Desired Future Condition Explanatory Report (Draft 4) Carrizo-Wilcox/Queen City/Sparta Aquifers for Groundwater Management Area 11

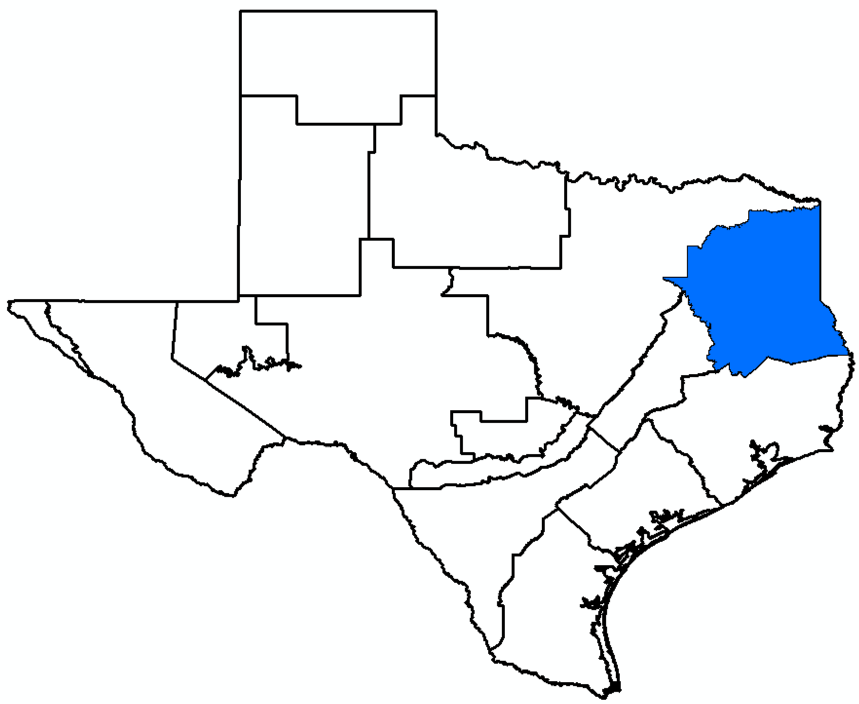

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Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 Groundwater Management Area 11

Groundwater Management Area 11 is one of sixteen groundwater management areas in Texas, and covers a large portion of the northeast part of the state (Figure 1).

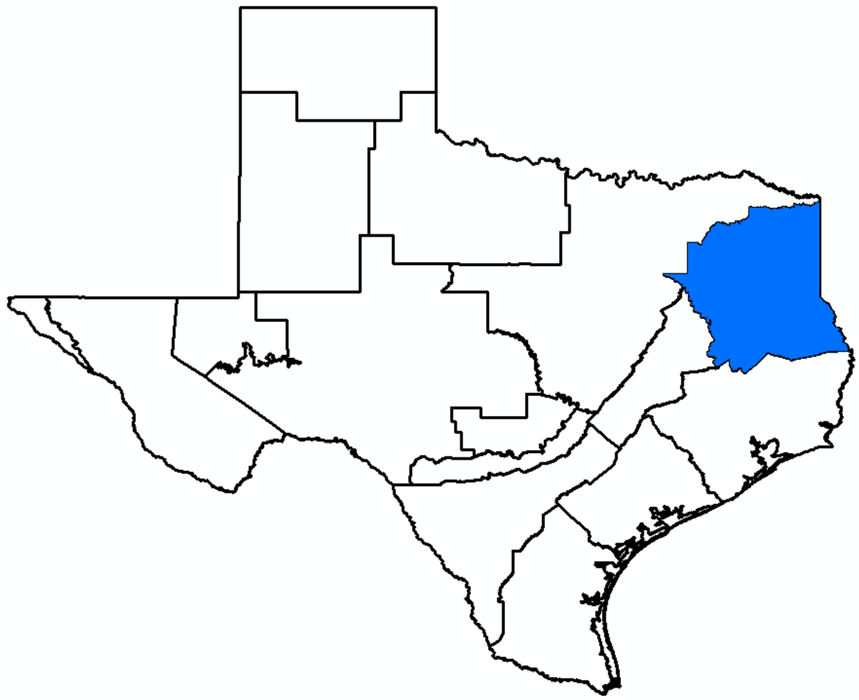

Figure 1. Groundwater Management Area 11

Groundwater Management Area 11 covers all or portions of the following counties: Anderson, Angelina, Bowie, Camp, Cass, Cherokee, Franklin, Gregg, Harrison, Henderson, Hopkins, Houston, Marion, Morris, Nacogdoches, Panola, Rains, Rusk, Sabine, San Augustine, Shelby, Smith, Titus, Trinity, Upshur, Van Zandt, and Wood (Figure 2).

There are four groundwater conservation districts in Groundwater Management Area 11: Neches & Trinity Valleys Groundwater Conservation District, Panola County Groundwater Conservation District, Pineywoods Groundwater Conservation District, and Rusk County Groundwater Conservation District (Figure 3).

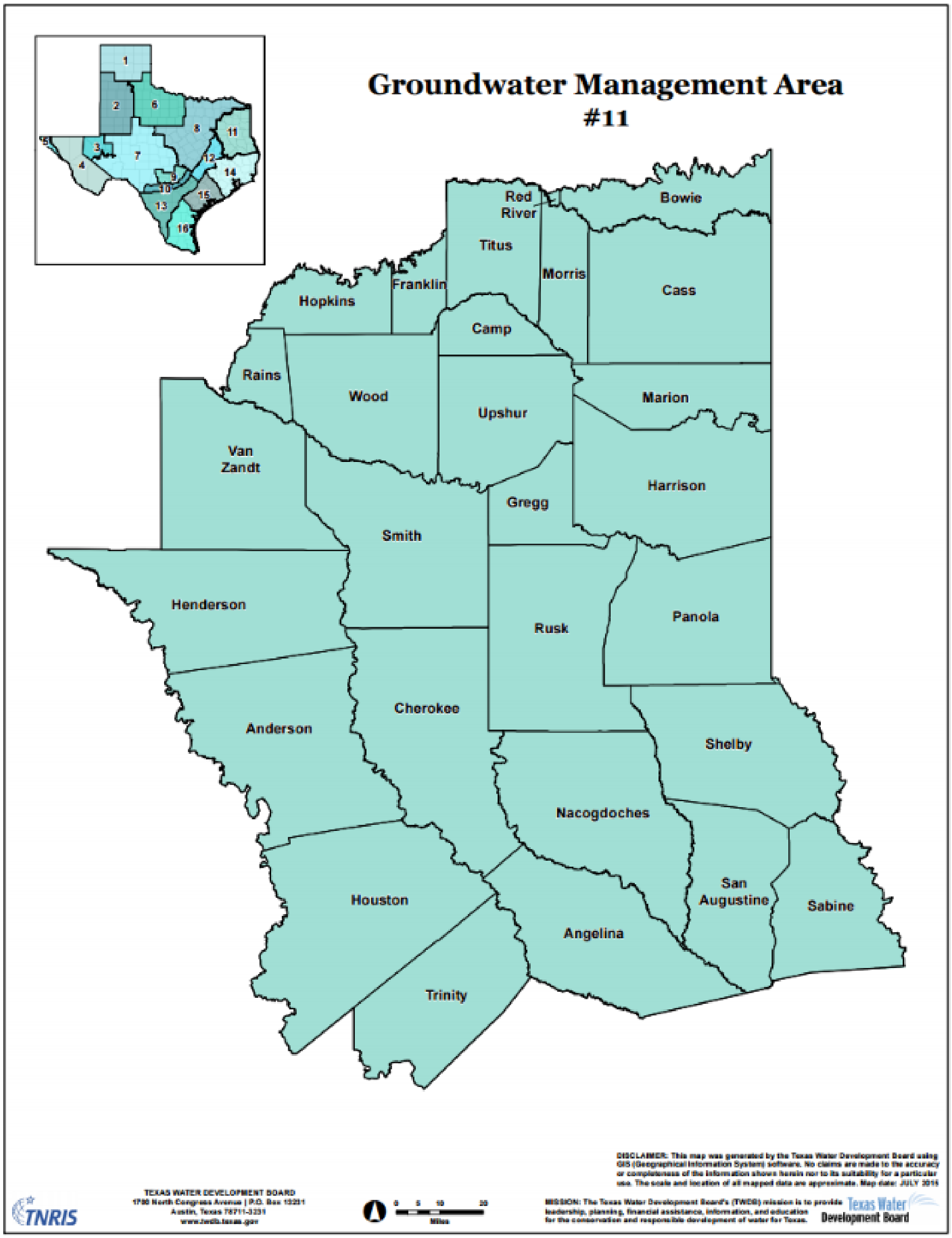

Figure 2. Counties Entirely or Partially in GMA 11 (from TWDB)

