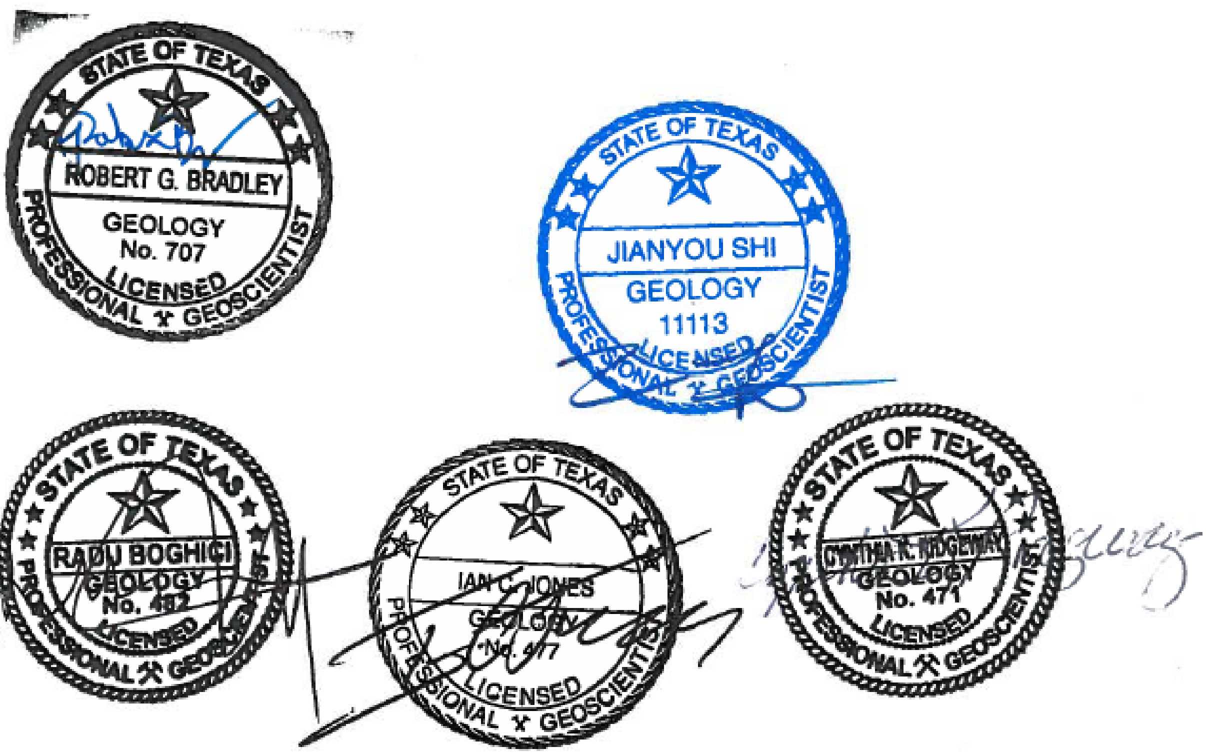
GAM Task 13-030: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 7

by Ian C. Jones, Ph.D., P.G., Robert Bradley, P.G., Radu Boghici, P.G.,
William Kohlrenken, and Jerry Shi, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
(512) 463-6641[1]
October 2, 2013



The seals appearing on this document were authorized by Ian C. Jones, P.G. 477, Robert Bradley, P.G. 707, Radu Boghici, P.G. 482, Jerry Shi, P.G. 11113, and Cynthia K. Ridgeway, P.G. 471 on October 2, 2013. Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by William Kohlrenken under her direct supervision.

The total estimated recoverable storage in this report was calculated as follows: the Capitan Reef Complex, Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers (Ian Jones); the Hickory, Ellenburger-San Saba, and Marble Falls aquifers (Robert Bradley); the Blaine, Igneous, and Seymour aquifers (Radu Boghici); the Dockum, Lipan, and Ogallala aquifers (William Kohlrenken); and the Rustler Aquifer and the Edwards-Trinity (Plateau) Aquifer in Kinney County (Jerry Shi).

---

[1] This is the office telephone number for Ian Jones

This page is intentionally blank

GAM TASK 13-030: TOTAL ESTIMATED RECOVERABLE STORAGE FOR AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7

by Ian C. Jones, Ph.D., P.G., Robert Bradley, P.G., Radu Boghici, P.G.,
William Kohlrenken, and Jerry Shi, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
(512) 463-6641[2]
October 2, 2013

EXECUTIVE SUMMARY:

Texas Water Code, §36.108 (d) (Texas Water Code, 2011) states that, before voting on their proposed desired future conditions for a relevant aquifer within a groundwater management area, the groundwater conservation districts shall consider the total estimated recoverable storage as provided by the executive administrator of the Texas Water Development Board (TWDB) along with other factors listed in §36.108 (d). Texas Administrative Code Rule §356.10 (Texas Administrative Code, 2011) defines the total estimated recoverable storage as the estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume.

This report discusses the methods, assumptions, and results of an analysis to estimate the total recoverable storage for the Hickory, Ellenburger-San Saba, Marble Falls, Blaine, Capitan Reef Complex, Rustler, Dockum, Trinity, Edwards-Trinity (Plateau), Igneous, Ogallala, Pecos Valley, Lipan, and Seymour aquifers within Groundwater Management Area 7. Tables 1 through 28 summarize the total estimated recoverable storage required by the statute. Figures 4 through 17 indicate the official extent of the aquifers in Groundwater Management Area 7 used to estimate the total recoverable storage.

DEFINITION OF TOTAL ESTIMATED RECOVERABLE STORAGE:

The total estimated recoverable storage is defined as the estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25 percent and 75

[2] This is the office telephone number for Ian Jones

percent of the porosity-adjusted aquifer volume. In other words, we assume that between 25 and 75 percent of groundwater held within an aquifer can be removed by pumping.

The total recoverable storage was estimated for each aquifer within Groundwater Management Area 7 for the portion that lies within the official lateral aquifer boundaries as delineated by George and others (2011). Total estimated recoverable storage values may include a mixture of water quality types, including fresh, brackish, and saline groundwater, because the available data and the existing groundwater availability models do not permit the differentiation between different water quality types. The total estimated recoverable storage values also do not take into account the effects of land surface subsidence, degradation of water quality, or any changes to surface water-groundwater interaction that may occur due to pumping.

METHODS:

To estimate the total recoverable storage of an aquifer, we first calculated the total storage in an aquifer within the official aquifer boundary in the groundwater management area. The total storage is the volume of groundwater that can be removed by completely draining the aquifer.

Aquifers can be either unconfined or confined (Figure 1). A well screened in an unconfined aquifer will have a water level equal to the water level outside the well—in the aquifer. Thus, an unconfined aquifer has water levels within the aquifer. A confined aquifer is bounded by low permeable geologic units at the top and bottom, and the aquifer is under hydraulic pressure above the ambient atmospheric pressure. The water level in a well screened in a confined aquifer will be above the top of the aquifer. As a result, calculation of total storage is different for unconfined and confined aquifers. For an unconfined aquifer, the total storage is equal to the volume of groundwater removed to make the water level fall to the aquifer bottom. For a confined aquifer, the total storage contains two parts. The first part is the groundwater released from the aquifer when the water level falls from above the top of the aquifer to the top of the aquifer. The reduction of hydraulic pressure in the aquifer by pumping causes expansion of groundwater and deformation of aquifer solids. The aquifer is still fully saturated to this point. The second part—just like unconfined aquifer—is the groundwater released from the aquifer when the water level falls from the top to the bottom of the aquifer. Given the same aquifer area and water level drop, the amount of water released in the second part is much greater than the first part. The difference is quantified by two parameters: storativity or specific storage related to confined aquifer and specific yield related to unconfined aquifer. For example, storativity values range from 10^{-5} to 10^{-3} for most confined aquifers, while the specific yield values can be 0.01 to 0.3 for most unconfined aquifers. The equations for calculating the total storage are presented below:

- for unconfined aquifers

$$Total\ Storage\ = V_{drained} = Area \times S_y \times (Water\ Level - Bottom)$$

- for confined aquifers

$$Total\ Storage\ = V_{confined} + V_{drained}$$

  - confined part

$$V_{confined} = \ Area \times [\ S \times (Water\ Level - Top)]$$

or

$$V_{confined} = \ Area \times [\ S_s\ \times (\mathrm{Top} - \mathrm{Bottom}) \times (Water\ Level - Top)]$$

  - unconfined part

$$V_{drained} = \ Area \times \left[S_y \times (Top - Bottom)\right]$$

where:

- $V_{drained}$ = storage volume due to water draining from the formation (acre-feet)
- $V_{confined}$ = storage volume due to elastic properties of the aquifer and water(acre-feet)
- *Area* = area of aquifer (acre)
- *Water Level* = groundwater elevation (feet above mean sea level)
- *Top* = elevation of aquifer top (feet above mean sea level)
- *Bottom* = elevation of aquifer bottom (feet above mean sea level)
- S_y = specific yield (no units)
- S_s = specific storage (1/feet)
- S = storativity or storage coefficient (no units)

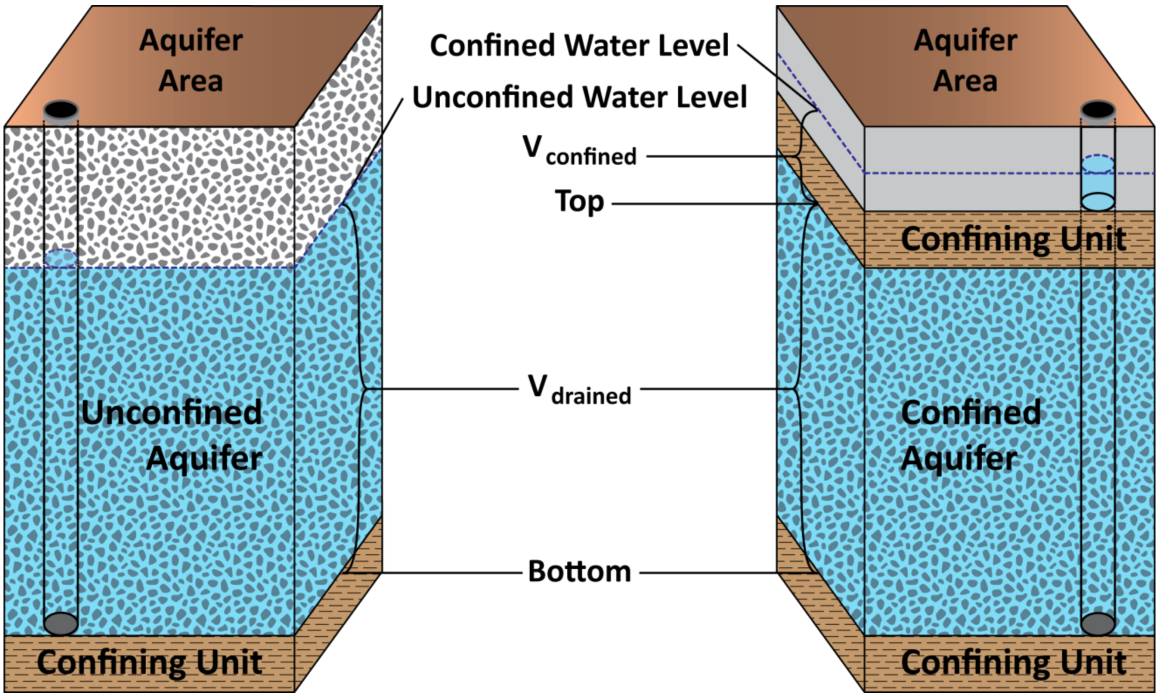


FIGURE 1. SCHEMATIC SHOWING THE DIFFERENCE BETWEEN UNCONFINED AND CONFINED AQUIFERS.

As presented in the equations, calculation of the total storage requires data, such as aquifer top, aquifer bottom, aquifer storage properties, and water level. For the Blaine, Rustler, Dockum, Trinity, Edwards-Trinity (Plateau), Ogallala, Pecos Valley, Lipan, and Seymour aquifers in Groundwater Management Area 7, we extracted this information from existing groundwater availability model input and output files on a cell-by-cell basis. For aquifers without groundwater availability model(s), analogous approaches were used.

For the Capitan Reef Complex Aquifer in Groundwater Management Area 7, we used surfaces for the aquifer top and base constructed by Standen and others (2009). Due to insufficient water-level data to construct a water-level map we calculated total storage for the Capitan Reef Complex Aquifer assuming that $V_{confined}$ is very small relative to $V_{drained}$ and therefore insignificant. We extracted the aquifer top and base data using a grid with 1 square mile cells (Figure 2) and calculated total storage for each cells using the above equations. Finally, the total estimated recoverable storage was calculated as the product of the total storage and an estimated factor ranging from 25 percent to 75 percent.

