HILL COUNTRY UNDERGROUND WATER CONSERVATION DISTRICT

GROUNDWATER MANAGEMENT PLAN

Adopted August 14, 2018

District Office
508 South Washington
Fredericksburg, Texas 78624
Phone: (830) 997-4472
Email: hcuwcd@austin.rr.com

HILL COUNTRY UNDERGROUND WATER CONSERVATION DISTRICT
GROUNDWATER MANAGEMENT PLAN
Adopted August 14, 2018

TABLE OF CONTENT

HILL COUNTRY UNDERGROUND WATER CONSERVATION DISTRICT
GROUNDWATER MANAGEMENT PLAN

Adopted August 14, 2018

The District was created to cover Gillespie County by the Acts of the 70th Legislative Session (1987), HB 792, Chapter 865 in accordance with Article XVI, Section 59 of the Texas Constitution, and Chapter 35 and 36 of the Texas Water Code, as amended. The citizens of Gillespie County confirmed creation of the District by an election held in August 1987. The District was formed to protect the underground water resources for the citizens of Gillespie County so that proper management techniques could be implemented at the local level to address local conditions within the county. The creation of the District was in advance of the Hill Country Area, which included Gillespie County, being declared a Priority Groundwater Management Area by the then Texas Water Commission in 1990. This declaration gave notice to the residents of the area that water availability and quality will be at risk within the next 50 years. To manage the groundwater resources under its jurisdiction the District is charged with the rights and responsibilities specified in its enabling legislation; the provisions of Chapter 36 of the Texas Water Code; this Groundwater Management Plan, and the District Rules.

District Mission

The Mission of the Hill Country Underground Water Conservation District (District) is to protect and enhance the groundwater resources of Gillespie County while protecting groundwater users and maintain the economic viability of the community it serves by adopting and enforcing rules consistent with State law.

Purpose of Groundwater Management Plan

Senate Bill 1 (SB 1), enacted by the 75th Texas Legislature in 1997, and Senate Bill 2 (SB 2), enacted by the 77th Texas Legislature in 2001, established a comprehensive statewide planning process and the actions necessary for districts to manage and conserve the groundwater resources of the State of Texas. These bills required all underground water conservation districts to develop a groundwater management plan which defines the water needs and supply within each district and the goals each district will use to manage the underground water in order to meet its needs. In addition, the 79th Texas Legislature enacted HB 1763 in 2005 that requires joint planning among districts that are in the same Groundwater Management Area (GMA). These districts must establish the Desired Future Conditions (DFCs) of the aquifers within their respective GMAs. Through this process, the districts will submit the DFCs to the executive administrator of the Texas Water Development Board (TWDB) who will provide each district with the estimates concerning the Modeled Available Groundwater (MAG) in the management area based on the DFCs of the aquifers in the area. Technical information, such as details for how the DFCs of the aquifers within the District's jurisdiction will be addressed and the amount of MAG from such aquifers are required by statute to be included in the District's groundwater management plan and will guide the District's regulatory and management policies.

This groundwater management plan is required by the Chapter 36 and developed in accordance with instructions from the TWDB. Chapter 36 requires use of certain data provided by the TWDB. The projections of future water demands, surface water availability, water management strategies, and estimates of historical groundwater use in Gillespie County were all provided to the District by TWDB. This document should be considered as a groundwater management plan and will be used to identify activities or programs that the District will develop. The District considers the collection and development of site-specific data on groundwater use in Gillespie County and the groundwater sources of Gillespie County to be a high priority. This groundwater management plan will be updated as the District develops the site-specific data on the local groundwater use and aquifer conditions. The District is not restricted by the TCEQ or TWDB as to the frequency with which the management plan may be updated if considered it is appropriate by the District.

The Hill Country Underground Water Conservation District's groundwater management plan satisfies the requirements of SB 1, SB 2, HB 1763, the statutory requirements of Chapter 36 of the Texas Water Code, and the administrative requirements of the Texas Water Development Board's rules.

Technical District Information Required by Texas Administrative Code

Estimate of Modeled Available Groundwater in District Based on Desired Future Conditions

Texas Water Code §36.001 defines modeled available groundwater as "the amount of water that the executive administrator determines may be produced on an average annual basis to achieve a desired future condition established under Section 36.108".

The joint planning process set forth in Texas Water Code §36.108 must be collectively conducted by all groundwater conservation districts within the same GMA. The District is a member of GMA 7. GMA 7 adopted DFCs for Gillespie County for the Edwards-Trinity Plateau (Edwards), Trinity (Hensel) (GR10-043_MAG v.2), Ellenburger (AA10-10_MAG), and Hickory (AA10-11_MAG) on June 29, 2010. The adopted DFCs were then forwarded to the TWDB for the development of the MAG calculations. The submittal package for the DFCs can be found here:

http://www.twdb.texas.gov/groundwater/docs/DFC/GMA7_DFC_Adopted_2010-0729.pdf

Modeled available groundwater for Groundwater Management Area 7

http://www.twdb.texas.gov/groundwater/management_areas/gma7.asp

A summary of the desired future conditions and the modeled available groundwater are summarized below:

GILLESPIE COUNTY

Aquifer	Desired Future Conditions	Modeled Available Groundwater (AF/yr)	MAG
Edwards-Trinity Plateau (Edwards)	7' drawdown	2,514	GR-10-043 MAG v. 2
Trinity (Hensel)	7' drawdown	2,482	GR-10-043 MAG v. 2
Ellenburger	5' drawdown	6,271	AA 10-10 MAG
Hickory	7' drawdown	1,659	AA 10-11 MAG
Total		**12,926**	

Amount of Groundwater Being Used within the District on an Annual Basis
Please refer to Appendix A: *Estimated Historical Water Use And 2017 State Water Plan Datasets*

Projected Surface Water Supply within the District
Please refer to Appendix A: *Estimated Historical Water Use And 2017 State Water Plan Datasets*

Projected Total Demand for Water within the District
Please refer to Appendix A: *Estimated Historical Water Use And 2017 State Water Plan Datasets*

Projected Water Supply Needs within the District
Please refer to Appendix A: *Estimated Historical Water Use And 2017 State Water Plan Datasets. The data for this and other strategies can be found in Appendix A.*

Project Water Management Strategies
In the State Water Plan, there shows a need of -848 acre feet out to the year 2070 for Fredericksburg (-222 acre feet) and manufacturing (-626 acre feet). To address this need, the District will assist the entities involved in identifying the locations for expansion of current groundwater supplies from the Ellenburger-San Saba Aquifer, or any other suitable aquifer within the District.

