundwater Conservation District Management Plan

Rohit R. Goswami, Ph.D.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 463-0495
August 4, 2016

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by Rohit R. Goswami under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on August 4, 2016.

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GAM RUN 16-003: SAN PATRICIO COUNTY GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

Rohit R. Goswami, Ph.D.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 463-0495
August 4, 2016

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2015), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the executive administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

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.

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

The groundwater management plan for the San Patricio County Groundwater Conservation District should be adopted by the district on or before March 21, 2017 and submitted to the Executive Administrator of the TWDB on or before April 20, 2017. The current management plan for the San Patricio County Groundwater Conservation District expires on June 19, 2017.

The Gulf Coast Aquifer System is the only aquifer identified by TWDB in the San Patricio County Groundwater Conservation District. Information for the Gulf Coast Aquifer System was extracted from version 1.01 of the groundwater availability model for the central portion of the Gulf Coast Aquifer System (Chowdhury and others, 2004).

This report discusses the methods, assumptions, and results from model runs using the groundwater availability model for the central portion of the Gulf Coast Aquifer System. This model run report replaces the results of GAM Run 09-015 (Aschenbach, 2009). GAM Run 16-003 meets current standards set after the release of GAM Run 09-015. Table 1 summarizes the groundwater availability model data required by statute, and Figure 1 shows the area of the models from which the values in the tables were extracted. If after review of the figure, 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 for the central portion of the Gulf Coast Aquifer System (Chowdhury and others, 2004) was run for this analysis. San Patricio County Groundwater Conservation District water budgets were extracted for the historical model period (1981 through 1999) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface water outflow, inflow to the district, and outflow from the district for the Gulf Coast Aquifer System within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Gulf Coast Aquifer System

1. 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.

2. 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.

3. 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).

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 model for the Gulf Coast Aquifer System within the district and averaged over the historical calibration period of the model run in the district, 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 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 ONE ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	9,977
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	10,100
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	9,013
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	3,807
Estimated net annual volume of flow between each aquifer in the district[1]	From Gulf Coast Aquifer System to formations containing brackish water	3,216

[1] The model assumes no cross-formational flow between base of the Jasper Aquifer and parts of the Catahoula Formation with underlying formations.