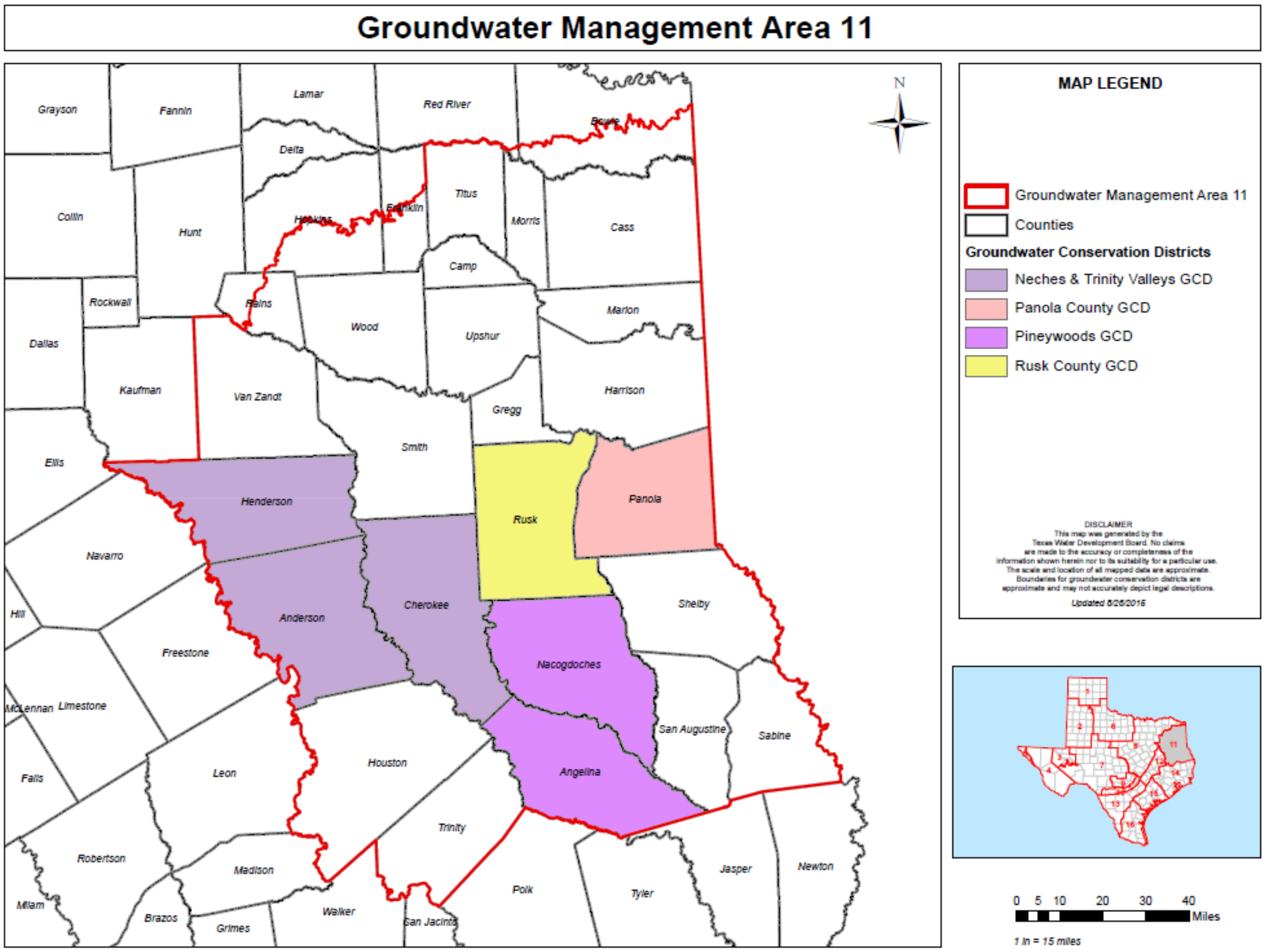

Figure 3. Groundwater Conservation Districts in GMA 11 (from TWDB)

2.0 Desired Future Condition

2.1 Background

The joint planning process is a result of HB 1763 that was adopted by the Texas State Legislature in 2005. Every five years, groundwater conservation districts within a groundwater management area must adopt desired future conditions (DFCs) for relevant aquifers within the groundwater management area. Desired future conditions are defined as a quantified condition of groundwater at a specified time or times in the future. Once the desired future conditions are adopted, the Texas Water Development Board calculates the modeled available groundwater (MAG) for the aquifer, which is the amount of pumping that will achieve the desired future condition. The desired future condition is essentially a planning goal.

As a result of the definition of desired future condition (i.e. quantified condition), and the use of models to calculate the modeled available groundwater, groundwater availability models are an important aspect of developing desired future conditions. The Texas Water Development Board developed groundwater availability models for nearly all aquifers in the state. These are used by groundwater conservation districts and regional planning groups as tools to define groundwater availability. However, as with any model, there are limitations to their use. These limitations must be considered and understood when using the results or output from the model.

In 2010, GMA 11 adopted desired future conditions for the Sparta, Queen City, and Carrizo-Wilcox aquifers. The desired future conditions were expressed in terms of average drawdown from 2000 to 2060. The overall average drawdown for GMA 11 for all aquifers was 17 feet. A table was also included in the desired future condition resolution that listed average drawdown for each county and each model layer. This table was generated from a simulation using the groundwater availability model of the area. This approach provided a means for the Texas Water Development Board to calculate modeled available groundwater values.

The use of average drawdown for purposes of developing desired future conditions is often confusing and misunderstood. Common misunderstandings include stating that the average drawdown is the same everywhere in the entire area of interest (i.e. county). Variations in pumping locations and amounts, and the natural variation of aquifer hydraulic conductivity and thickness will always result in varying drawdowns within the area of interest. In general, a regional average positive drawdown suggests that pumping has increased during the period of interest. Zero drawdown suggests that pumping is relatively constant. Negative drawdown suggests that there has been a pumping reduction. However, as is developed further in the technical memoranda that were developed as part of this proves, the presence of “negative drawdowns”, or groundwater level increases, are the result of model limitations.

In 2010, there were instances where simulated future pumping was less than historic pumping as defined in the calibrated model. This, as expected, resulted in groundwater level recoveries (i.e. negative drawdown). In other instances, (i.e. the Queen City Aquifer) pumping was significantly above historic amounts.

The development of the desired future conditions by GMA 11 in 2010 was based on evaluating a range of alternative model simulations, and understanding the impacts of different amounts of pumping. During the development of the desired future condition in 2010, there was virtually no public input, despite numerous efforts to seek input from key stakeholders in GMA 11 by groundwater conservation district representatives.

In response to specific input from various stakeholders, this round of joint planning included integration of the planned Forestar project and all the recommended and alternative water management strategies in the regional water plans from Region D and Region I. This additional pumping was included as a base case, and the effects of decreasing and increasing the base pumping was evaluated. The process also included a closer evaluation of the output of the model and addressing more fully the limitations of using the model to develop desired future conditions. A key objective of developing the base case was that all pumping was the same as or greater than historic pumping as a means to reduce or eliminate planned groundwater level recoveries. However, as developed as described in the technical memoranda that were developed as part of this process, there continued to be instances of negative drawdown which are attributable to model limitations.

2.2 Adopted Desired Future Condition

Appendix A is the resolution that was adopted by GMA 11 regarding the desired future conditions for the Carrizo-Wilcox, Queen City, and Sparta aquifers. GMA 11 Technical Memorandum 16-02 (Draft 2), dated March 25, 2016, summarizes how the results of groundwater availability model simulations were used to developed the desired future conditions for the Sparta, Queen City, and Carrizo-Wilcox aquifers for GMA 11.