Please refer to Appendix A: *Estimated Historical Water Use And 2017 State Water Plan Datasets. The data for this and other strategies can be found in Appendix A.*

Annual Amount of Recharge From Precipitation to the Groundwater Resources within the District

Please refer to Appendix B: *GAM Run 17-009*

Edwards-Trinity Plateau (Edwards) – Table 1, p.8
Trinity (Hensel) – Table 2, p.10
Ellenburger-San Saba – Table 3, p.12
Hickory – Table 4, p. 14

Annual Volume of Water that Discharges from the Aquifer to Springs and Surface Water Bodies

Please refer to Appendix B: *GAM Run 17-009*

Edwards-Trinity Plateau (Edwards) – Table 1, p.8
Trinity (Hensel) – Table 2, p. 10
Ellenburger-San Saba – Table 3, p.12
Hickory – Table 4, p.14

Estimate of the Annual Volume of Flow into the District, out of the District, and Between Aquifers in the District

Please refer to Appendix B: *GAM Run 17-009*

Edwards-Trinity Plateau (Edwards) – Table 1, p.8
Trinity (Hensel) – Table 2, p. 10
Ellenburger-San Saba – Table 3, p.12
Hickory – Table 4, p.14

Methodology to Track District Progress in Achieving Management Goals

The District's General Manager will prepare and present an annual report to the Board of Directors on District performance in regards to achieving management goals and objectives for the calendar year. The report will be presented during the first regular board meeting of the calendar year beginning in 2019. The report will include the number of instances each activity was engaged in during the year. The Board will maintain the report on file, for public inspections at the District's offices upon adoption in a regular noticed meeting of the Board.

Actions, Procedures, Performance and Avoidance for District Implementation of Groundwater Management Plan

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

Rules adopted by the District for permitting of wells and the use of groundwater shall comply with TWC Chapter 36 and the provisions of this groundwater management plan. All rules will be adhered to and enforced. The promulgation and enforcement of the rules will be based on the best technical evidence available to the District. District Rules can be found here at:

http://hcuwcd.org/RulesAmendedJune10-2014.pdf

The District shall treat all citizens with equality. Citizen may apply to the District for discretion in enforcement of the rules on grounds of adverse economic effect or unique local aquifer characteristic. In granting of discretion to any rule, the Board shall consider the potential for adverse effect on adjacent landowners and aquifer conditions. The exercise of said discretion by the Board shall not be construed as limiting power of the Board.

The District will seek cooperation and coordination in the implementation of this plan, and all District activities, with appropriate state, regional or local water management entities. The meetings of the Board of the District are noticed and conducted at all times in accordance with the Texas Open Meetings Law. The District has also made available for public inspection all official documents, reports, records and minutes of the District pursuant with the Texas Public Information Act will continue to do in the future.

Management Goals

A. Providing the most efficient use of groundwater

A.1 Objective – Each year the District will assist the Gillespie County Commissioners Court in the evaluation of water availability studies submitted in accordance with Gillespie County Subdivision requirements.

A.1 Performance Standard – Each year the District will report the number of groundwater availability reports that the District reviewed and certified as having sufficient or insufficient water resources available.

A.2 Objective – Each year the District will require all new exempt wells that are constructed within the boundaries of the District to be registered with the District in accordance with the District Rules.

A.2 Performance Standard – The number of exempt wells registered by the District for the year will be incorporated into the Annual Report submitted to the Board of Directors.

A.3 Objective – Each year the District will regulate the production of groundwater by maintaining a system of permitting the use and production of groundwater within the boundaries of the District in accordance with the District Rules.

A.3 Performance Standard – Each year the District will accept and process applications for the permitted use of groundwater in the District in accordance with the permitting process established by the District Rules. The number and type of applications made for the permitted use of groundwater in the District, and the number and type of permits issued by the District will be included in the Annual Report given to the Board of Directors.

B. Controlling and preventing waste of groundwater

B.1 **Objective** - Each year the District will provide information on eliminating and reducing the waste of groundwater and focusing on water quality protection. This may be accomplished annually by one of the following methods:

a) When requested conduct classroom presentations;
b) When requested sponsor an educational program/curriculum
c) Post information on the District's web site;
d) Submit newspaper articles for publication;
e) Conduct public presentations
f) Distribute brochures/literature

B.1 **Performance Standard** - The annual report will include a summary of the District activities during the year to disseminate educational information on eliminating and reducing the wasteful use of groundwater focusing on water quality protection. The number of instances for each activity utilized by the District will be included in the report.

C. Controlling and Preventing Subsidence

The rigid geologic framework of the region precludes significant subsidence from occurring thereby this goal is not applicable to the operations of the District**.**

D. Addressing conjunctive surface water management issues

D.1 **Objective** - To evaluate the ground to surface water interrelationships within the District, each year the District will conduct stream flow measurements along eight (8) sites of the Pedernales River between Bear Creek and Palo Alto Creek at least four (4) times per year.

D.1 **Performance Standard** - Each year the number of stream flow measurements taken annually will be presented in the District's annual report.

D.2 **Objective** - Each year, the District will participate in the regional planning process by attending a minimum of two meetings of the Lower Colorado Regional Water Planning Group (Region K) per fiscal year.