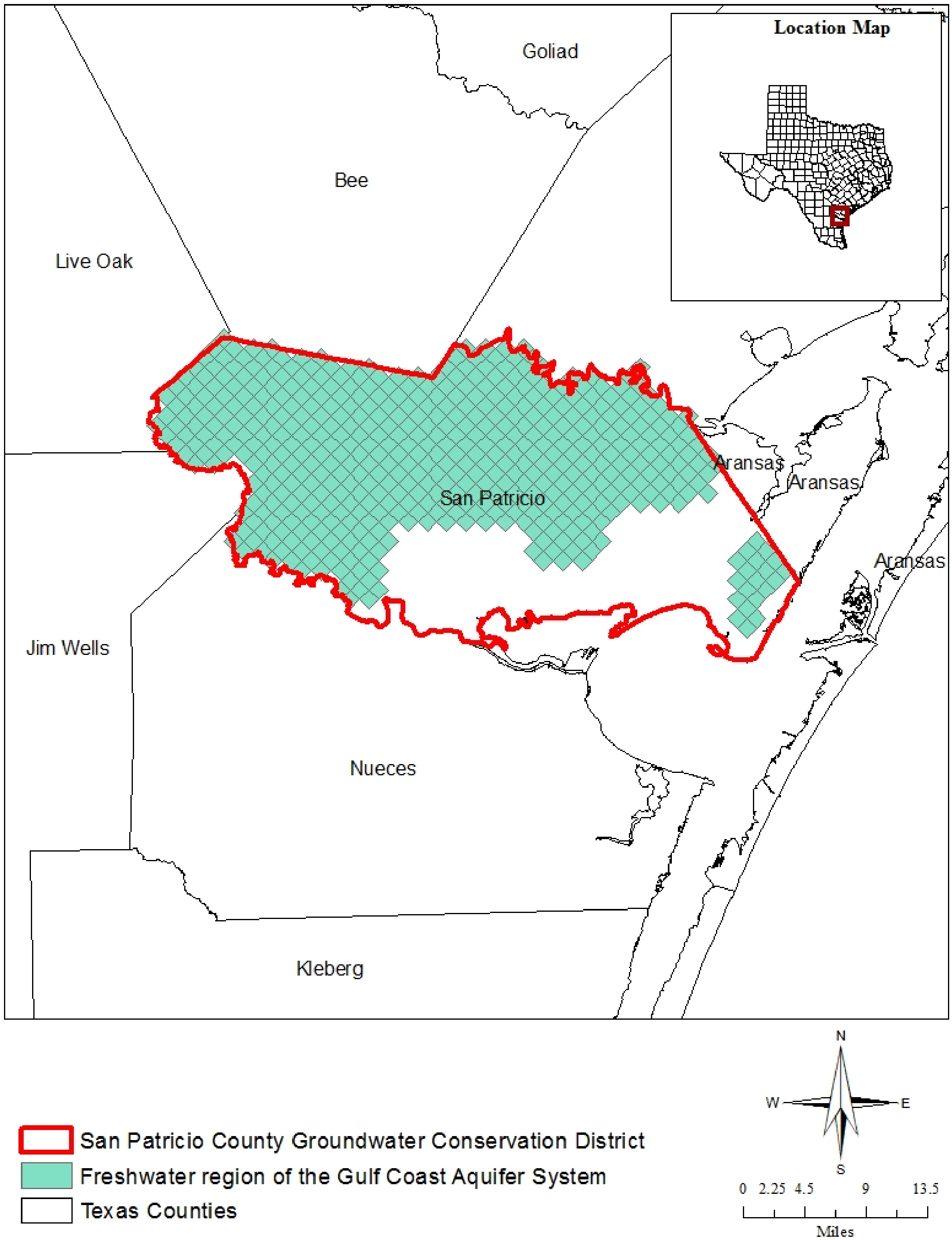

FIGURE1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE GULF COAST AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED FOR THE SAN PATRICIO COUNTY GROUNDWATER CONSERVATION DISTRICT.

LIMITATIONS:

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

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

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

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

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

REFERENCES:

Aschenbach, E., 2009, GAM Run 09-015: Texas Water Development Board, GAM Run 09-015 Report, 5 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR09-15.pdf.

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GAM RUN 17-025 MAG: MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 16

Rohit Raj Goswami, Ph.D., P.E.
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(512) 463-0495
May 19, 2017

STATE OF TEXAS
ROHIT R. GOSWAMI
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PROFESSIONAL ENGINEER

05/19/2017

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GAM RUN 17-025 MAG: MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 16

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May 19, 2017

EXECUTIVE SUMMARY:

The modeled available groundwater for Groundwater Management Area 16 (Figure 1) for the Gulf Coast Aquifer System is summarized by decade for the groundwater conservation districts and counties (Table 1) and for use in the regional water planning process (Table 2). The modeled available groundwater estimates range from approximately 233,000 acre-feet per year in 2020 to 312,000 acre-feet per year in 2060 (Tables 1 and 2). The estimates were extracted from results of a model run using the alternative groundwater availability model for Groundwater Management Area 16 (version 1.01). The model run files, which meet the desired future conditions of Groundwater Management Area 16, were submitted to the Texas Water Development Board (TWDB) as part of the Desired Future Conditions Explanatory Report for Groundwater Management Area 16. The explanatory report and other materials submitted to the TWDB were determined to be administratively complete on April 19, 2017.

REQUESTOR:

Mr. David O'Rourke, consultant for Groundwater Management Area 16.

DESCRIPTION OF REQUEST:

In a letter dated January 25, 2017, Mr. David O'Rourke, 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. All other aquifers in Groundwater Management Area 16 (Carrizo-Wilcox and Yegua-Jackson) were declared non-relevant for joint planning purposes. The Gulf Coast Aquifer System includes the Chicot Aquifer, Evangeline Aquifer, and the Jasper Aquifer. Clarifications to the submitted materials were received by TWDB on April 4, 2017. The desired future conditions for the Gulf Coast Aquifer System, as described in Resolution No. 2017-01 and adopted January 17, 2017, by the groundwater conservation districts within Groundwater Management Area 16, are described below:

Groundwater Management Area 16 [all counties]

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 62 feet in December 2060 from estimated year 2010 conditions.

Bee Groundwater Conservation District

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 76 feet in December 2060 from estimated year 2010 conditions.

Live Oak Underground Water Conservation District

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 34 feet in December 2060 from estimated year 2010 conditions.