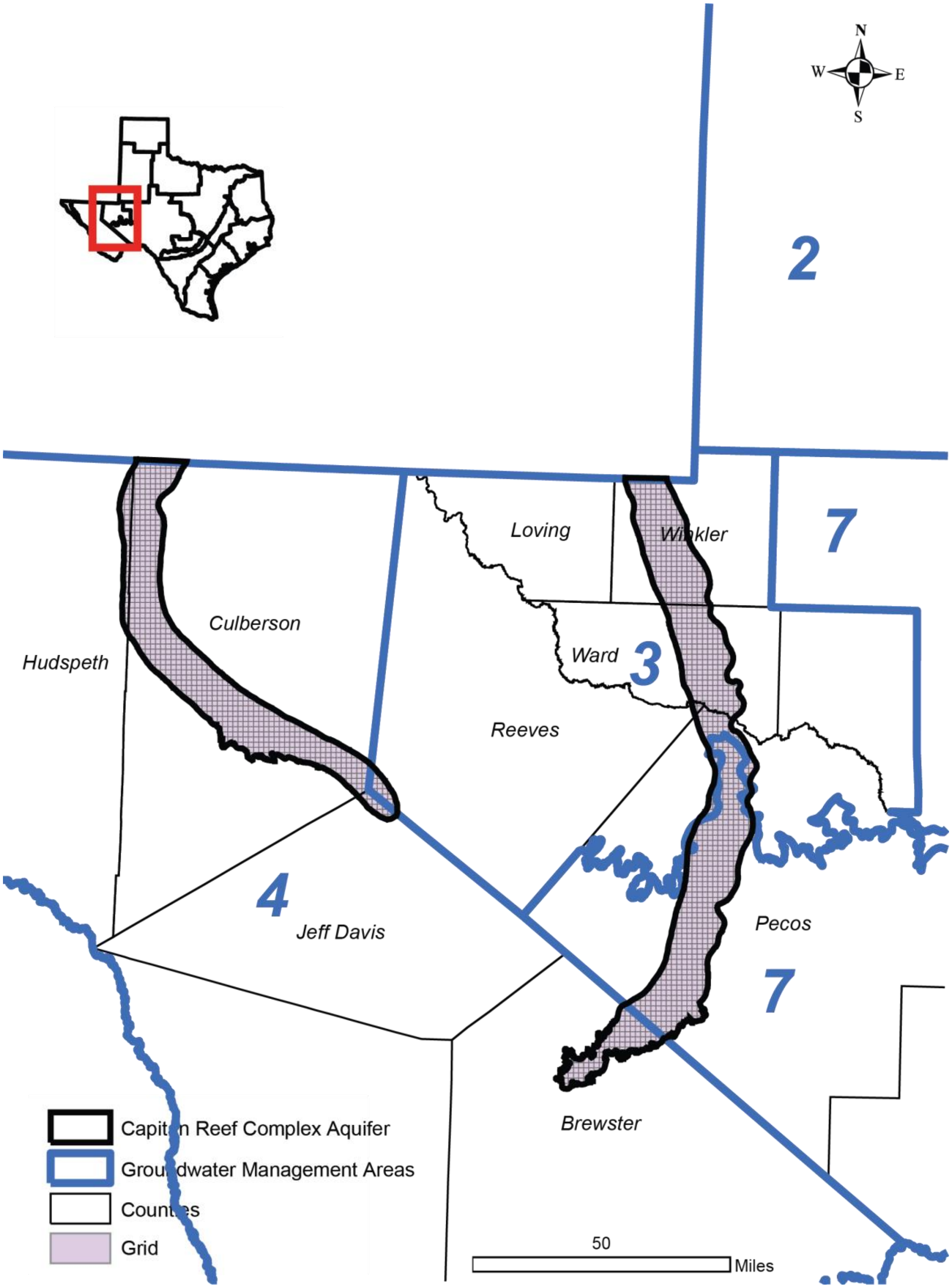


FIGURE 2. THE GRID CELLS USED TO CALCULATE TOTAL STORAGE FOR THE CAPITAN REEF COMPLEX AQUIFER IN GMA 7.

The following methodology was used to estimate total recoverable storage for parts of the Pecos Valley, Trinity, and Edwards-Trinity (Plateau) aquifers in Groundwater Management Area 7 that were not included in the 1-layer alternative groundwater flow model covering these aquifers (Hutchison and others, 2011a). The excluded parts of the respective aquifers are relatively thin and mostly located along the margins of the respective aquifers in the western part of the model.

Recoverable storage in areas outside of the model but within the official aquifer boundaries was estimated by first establishing a relationship between aquifer thickness and saturated thickness. Where aquifer thickness is the difference between the elevations of the aquifer top and base, and saturated thickness is the difference between the water table and aquifer base elevations. In each of the three aquifers included in this model there is a generally linear relationship between aquifer thickness and saturated thickness. In the Pecos Valley Aquifer, the ratio between saturated thickness and aquifer thickness is approximately 0.8, while in the Edwards-Trinity (Plateau) and Trinity aquifers, it is 0.9 and 0.6, respectively. Saturated thickness in the non-modeled areas was estimated using these ratios.

The three aquifers—Pecos Valley and Edwards-Trinity (Plateau) aquifers, and the Hill Country portion of the Trinity Aquifer—were assumed to be unconfined. Consequently, storage in each model cell representing parts of the respective aquifers excluded from the groundwater flow model was estimated using the following equation:

$$Total\ Storage = V_{drained} = Area \times S_y \times H_{sat}$$

where:

- $V_{drained}$ = storage volume due to water draining from the formation (acre-feet)
- $Area$ = area of aquifer (acre)
- S_y = specific yield (no units)
- H_{sat} = estimated saturated thickness (feet)

Storage volumes estimated using this method were added to the storage volumes from the modeled area to estimate the total recoverable storage for the entire aquifer.

The "Method of the Wedges" was used to calculate total storage for the Igneous Aquifer in Groundwater Management Area 7 which was excluded from the groundwater availability model for the Igneous Aquifer (Beach and others, 2004a). This area occurs along the margins of the Igneous Aquifer where the aquifer pinches out and is difficult to model. Total storage in this part of the aquifer was calculated based on the assumption that it takes the form of a right-wedge (Figure 3). Total storage was calculated by multiplying the volume of the assumed right-wedge by an assumed specific yield.

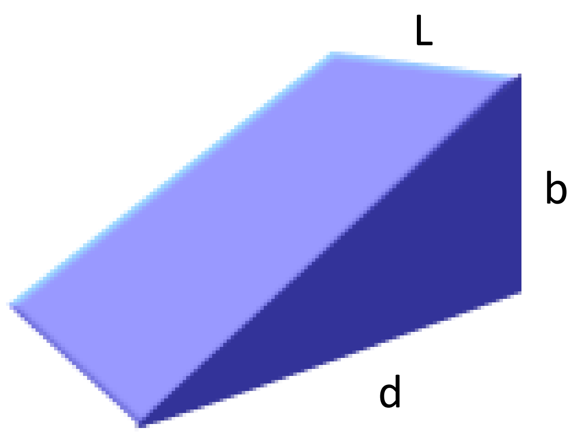


FIGURE 3. A SCHEMATIC OF THE RIGHT-WEDGE USED TO CALCULATE TOTAL STORAGE IN THE IGNEOUS AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

The volume of the right-edge was calculated using the formula:

$$V = 0.5 \times b \times L \times d$$

Where:

- *b* = the average saturated thickness of the last row of active model cells bordering the "wedge";
- *L* = the length of the last row of active model cells bordering the "wedge"; and
- *d* = the average distance between the last row of active model cells and the aquifer boundary.

In the case of the Edwards-Trinity (Plateau) Aquifer in Kinney County, aquifer bottom, area, storativity, and water levels were extracted from the input and output files of the alternative groundwater flow model for Kinney County (Hutchison and others, 2011b) on a cell-by-cell basis. Specific yield was not included in the model Layer-Property Flow package in this model because the Kinney County groundwater flow model simulated all hydrostratigraphic units as confined aquifers. The specific yield values for the Edwards-Trinity (Plateau) Aquifer were derived from the groundwater availability model by Anaya and Jones (2009), where a specific yield value of 0.014 was assigned for the Edwards Group and a specific yield value of 0.003 Trinity Group in the Edwards-Trinity (Plateau) Aquifer. A FORTRAN-90 program was developed and used to expedite the storage calculation. The total recoverable storage was calculated as the product of the total storage and an estimated factor ranging from 25 percent to 75 percent.

The water-level data from the TWDB Groundwater Database were used to develop the potentiometric surface and the total storage estimate for the Hickory, Ellenburger-San Saba, and Marble Falls aquifers. These water-level measurements were used to construct a potentiometric surface grid using Surfer® software. The base of the Hickory and Ellenburger-San Saba aquifers outcrop were derived from the Source Water Assessment Project (SWAP) data created by the United States Geological Survey (2002a; 2002b). These surfaces were re-created as grids in Surfer® software and used to calculate aquifer volumes. For the subcrop area, we used the top and bottom of the Hickory and Ellenburger-San Saba aquifers from Standen and others (2007). The confined volumes were calculated by first taking the difference in the potentiometric surface and tops of the respective aquifers in subcrop. This value was multiplied by a storage coefficient of 10-5 for the Hickory Aquifer and 0.0022 for the Ellenburger-San Saba aquifers, resulting in the total storage volume for the portion above the top of the aquifer. The unconfined volumes were calculated by multiplying the aquifer thickness by an assumed specific yield value of 0.03. Zonal statistics in ArcMap 10.1 software summed the data from grid calculations by county and groundwater conservation district. To calculate the estimated total estimated aquifer storage for the Marble Falls aquifer, the average saturated thickness was multiplied by the specific yield and aquifer area.

PARAMETERS AND ASSUMPTIONS:

Hickory and Ellenburger-San Saba Aquifers

- The Hickory and Ellenburger-San Saba aquifers within Groundwater Management Area 7 are unconfined in outcrop and confined in the subcrop areas.
- Limited storage data is available, but because the calculations include all of the Hickory and Ellenburger-San Saba aquifers, we used a storage coefficient of 10^{-4} and a specific yield of 0.03 (Bluntzer, 1992).

Marble Falls Aquifer

- The Marble Falls Aquifer—which only occurs in outcrop—is assumed to be unconfined.
- The saturated thickness is estimated at 60 feet based on available data (Texas Water Development Board Groundwater Database; Texas Department of Licensing and Regulation, 2013). No storage data was located for the area, but the specific yield is estimated to be 3 percent (American Society of Civil Engineers, 1996).

Blaine and Seymour Aquifers

- We used version 1.01 of the groundwater availability model for the Seymour and Blaine aquifers. See Ewing and others (2004) for assumptions and limitations of the groundwater availability model.
- This groundwater availability model includes two layers, representing the Seymour (Layer 1) and Blaine (Layer 2) aquifers. In areas where the Blaine Aquifer does not exist the model roughly replicates the various Permian units located in the study area.
- Of the two layers, total estimated recoverable storage was determined using the cells in the model that represent the Blaine Aquifer in layer 2.

Capitan Reef Complex Aquifer

- The Capitan Reef Complex Aquifer within Groundwater Management Area 7 is under confined conditions throughout the area.

- The potentiometric surface was not constructed due to insufficient water-level data. Instead, we assumed that confined part of total storage is much smaller than the unconfined part and is therefore insignificant. The justification for this assumption is that the aquifer thickness and specific yield used to calculate the unconfined part of the total storage are much larger than the confined head—difference between the water level and aquifer top elevations—and the storativity or specific storage used to calculate the confined part of the total storage.
- We used the base and top of the Capitan Reef Complex Aquifer constructed by Standen and others (2009). These surfaces were used to calculate aquifer thickness.
- No storage data were discovered for the area. We used a conservative estimate for the specific yield of 0.05 based on borehole geophysics data for the Capitan Reef Complex Aquifer (Garber and others, 1989).
- The total storage was calculated for each cell by multiplying cell area, aquifer thickness and a specific yield of 0.05.

Rustler Aquifer

- We used version 1.01 of the groundwater availability model for the Rustler Aquifer to estimate the total recoverable storage for the Rustler Aquifer. See Ewing and Others (2012) for assumptions and limitations of the groundwater availability model.
- This groundwater availability model includes two numerical layers which represent Dockum Aquifer/Dewey Lake Formation (Layer 1) and Rustler Aquifer (Layer 2).
- Model Layer 2 was used to calculate the total estimated recoverable storage for the Rustler Aquifer.