D.2 **Performance Standard-** Each year, attendance at Region K meetings by a representative of the District will be reflected in the District's annual report and will include the number of meetings attended and the dates.

E. Addressing natural resources issues that impact the use and availability of groundwater and which are impacted by the use of groundwater

E.1. Objective – Each year the District will monitor water levels within the District by measuring the water level on selected wells representative of the various aquifers within the District. The water level monitoring network and measuring schedule is as follows:

Aquifer	# of Wells	Frequency
Ellenburger	35 +/-	6 times per year
Hensel	40 +/-	2 times per year
Edwards, Hickory, Mid-Cambrian and Precambrian	50 +/-	2 times per year

E.1 Performance Standard – Each year the District's annual report will provide a status on the number of monitor wells measured.

F. Addressing Drought Conditions

F.1 Objective - Continue to monitor aquifer conditions in response to drought conditions to improve and refine trigger conditions and update, as warranted, the District's Drought Management Plan adopted on March 10, 2009.

F.1 Performance Standard - Each year the District's annual report will provide to the Board the number of any new trigger conditions identified and changes made to the Drought Management Plan.

F.2 Objective - Review applicable data to determine status of drought condition, and if necessary, report to the Board on the need to implement the drought management plan.

F.2 Performance Standard – Each year the District's annual report will include the number of times reported to the Board on the need to implement the drought management plan.

F.3 Objective - Each year the District will provide to the public on the District website information concerning the status of drought conditions and stage of drought.

F.3 Performance Standard – Each year the District's annual report will include the number of drought notices or articles placed on the District's website.

F.4 Objective – Continue to monitor drought conditions through the TWDB Water Data for Texas drought link https://waterdatafortexas.org/drought

F.4 Performance Standard – Each year the District's annual report will include a summary of the TWDB Water Data for Texas drought link activities.

G. Addressing Conservation, Recharge Enhancement, Rainwater Harvesting, and Brush Control and Precipitation Enhancement

G.1 Objective - Each year the District will promote conservation by one or more of the following methods:

a) Upon request conduct classroom conservation presentations;
b) Post conservation information on the District's web site;
c) Upon request conduct a public conservation presentation;
d) Distribute conservation brochures/literature to the public

G.1 Performance Standard – Each year the District's annual report will include a summary of the District's activity during the year to promote conservation. The number of instances for each activity utilized by the District will be included in the report.

G.2 Objective – Each year the District will provide information about recharge enhancement on the District web site or by brochures/literature available at the District office.

G.2 Performance Standard – Each year the District annual report will include a summary of the District's activity regarding recharge enhancement.

G.3 Objective – Each year, the District will promote rainwater harvesting by posting information on rainwater harvesting on the District web site or by brochures/literature available at the District office.

G.3 Performance Standard – Each year the District annual report will include a summary of the District's activity regarding rainwater harvesting.

G.4 Objective – Each year the District will provide information about brush control on the District web site or by brochures/literature available at the District office.

G.4 Performance Standard – Each year the District annual report will include a summary of the District's activity regarding brush control.

G. 5 Precipitation Enhancement - Cost prohibitive, results questionable. The management goal is not applicable to the operations of the District.

H. Addressing the Desired Future Conditions of the Groundwater Resources

H.1 Objective – Begin evaluating the water level data obtained from the District's water level monitoring programs to develop a method for tracking the DFCs for the aquifers within the District.

H.1 Performance Standard – The annual reporting of how the DFCs are being met will be included in the District's Annual Report to the District's Board of Directors.

H.2 **Objective –** Monitor pumpage within the District to evaluate District compliance with aquifer desired future conditions and to determine if pumpage exceeds or is under MAG numbers.

H.2 **Performance Standard –** The annual reporting of groundwater pumpage will be included in the District's Annual Report to the District Board of Directors.

Appendix A

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

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2017. TWDB staff anticipates the calculation and posting of these estimates at a later date.

GILLESPIE COUNTY

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2016	GW	3,673	24	4	0	2,200	629	6,530
	SW	0	0	0	0	186	209	395
2015	GW	3,582	19	5	0	2,414	607	6,627
	SW	0	0	0	0	150	202	352
2014	GW	3,907	19	12	0	2,238	597	6,773
	SW	0	0	0	0	191	199	390
2013	GW	4,891	21	4	0	2,216	571	7,703
	SW	0	0	5	0	62	191	258
2012	GW	5,008	14	0	0	1,942	652	7,616
	SW	0	0	5	0	338	216	559
2011	GW	5,090	14	1	0	3,153	1,383	9,641
	SW	0	0	3	0	312	461	776
2010	GW	4,255	6	1	0	1,275	1,343	6,880
	SW	0	0	2	0	186	448	636
2009	GW	4,200	6	1	0	1,915	750	6,872
	SW	0	0	2	0	263	250	515
2008	GW	4,244	6	1	0	1,969	804	7,024
	SW	0	0	2	0	158	268	428
2007	GW	4,049	6	0	0	179	732	4,966
	SW	0	0	0	0	159	245	404
2006	GW	4,342	6	0	0	2,117	701	7,166
	SW	0	9	0	0	346	234	589
2005	GW	4,189	6	0	0	1,935	706	6,836
	SW	0	9	0	0	274	236	519
2004	GW	3,783	6	0	0	2,378	462	6,629
	SW	0	9	0	0	71	510	590
2003	GW	3,816	6	0	0	2,246	457	6,525
	SW	0	9	0	0	53	505	567
2002	GW	3,952	6	0	0	2,246	486	6,690
	SW	0	9	0	0	118	536	663
2001	GW	4,018	6	0	0	2,246	493	6,763
	SW	0	9	0	0	118	545	672

Appendix A

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

GILLESPIE COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
K	COUNTY-OTHER, GILLESPIE	COLORADO	HIGHLAND LAKES LAKE/RESERVOIR SYSTEM	56	56	56	56	56	56
K	LIVESTOCK, GILLESPIE	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	515	515	515	515	515	515
K	LIVESTOCK, GILLESPIE	GUADALUPE	GUADALUPE LIVESTOCK LOCAL SUPPLY	13	13	13	13	13	13
K	MANUFACTURING, GILLESPIE	COLORADO	COLORADO OTHER LOCAL SUPPLY	158	158	158	158	158	158
	Sum of Projected Surface Water Supplies (acre-feet)			**742**	**742**	**742**	**742**	**742**	**742**

Appendix A

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.