Table 5 from GMA 11 Technical Memorandum 16-02 (Draft 2), dated March 25, 2016 lists the proposed desired future conditions, and is presented below in Table 1. As described in the technical memorandum, the proposed desired future conditions are average drawdowns (in feet) from year 2000 conditions to 2070 conditions were largely based on GAM Scenario 4. Based on an analysis of model output and model limitations, the output from the model was modified to develop the proposed desired future conditions as follows:

- Layers 2 and 4 (the confining units) were eliminated, and Table 5 includes only aquifer units. Areas that have no active cells are designated as NP (for not present).
- Layers 5, 6, 7, and 8 are combined, and a single drawdown value for the Carrizo-Wilcox Aquifer are listed
- All areas that are less than 200 square miles are eliminated (noted as NRS, or not relevant for purposes of joint planning due to size of area).
- Areas with negative drawdown that are greater than 200 square miles have had the negative drawdown cells eliminated from the average drawdown calculation, effectively assuming that those cells have a zero drawdown, and that the negative drawdown areas are a result of model limitations, as discussed (designated in yellow).
- The desired future condition in Panola County for the Carrizo-Wilcox Aquifer is listed as 3 feet. The actual average using all data from the model is 2 feet. If the areas with negative

drawdown are assumed to be zero, the revised average is 4 feet. As presented at the March 22, 2016 GMA 11 meeting, Mr. Wade Oliver (representing the Panola County GCD) evaluated the average drawdown under Scenario 4 using an alternative analytical modeling approach and concluded that the drawdown was 3 feet. Thus, Mr. Oliver's result is consistent with the midpoint between the two GAM-based drawdown approaches.

Table 1. Desired Future Conditions - Average Drawdown (ft) from 2000 to 2070

County	Sparta Aquifer	Queen City Aquifer	Carrizo-Wilcox Aquifer
Anderson	NRS	9	90
Angelina	16	NRS	48
Bowie	NP	NP	5
Camp	NP	NRS	33
Cass	NP	10	68
Cherokee	NRS	14	99
Franklin	NP	NP	14
Gregg	NP	NRS	58
Harrison	NP	1	18
Henderson	NP	5	50
Hopkins	NP	NP	3
Houston	3	6	80
Marion	NP	24	45
Morris	NP	NRS	46
Nacogdoches	5	4	29
Panola	NP	NP	3
Rains	NP	NP	1
Rusk	NP	NRS	23
Sabine	1	NP	9
SanAugustine	2	NP	7
Shelby	NP	NP	1
Smith	NP	17	119
Titus	NP	NRS	11
Trinity	9	NRS	51
Upshur	NP	9	77
VanZandt	NP	NRS	21
Wood	NP	5	89
GMA11	4	10	56

Notes: NP = Not present
NRS = Not Relevant due to size (less than 200 square miles)
Yellow Cells represent average drawdown calculations that assume negative drawdown is zero (model artifact and model limitation)
Green Cell represents the recommended DFC for Panola County as described in report

3.0 Policy Justification

As developed more fully in this report, the proposed desired future condition was adopted after considering:

- Aquifer uses and conditions within Groundwater Management Area 11
- Water supply needs and water management strategies included in the 2016 Regional Water Plans
- Hydrologic conditions within Groundwater Management Area 11 including total estimated recoverable storage, average annual recharge, inflows, and discharge
- Other environmental impacts, including spring flow and other interactions between groundwater and surface water
- The impact on subsidence
- Socioeconomic impacts reasonably expected to occur
- The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 11 in groundwater as recognized under Texas Water Code Section 36.002
- The feasibility of achieving the desired future condition
- Other information

In addition, the proposed desired future condition provides a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater in Groundwater Management Area 11.

There is no set formula or equation for calculating groundwater availability. This is because an estimate of groundwater availability requires the blending of policy and science. Given that the tools for scientific analysis (groundwater models) contain limitations and uncertainty, policy provides the guidance and defines the bounds that science can use to calculate groundwater availability.

As developed more fully below, many of these factors could only be considered on a qualitative level since the available tools to evaluate these impacts have limitations and uncertainty.

4.0 Technical Justification

4.1 Groundwater Availability Model

The proposed desired future condition for the Carrizo-Wilcox/Queen City/Sparta Aquifers was developed based on simulations of alternative scenarios of future pumping using the Groundwater Availability Model (GAM) of the northern Carrizo-Wilcox, Queen City, and Sparta aquifers (Kelley and others, 2004). This GAM superseded the GAM of the northern Carrizo-Wilcox Aquifer (Fryar and others, 2003). The GAM used in this process was developed to make predictions of groundwater availability through 2050 based on current projections of groundwater demands during drought-of-record conditions (Kelley and others, 2004, pg. xxvii). The calibration period for the GAM was 1980 to 1989, and the verification period was 1990 to 1999. The documentation for the GAM stated that the GAM provides an "integrated tool for the assessment of water management strategies to directly benefit state planners, Regional Water Planning Groups (RWPGs), and Groundwater Conservation Districts (GCDs)". Furthermore, the documentation stated that based on the model grid (one square mile), the GAM is "not capable of predicting aquifer responses at specific points such as a particular well", and that the GAM is "accurate at the scale of tens of miles, which is adequate to understand groundwater availability at the regional scale" (Kelley and others, 2004, pg. xxviii).

Conceptually, the model simulates groundwater flow in eight layers as shown in Figure 4. Due to the vertical interaction between aquifer units that is simulated in the GAM, the proposed desired future condition for all three aquifers were developed together.

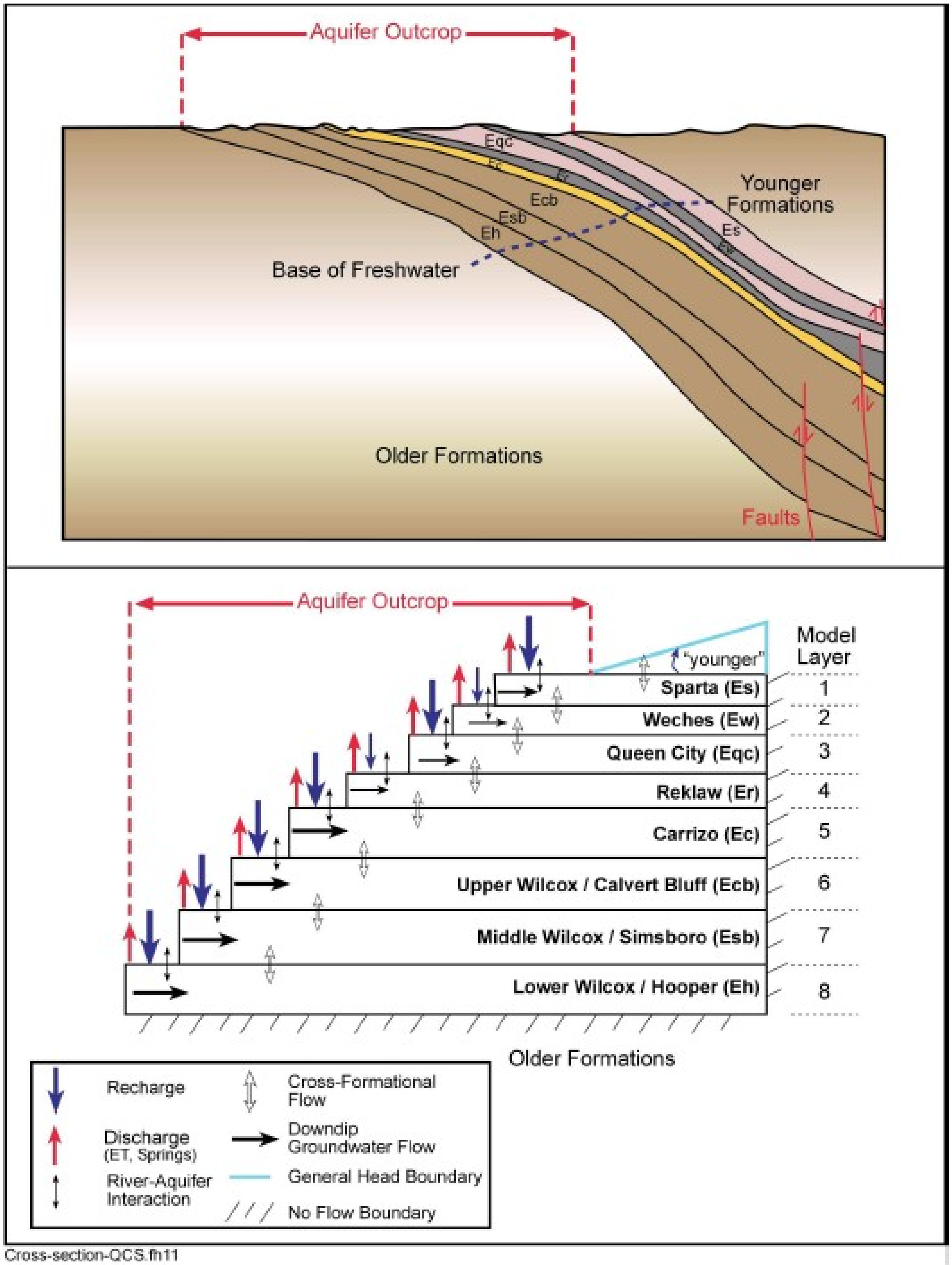

Figure 4. Conceptual Model of Flow (from Kelley and others, 2004, Figure 5.1)