Dockum Aquifer

- We used version 1.01 of the groundwater availability model for the Dockum Aquifer to estimate the total recoverable storage for the aquifer. See Ewing and other (2008) for assumptions and limitations of the groundwater availability model.
- This 3-layer groundwater availability model includes two layers—layers 2 and 3—which represent the Dockum Aquifer.
- The groundwater availability model for the Dockum Aquifer includes down-dip portions of the Dockum Group that are not included in the official aquifer boundaries (Ewing and other, 2008). The down-dip boundary of the Dockum Aquifer is based on the 5,000 milligrams per liter (mg/L) total dissolved solids concentration line while the model extends beyond the 5,000 mg/L total dissolved solids line incorporating highly saline parts of the Dockum Group.

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

- We used the alternative groundwater flow model for the Edwards-Trinity (Plateau) Aquifer. See Hutchison and others (2011a) for assumptions and limitations of the alternative numerical groundwater flow model.
- We used the alternative groundwater flow model for the Edwards-Trinity (Plateau) Aquifer instead of the 2-layer official groundwater availability model (Anaya and Jones, 2009) because the alternative groundwater flow model has better water-level calibration statistics.
- This 1-layer groundwater flow model simulates groundwater flow through the Pecos Valley and Edwards-Trinity (Plateau) aquifers, and the Hill Country portion of the Trinity Aquifer.
- In this model, where the Pecos Valley and Edwards-Trinity (Plateau) aquifer overlap, total storage is assigned to the Pecos Valley Aquifer.

Edwards-Trinity (Plateau) Aquifer in Kinney County

- We used version 1.01 of the alternative groundwater flow model for the Kinney County area to estimate the total recoverable storage for the Edwards (Balcones Fault Zone) and Edwards-Trinity (Plateau) aquifers in Kinney County. See Hutchison and Others (2011b) for assumptions and limitations of the numerical groundwater flow model.

- This groundwater flow model includes four numerical layers which represent the Carrizo-Wilcox Aquifer (Layer 1), Upper Cretaceous units (Layer 2), the Edwards (Balcones Fault Zone) and Edwards Unit of the Edwards-Trinity (Plateau) Aquifer (Layer 3), and the Trinity Unit of the Edwards-Trinity (Plateau) Aquifer (Layer 4).
- Model Layers 3 and 4 were used to calculate the total estimated recoverable storage for the Edwards-Trinity (Plateau) Aquifer in the Groundwater Management Area 7 in Kinney County.

Igneous Aquifer

- The part of the Igneous Aquifer in Groundwater Management Area 7 is not included in version 1.01 of the Igneous Aquifer and parts of the West Texas Bolsons—Wild Horse, Michigan, Ryan, and Lobo flats (Beach and others,2004a).
- Total storage was calculated based on aquifer thickness and length data obtained from the groundwater availability model by Beach and others (2004a) and an assumed specific yield value of 0.01. Please see the Methods Section for the approach used.

Ogallala Aquifer

- We used version 2.01 of the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer to estimate the total recoverable storage for the southern portion of the Ogallala Aquifer. This model is an expansion on and update to the previously developed groundwater availability model for the southern portion of the Ogallala Aquifer described in Blandford and others (2003). See Blandford and others (2008) and Blandford and others (2003) for assumptions and limitations of the groundwater availability model.
- This groundwater availability model includes 4 layers which represent the southern portion of the Ogallala Aquifer (Layer 1) and the Edwards-Trinity (High Plains) Aquifer (primarily Edwards, Comanche Peak, and Antlers Sand formations; Layers 2-4).
- Of the four layers, total estimated recoverable storage was determined for the Ogallala Aquifer (Layer 1) in Groundwater Management Area 7.

Lipan Aquifer

- We used version 1.01 of the groundwater availability model for the Lipan Aquifer to estimate the total recoverable storage (Beach and others, 2004b).
- This groundwater availability model includes one layer that represents the Quaternary Leona Formation, the underlying Permian Formations, and the Edwards-Trinity (Plateau) Aquifer to the west, south, and north. The basis for the extent of the model boundaries for the Lipan Aquifer was developed using the boundaries recognized by TWDB prior to the boundary changes discussed in the 2007—Water For Texas state water plan.
- We used the version 1.01 of the groundwater availability model for the Dockum Aquifer to estimate total storage values for parts of the Lipan Aquifer that were not included in the groundwater availability model for the Lipan Aquifer and overlapped with the Dockum Aquifer. Layer 1 of the model represents overlying stratigraphic units, where the overlying stratigraphic units are within the Lipan Aquifer boundary, we assume the volumes represent the Lipan Aquifer.

RESULTS:

Tables 1 through 28 summarize the total estimated recoverable storage required by statute. The county and groundwater conservation district total estimates are rounded within two significant figures. Figures 4 through 17 indicates the extents of the Hickory, Ellenburger-San Saba, Marble Falls, Blaine, Capitan Reef Complex, Rustler, Dockum, Trinity, Edwards-Trinity (Plateau), Igneous, Ogallala, Pecos Valley, Lipan, and Seymour aquifers in Groundwater Management Area 7 used to estimate the total recoverable storage volume.

TABLE 1. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE HICKORY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Coleman	1,500,000	375,000	1,125,000
Concho	2,800,000	700,000	2,100,000
Gillespie	7,200,000	1,800,000	5,400,000
Kimble	5,900,000	1,475,000	4,425,000
Llano	1,000,000	250,000	750,000
Mason	5,400,000	1,350,000	4,050,000
McCulloch	8,500,000	2,125,000	6,375,000
Menard	4,500,000	1,125,000	3,375,000
San Saba	7,500,000	1,875,000	5,625,000
Total	44,300,000	11,075,000	33,225,000

TABLE 2. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[3] FOR THE HICKORY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	8,400,000	2,100,000	6,300,000
Hickory UWCD[4] No. 1	18,000,000	4,500,000	13,500,000
Hill Country UWCD	7,200,000	1,800,000	5,400,000
Kimble County GCD	5,500,000	1,375,000	4,125,000
Lipan-Kickapoo GCD	1,900,000	475,000	1,425,000
Menard County UWD[5]	3,300,000	825,000	2,475,000
Total	44,300,000	11,075,000	33,225,000

[3] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.
[4] UWCD is the abbreviation for Underground Water Conservation District.
[5] UWD is the abbreviation for Underground Water District.

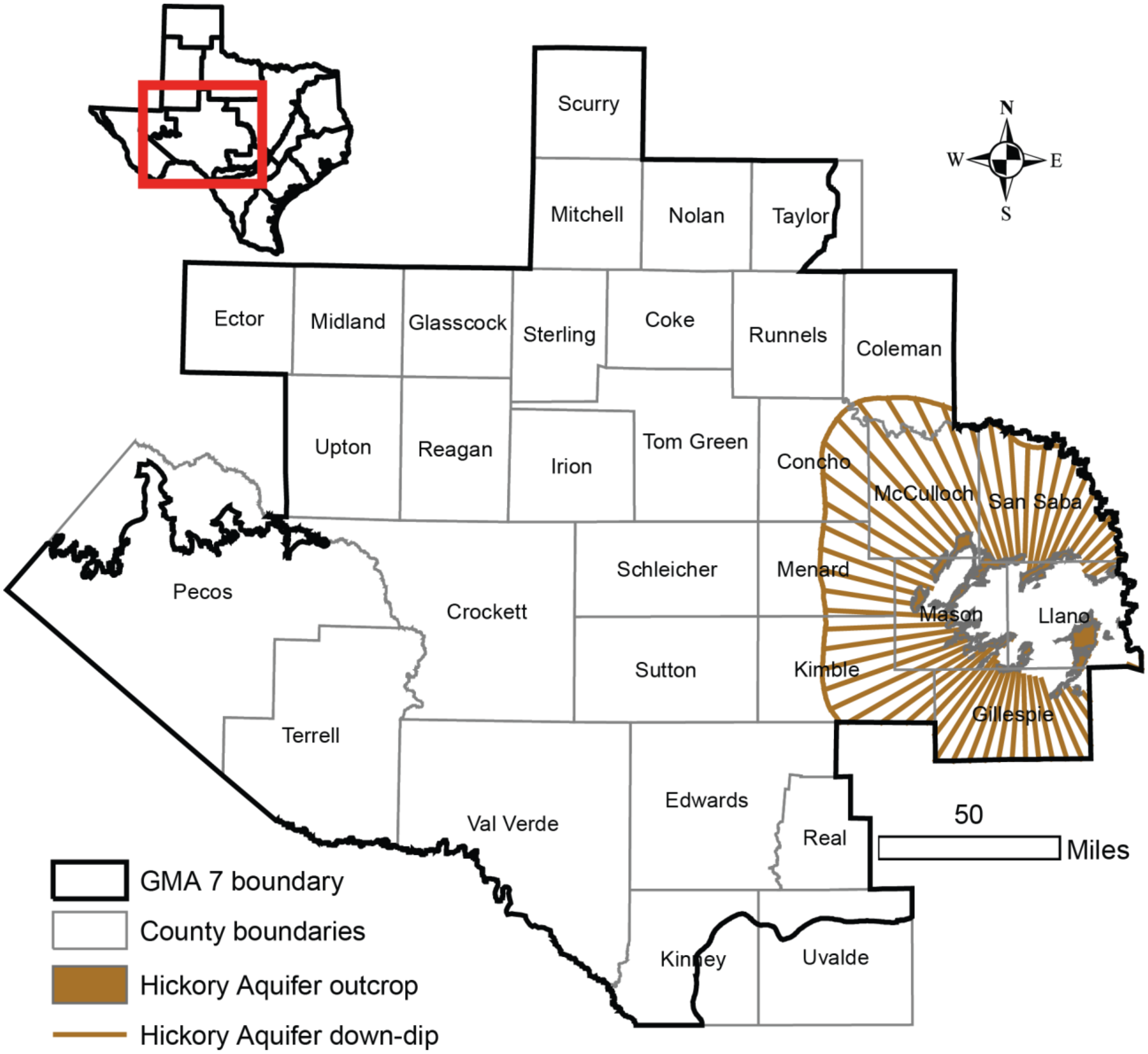


FIGURE 4. AREA OF THE HICKORY AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE WITHIN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 3. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE ELLENBURGER-SAN SABA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Coleman	1,400,000	350,000	1,050,000
Concho	62,000	15,500	46,500
Gillespie	6,500,000	1,625,000	4,875,000
Kimble	6,000,000	1,500,000	4,500,000
Llano	350,000	87,500	262,500
Mason	1,900,000	475,000	1,425,000
McCulloch	16,000,000	4,000,000	12,000,000
Menard	1,600,000	400,000	1,200,000
San Saba	20,000,000	5,000,000	15,000,000
Total	53,812,000	13,453,000	40,359,000

TABLE 4. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[6] FOR THE ELLENBURGER-SAN SABA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	17,850,000	4,462,500	13,387,500
Hickory UWCD[7] No. 1	23,019,000	5,754,750	17,264,250
Hill Country UWCD	6,500,000	1,625,000	4,875,000
Kimble County GCD	5,300,000	1,325,000	3,975,000
Lipan-Kickapoo GCD	43,000	10,750	32,250
Menard County UWD[8]	1,100,000	275,000	825,000
Total	53,812,000	13,453,000	40,359,000

[6] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.
[7] UWCD is the abbreviation for Underground Water Conservation District.
[8] UWD is the abbreviation for Underground Water District.