GILLESPIE COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
K	COUNTY-OTHER, GILLESPIE	COLORADO	1,756	1,829	1,891	1,990	2,098	2,208
K	COUNTY-OTHER, GILLESPIE	GUADALUPE	67	69	71	75	79	83
K	FREDERICKSBURG	COLORADO	3,146	3,327	3,476	3,672	3,866	4,058
K	IRRIGATION, GILLESPIE	COLORADO	2,058	2,031	2,003	1,978	1,953	1,928
K	LIVESTOCK, GILLESPIE	COLORADO	1,030	1,030	1,030	1,030	1,030	1,030
K	LIVESTOCK, GILLESPIE	GUADALUPE	32	32	32	32	32	32
K	MANUFACTURING, GILLESPIE	COLORADO	1,049	1,102	1,151	1,192	1,276	1,366
K	MINING, GILLESPIE	COLORADO	4	4	4	4	4	4
		Sum of Projected Water Demands (acre-feet)	**9,142**	**9,424**	**9,658**	**9,973**	**10,338**	**10,709**

Appendix A

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

GILLESPIE COUNTY All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
K	COUNTY-OTHER, GILLESPIE	COLORADO	559	486	424	325	217	107
K	COUNTY-OTHER, GILLESPIE	GUADALUPE	28	26	24	20	16	12
K	FREDERICKSBURG	COLORADO	690	509	360	164	-30	-222
K	IRRIGATION, GILLESPIE	COLORADO	444	471	499	524	549	574
K	LIVESTOCK, GILLESPIE	COLORADO	528	528	528	528	528	528
K	LIVESTOCK, GILLESPIE	GUADALUPE	22	22	22	22	22	22
K	MANUFACTURING, GILLESPIE	COLORADO	-309	-362	-411	-452	-536	-626
K	MINING, GILLESPIE	COLORADO	51	51	51	51	51	51
	Sum of Projected Water Supply Needs (acre-feet)		**-309**	**-362**	**-411**	**-452**	**-566**	**-848**

Appendix A

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

GILLESPIE COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, GILLESPIE, COLORADO (K)							
BRUSH CONTROL	COLORADO RUN-OF-RIVER [GILLESPIE]	425	425	425	425	425	425
DROUGHT MANAGEMENT	DEMAND REDUCTION [GILLESPIE]	263	274	284	299	315	331
		688	**699**	**709**	**724**	**740**	**756**
COUNTY-OTHER, GILLESPIE, GUADALUPE (K)							
DROUGHT MANAGEMENT	DEMAND REDUCTION [GILLESPIE]	10	10	11	11	12	12
		10	**10**	**11**	**11**	**12**	**12**
FREDERICKSBURG, COLORADO (K)							
DROUGHT MANAGEMENT	DEMAND REDUCTION [GILLESPIE]	472	499	521	551	580	609
MUNICIPAL CONSERVATION - FREDERICKSBURG	DEMAND REDUCTION [GILLESPIE]	317	599	733	916	1,094	1,301
		789	**1,098**	**1,254**	**1,467**	**1,674**	**1,910**
MANUFACTURING, GILLESPIE, COLORADO (K)							
EXPANSION OF CURRENT GROUNDWATER SUPPLIES - ELLENBURGER-SAN SABA AQUIFER	ELLENBURGER-SAN SABA AQUIFER [GILLESPIE]	626	626	626	626	626	626
		626	**626**	**626**	**626**	**626**	**626**
Sum of Projected Water Management Strategies (acre-feet)		**2,113**	**2,433**	**2,600**	**2,828**	**3,052**	**3,304**

GAM Run 17-009: Hill Country Underground Water Conservation District Groundwater Management Plan

Roberto Anaya, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-463-6115
January 12, 2018

STATE OF TEXAS
Roberto Anaya
Geology
No. 480
LICENSED
PROFESSIONAL GEOSCIENTIST

1/12/18

This page is intentionally blank.

GAM RUN 17-009: HILL COUNTRY UNDERGROUND WATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Roberto Anaya, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-463-6115
January 12, 2018

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.

The TWDB provides data and information to the Hill Country Underground Water Conservation District in two parts. Part 1 is the Estimated Historical Water Use/State Water Plan dataset report, which will be provided to you separately by the TWDB Groundwater Technical Assistance Department. Please direct questions about the water data report to Mr. Stephen Allen at 512-463-7317 or stephen.allen@twdb.texas.gov. Part 2 is the required groundwater availability modeling information 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 Hill Country Underground Water Conservation District should be adopted by the district on or before April 30, 2018, and submitted to the

Executive Administrator of the TWDB on or before May 30, 2018. The current management plan for the Hill Country Underground Water Conservation District expires on July 29, 2018.