McMullen Groundwater Conservation District

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 9 feet in December 2060 from estimated year 2010 conditions.

Red Sands Groundwater Conservation District

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 40 feet in December 2060 from estimated year 2010 conditions.

Kenedy County Groundwater Conservation District

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 40 feet in December 2060 from estimated year 2010 conditions.

Brush Country Groundwater Conservation District

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 69 feet in December 2060 from estimated year 2010 conditions.

Duval County Groundwater Conservation District

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 104 feet in December 2060 from estimated year 2010 conditions.

San Patricio County Groundwater Conservation District

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 48 feet in December 2060 from estimated year 2010 conditions.

Starr County Groundwater Conservation District

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 69 feet in December 2060 from estimated year 2010 conditions.

No District - Cameron County

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 70 feet in December 2060 from estimated year 2010 conditions.

No District - Hidalgo County

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 118 feet in December 2060 from estimated year 2010 conditions.

No District - Kleberg County

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 28 feet in December 2060 from estimated year 2010 conditions.

No District - Nueces County

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 21 feet in December 2060 from estimated year 2010 conditions.

No District - Webb County

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 113 feet in December 2060 from estimated year 2010 conditions.

No District - Willacy County

Drawdown of the Gulf Coast Aquifer System shall not exceed an average of 40 feet in December 2060 from estimated year 2010 conditions.

METHODS:

The alternative groundwater availability model for Groundwater Management Area 16 (Hutchison and others, 2011) was run using the model files submitted with the explanatory report (O'Rourke, 2017). Model-calculated water levels were extracted for the years 2010 and 2060, and drawdown was calculated as the difference between water levels at the beginning of 2010 and water levels at the end of 2060. Drawdown averages were calculated for the Gulf Coast Aquifer System by county, groundwater conservation districts, and the entire groundwater management area. As specified in the explanatory report (O'Rourke, 2017), drawdown for model cells that became dry during the simulation (water level dropped below the base of the cell) were excluded from the averaging. The calculated drawdown averages were compared with the desired future conditions to verify that the pumping scenario specified by the district representatives achieved the desired future conditions within a one-foot variance.

The modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Table 1 presents the annual pumping rates by county and groundwater conservation district, subtotaled by groundwater conservation district, and then summed for Groundwater Management Area 16. Table 2 presents the annual pumping rates by county, river basin, regional water planning area, and groundwater conservation district within Groundwater Management Area 16.

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "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 groundwater availability are described below:

- The analysis used version 1.01 of the alternate groundwater availability model for Groundwater Management Area 16. See Hutchison and others (2011) for assumptions and limitations of the model.

- 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).

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

- Groundwater Division checked the validity of the assertion that starting water levels in the model were comparable to the measured water-level conditions at the end of year 2010. Water-level values were averaged over the entire area of Groundwater Management Area 16 for the measured and modeled conditions between the years 2000 and 2010. These averaged water-level values are reported in Table 3. As presented in Table 3, the average water-levels indicate that conditions in the field did not change significantly, however, model estimated values differ significantly (by over 12 feet). Such a difference in the model estimates can be explained by the difference in values of pumping and recharge used in the model and those occurring in the field for the period between the years 2000 and 2010. It is important to note here that the groundwater availability model for Groundwater Management Area 16 was constructed using the confined aquifer assumption (and LAYCON=0 option) available within MODFLOW-96. Such an assumption leads to an almost linear response between pumping and drawdown. The Groundwater Division checked and verified the validity of the assumption by taking out the pumping input in the model from the years 2000 to 2010 and obtaining equivalent drawdown values in the year 2060. Based on the analysis, we conclude that the submitted model files are acceptable for developing estimates 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 averages and modeled available groundwater values are based on official aquifer boundaries (Figures 1 and 2).

- Drawdown values for cells with water levels below the base elevation of the cell ("dry" cells) were excluded from the averaging. However, pumping values from those cells were included in the calculation of modeled available groundwater.

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

- Average drawdown per county may include some model cells that represent portions of surface water such as bays, reservoirs, and the Gulf of Mexico.

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 233,000 acre-feet per year in 2020 to 312,000 acre-feet per year in 2060 (Tables 1 and 2). The modeled available groundwater is summarized by groundwater conservation district and county (Table 1) and by county, river basin, and regional water planning area for use in the regional water planning process (Table 2). Small differences of values between table summaries are due to rounding errors.