4.2 Limitations of the Groundwater Availability Model

The limitations of the groundwater model for use in this process were of importance to GMA 11 and to stakeholders. Initially, GMA 11 worked to develop a base scenario that included future pumping equal to the current modeled available groundwater (MAG), plus the planned Forestar project and all recommended and alternative strategies from the regional water plans (Region D and Region I) as a base case. This base case was designated as Scenario 4. GMA 11 also reviewed the results of Scenarios 1, 2 and 3, which represented decreased pumping as compared to the base case, and the results of Scenarios 5, 6, and 7, which represented increased pumping as compared to the base case. Details of the results of these scenarios were summarized in Technical Memorandum 15-01, and were discussed at the November 4, 2015 GMA 11 meeting.

The simulations were run from 2000 to 2070. The Groundwater Availability Model (GAM) for the area was calibrated from 1975 to 1999. Thus, the simulations simply started where the calibrated model ended, and continued through the planning period that is defined by the Texas Water Development Board guidelines for this round of joint planning.

The results showed that there were areas within GMA 11 with simulated rising water from 2000 to 2070. This was attributed to the fact that the last year of the calibration period (1999) was a dry year, and the simulation assumed average recharge conditions from 2000 to 2070. With no change in pumping in an area, it would be expected that groundwater levels would rise because of the increased recharge after 1999. To address this issue, an attempt was made to extend the calibration period of the model to 2013.

At the November 4, 2015 meeting where the simulations were discussed, a recommendation was made to attempt to update the calibration period of the model to have a more recent starting date for desired future conditions, and to address negative drawdowns. In general, the attempt was unsuccessful. However, as developed in Technical Memorandum 16-01, the effort yielded a better understanding of the limitations of the model for desired future condition development that were used by GMA 11. In summary, it appears that the rising water levels are a result of the inability of the model to discharge the water that comes from precipitation. The result is that the negative drawdowns in Scenario 4 as documented in Technical Memorandum 15-01 could be considered zero drawdowns.

4.3 Use of the Groundwater Availability Model in the Joint Planning Process

The process of using the groundwater model in developing desired future conditions revolves around the concept of incorporating many of the elements of the nine factors (e.g. current uses and water management strategies in the regional plan). In GMA 11, several model runs were completed and the results discussed prior to adopting a desired future condition. Some critics of the process asserted that the districts were "reverse-engineering" the desired future conditions by specifying pumping (e.g., the modeled available groundwater) and then adopting the resulting drawdown as the desired future condition. However, it must be remembered that among the input parameters for a predictive groundwater model run is pumping, and among the outputs of a predictive groundwater model run is drawdown. Thus, an interactive or iterative approach of running several predictive scenarios with models and then evaluating the results is a necessary (and time-consuming) step in the process of developing desired future conditions.

One part of the reverse-engineering critique of the process has been that "science" should be used in the development of desired future conditions. The critique plays on the unfortunate name of the groundwater models in Texas (Groundwater Availability Models) which could suggest that the models yield an availability number. This is simply a mischaracterization of how the models work (i.e. what is a model input and what is a model output).

The critique also relies on a narrow definition of the term *science* and fails to recognize that the adoption of a desired future condition is primarily a policy decision. The call to use science in the development of desired future conditions seems to equate the term *science* with the terms *facts* and *truth*. Although the Latin origin of the word means knowledge, the term *science* also refers to the application of the scientific method. The scientific method is discussed in many textbooks and can be viewed to quantify cause-and-effect relationships and to make useful predictions.

In the case of groundwater management, the scientific method can be used to understand the relationship between groundwater pumping and drawdown, or groundwater pumping and spring flow. A groundwater model is a tool that can be used to run "experiments" to better understand the cause-and-effect relationships within a groundwater system as they relate to groundwater management.

Much of the consideration of the nine statutory factors involves understanding the effects or the impacts of a desired future condition (e.g. groundwater-surface water interaction and property rights). The use of the models in this manner in evaluating the impacts of alternative futures is an effective means of developing information for the groundwater conservation districts as they develop desired future conditions.

5.0 Factor Consideration

Section 36.108(d) of the Texas Water Code requires that groundwater conservation districts include documentation of how nine listed factors were considered prior to proposing a desired future condition, and how the proposed desired future condition impact each factor. This section of the explanatory report summarizes the information that the groundwater conservation districts used in its deliberations and discussions.

5.1 Aquifer Uses and Conditions

The aquifer uses and conditions were summarized in Technical Memorandum 15-01, and were discussed at the GMA 11 meeting on November 4, 2015.

Historic pumping estimates were developed from the Texas Water Development Board (TWDB) pumping database (1980 and 1984 to 2012) and from the calibrated GAM (1975 to 1999). These estimates were then compared to the current modeled available groundwater (future pumping to meet the desired future condition).

The pumping estimates from TWDB are presented in tabular form in Appendix B for all aquifers. These historic pumping estimates are graphically compared with the calibrated GAM and the current modeled available groundwater (MAG) in Appendix C, organized by aquifer (Sparta, Queen City, and Carrizo-Wilcox). A county map of GMA 11 is also included in Appendix C for reference purposes.

Please note that the estimates for the calibrated GAM also include model input and output. For this GAM, some model cells went dry during the simulation period (1975 to 1999). This causes all pumping in that cell to be set to zero. Thus, in some counties, the input pumping is higher than the output pumping. Since the current DFC is based on a model simulation, the output pumping was used by TWDB to set the MAG.

A brief discussion of the graphs in each aquifer is presented below.

5.1.1 Sparta Aquifer

In general, the TWDB pumping estimates and the calibrated GAM estimates of historic pumping are reasonably close, with a few exceptions. However, these exceptions represent a small amount of pumping.

In general, the modeled available groundwater is higher than the historic pumping, with some notable exceptions. In Houston County, the MAG is higher than the calibrated model, but the TWDB estimates of pumping has increased in recent years. The MAG is lower than the estimated pumping in the last few years.

In Smith and Wood counties, the TWDB includes estimates for pumping from the Sparta Aquifer. The Sparta Aquifer does not exist in these two counties.

Please note that there are no significant differences between input and output pumping from the GAM and that the MAGs are essentially constant from 2010 to 2060. This means that there are no dry cell issues.

5.1.2 Queen City Aquifer

In general, the TWDB pumping estimates and the calibrated GAM estimates of historic pumping are reasonably close, with the exception of Rusk County. However, this exception represents a small amount of pumping.

Except for Rusk County, all MAGs are considerably higher than the estimated historic pumping from the calibrated GAM. In Houston County, the MAG is higher than the calibrated GAM estimate of historic pumping, but lower than a few of the more recent years of estimated pumping from the TWDB pumping database.

Please note that there are no significant differences between input and output pumping from the GAM and that the MAGs are essentially constant from 2010 to 2060. This means that there are no significant dry cell issues.

5.1.3 Carrizo-Wilcox Aquifer

Please note that unlike the Sparta and the Queen City aquifers, there appear to be more instances where TWDB pumping database and calibrated GAM pumping estimates are different. For example, in Anderson County, the rate of increase in pumping is greater in the TWDB database than in the calibrated GAM. The MAG in Anderson County is almost twice the 1999 estimate of pumping from the calibrated model, but about equal to or slightly less than recent pumping estimates from the TWDB database.

In Angelina County, the TWDB database pumping estimates show a decline in pumping during the historic period of record, but these pumping estimates are higher than the calibrated GAM pumping estimates. The MAG in Angelina County is higher than the calibrated GAM historic pumping estimates, but is lower than TWDB pumping estimates of the 1990s.