We used the groundwater availability models for the Edwards-Trinity (Plateau) and Pecos Valley aquifers version 1.01 (Anaya and Jones, 2009) and the Minor Aquifers of the Llano Uplift Region (Shi and others, 2016) to estimate the management plan information for the aquifers within the Hill Country Underground Water Conservation District. This report replaces the results of GAM Run 12-015 (Jones, 2012). GAM Run 17-009 meets current standards set after the release of GAM Run 12-015 and includes updated information for the Edwards-Trinity (Plateau) Aquifer groundwater availability model using an updated grid attribute tableand results from the recently released groundwater availability model for the Minor Aquifers of the Llano Uplift Region (Shi and others, 2016). Tables 1 through 4 summarize the groundwater availability model data required by statute and Figures 1 through 4 show the area of the models from which the values in the tables were extracted. If, after review of the figures, the Hill Country Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability models mentioned above were used to estimate information for the Hill Country Underground Water Conservation District management plan. Water budgets were extracted for the historical model periods for the Edwards-Trinity (Plateau) Aquifer, and the Trinity Aquifer (1980 through 1999) using ZONEBUDGET Version 3.01 (Harbaugh, 2009) and from the groundwater availability model for the Minor Aquifers of the Llano Uplift Region (Shi and others, 2016) (1981 through 2010) using ZONEBUDGET USG Version 1.00 (Panay and others, 2013). The average annual water budget values for recharge, surface-water outflow, inflow to the district, and outflow from the district for the aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Edwards-Trinity (Plateau) Aquifer

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers. See Anaya and Jones (2009) for assumptions and limitations of the model.
- The groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers contains 2 layers: Layer 1 (the Edwards Group and equivalent limestone hydrostratigraphic units of the Edwards-Trinity (Plateau) Aquifer System, and layer 2 (comprised of the undifferentiated Trinity Group hydrostratigraphic units of the Edwards-Trinity (Plateau) Aquifer System). The two layers were combined for calculating water budget flows in the Edwards-Trinity (Plateau) Aquifer System within the district.
- The model was run with MODFLOW-96 (Harbaugh and others, 1996).

Trinity Aquifer

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers. See Anaya and Jones (2009) for assumptions and limitations of the model.
- The groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers contains 2 layers. However, only layer 2 (comprised of the undifferentiated Trinity Group hydrostratigraphic units) was used for calculating water budget flows in the Hill Country portion of the Trinity Aquifer within the district.
- We used the groundwater availability model for the Edwards-Trinity (Plateau) instead of the groundwater availability model for the Hill Country portion of the Trinity Aquifer because the Edwards-Trinity (Plateau) Aquifer model covers the entire geographical areas of district. Both groundwater availability models are aligned with different model grid orientations which prevent combining the results from each without double accounting or omitting important water budget information.
- The model was run with MODFLOW-96 (Harbaugh and others, 1996).

Ellenburger-San Saba and Hickory Aquifers

- We used version 1.01 of the groundwater availability model for the Minor Aquifers in the Llano Uplift Region. See Shi and others (2016) for assumptions and limitations of the model.

- The groundwater availability model for the Minor Aquifers in Llano Uplift Region contains eight layers:

    - Layer 1 — the Trinity Aquifer, Edwards-Trinity (Plateau) Aquifer, and younger alluvium deposits
    - Layer 2 — confining units
    - Layer 3 — the Marble Falls Aquifer and equivalent
    - Layer 4 — confining units
    - Layer 5 — the Ellenburger-San Saba Aquifer and equivalent
    - Layer 6 — confining units
    - Layer 7 — the Hickory Aquifer and equivalent
    - Layer 8 — confining (Precambrian) units

- Perennial rivers and reservoirs were simulated using MODFLOW-USG river package. Springs were simulated using MODFLOW-USG drain package. For this management plan, groundwater discharge to surface water includes groundwater leakage to the river and drain boundaries.

- The model was run with MODFLOW-USG beta (development) version (Panday and others, 2013).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Edwards-Trinity (Plateau), Trinity, Ellenburger-San Saba, and Hickory aquifers located within Hill Country Underground Water Conservation District and averaged over the historical calibration periods, as shown in Tables 1through 4.

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

2. Surface-water outflow—the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.

3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.

4. Flow between aquifers—the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

The information needed for the district's management plan is summarized in Tables 1 through 4. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

TABLE 1. SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FOR HILL COUNTRY UNDERGROUND WATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	17,396
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	12,935
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	4,431
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	8,810
Estimated net annual volume of flow between each aquifer in the district	From the Edwards-Trinity (Plateau) Aquifer to the Trinity Aquifer	1,073
	From the Edwards-Trinity (Plateau) Aquifer to the Ellenburger-San Saba Aquifer	949[1]
	From the Edwards-Trinity (Plateau) Aquifer to the Hickory Aquifer	11[2]

[1] The estimated net annual volume of flow between the Edwards-Trinity (Plateau) and the Ellenburger-San Saba aquifers was calculated from version 1.01 of the groundwater availability model for the Minor Aquifers in the Llano Uplift Region.

[2] The estimated net annual volume of flow between the Edwards-Trinity (Plateau) and the Hickory aquifers was calculated from version 1.01 of the groundwater availability model for the Minor Aquifers in the Llano Uplift Region.