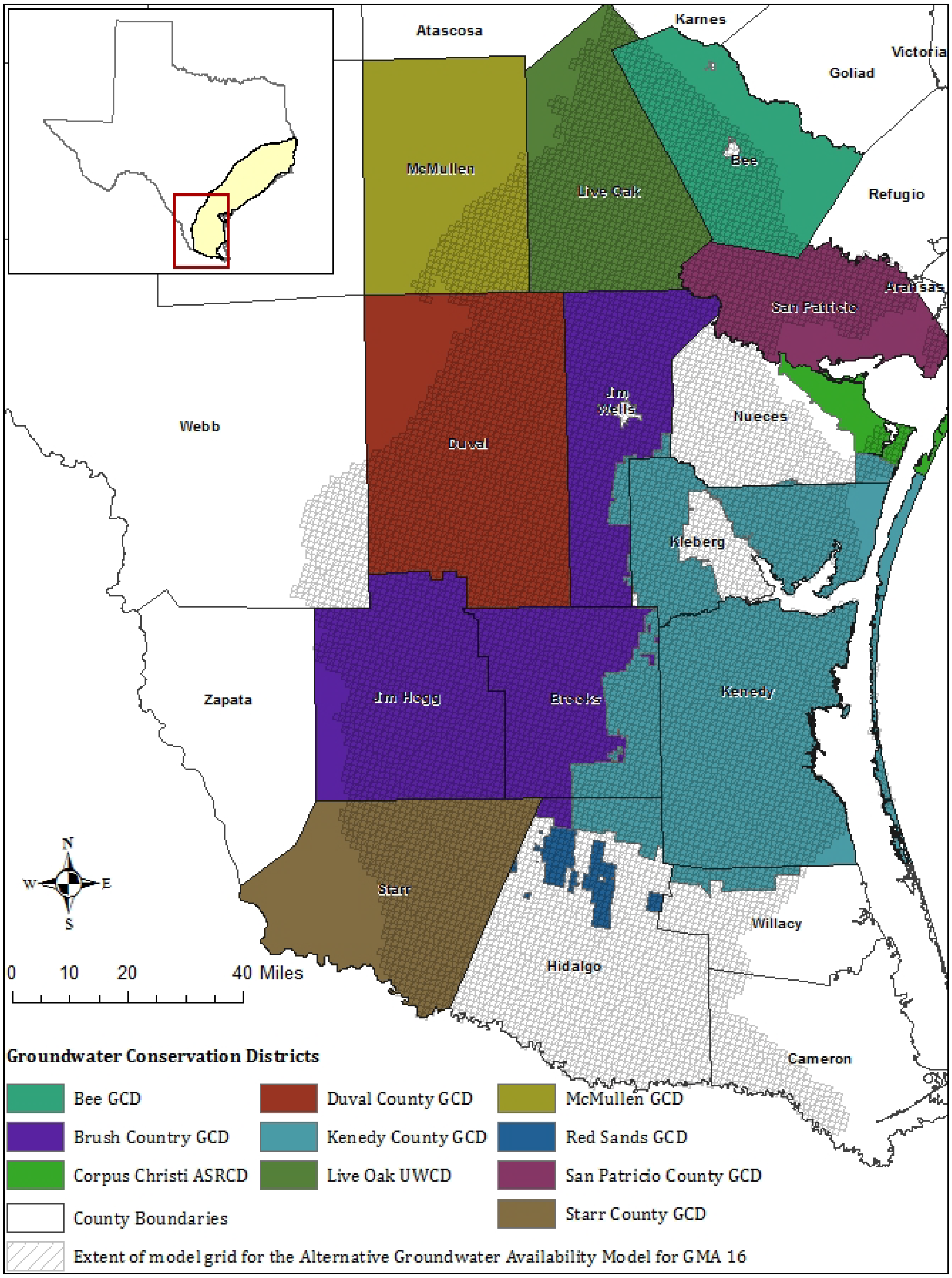

FIGURE 1. MAP SHOWING GROUNDWATER CONSERVATION DISTRICTS (GCDS), COUNTIES, AND GULF COAST AQUIFER SYSTEM EXTENT IN GROUNDWATER MANAGEMENT AREA 16 OVERLAIN ON THE EXTENT OF THE ALTERNATIVE GROUNDWATER AVAILABILITY MODEL FOR GROUNDWATER MANAGEMENT AREA 16.