In Bowie County, the effect of dry cells can be seen in the calibrated GAM estimates. Please note the deviation in input and output pumping estimates in the early 1980s, and the declining MAG values.

In Hopkins County, there appear to be some dry cells (deviation in input and output calibrated GAM pumping and declining MAG). Also, the MAG is lower than both sets of historic pumping. This resulted in “negative drawdown” or recovery for the DFC that was adopted in 2010.

In Nacogdoches County, a significant difference is evident in the TWDB database estimate of historic pumping and the calibrated GAM.

5.1.4 Discussion

Specific issues that needed to be addressed based on this review include resolving differences between TWDB database estimates of historic pumping, calibrated GAM estimates of historic pumping, and developing estimates of future pumping that represent increases in pumping.

The amount of future pumping is largely a policy decision by the representatives of GMA 11. However, from the previous joint planning process, the DFCs and MAGs appear to represent a planning and policy goal of increased pumping in the future. This review was more thorough than during the previous round of joint planning as evidenced by the increased interest in the process now as compared to 2010.

5.2 Water Supply Needs and Water Management Strategies

As described above, the base simulation included estimates of future pumping based on the regional water plan data, and the proposed Forestar project. Six additional simulations would also be completed, three that sequentially increase pumping from the base amounts, and three that sequentially decrease pumping from the base amount. The objective of these simulations is provide the groundwater conservation districts in Groundwater Management Area 11 an opportunity to evaluate alternatives, assess the sensitivity to increases or decreases in pumping, and provide a frame of reference for discussion of the balancing between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater.

Forestar had previously developed three alternative simulations for its proposed project. These simulations were reviewed by the Texas Water Development Board (Oliver, 2012). Scenarios A and B included changes in pumping during the simulation period due to anticipated droughts. Scenario C, on the other hand, represented constant pumping during the simulation period. Because the simulations during the last round of joint planning did not factor changes during drought periods, and because the simulations were based on average conditions during all years, Scenario C of the Forestar proposed project was selected for the simulations as a starting point, since it also included future pumping that was the basis for the DFC and MAG developed in 2010 by GMA 11 (Oliver, 2010).

All simulations used the Scenario C model files as a foundation (Oliver, 2012). These files were selected because they included the Forestar pumping as well as the pumping associated with the DFC adopted in 2010 and the MAG that was issued by the TWDB. The files were modified to extend the simulation to 2070, and thus represented a 71-year simulation (2000 to 2070). Drawdowns were calculated from 1999 conditions (the final stress period of the calibrated model), as was done with the current DFCs.

The well files from Scenario C were replaced by seven new pumping files that were developed as follows:

- Scenario 1 = 70 % of Base Pumping
- Scenario 2 = 80 % of Base Pumping
- Scenario 3 = 90 % of Base Pumping
- Scenario 4 = Base Pumping
- Scenario 5 = 110 % of Base Pumping
- Scenario 6 = 120 % of Base Pumping
- Scenario 7 = 130 % of Base Pumping

Detailed summaries of input pumping are presented in Technical Memorandum 15-01. The base simulation pumping was developed using:

- The simulated pumping file for Scenario C
- The calibrated GAM pumping file
- TWDB pumping database estimates of historic pumping
- Regional Water Group (Regions D and I) groundwater pumping strategies

The results of this analysis are presented in below in Table 1 (Sparta Aquifer), Table 2 (Queen City Aquifer), and Table 3 (Carrizo-Wilcox Aquifer).

5.2.1 Sparta Aquifer

Table 2 summarizes the data associated with developing the base pumping for the simulations for the Sparta Aquifer. Base pumping for the Sparta Aquifer for all but two counties was set equal to that used in the Forestar Scenario C simulations.

Houston County was set higher than Scenario C to reflect the TWDB pumping database pumping estimate. Scenario C included 4,359 AF/yr of pumping in Rusk County. There are only four cells in layer 1 of the model in Rusk County and this pumping was eliminated.

Finally, please note that the TWDB pumping database included estimates of Sparta Aquifer pumping in Morris, Smith and Wood counties that was not included since the aquifer does not exist in these counties.

Region D and Region I had no groundwater pumping strategies for the Sparta Aquifer, so no additional pumping was included.

Table 2. Development of Base Pumping for Simulations - Sparta Aquifer
All Pumping in AF/yr

County	TWDB Pumping Database Estimate for 2012	Calibrated GAM Estimate for 1999	Forestar Scenario C Simulations	RWP Strategies - 2020	RWP Strategies - 2070	Base Pumping for Simulations
Anderson	266	157	616			616
Angelina	93	282	689			689
Cherokee	153	221	359			359
Houston	1,498	709	895			1,498
Morris	6					
Nacogdoches	121	339	408			408
Rusk		0	4,359			0
Sabine	59	66	295			295
San Augustine	175	60	205			205
Smith	961					
Trinity		15	615			615
Wood	54					
Total	**3,386**	**1,849**	**8,441**	**0**	**0**	**4,685**

5.2.2 Queen City Aquifer

Table 3 summarizes the data associated with developing the base pumping for the simulations for the Queen City Aquifer.

Please note that the Scenario C pumping is considerably higher than the historic estimates of pumping, except for Rusk County.

The base pumping for the simulations simply added the pumping for regional water planning group strategies in 2070 to all years in Camp, Smith, Titus, Upshur and Van Zandt counties. It would be reasonable to expect that these strategies could have been absorbed into the current MAG. However, in the interest of investigating the effect of additional pumping, the strategies were simply added to the simulations.

Table 3. Development of Base Pumping for Simulations - Queen City Aquifer
All Pumping in AF/yr

County	TWDB Pumping Database Estimate for 2012	Calibrated GAM Estimate for 1999	Forestar Scenario C Simulations	RWP Strategies - 2020	RWP Strategies - 2070	Base Pumping for Simulations
Anderson	1,050	770	20,852			20,852
Angelina		96	1,100			1,100
Camp	1	253	3,772	0	783	4,555
Cass	19	525	39,115			39,115
Cherokee	906	903	23,403			23,403
Gregg	145	287	7,568			7,568
Harrison	116	408	10,323			10,323
Henderson	645	784	15,838			15,838
Houston	434	244	2,321			2,321
Marion	5	151	15,591			15,591
Morris	25	205	9,577			9,577
Nacogdoches	233	313	4,992			4,992
Rusk		57	58			58
San Augustine		0	7			7
Smith	2,668	1,173	54,158	1,610	5,167	59,325
Titus		2	138	45	45	183
Upshur	619	1,284	25,597	970	1,775	27,372
Van Zandt	236	251	3,872	699	1,005	4,877
Wood	167	1,443	10,105			10,105
Total	**7,269**	**9,149**	**248,387**	**3,324**	**8,775**	**257,162**

5.2.3 Carrizo-Wilcox Aquifer

Table 4 summarizes the data associated with developing the base pumping for the simulations for the Carrizo-Wilcox Aquifer, which is represented in the GAM by four layers (Layers 5 to 8). Because the TWDB considers the Carrizo-Wilcox a single aquifer and all pumping estimates in the pumping database are combined, the calibrated GAM estimates are presented as the sum of the four model layers.

Please note that Table 4 includes an additional column as compared to Tables 1 and 2. In reviewing the individual layer pumping amounts between the calibrated GAM and Scenario C pumping files, there were instances where pumping in individual cells in the Scenario C files was lower than the calibrated model. Thus, the additional column represents the sum of the pumping when the maximum pumping in a cell between the calibrated model and Scenario C is assigned. The 2070 strategies were then added to the sum of maximum pumping column to obtain the base pumping for these simulations.

For all counties except Cass County, it appears that the strategies could have been absorbed into the current MAG. Cass County includes a strategy that represents a significant increase in pumping. In the interest of investigating the effect of additional pumping, all strategies were simply added to the simulations.