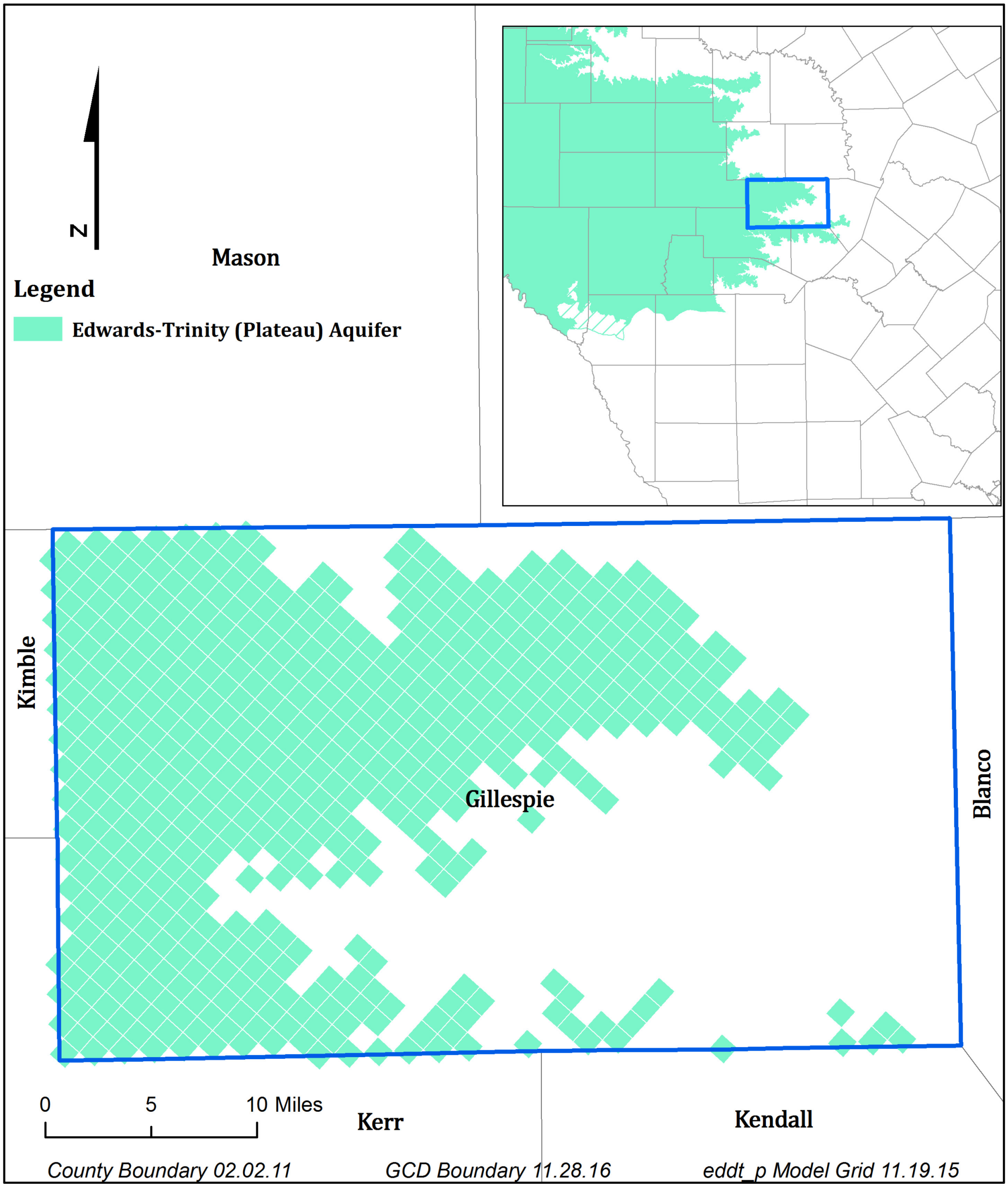

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE EDWARDS-TRINITY (PLATEAU) AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER FOR HILL COUNTRY UNDERGROUND WATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	28,756
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Trinity Aquifer	25,625
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	412
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	1,473
Estimated net annual volume of flow between each aquifer in the district	From the Edwards-Trinity (Plateau) Aquifer to the Trinity Aquifer	1,073
	From the Trinity Aquifer to the Ellenburger-San Saba Aquifer	91[3]

[3] The estimated net annual volume of flow between the Trinity and the Ellenburger-San Saba aquifers was calculated from version 1.01 of the groundwater availability model for the Minor Aquifers in the Llano Uplift Region.