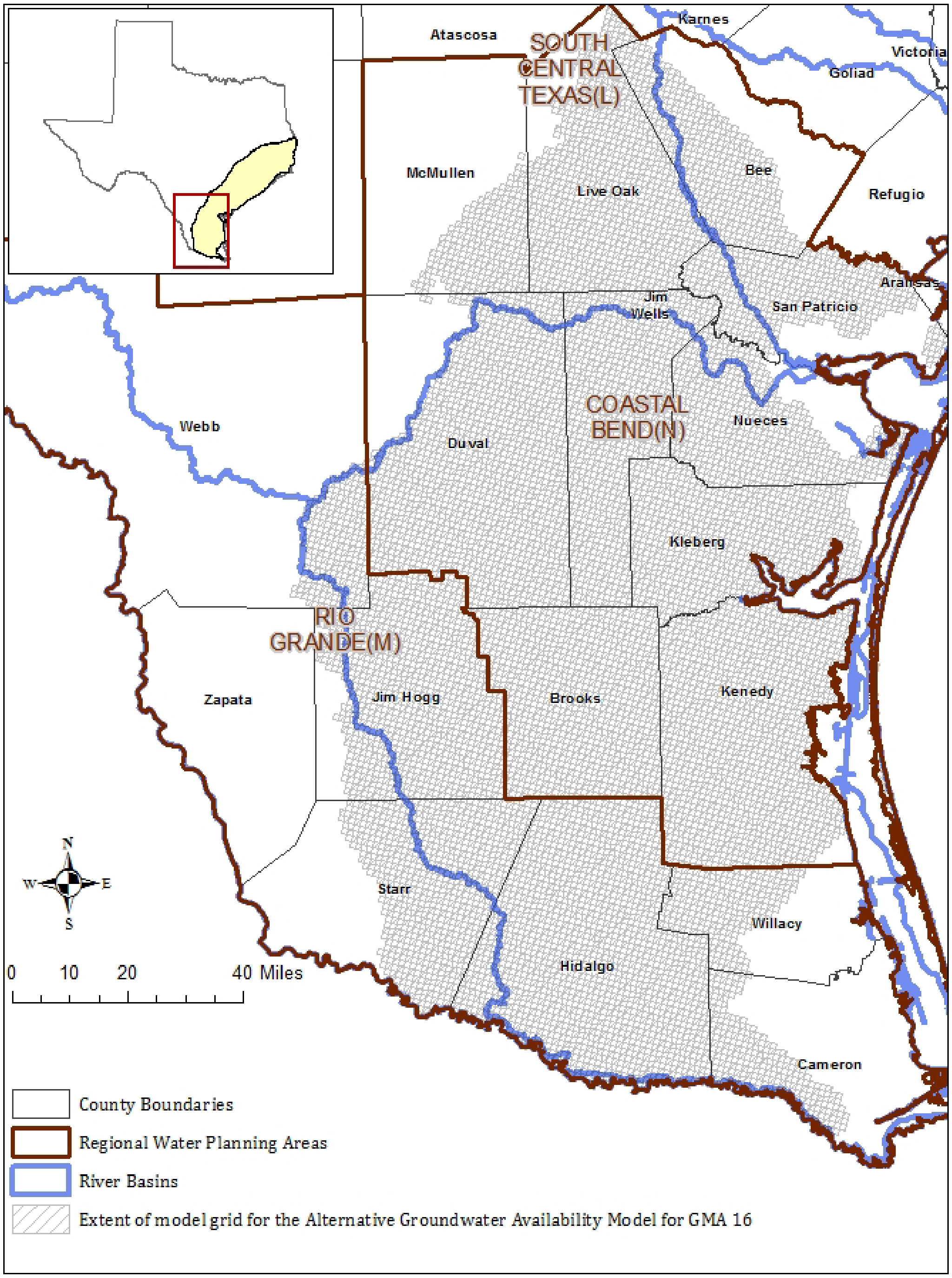

FIGURE 2. **MAP SHOWING THE EXTENT OF THE GULF COAST AQUIFER SYSTEM, REGIONAL WATER PLANNING AREAS, COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 16 OVERLAIN ON THE EXTENT OF THE ALTERNATIVE GROUNDWATER AVAILABILITY MODEL FOR GROUNDWATER MANAGEMENT AREA 16.**