**Table 4. Development of Base Pumping for Simulations - Carrizo-Wilcox Aquifer
All Pumping in AF/yr**

County	TWDB Pumping Database Estimate for 2012	Calibrated GAM Estimate for 1999	Forestar Scenario C Simulations	Sum of Maximum Pumping for GAM and Scenario C	RWP Strategies - 2020	RWP Strategies - 2070	Base Pumping for Simulations
Anderson	8,856	4,681	29,066	29,066			29,066
Angelina	10,703	19,386	26,642	26,642	5,600	5,600	32,242
Bowie	2,409	3,524	12,691	12,967	3,700	4,140	17,107
Camp	2,414	1,321	4,045	4,047			4,047
Cass	1,370	2,768	3,767	3,943	11,659	15,224	19,167
Cherokee	6,518	7,856	20,672	20,672	0	250	20,922
Franklin	513	1,489	9,799	10,100			10,100
Gregg	2,047	2,700	7,643	7,643	280	393	8,036
Harrison	4,522	3,998	8,887	9,099	1,842	2,196	11,295
Henderson	6,218	7,610	9,550	9,550	600	4,865	14,415
Hopkins	3,994	4,987	4,245	6,583	820	940	7,523
Houston	2,227	835	22,928	22,929	3,500	3,500	26,429
Marion	558	1,124	2,077	2,080	432	648	2,728
Morris	697	1,255	2,660	2,665			2,665
Nacogdoches	5,562	14,210	21,116	21,117	1,644	3,059	24,176
Panola	4,007	4,447	9,788	9,933			9,933
Rains	537	1,129	1,737	1,956			1,956
Rusk	8,008	7,637	20,829	20,830			20,830
Sabine	285	741	6,849	6,850			6,850
San Augustine	424	632	1,788	1,788			1,788
Shelby	3,176	3,559	12,521	12,521			12,521
Smith	22,456	13,506	33,215	33,215	1,739	2,712	35,927
Titus	543	1,985	11,054	11,089			11,089
Trinity		27	2,214	2,214			2,214
Upshur	3,231	4,549	7,128	7,128			7,128
Van Zandt	4,489	5,779	10,996	11,024			11,024
Wood	7,070	4,455	21,735	21,738			21,738
Total	**112,834**	**126,190**	**325,642**	**329,389**	**31,816**	**43,527**	**372,916**

5.3 Hydrologic Conditions within Groundwater Management Area 11

As required by statute, the groundwater conservation districts in Groundwater Management Area 11 considered total estimated recoverable storage, average annual recharge, inflows, and discharge prior to adopting a proposed desired future condition.

5.3.1 Total Estimated Recoverable Storage

As required by statute, the Texas Water Development Board provided the groundwater conservation districts in Groundwater Management Area 11 with estimates of total recoverable storage (Wade and others, 2014). This report is included as Appendix D.

A summary of total storage and the estimated range of recoverable storage for the three aquifers is presented in Table 5.

Table 5. Summary of Total Storage and the Estimated Range of Recoverable Storage

Aquifer	Total Storage (million acre-feet)	Estimated Range of Recoverable Storage (million acre-feet)
Sparta	55.3	13.8 to 41.5
Queen City	142.0	35.5 to 106.5
Carrizo-Wilcox	2,070.6	517.7 to 1,553.0

These estimates are essentially the sum of three components: 1) the outcrop area, 2) the artesian portion of the downdip area, and 3) the saturated portion of the downdip area. The storage estimates were developed from the groundwater availability model of the area (Kelley and others, 2004)

In the outcrop area, the saturated thickness is the 1999 groundwater elevation minus the aquifer bottom elevation for each model cell. In each cell, the storage is then calculated as the saturated thickness times the area (640 acres) times the specific yield. The model estimates specific yield as either 0.1 or 0.15 depending on the specific cell. These cell storage values are then summed to arrive at a total storage for the Carrizo-Wilcox outcrop areas of 114 million acre-feet.

In the artesian portion of the downdip, the artesian zone thickness is the difference between the 1999 groundwater elevation and the elevation of the top of the aquifer. In each cell, the artesian storage is calculated as the artesian zone thickness times the area (640 acres) times the storativity. Storativity values range between 7.3E-05 to 9.93E-03. Total artesian zone storage is 65 million acre-feet for the Carrizo-Wilcox Aquifer.

In the saturated portion of the downdip area, saturated thickness is calculated differently depending on whether the head is above or below the top of the aquifer. If the head is below the top of the aquifer, the saturated thickness is the difference between the 1999 groundwater elevation and the elevation of the bottom of the aquifer. If the head is above the top of the aquifer, the saturated thickness is the thickness of the aquifer. The storage is then calculated as the saturated zone thickness times the area (640 acres) times the specific yield. The specific yield is either 0.1 or 0.15 depending on the layer. Total storage in the saturated portion of the downdip area is calculated to be 1,879 million acre-feet.

A key parameter in these calculations is the specific yield in the downdip portion of the aquifer. In most cases, the model's estimate of specific yield in the downdip area is never "used" in model. 23,320 cells of the 58,269 cells in the downdip area have an artesian head of over 500 feet, which is about 40 percent of the cells in the model. Unless heads drop below the top of the aquifer, these parameters are simply place holders, and were never calibrated.

In general, a specific yield values of 0.1 to 0.15 is representative of a clean sand. As drilling and electric logs show, interlayered sands and clays are common in the Carrizo-Wilcox. The model has thick layers (about 24 percent of the cells are over 500 feet thick). Thick cells increase the chance of interbedded clay, and this would result in reduced specific yield estimates. Although the higher specific yield values may be appropriate for individual sand units, the thicker layers increase the chance that the overall specific yield value is lower than the place-holder value in the model input files.

If the calculation is made with a specific yield value of 0.001 to reflect the interbedded clays, the total storage for the saturated portion of the downdip area is 188 million acre-feet (as compared to 1,879 million acre-feet reported by the TWDB).

When the model was developed in 2004, it is doubtful that the developers considered the possibility of using the model to calculate total aquifer storage, and simply used place holder values. As described in the technical memoranda and summarized above, the problems with future simulations in the outcrop area may be due flat gradients that restrict flow from the outcrop area to the downdip area. This restriction may be the result of underestimated drawdown due to pumping or drought conditions. If the specific yield were reduced in these areas, gradient might improve conditions to model water into the downdip area, and prevent unrealistic increases in outcrop storage during the calibration period of the GAM.

In summary, the total estimated recoverable storage may be overestimated by one or two orders of magnitude, as evidenced by limitations of the GAM.

5.3.2 Average Annual Recharge, Inflows and Discharge

The groundwater budgets for Groundwater Management Area 11 for the Carrizo-Wilcox Aquifer were spilt into four parts:

- The outcrop area of the Carrizo (Layer 5 of the GAM) in Table 6
- The downdip area of the Carrizo (Layer 5 of the GAM) in Table 7

- The outcrop area of the Wilcox (Layers 6, 7 and 8 of the GAM) in Table 8
- The downdip area of the Wilcox (Layers 6, 7 and 8 of the GAM) in Table 9

For all groundwater budgets, only the areas of the official aquifer boundary are presented. Consequently, there are entries in the water budget tables labeled "Unofficial". These entries represent flows into and out of the official aquifer boundaries from areas within GMA 11 that are not considered official parts of the aquifer.

Each of the groundwater budgets presents a side by side comparison of the average values for the calibration period of the GAM (1975 to 1999) and the average values of Scenario 4 (2000 to 2070) for Scenario 4, the basis of the desired future condition.

Table 6. Groundwater Budget of the Outcrop Area of the Carrizo Aquifer
All Values in AF/yr

	1975-1999	2000-2070
Inflow		
Recharge	117,984	115,143
Reservoir	157	0
GMA 12	536	580
Total	118,676	115,723

Outflow		
Downdip	16,097	24,578
Vertical (Wilcox)	12,331	15,421
Pumping	4,253	12,610
Drain	167	649
ET	19,305	34,927
RIV	0	22
Stream	33,448	26,634
Total	85,600	114,841

Inflow-Outflow	33,076	882
Model Calculated Storage Change	33,075	882
Model Error	1	0

Table 7. Groundwater Budget of the Downdip Area of the Carrizo Aquifer All Values in AF/yr

	1975-1999	2000-2070
Inflow		
GMA 12	5,427	10,509
Vertical (Reklaw)	39,720	58,774
Outcrop	16,097	24,592
Unofficial	3,444	7,597
Louisiana	4	23
Total	64,691	101,495
Outflow		
Pumping	56,160	133,919
Vertical (Wilcox)	19,682	21,587
Total	75,842	155,506
Inflow-Outflow	-11,151	-54,011
Model Calculated Storage Change	-11,152	-54,012
Model Error	0	0