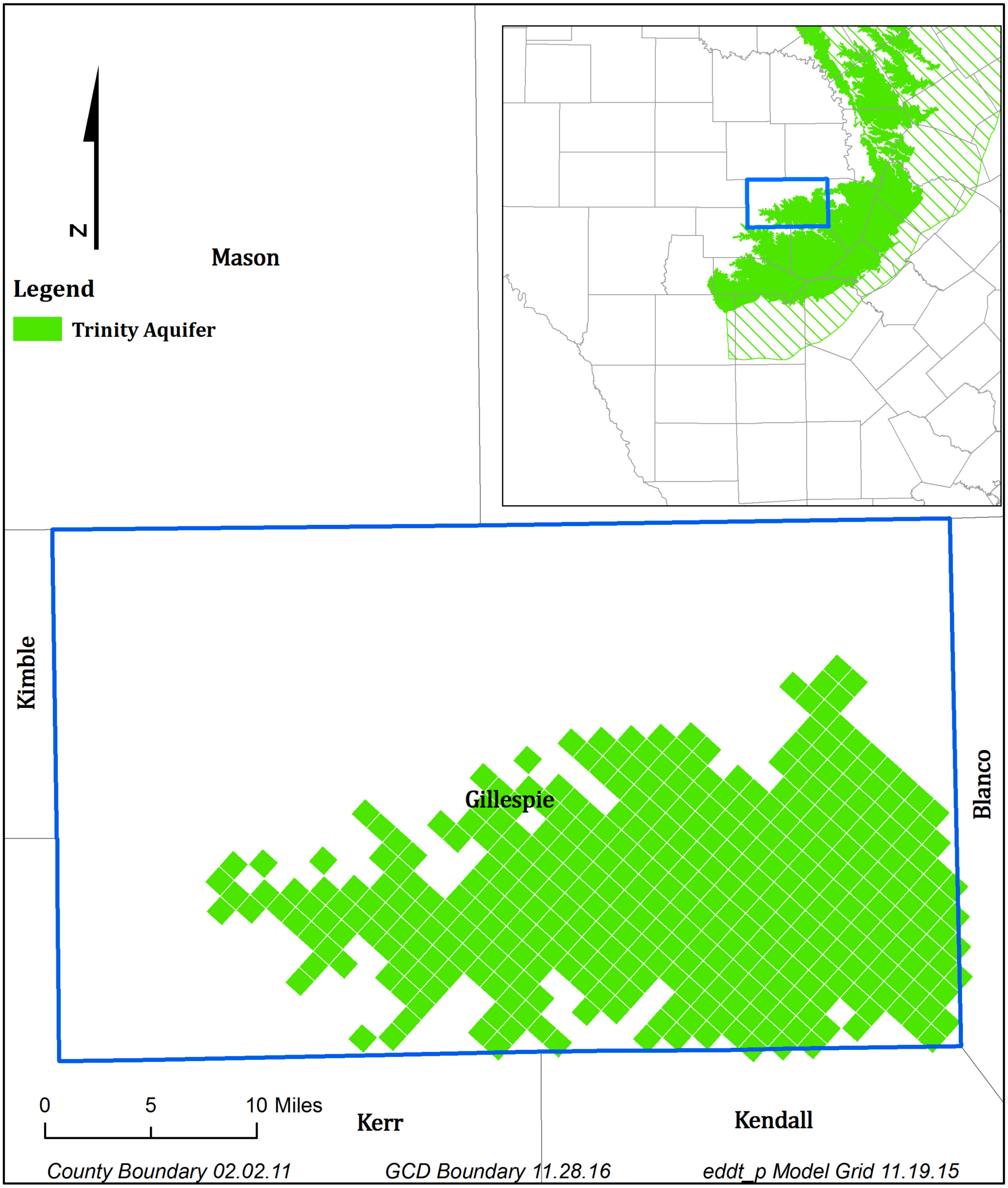

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE TRINITY AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE ELLENBURGER-SAN SABA AQUIFER FOR HILL COUNTRY UNDERGROUND WATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ellenburger-San Saba Aquifer	941
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ellenburger-San Saba Aquifer	1,594
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	613
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	8,215
Estimated net annual volume of flow between each aquifer in the district	From Edwards-Trinity (Plateau) Aquifer to Ellenburger-San Saba Aquifer	949
	From Trinity Aquifer to Ellenburger-San Saba Aquifer	91
	From Quaternary Alluvium to Ellenburger-San Saba Aquifer	13
	From confining unit between Cretaceous aquifers and Marble Falls Formation to Ellenburger-San Saba Aquifer	29
	From Ellenburger-San Saba Aquifer to Marble Falls Formation brackish zone	152
	From confining unit between Marble Falls Formation and Ellenburger-San Saba Aquifer to Ellenburger-San Saba Aquifer	33,835
	From Ellenburger-San Saba Aquifer to Ellenburger-San Saba brackish zone	1,421
	From Ellenburger-San Saba Aquifer to confining unit between Ellenburger-San Saba and Hickory aquifers	23,701
	From Hickory Aquifer to Ellenburger-San Saba Aquifer	3,381
	From Pre-Cambrian confining unit to Ellenburger-San Saba Aquifer	629