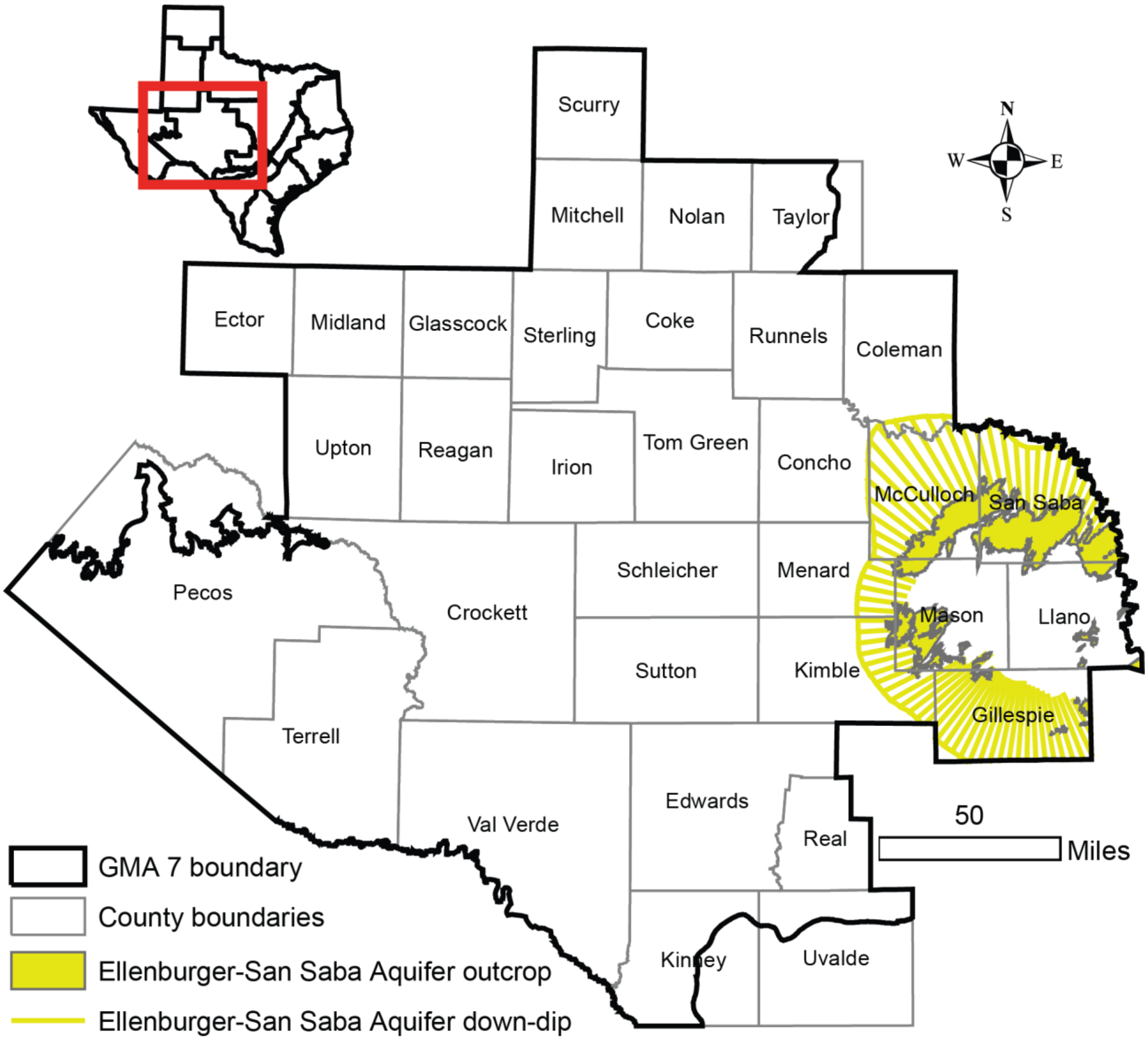


FIGURE 5. AREA OF THE ELLENBURGER-SAN SABA AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE WITHIN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 5. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE MARBLE FALLS AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Kimble	2,400	600	1,800
Llano	2,100	525	1,575
Mason	5,300	1,325	3,975
McCulloch	33,000	8,250	24,750
San Saba	144,000	36,000	108,000
Total	186,800	46,693	140,078

TABLE 6. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[9] FOR THE MARBLE FALLS AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	55,000	13,750	41,250
Hickory UWCD[10] No. 1	130,000	32,500	97,500
Kimble County GCD	970	243	728
Total	130,970	32,743	98,228

[9] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.
[10] UWCD is the abbreviation for Underground Water Conservation District.

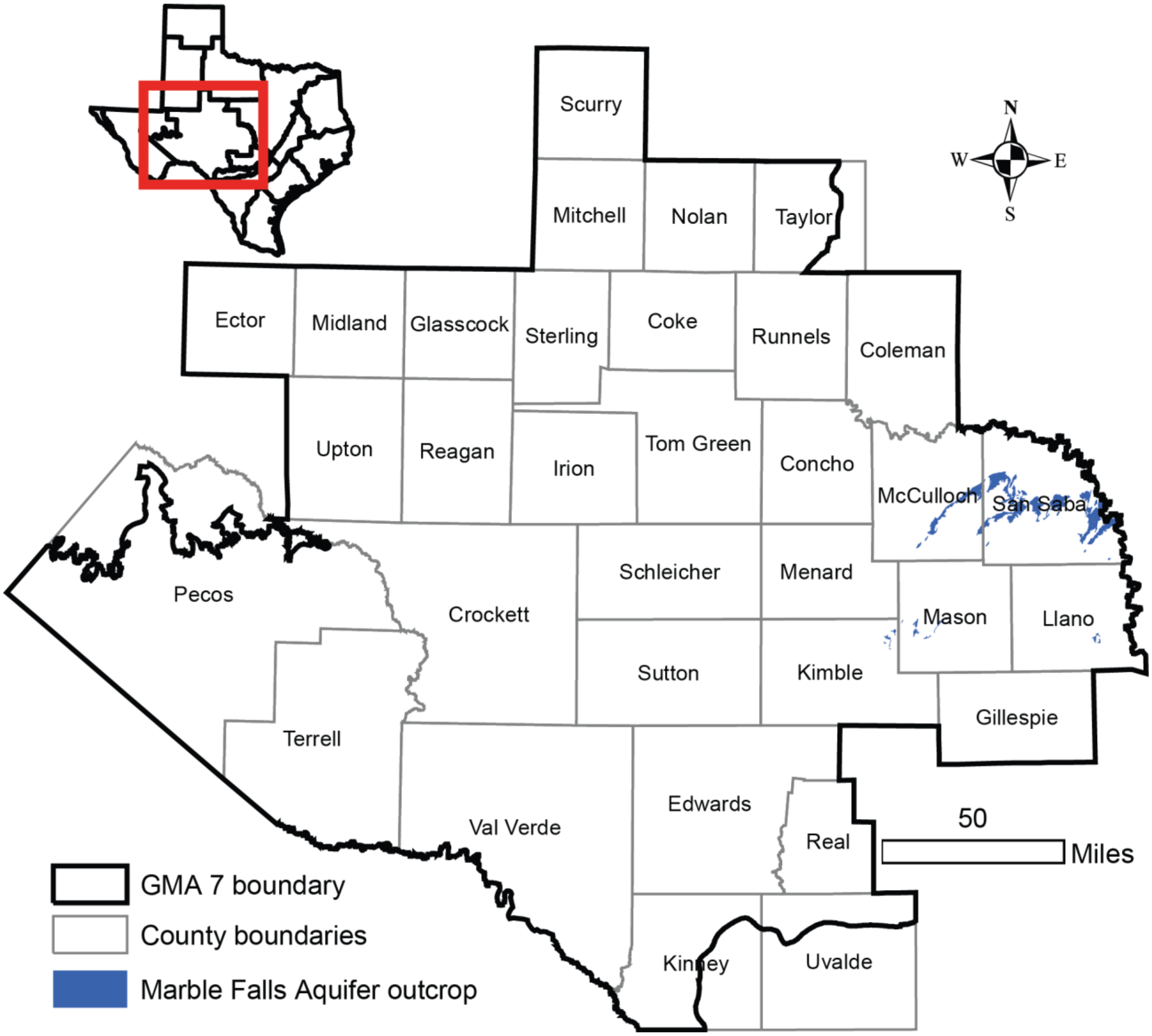


FIGURE 6. AREA OF THE MARBLE FALLS AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR WITHIN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 7. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE BLAINE AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Nolan	260,000	65,000	195,000
Total	260,000	65,000	195,000

TABLE 8. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[11] FOR THE BLAINE AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Wes-Tex GCD	260,000	65,000	195,000
Total	260,000	65,000	195,000

[11] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.

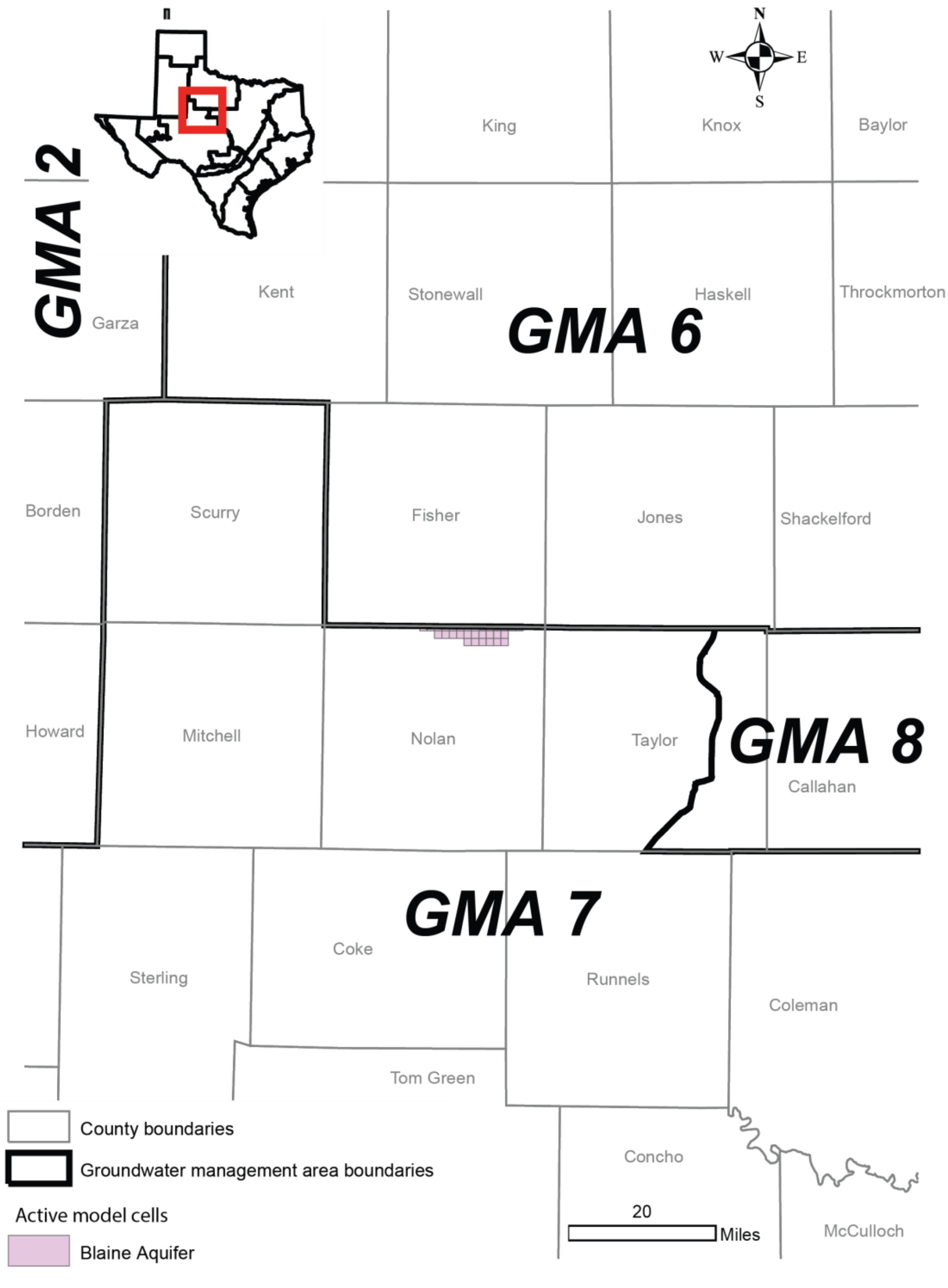


FIGURE 7. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE SEYMOUR AND BLAINE AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE BLAINE AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 9. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE CAPITAN REEF COMPLEX AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Pecos	14,000,000	3,500,000	10,500,000
Total	14,000,000	3,500,000	10,500,000

TABLE 10. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[12] FOR THE CAPITAN REEF COMPLEX AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Middle Pecos GCD	14,000,000	3,500,000	10,500,000
Total	14,000,000	3,500,000	10,500,000

[12] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.