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 2010 AND 2060. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District (GCD)	County	Aquifer	2010	2020	2030	2040	2050	2060
Bee GCD	**Bee**	**Gulf Coast Aquifer System**	**7,689**	**8,971**	**10,396**	**11,061**	**11,392**	**11,584**
Brush Country GCD	Brooks	Gulf Coast Aquifer System	3,657	3,657	3,657	3,657	3,657	3,657
Brush Country GCD	Hidalgo	Gulf Coast Aquifer System	131	131	131	131	131	131
Brush Country GCD	Jim Hogg	Gulf Coast Aquifer System	6,174	6,174	6,174	6,174	6,174	6,174
Brush Country GCD	Jim Wells	Gulf Coast Aquifer System	4,220	8,710	9,075	9,403	9,768	10,060
Brush Country GCD		**Gulf Coast Aquifer System**	**14,182**	**18,672**	**19,037**	**19,365**	**19,730**	**20,022**
Corpus Christi ASRCD	**Nueces**	**Gulf Coast Aquifer System**	**328**	**342**	**356**	**370**	**384**	**398**
Duval County GCD	**Duval**	**Gulf Coast Aquifer System**	**18,973**	**20,571**	**22,169**	**23,764**	**25,363**	**26,963**
Kenedy County GCD	Brooks	Gulf Coast Aquifer System	1,155	1,925	2,695	3,465	4,235	4,235
Kenedy County GCD	Willacy	Gulf Coast Aquifer System	289	482	674	867	1,060	1,060
Kenedy County GCD	Hidalgo	Gulf Coast Aquifer System	364	607	849	1,092	1,335	1,335
Kenedy County GCD	Jim Wells	Gulf Coast Aquifer System	261	434	608	783	957	957
Kenedy County GCD	Nueces	Gulf Coast Aquifer System	151	251	351	452	552	552
Kenedy County GCD	Kenedy	Gulf Coast Aquifer System	7,981	13,301	18,621	23,941	29,261	29,261
Kenedy County GCD	Kleberg	Gulf Coast Aquifer System	3,788	6,314	8,839	11,364	13,889	13,889
Kenedy County GCD		**Gulf Coast Aquifer System**	**13,989**	**23,314**	**32,637**	**41,964**	**51,289**	**51,289**
Live Oak UWCD	**Live Oak**	**Gulf Coast Aquifer System**	**6,556**	**8,338**	**9,343**	**8,564**	**8,441**	**8,441**
McMullen GCD	**McMullen**	**Gulf Coast Aquifer System**	**510**	**510**	**510**	**510**	**510**	**510**
Red Sands GCD	**Hidalgo**	**Gulf Coast Aquifer System**	**1,368**	**1,667**	**1,966**	**2,265**	**2,563**	**2,863**
San Patricio County GCD	**San Patricio**	**Gulf Coast Aquifer System**	**14,201**	**43,611**	**45,016**	**46,422**	**47,828**	**49,234**
Starr County GCD	**Starr**	**Gulf Coast Aquifer System**	**2,742**	**3,722**	**4,701**	**5,681**	**6,659**	**7,639**
No District-Bee	Bee	Gulf Coast Aquifer System	0	0	0	0	0	0
No District-Cameron	Cameron	Gulf Coast Aquifer System	5,378	6,688	7,999	9,311	10,620	11,932
No District-Hidalgo	Hidalgo	Gulf Coast Aquifer System	15,908	85,634	90,905	96,175	101,445	106,715

Groundwater Conservation District (GCD)	County	Aquifer	2010	2020	2030	2040	2050	2060
No District-Jim Wells	Jim Wells	Gulf Coast Aquifer System	0	0	0	0	0	0
No District-Kleberg	Kleberg	Gulf Coast Aquifer System	3,857	4,051	4,243	4,436	4,629	4,822
No District-Nueces	Nueces	Gulf Coast Aquifer System	5,753	5,996	6,240	6,487	6,731	6,974
No District-Webb	Webb	Gulf Coast Aquifer System	450	620	789	959	1,129	1,299
No District-Willacy	Willacy	Gulf Coast Aquifer System	544	664	785	905	1,024	1,145
No District-Total		**Gulf Coast Aquifer System**	**31,890**	**103,653**	**110,961**	**118,273**	**125,578**	**132,887**
GMA 16 Total		**Gulf Coast Aquifer System**	**112,428**	**233,371**	**257,092**	**278,239**	**299,737**	**311,830**

TABLE 2. MODELED AVAILABLE GROUNDWATER BY DECADE 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), RIVER BASIN, AND AQUIFER.