Table 8. Groundwater Budget of the Outcrop Area of the Wilcox Aquifer All Values in AF/yr

Inflow

	1975-1999	2000-2070
Recharge	256,075	250,896
Reservoir/River	7,301	8,216
GMA 12	343	311
GMA 8	7	11
Louisiana	N/A	915
Total	263,726	260,349

Outflow

	1975-1999	2000-2070
Downdip	41,097	50,476
Pumping	12,651	42,871
Drain	4,783	4,498
ET	48,503	51,138
Stream	120,690	79,599
Louisiana	119	0
Unofficial	11,035	4,300
Total	238,878	232,882

	1975-1999	2000-2070
Inflow-Outflow	24,848	27,467
Model Calculated Storage Change	24,862	27,470
Model Error	-15	-2

Table 9. Groundwater Budget of the Downdip Area of the Wilcox Aquifer
All Values in AF/yr

	1975-1999	2000-2070
Inflow		
Recharge	501	1,423
GMA 12	6,267	8,975
Vertical (Carrizo)	32,013	30,548
Outcrop	41,097	50,476
Unofficial	2,035	3,863
Louisiana	N/A	165
Total	81,912	95,449
Outflow		
Pumping	42,763	149,459
GMA 14	34	25
Louisiana	209	N/A
Total	43,006	149,484
Inflow-Outflow	38,907	-54,034
Model Calculated Storage Change	38,906	-54,034
Model Error	0	0

The GAM is not necessarily calibrated to a degree where surface water impacts of increased pumping are particularly reliable or can be viewed as quantitative. However, the GAM is the best tool to address this factor. Since the GAM is an imperfect tool, the conclusion of this analysis is that the increased pumping will cause impacts beyond the reduction in storage.

5.4 Other Environmental Impacts, Including Spring Flow and Other Interactions between Groundwater and Surface Water

The evaluation of all water budget components was discussed in Section 5.3.2 above.

5.5 Subsidence

Subsidence has not been an issue historically in these aquifers.

5.6 Socioeconomic Impacts

The Texas Water Development Board prepared reports on the socioeconomic impacts of not meeting water needs for each of the Regional Planning Groups during development of the 2011 Regional Water Plans. Because the development of this desired future condition used the State

Water Plan demands and water management strategies as an important foundation, it is reasonable to conclude that the socioeconomic impacts associated with this proposed desired future condition can be evaluated in the context of not meeting the listed water management strategies. Groundwater Management Area 11 is covered by Regional Planning Groups D and I. The socioeconomic impact reports for Regions D and I in Appendix E.

5.7 Impact on Private Property Rights

The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 11 in groundwater is recognized under Texas Water Code Section 36.002.

The desired future conditions adopted by GMA 11 are consistent with protecting property rights of landowners who are currently pumping groundwater and landowners who have chosen to conserve groundwater by not pumping. All current and projected uses (as defined in the Region D plan and the Region I plan as well as the Forestar project) were included in Scenario 4 (the basis for the desired future condition). The increase in pumping associated with meeting the water management strategies will cause impacts to exiting well owners and to surface water. However, as required by Chapter 36 of the Water Code, GMA 11 considered these impacts and balanced them with the increasing demand of water in the GMA 11 area, and concluded that, on balance and with appropriate monitoring and project specific review during the permitting process, all the strategies and the Forestar project can be included in the desired future condition.

5.8 Feasibility of Achieving the Desired Future Condition

Groundwater levels are routinely monitored by the districts and by the TWDB in GMA 11. Evaluating the monitoring data is a routine task for the districts, and the comparison of these data with the desired future condition and model results that were used to develop the DFCs is covered in each district's management plan. These comparisons will be useful to guide the update of the DFCs that are required every five years.

5.9 Other Information

5.9.1 Solicitation of Stakeholder Participation

The groundwater conservation districts of Groundwater Management Area 11 solicited participation and feedback from 826 stakeholders (mostly water user groups). Specifically, a letter was sent to each group in early September, 2015 seeking their input on estimates of future pumping and any other concerns.

The letter template and the list of organizations that received the letter are presented in Appendix F.

No specific response was received from any letter recipient.

5.9.2 Aquifers Not Relevant for Purposes of Joint Planning

As documented in the resolution adopting desired future conditions, the groundwater conservation districts in Groundwater Management Area 11 have classified the following aquifers as not relevant for the purposes of joint planning:

- Gulf Coast Aquifer
- Nacatoch Aquifer
- Trinity Aquifer
- Yegua-Jackson Aquifer

Documentation in support of the classification are presented in Appendix G.

6.0 Discussion of Other Desired Future Conditions Considered

There were 7 scenarios and 7 GAM simulations completed as part of the development of the desired future conditions. Results of these simulations were presented at GMA 11 meetings and in technical memoranda. Based on a review of the materials and recognizing the limitations of the GAM, the groundwater conservation districts in GMA 11 decided that Scenario 4 met all identified future water needs and balanced the property rights of landowners in GMA 11.

7.0 Discussion of Other Recommendations

Public comments were invited and each district held a public hearing on the proposed desired future condition as follows:

Groundwater Conservation District	Date of Public Hearing	Number of Comments Received
Neches & Trinity Valleys GCD	June 16, 2016	None
Panola County GCD	June 16, 2016	One Written
Pineywoods GCD	July 14, 2016	None
Rusk County GCD	July 11, 2016	One Oral

The written comment submitted to Panola County GCD was from Tony Smith, the Senior Project Manager for Carollo Engineers, Inc., in response to cooperative efforts between Region D planning group and GMA 11. Mr. Smith stated that "his analysis indicates that the simulation results from GMA 11 Technical Memo 16-02, Draft 2 (Scenario 4) are adequate to meet or exceed the Region D existing groundwater supplies and the identified Region D groundwater management strategies identified in the 2016 Regional Water Plan", and that "no shortages were found".

The oral comment at the Rusk County GCD public hearing was an expression of concern regarding the proposed DFC in Smith County, and the possible effects on neighboring county's DFC, and recommended that the current DFCs not be changed.

The 2010 DFCs for Rusk County for the Carrizo-Wilcox Aquifer were presented as follows for each individual aquifer.

- Carrizo Aquifer: 6 feet
- Upper Wilcox Aquifer: 6 feet
- Middle Wilcox Aquifer: 23 feet
- Lower Wilcox Aquifer: 21 feet

The 2016 proposed DFCs were adopted as for the entire Carrizo-Wilcox Aquifer as summarized in Table 5 of Tech Memo 16-02 (Scenario 4). For Rusk County, the proposed DFC was 23 feet. However, in Tech Memo 16-01, the drawdowns associated with each individual aquifer for Scenario 4 were listed in Table 5 which provide a means of comparison to the 2010 DFCs:

- Carrizo Aquifer: 8 feet
- Upper Wilcox Aquifer: 9 feet
- Middle Wilcox Aquifer: 34 feet
- Lower Wilcox Aquifer: 38 feet

In general, the higher drawdowns can be attributed primarily to higher pumping in surrounding counties in Scenario 4 as compared with the basis for the 2010 DFC:

- Cherokee County
  - 11,222 AF/yr (current MAG in all years)
  - 20,457 AF/yr (pumping to achieve 2016 DFC)
- Rusk County
  - 20,814 AF/yr (current MAG in 2060)
  - 20,803 AF/yr (pumping to achieve 2016 DFC in 2070)
- Smith County
  - 33,225 AF/yr (current MAG in 2060)
  - 35,865 AF/yr (pumping to achieve 2016 DFC in 2070)

From this summary, pumping in Smith County under the 2016 DFC is not much higher than the current MAG. However, pumping in Cherokee County is higher under the 2016 DFC than the current MAG. The small increases in drawdown in Rusk County between the 2010 DFC and the 2016 DFC appear to be attributable to higher pumping in Cherokee County because of the Forestar project.

The groundwater conservation districts decided to include the Forestar project in the basis for the desired future conditions that were adopted after evaluating the relative impacts in surrounding counties and found that the impacts were minor. The alternative of not changing the DFCs was discussed and was rejected after considering the Forestar project and the regional planning water management strategies. If the desired future condition were to remain unchanged, there would be impacts on the ability of the region to meet its future water demands as defined by the Region D plan and the Region I plan.