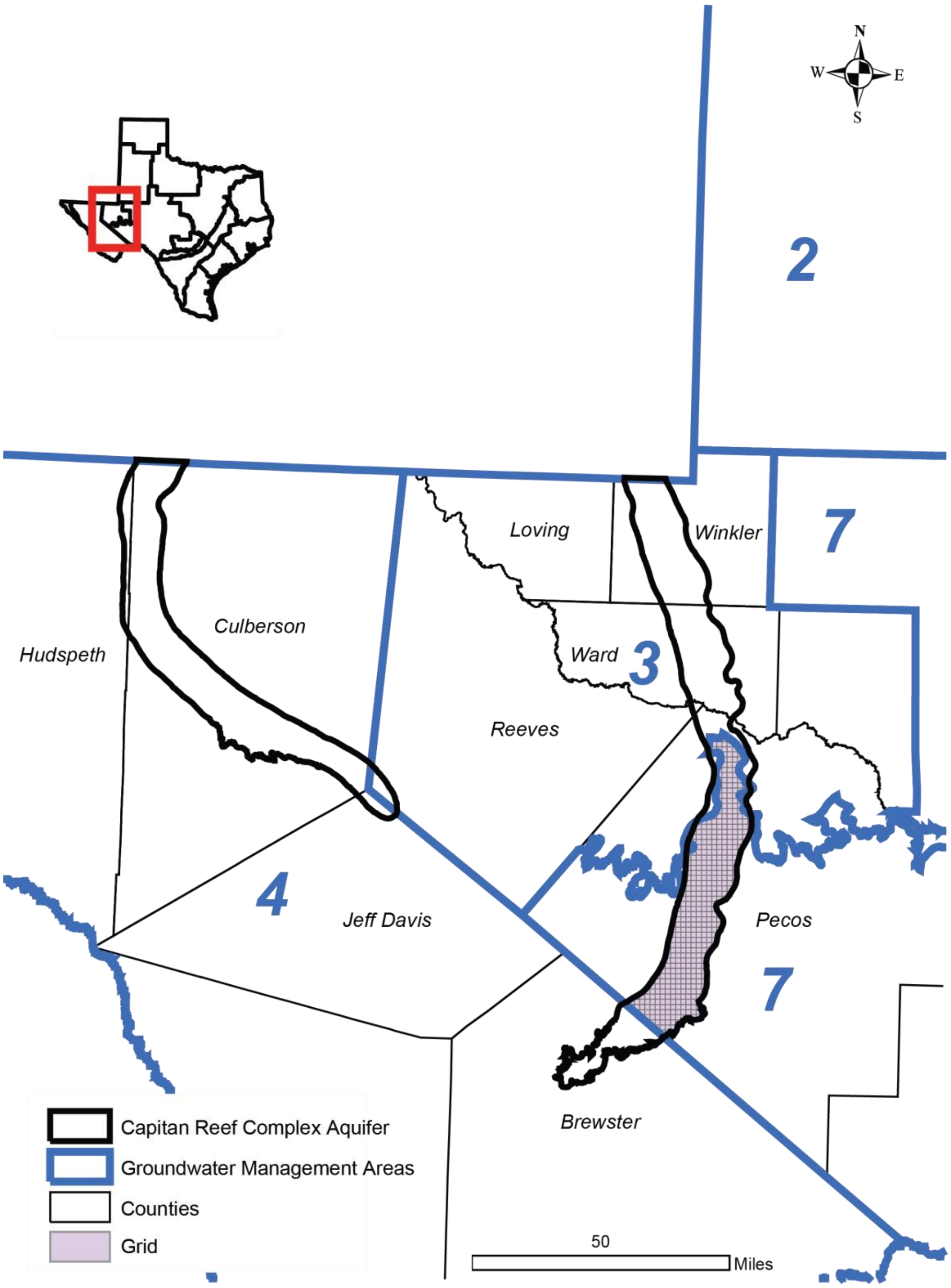


FIGURE 8. AREA OF THE CAPITAN REEF COMPLEX AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE WITHIN GROUNDWATER MANAGEMENT AREA 7.

TABLE 11. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE RUSTLER AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Pecos	5,000,000	1,250,000	3,750,000
Total	5,000,000	1,250,000	3,750,000

TABLE 12. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[13] FOR THE RUSTLER AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Middle Pecos GCD	5,000,000	1,250,000	3,750,000
Total	5,000,000	1,250,000	3,750,000

[13] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.

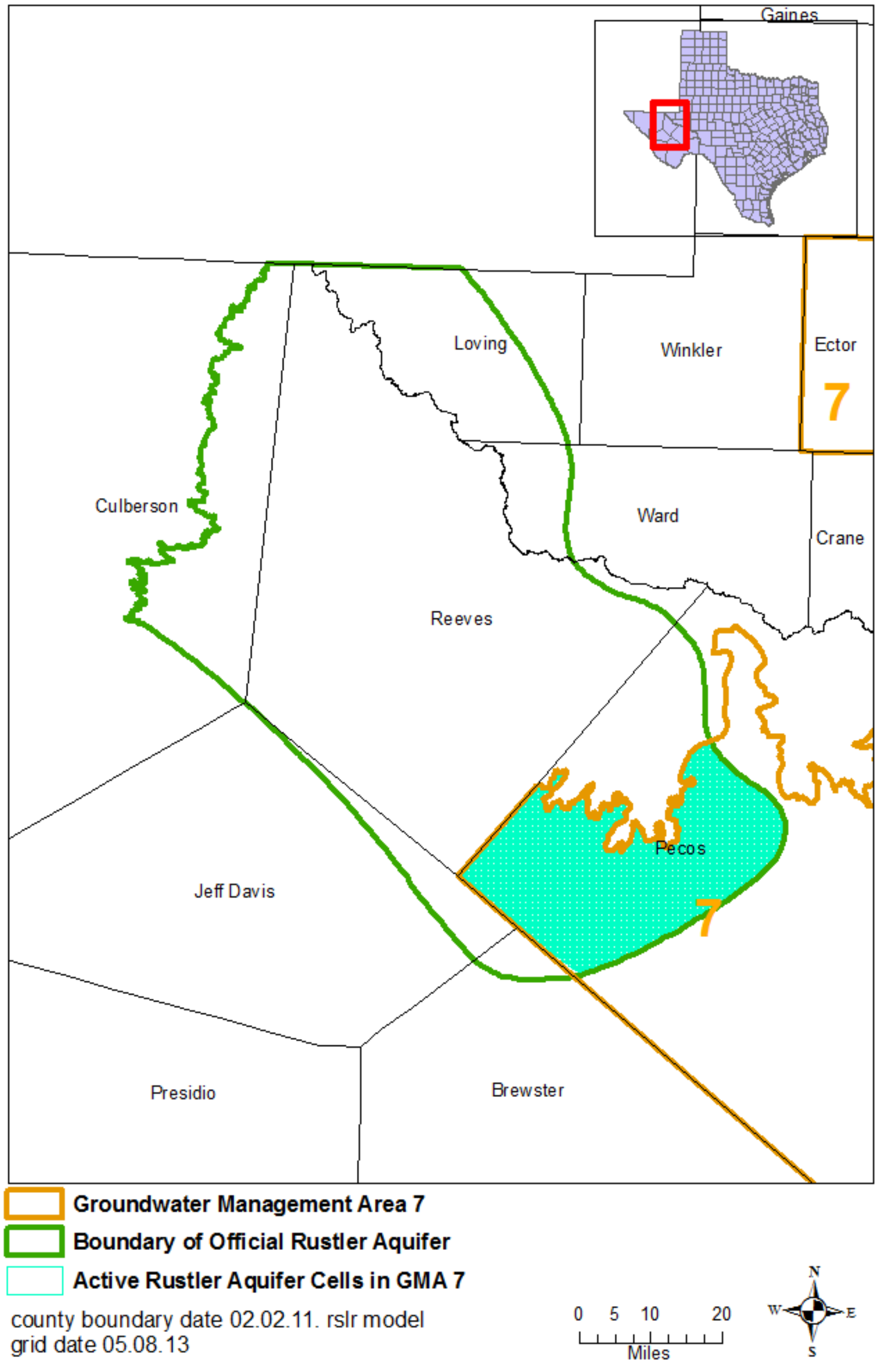


FIGURE 9. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE RUSTLER AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 13. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE DOCKUM AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Coke	520,000	130,000	390,000
Crockett	14,000,000	3,500,000	10,500,000
Ector	100,000,000	25,000,000	75,000,000
Glasscock	11,000,000	2,750,000	8,250,000
Irion	9,100,000	2,275,000	6,825,000
Midland	10,000,000	2,500,000	7,500,000
Mitchell	27,000,000	6,750,000	20,250,000
Nolan	2,100,000	525,000	1,575,000
Pecos	2,500,000	625,000	1,875,000
Reagan	17,000,000	4,250,000	12,750,000
Scurry	32,000,000	8,000,000	24,000,000
Sterling	33,000,000	8,250,000	24,750,000
Tom Green	1,100,000	275,000	825,000
Upton	9,300,000	2,325,000	6,975,000
Total	268,620,000	67,155,000	201,465,000

TABLE 14. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[14] FOR THE DOCKUM AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	160,000,000	40,000,000	120,000,000
Coke County UWCD[15]	520,000	130,000	390,000
Crockett County GCD	14,000,000	3,500,000	10,500,000
Glasscock GCD	11,000,000	2,750,000	8,250,000
Irion County WCD[16]	9,600,000	2,400,000	7,200,000
Lone Wolf GCD	27,000,000	6,750,000	20,250,000
Middle Pecos GCD	2,500,000	625,000	1,875,000
Santa Rita UWCD	17,000,000	4,250,000	12,750,000
Sterling County UWCD	33,000,000	8,250,000	24,750,000
Wes-Tex GCD	2,100,000	525,000	1,575,000
Total	276,720,000	69,180,000	207,540,000

[14] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.
[15] UWCD is the abbreviation for Underground Water Conservation District.
[16] WCD is the abbreviation for Water Conservation District.

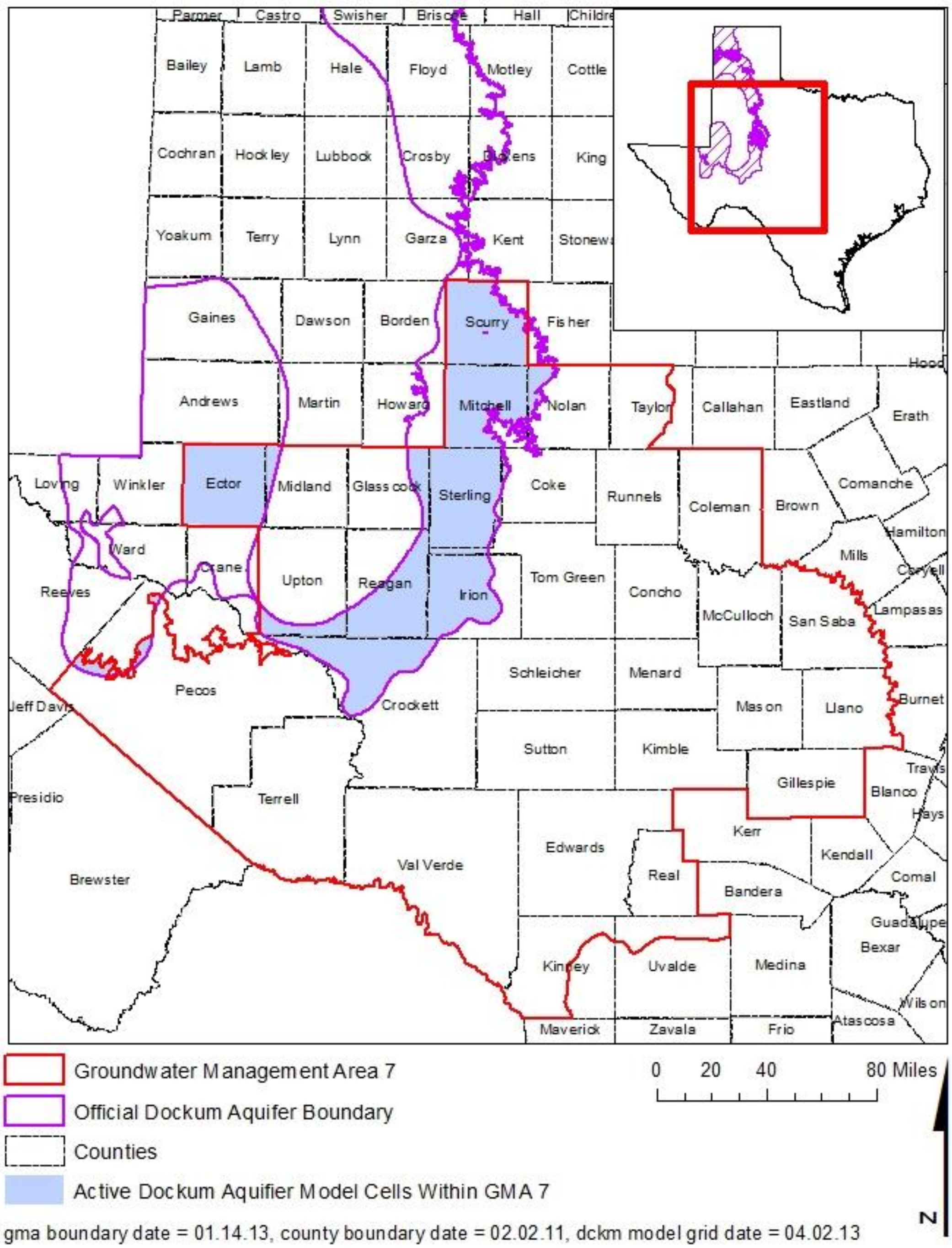


FIGURE 10. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 15. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE TRINITY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Gillespie	270,000	67,500	202,500
Real	23,000	5,750	17,250
Uvalde	230,000	57,500	172,500
Total	523,000	130,750	392,250