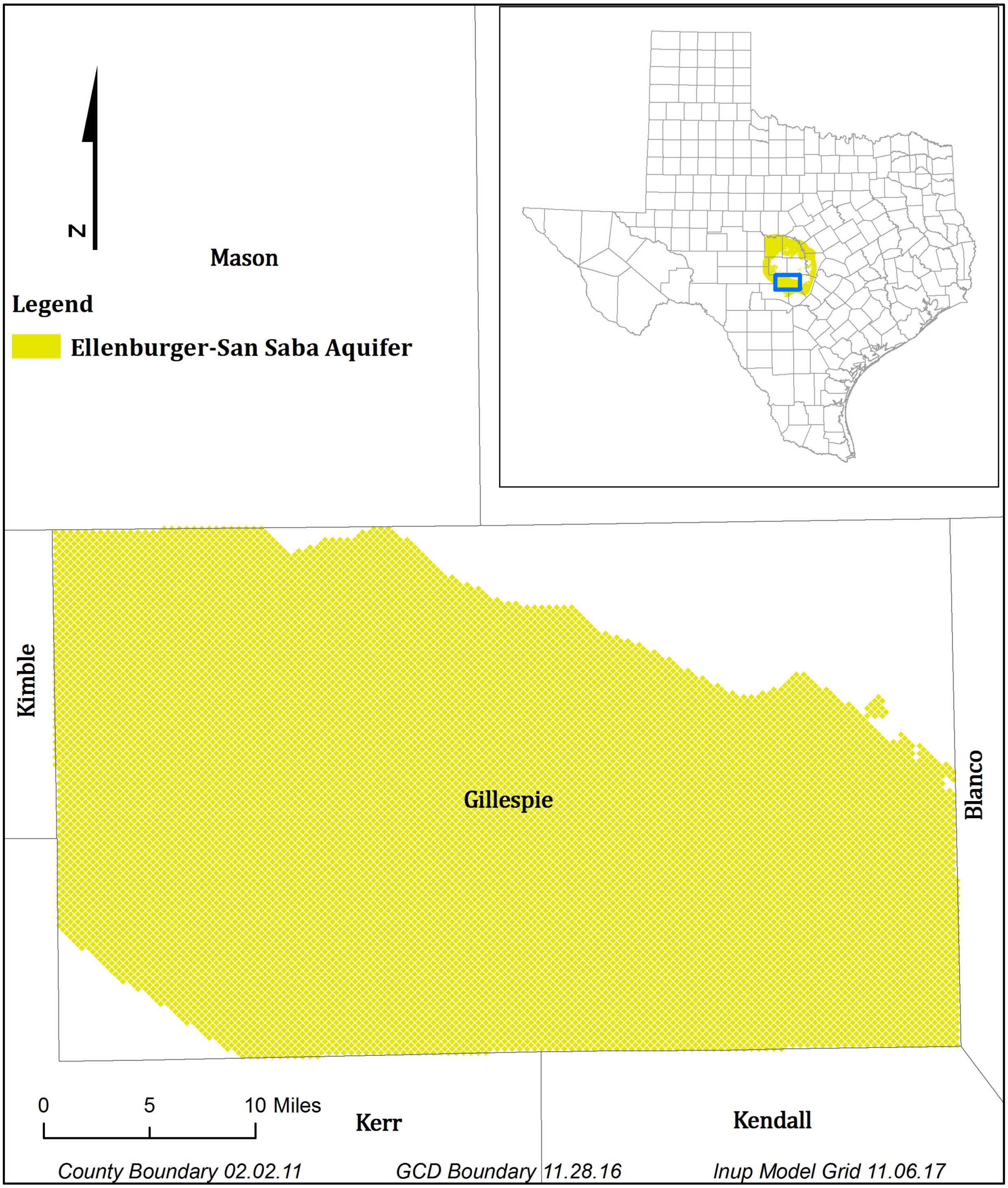

FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT REGION FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE ELLENBURGER-SAN SABA EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 4. SUMMARIZED INFORMATION FOR THE HICKORY AQUIFER FOR HILL COUNTRY UNDERGROUND WATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Hickory Aquifer	263
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Hickory Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	1,472
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	17,803
Estimated net annual volume of flow between each aquifer in the district	From Edwards-Trinity (Plateau) Aquifer to Hickory Aquifer	11
	From Hickory Aquifer to Marble Falls Formation brackish zone	122
	From Hickory Aquifer to confining unit between Marble Falls Formation and Ellenburger-San Saba Aquifer	32
	From Hickory Aquifer to Ellenburger-San Saba Aquifer	3,381
	From Ellenburger-San Saba Aquifer brackish zone to Hickory Aquifer	291
	From confining unit between Ellenburger-San Saba and Hickory aquifers to Hickory Aquifer	25,288
	From Hickory Aquifer to Hickory Aquifer brackish zone	289
	From Hickory Aquifer to Pre-Cambrian confining unit	4,893

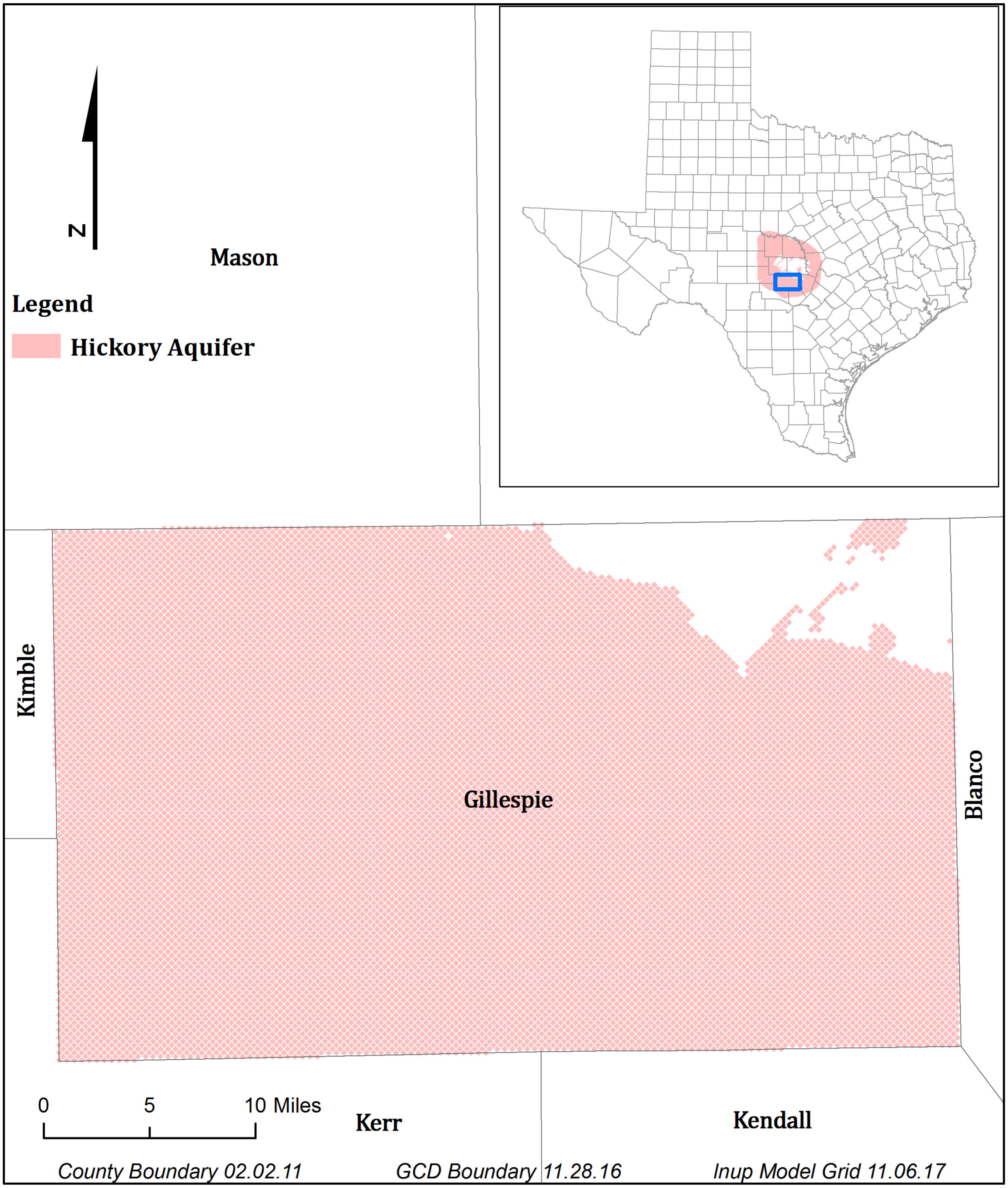

FIGURE 4. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT REGION FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE HICKORY AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS:

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

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

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

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

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

REFERENCES:

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

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 ground-water flow model: U.S. Geological Survey Open-File Report 96–485, 56 p.

Jones, I., 2012, GAM Run 12-015: Hill Country Underground Water Conservation District 1 Management Plan, 12 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR12-015.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.

Panday, S., Langevin, C.D., Niswonger, R.G., Ibaraki, M., and Hughes, J.D., 2013, MODFLOW–USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p.

Shi, J., Boghici, R., Kohlrenken, W., and Hutchison, W.R., 2016, Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory). Texas Water Development Board, draft report, June 2016 (under final review), 403p.

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