County	RWPA	River Basin	Aquifer	2020	2030	2040	2050	2060
Bee	N	Nueces	Gulf Coast Aquifer System	770	893	949	978	995
Bee	N	San Antonio-Nueces	Gulf Coast Aquifer System	8,201	9,503	10,112	10,414	10,589
Brooks	N	Nueces-Rio Grande	Gulf Coast Aquifer System	5,582	6,352	7,122	7,892	7,892
Cameron	M	Nueces-Rio Grande	Gulf Coast Aquifer System	6,301	7,536	8,771	10,005	11,241
Cameron	M	Rio Grande	Gulf Coast Aquifer System	387	463	540	615	691
Duval	N	Nueces	Gulf Coast Aquifer System	326	351	376	401	428
Duval	N	Nueces-Rio Grande	Gulf Coast Aquifer System	20,245	21,818	23,388	24,962	26,535
Hidalgo	M	Nueces-Rio Grande	Gulf Coast Aquifer System	86,405	91,810	97,216	102,620	107,784
Hidalgo	M	Rio Grande	Gulf Coast Aquifer System	1,634	2,041	2,447	2,854	3,260
Jim Hogg	M	Nueces-Rio Grande	Gulf Coast Aquifer System	5,236	5,236	5,236	5,236	5,236
Jim Hogg	M	Rio Grande	Gulf Coast Aquifer System	938	938	938	938	938
Jim Wells	N	Nueces	Gulf Coast Aquifer System	593	593	593	593	593
Jim Wells	N	Nueces-Rio Grande	Gulf Coast Aquifer System	8,551	9,090	9,593	10,132	10,424
Kenedy	N	Nueces-Rio Grande	Gulf Coast Aquifer System	13,301	18,621	23,941	29,261	29,261
Kleberg	N	Nueces-Rio Grande	Gulf Coast Aquifer System	10,365	13,082	15,800	18,518	18,711
Live Oak	N	Nueces	Gulf Coast Aquifer System	8,297	9,297	8,522	8,400	8,400
Live Oak	N	San Antonio-Nueces	Gulf Coast Aquifer System	41	46	42	41	41
McMullen	N	Nueces	Gulf Coast Aquifer System	510	510	510	510	510
Nueces	N	Nueces-Rio Grande	Gulf Coast Aquifer System	5,862	6,191	6,522	6,851	7,079
Nueces	N	Nueces	Gulf Coast Aquifer System	727	756	787	816	845
Nueces	N	San Antonio-Nueces	Gulf Coast Aquifer System	0	0	0	0	0
San Patricio	N	Nueces	Gulf Coast Aquifer System	4,130	4,502	4,874	5,247	5,619
San Patricio	N	San Antonio-Nueces	Gulf Coast Aquifer System	39,481	40,514	41,548	42,581	43,615
Starr	M	Nueces-Rio Grande	Gulf Coast Aquifer System	1,497	1,891	2,285	2,678	3,072

County	RWPA	River Basin	Aquifer	2020	2030	2040	2050	2060
Starr	M	Rio Grande	Gulf Coast Aquifer System	2,225	2,810	3,396	3,981	4,567
Webb	M	Rio Grande	Gulf Coast Aquifer System	98	125	152	179	206
Webb	M	Nueces	Gulf Coast Aquifer System	18	22	27	32	37
Webb	M	Nueces-Rio Grande	Gulf Coast Aquifer System	504	642	780	918	1,056
Willacy	M	Nueces-Rio Grande	Gulf Coast Aquifer System	1,146	1,459	1,772	2,084	2,205
GMA 16-Total			**Gulf Coast Aquifer System**	**233,371**	**257,092**	**278,239**	**299,737**	**311,830**

TABLE 3. COMPARISON OF MEASURED AND MODELED WATER-LEVELS AVERAGED OVER GROUNDWATER MANAGEMENT AREA 16 FROM THE DECADAL YEARS 2000 AND 2010. VALUES OF FIELD MEASURED WATER-LEVELS WERE OBTAINED FROM THE TWDB GROUNDWATER DATABASE (GWDB).

Average water levels in Groundwater Management Area 16 (in feet above mean sea level)		
	Year 2000	**Year 2010**
Field measurements (GWDB)	114.1	114.4
Model estimated	119.5	107.1

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.

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