TABLE 16. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[17] FOR THE TRINITY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Hill Country UWCD[18]	270,000	67,500	202,500
Real-Edwards C & R[19] District	23,000	5,750	17,250
Uvalde County UWCD	230,000	57,500	172,500
Total	523,000	130,750	392,250

[17] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.
[18] UWCD is the abbreviation for Underground Water Conservation District.
[19] C &R is the abbreviation for Conservation and Reclamation

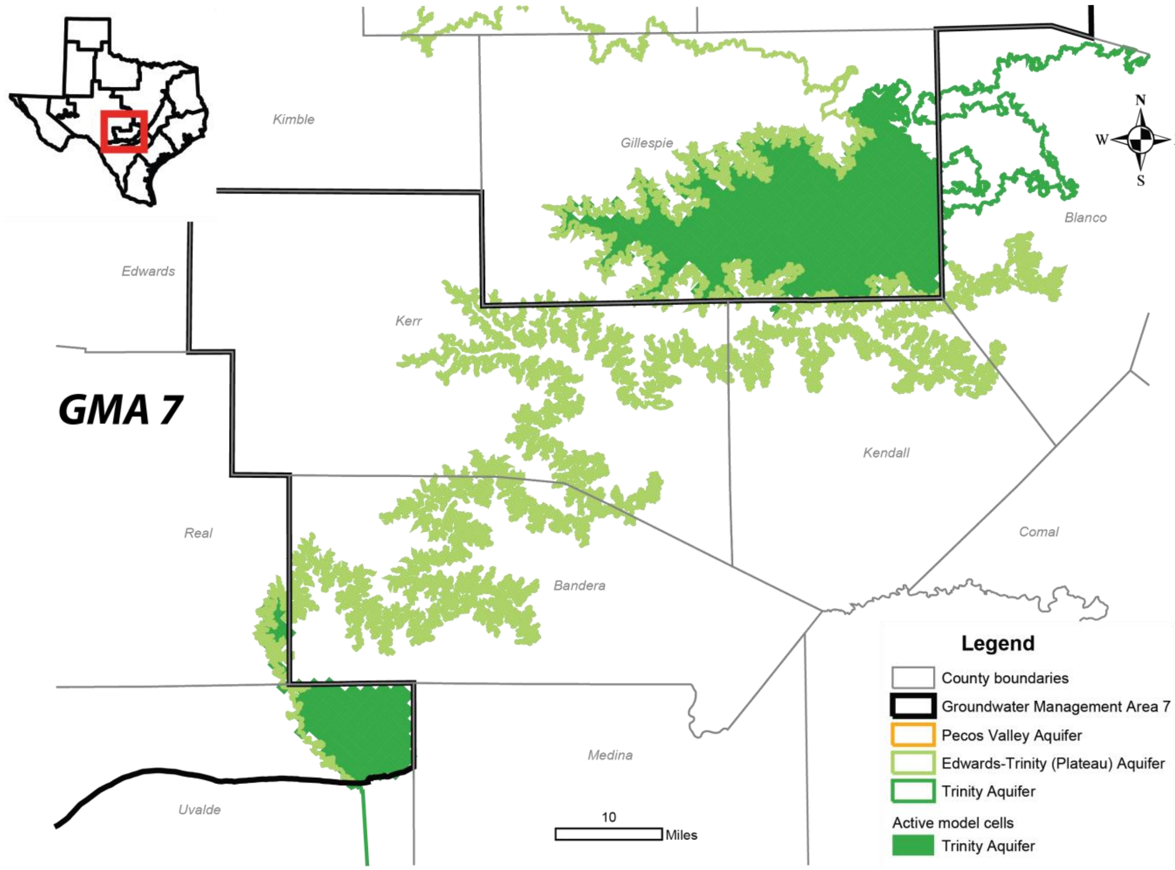


FIGURE 11. AREA OF THE TRINITY AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE WITHIN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 17. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Coke	120,000	30,000	90,000
Concho	79,000	19,750	59,250
Crockett	1,500,000	375,000	1,125,000
Ector	220,000	55,000	165,000
Edwards	5,000,000	1,250,000	3,750,000
Gillespie	430,000	107,500	322,500
Glasscock	270,000	67,500	202,500
Irion	420,000	105,000	315,000
Kimble	1,100,000	275,000	825,000
Kinney[20]	4,400,000	1,100,000	3,300,000
Mason	51,000	12,750	38,250
McCulloch	93,000	23,250	69,750
Menard	250,000	62,500	187,500
Midland	240,000	60,000	180,000
Nolan	170,000	42,500	127,500
Pecos	3,100,000	775,000	2,325,000
Reagan	560,000	140,000	420,000
Real	1,600,000	400,000	1,200,000

[20] Total storage values for Kinney County are based on the alternative model by Hutchison and others (2011), the other total storage values were based on the groundwater availability model by Anaya and Jones (2009).

County	***Total Storage (acre-feet)***	***25 percent of Total Storage (acre-feet)***	***75 percent of Total Storage (acre-feet)***
Schleicher	890,000	222,500	667,500
Sterling	150,000	37,500	112,500
Sutton	1,800,000	450,000	1,350,000
Taylor	78,000	19,500	58,500
Terrell	4,500,000	1,125,000	3,375,000
Tom Green	250,000	62,500	187,500
Upton	550,000	137,500	412,500
Uvalde	1,000,000	250,000	750,000
Val Verde	10,000,000	2,500,000	7,500,000
Total	38,821,000	9,705,250	29,115,750

TABLE 18. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[21] FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	11,000,000	2,750,000	8,250,000
Coke County UWCD[22]	120,000	30,000	90,000
Crockett County GCD	1,500,000	375,000	1,125,000
Glasscock GCD	320,000	80,000	240,000
Hickory UWCD No. 1	210,000	52,500	157,500
Hill Country UWCD	430,000	107,500	322,500
Irion County WCD[23]	450,000	112,500	337,500
Kimble County GCD	1,100,000	275,000	825,000
Kinney County GCD[24]	4,400,000	1,100,000	3,300,000
Lipan-Kickapoo WCD	220,000	55,000	165,000
Menard County UWD[25]	210,000	52,500	157,500
Middle Pecos GCD	3,100,000	775,000	2,325,000
Plateau UWC[26] and Supply District	890,000	222,500	667,500

[21] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.
[22] UWCD is the abbreviation for Underground Water Conservation District.
[23] WCD is the abbreviation for Water Conservation District.
[24] Total storage values for Kinney County GCD are based on the alternative model by Hutchison and others (2011), the other total storage values were based on the groundwater availability model by Anaya and Jones (2009).
[25] UWD is the abbreviation for Underground Water District.
[26] UWC is the abbreviation for Underground Water Conservation.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Real-Edwards C & R[27] District	6,600,000	1,650,000	4,950,000
Santa Rita UWCD	520,000	130,000	390,000
Sterling County UWCD	160,000	40,000	120,000
Sutton County UWCD	1,800,000	450,000	1,350,000
Terrell County GCD	4,500,000	1,125,000	3,375,000
Uvalde County UWCD	1,000,000	250,000	750,000
Wes-Tex GCD	170,000	42,500	127,500
Total	38,700,000	9,675,000	29,025,000

[27] C & R is the abbreviation for Conservation and Reclamation.

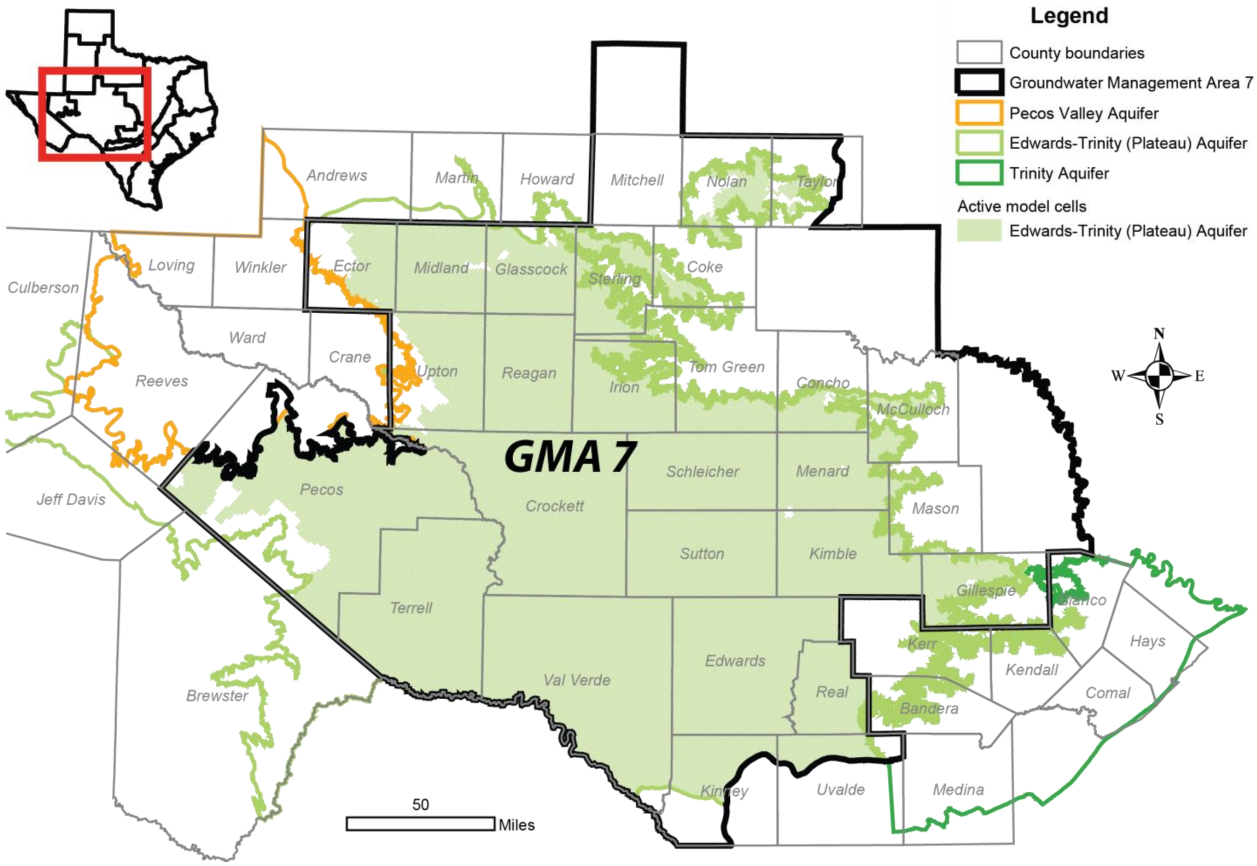


FIGURE 12. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER AND THE ALTERNATIVE GROUNDWATER FLOW MODEL FOR KINNEY COUNTY USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 19. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE IGNEOUS AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Pecos	350	88	263
Total	350	88	263

TABLE 20. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[28] FOR THE IGNEOUS AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Middle Pecos GCD	350	88	263
Total	350	88	263

[28] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.

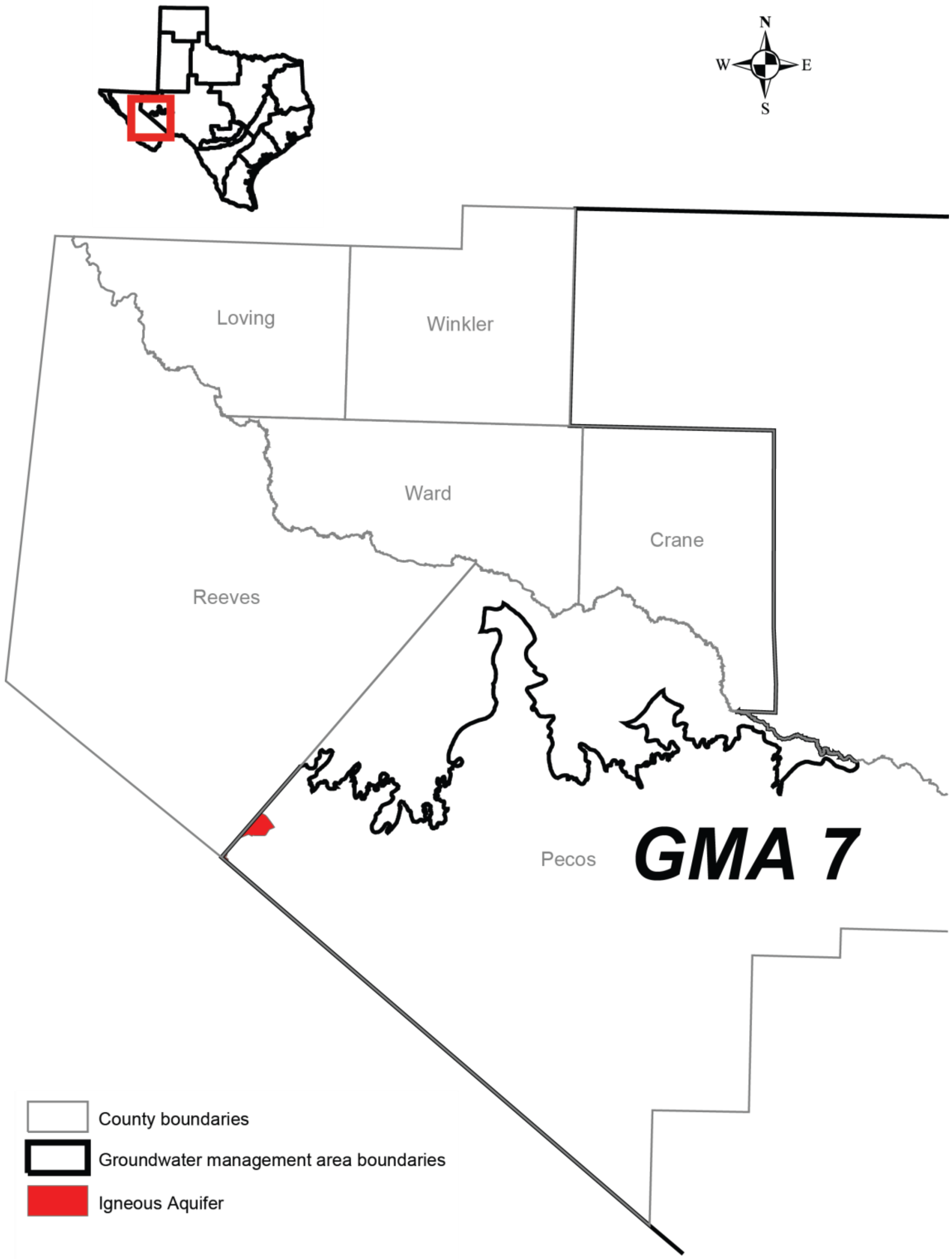


FIGURE 13. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE IGNEOUS AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE IGNEOUS AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 21. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE OGALLALA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Ector	840,000	210,000	630,000
Glasscock	2,000,000	500,000	1,500,000
Midland	3,500,000	875,000	2,625,000
Total	6,340,000	1,585,000	4,755,000

TABLE 22. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[29] FOR THE OGALLALA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	4,400,000	1,100,000	3,300,000
Glasscock GCD	2,000,000	500,000	1,500,000
Total	6,400,000	1,600,000	4,800,000

[29] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.

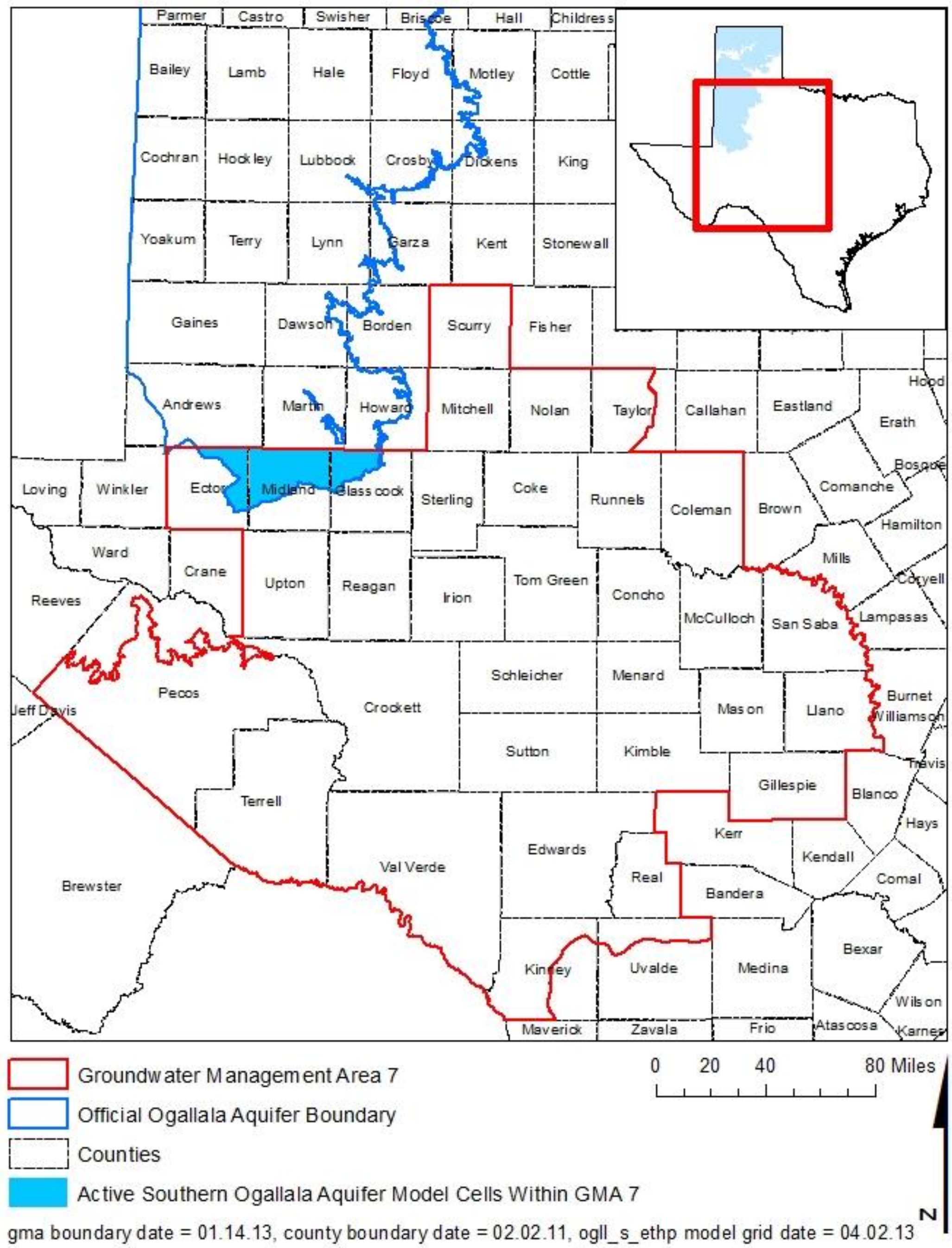


FIGURE 14. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER AND THE SOUTHERN PORTION OF THE OGALLALA AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 23. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE PECOS VALLEY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Crockett	160,000	40,000	120,000
Ector	5,900,000	1,475,000	4,425,000
Pecos	910,000	227,500	682,500
Upton	4,400,000	1,100,000	3,300,000
Total	11,370,000	2,842,500	8,527,500

TABLE 24. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[30] FOR THE PECOS VALLEY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	10,000,000	2,500,000	7,500,000
Crockett County GCD	160,000	40,000	120,000
Middle Pecos GCD	910,000	227,500	682,500
Total	11,070,000	2,767,500	8,302,500

[30] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.

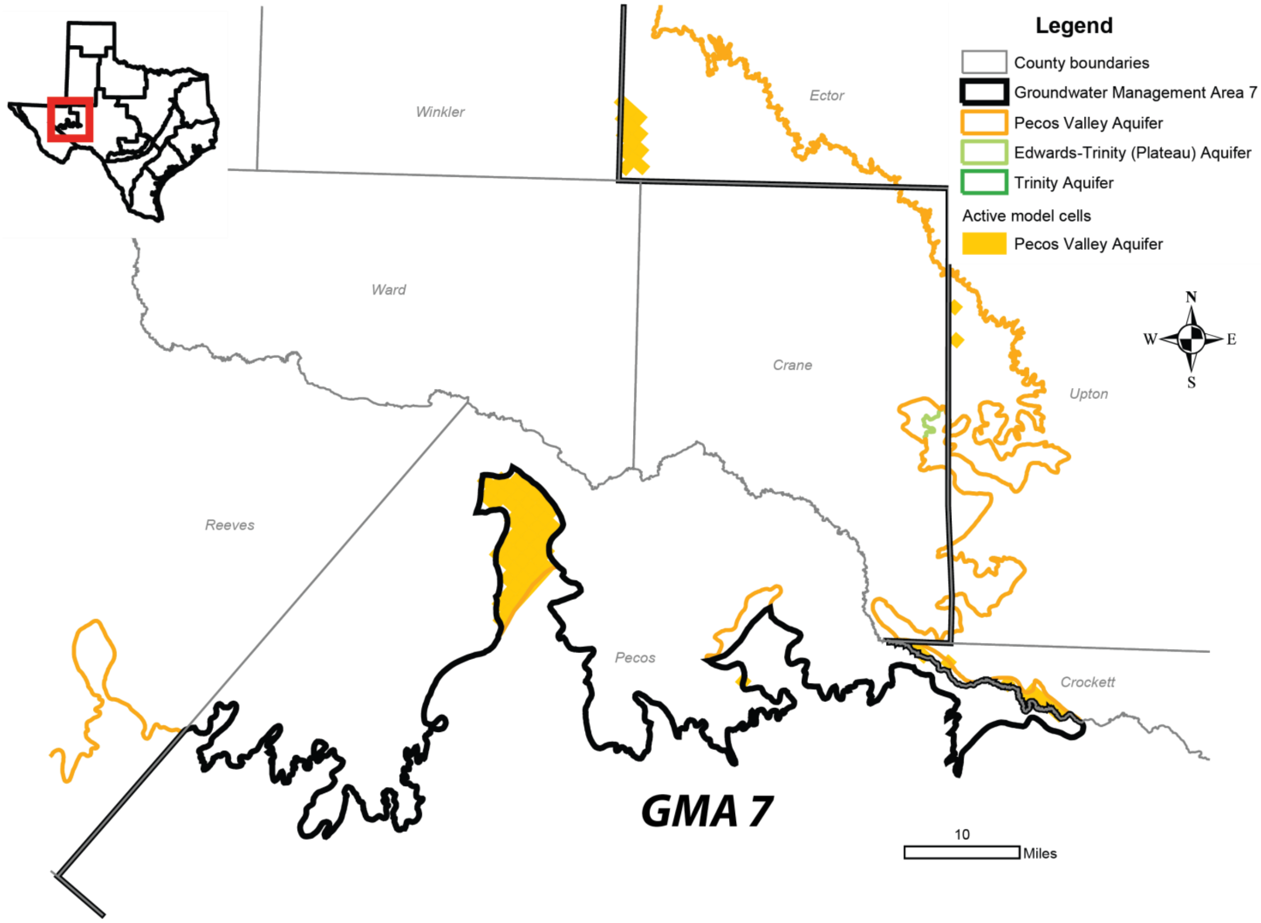


FIGURE 15. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE PECOS VALLEY AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 7.

TABLE 25. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE LIPAN AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Coke	13,000	3,250	9,750
Concho	720,000	180,000	540,000
Glasscock	6,000	1,500	4,500
Irion	100,000	25,000	75,000
Runnels	400,000	100,000	300,000
Sterling	41,000	10,250	30,750
Schleicher	7,500	1,875	5,625
Tom Green	2,900,000	725,000	2,175,000
Total	4,200,000	1,046,875	3,140,625

TABLE 26. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[31] FOR THE LIPAN AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	330,000	82,500	247,500
Coke County UWCD[32]	13,000	3,250	9,750
Glasscock GCD	6,000	1,500	4,500
Irion County WCD[33]	110,000	27,500	82,500
Lipan-Kickapoo WCD	3,600,000	900,000	2,700,000
Plateau UWC[34] and Supply District	7,500	1,875	5,625
Sterling County UWCD	45,000	11,250	33,750
Total	4,100,000	1,027,875	3,083,625

[31] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.
[32] UWCD is the abbreviation for Underground Water Conservation District.
[33] WCD is the abbreviation for Water Conservation District.
[34] UWC is the abbreviation for Underground Water Conservation.

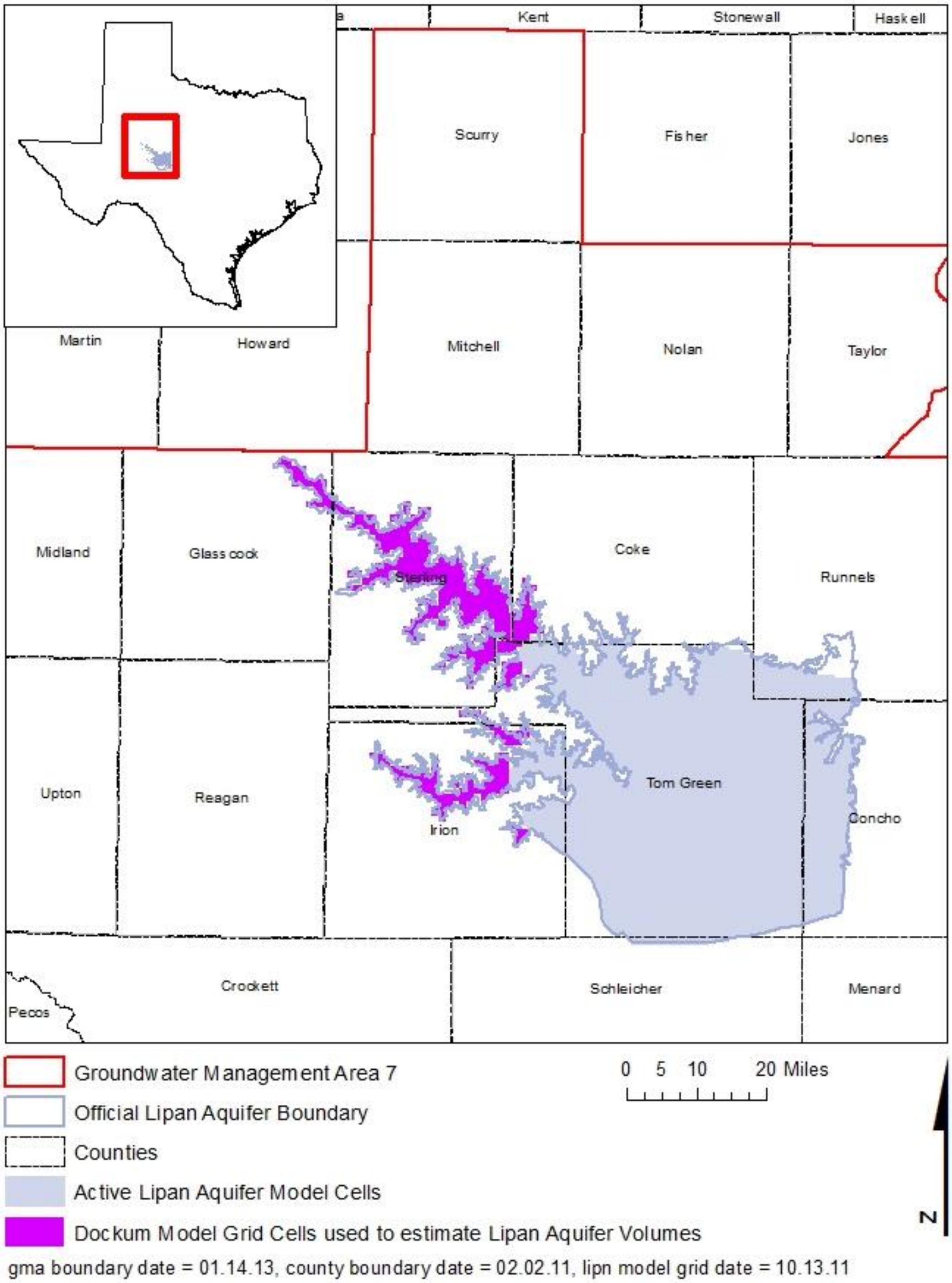


FIGURE 16. EXTENT OF THE GROUNDWATER AVAILABILITY MODELS FOR THE DOCKUM AND LIPAN AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE LIPAN AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 27. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE SEYMOUR AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Taylor	610	153	458
Total	610	153	458

TABLE 28. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[35] FOR THE SEYMOUR AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 7. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	610	153	458
Total	610	153	458

[35] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to within two significant figures.

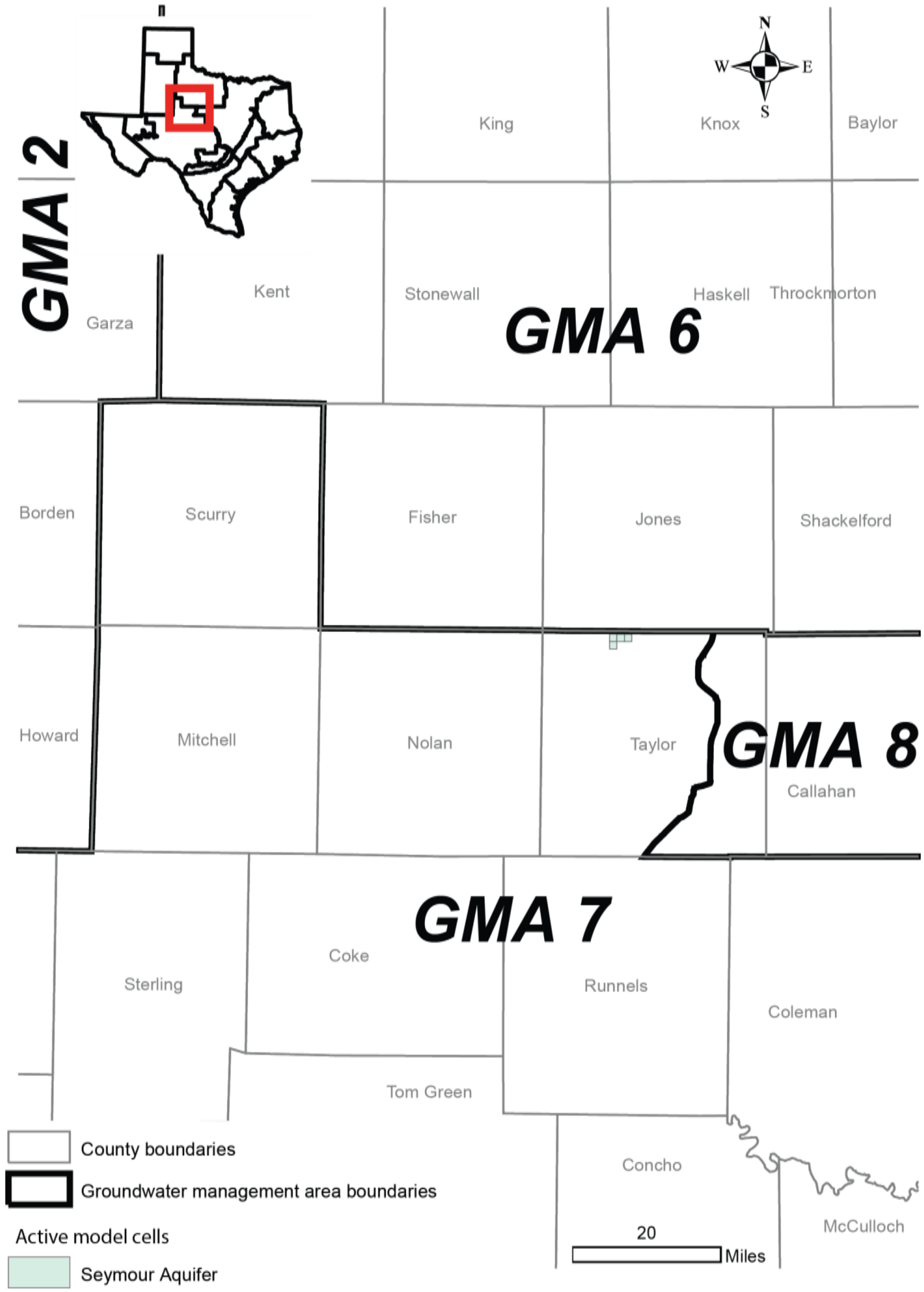


FIGURE 17. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE SEYMOUR AND BLAINE AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE SEYMOUR AQUIFER IN GROUNDWATER MANAGEMENT AREA (GMA) 7.

LIMITATIONS

The groundwater models used in completing this analysis are the best available scientific tools 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."*

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.

REFERENCES:

American Society of Civil Engineers, 1996, Hydrology Handbook, second edition, Manuals and Reports on Engineering Practice, No. 28: American Society of Civil Engineers, 800p.

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, 113 p., http://www.twdb.texas.gov/groundwater/models/gam/eddt_p/ET-Plateau_Full.pdf .

Beach, J. A., Ashworth, J. B., Finch, Jr., S. T., Chastain-Howley, A., Calhoun, K., Urbanczyk, K. M., Sharp, J. M., and Olson, J., 2004a, Groundwater availability model for the Igneous and parts of the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) aquifers: contract report to the Texas Water Development Board, 208 p., http://www.twdb.texas.gov/groundwater/models/gam/igbl/IGBL_Model_Report.pdf .

Beach, J. A., Burton, S., and Kolarik, B., 2004b, Groundwater availability model for the Lipan Aquifer in Texas: contract report prepared for the Texas Water Development Board by LBG-Guyton Associates, 246 p., http://www.twdb.texas.gov/groundwater/models/gam/lipn/LIPN_Model_Report.pdf .

Blandford, T. N., Blazer, D. J., Calhoun, K. C., Dutton, A. R., Naing, T., Reedy, R. C., and Scanlon, B. R., 2003, Groundwater availability of the southern Ogallala aquifer in Texas and New Mexico—Numerical simulations through 2050: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 158 p.

Blandford, T. N., Kuchanur, M., Standen, A., Ruggiero, R., Calhoun, K. C., Kirby, P., and Shah, G., 2008, Groundwater availability model of the Edwards-Trinity (High Plains) Aquifer in Texas and New Mexico: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 176 p.

Bluntzer, R. L., 1992, Evaluation of ground-water resources of the Paleozoic and Cretaceous aquifers in the Hill Country of Central Texas: Texas Water Development Board Report 339, 130 p.

Ewing, J.E., Jones, T.L., Pickens, J.F., Chastain-Howley, A., Dean, K.E., Spear, A.A., 2004, Groundwater availability model for the Seymour Aquifer: Final report prepared for the Texas Water Development Board by INTERA, Inc., 533 p., http://www.twdb.texas.gov/groundwater/models/gam/symr/SYMR_Model_Report.pdf

Ewing, J. E., Jones, T. L., Yan, T., Vreugdenhil, A. M., Fryar, D. G., Pickens, J. F., Gordon, K., Nicot, J. P., Scanlon, B. R., Ashworth, J. B., and Beach, J., 2008, Groundwater Availability Model for the Dockum Aquifer – Final Report: contract report to the Texas Water Development Board, 510 p., http://www.twdb.texas.gov/groundwater/models/gam/dckm/DCKM_Model_Report.pdf .

Ewing, J. E., Kelley, V. A., Jones, T. L., Yan, T., Singh, A., Powers, D. W., Holt, R. M., and Sharp, J. M., Jr., 2012, Groundwater Availability Model Report for the Rustler Aquifer – Final Report: contract report to the Texas Water Development Board, 457 p., http://www.twdb.texas.gov/groundwater/models/gam/rslr/RSLR_GAM_Report.pdf .

Garber, R. A., Grover, G. A., and Harris, P. M., 1989, Geology of the Capitan Shelf Margin—subsurface data from the northern Delaware Basin: in Harris, P. M., and Grover, G. A., eds., Subsurface and outcrop examination of the Capitan Shelf Margin, northern Delaware Basin: Society of Economic Paleontologists and Mineralogists, SEPM Core Workshop no. 13, p. 3-269.

George, P. G., Mace, R. E., and Petrossian, R, 2011, Aquifers of Texas, Texas Water Development Board Report 380, http://www.twdb.texas.gov/groundwater/aquifer/index.asp

Hutchison, W. R., Jones, I. C., and Anaya, R., 2011a, Update of the Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas: Unpublished report, Texas Water Development Board, 60 p., http://www.twdb.texas.gov/groundwater/models/alt/eddt_p_2011/ETP_PV_One_Layer_Model.pdf

Hutchison, W. R., Shi, J., and Jigmond, M., 2011b, Groundwater Flow Model of the Kinney County Area. http://www.twdb.texas.gov/groundwater/models/gam/trnt_n/TRNT_N_Model_Report.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.

Standen, A. R., Ruggiero, R., Ashworth, J., Tybor, P. and Roeling, B., 2007, Llano Uplift Structure and Stratigraphy, TWDB contracted report, 0604830614, 78 p.

Standen, A., Finch, S., Williams, R., Lee-Brand, B., and Kirby, P., 2009, Capitan Reef Complex structure and stratigraphy: Prepared for the Texas Water Development Board, Contract 0804830794, 71 p.

Texas Administrative Code, 2011, http://info.sos.state.tx.us/pls/pub/readtac$ext.viewtac

Texas Department of Licensing and Regulation, 2013, Texas Well Record Submission and Retrieval System: Texas Department of Licensing and Regulation, Water Well and Pump Installers program.

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

United States Geological Survey, 2002a, Selected hydrogeologic datasets for the Ellenburger-San Saba in Texas: Source Water Assessment Project digital data. Open File Report.

USGS (United States Geological Survey), 2002b, Selected hydrogeologic datasets for the Hickory in Texas: Source Water Assessment Project digital data. Open File Report.