8.0 References

Fryar, D., Senger, R., Deeds, N., Pickens, J, Jones, T., Whallon, A.J., and Dean, K.E., 2003. Groundwater Availability Model for the Northern Carrizo-Wilcox Aquifer. INTERA Incorporated report prepared for the Texas Water Development Board, January 31, 2003, 529p.

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Oliver, W., 2010. GAM Task 10-009 Model Run Report. Texas Water Development Board, Groundwater Availability Modeling Section, September 3, 2010, 11p.

Oliver, W., 2012. GAM Run 11-010: Model Runs for the Carrizo-Wilcox, Queen City, and Sparta Aquifers in Groundwater Management Area 11. Texas Water Development Board, Groundwater Availability Modeling Section, July 30, 2012, 34p.

Wade, S., Shi, J., and Seiter-Weatherford, C., 2014. GAM Task 13-034: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 11. Texas Water Development Board, Groundwater Resources Division, April 2, 2014, 30 p.

Appendix A

Desired Future Conditions Resolution

Appendix B

TWDB Historic Pumping Estimates for Groundwater Management Area 11

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1980	ANDERSON	CARRIZO-WILCOX AQUIFER	2,267	349	854	0	0	139	3,609
1984	ANDERSON	CARRIZO-WILCOX AQUIFER	3,721	455	329	0	102	263	4,870
1985	ANDERSON	CARRIZO-WILCOX AQUIFER	4,277	303	405	0	113	275	5,373
1986	ANDERSON	CARRIZO-WILCOX AQUIFER	4,601	347	382	0	54	275	5,659
1987	ANDERSON	CARRIZO-WILCOX AQUIFER	4,884	346	359	0	54	282	5,925
1988	ANDERSON	CARRIZO-WILCOX AQUIFER	4,938	344	325	0	54	292	5,953
1989	ANDERSON	CARRIZO-WILCOX AQUIFER	5,044	431	303	0	27	303	6,108
1990	ANDERSON	CARRIZO-WILCOX AQUIFER	5,253	0	303	0	21	306	5,883
1991	ANDERSON	CARRIZO-WILCOX AQUIFER	4,910	0	318	0	24	311	5,563
1992	ANDERSON	CARRIZO-WILCOX AQUIFER	5,403	0	318	0	24	374	6,119
1993	ANDERSON	CARRIZO-WILCOX AQUIFER	5,400	0	315	0	171	366	6,252
1994	ANDERSON	CARRIZO-WILCOX AQUIFER	5,872	0	315	0	78	323	6,588
1995	ANDERSON	CARRIZO-WILCOX AQUIFER	6,473	0	430	0	180	321	7,404
1996	ANDERSON	CARRIZO-WILCOX AQUIFER	7,640	0	430	0	265	321	8,656
1997	ANDERSON	CARRIZO-WILCOX AQUIFER	7,324	0	430	0	254	321	8,329
1998	ANDERSON	CARRIZO-WILCOX AQUIFER	7,820	0	411	0	632	281	9,144
1999	ANDERSON	CARRIZO-WILCOX AQUIFER	7,381	0	430	0	309	288	8,408
2000	ANDERSON	CARRIZO-WILCOX AQUIFER	9,225	340	0	0	89	299	9,953
2001	ANDERSON	CARRIZO-WILCOX AQUIFER	8,555	340	0	0	89	146	9,130
2002	ANDERSON	CARRIZO-WILCOX AQUIFER	8,598	445	0	0	75	148	9,266
2003	ANDERSON	CARRIZO-WILCOX AQUIFER	8,920	445	0	0	16	133	9,514
2004	ANDERSON	CARRIZO-WILCOX AQUIFER	8,723	0	0	0	28	142	8,893
2005	ANDERSON	CARRIZO-WILCOX AQUIFER	9,013	0	0	0	52	34	9,099
2006	ANDERSON	CARRIZO-WILCOX AQUIFER	8,428	0	0	0	0	36	8,464
2007	ANDERSON	CARRIZO-WILCOX AQUIFER	7,495	0	0	0	263	36	7,794
2008	ANDERSON	CARRIZO-WILCOX AQUIFER	7,774	0	0	0	167	25	7,966
2009	ANDERSON	CARRIZO-WILCOX AQUIFER	7,930	0	0	0	394	26	8,350
2010	ANDERSON	CARRIZO-WILCOX AQUIFER	8,023	0	0	0	129	25	8,177
2011	ANDERSON	CARRIZO-WILCOX AQUIFER	8,559	0	0	0	229	25	8,813
2012	ANDERSON	CARRIZO-WILCOX AQUIFER	8,627	0	0	0	207	22	8,856
1980	ANDERSON	OTHER AQUIFER	146	0	0	0	0	43	189
1984	ANDERSON	OTHER AQUIFER	22	0	0	0	0	15	37
1985	ANDERSON	OTHER AQUIFER	19	0	0	0	0	17	36
1986	ANDERSON	OTHER AQUIFER	19	0	0	0	0	17	36
1987	ANDERSON	OTHER AQUIFER	17	0	0	0	0	17	34
1988	ANDERSON	OTHER AQUIFER	0	0	0	0	0	18	18
1989	ANDERSON	OTHER AQUIFER	0	0	0	0	0	19	19
1990	ANDERSON	OTHER AQUIFER	26	0	0	0	0	19	45
1991	ANDERSON	OTHER AQUIFER	14	0	0	0	0	19	33
1992	ANDERSON	OTHER AQUIFER	36	0	0	0	0	23	59
1993	ANDERSON	OTHER AQUIFER	56	0	0	0	0	23	79
1994	ANDERSON	OTHER AQUIFER	60	0	0	0	0	20	80
1995	ANDERSON	OTHER AQUIFER	50	0	0	0	0	20	70
1996	ANDERSON	OTHER AQUIFER	83	0	0	0	0	20	103
1997	ANDERSON	OTHER AQUIFER	84	0	0	0	0	20	104
1998	ANDERSON	OTHER AQUIFER	90	0	0	0	0	17	107
1999	ANDERSON	OTHER AQUIFER	85	0	0	0	0	18	103
2000	ANDERSON	OTHER AQUIFER	26	0	0	0	0	19	45
2001	ANDERSON	OTHER AQUIFER	29	0	0	0	0	10	39
2002	ANDERSON	OTHER AQUIFER	28	0	0	0	0	10	38
2003	ANDERSON	OTHER AQUIFER	27	0	0	0	0	9	36
2004	ANDERSON	OTHER AQUIFER	26	0	0	0	0	45	71
2005	ANDERSON	OTHER AQUIFER	28	0	0	0	0	11	39
2006	ANDERSON	OTHER AQUIFER	195	0	0	0	0	11	206
2007	ANDERSON	OTHER AQUIFER	161	0	0	0	0	11	172
2008	ANDERSON	OTHER AQUIFER	179	0	0	0	0	16	195
2009	ANDERSON	OTHER AQUIFER	190	0	0	0	0	17	207
2010	ANDERSON	OTHER AQUIFER	202	0	0	0	0	8	210
2011	ANDERSON	OTHER AQUIFER	209	0	0	0	0	8	217
2012	ANDERSON	OTHER AQUIFER	191	0	0	0	0	6	197
1980	ANDERSON	QUEEN CITY AQUIFER	824	0	753	0	0	289	1,866
1984	ANDERSON	QUEEN CITY AQUIFER	438	0	0	0	11	234	683
1985	ANDERSON	QUEEN CITY AQUIFER	422	0	0	0	12	244	678
1986	ANDERSON	QUEEN CITY AQUIFER	415	0	0	0	6	244	665
1987	ANDERSON	QUEEN CITY AQUIFER	384	0	0	0	6	250	640
1988	ANDERSON	QUEEN CITY AQUIFER	0	0	0	0	6	259	265
1989	ANDERSON	QUEEN CITY AQUIFER	0	0	0	0	1	269	270
1990	ANDERSON	QUEEN CITY AQUIFER	188	0	0	0	2	272	462
1991	ANDERSON	QUEEN CITY AQUIFER	106	0	0	0	2	277	385
1992	ANDERSON	QUEEN CITY AQUIFER	273	0	0	0	2	334	609
1993	ANDERSON	QUEEN CITY AQUIFER	422	0	0	0	1	328	751
1994	ANDERSON	QUEEN CITY AQUIFER	455	0	0	0	0	290	745
1995	ANDERSON	QUEEN CITY AQUIFER	380	0	0	0	0	288	668
1996	ANDERSON	QUEEN CITY AQUIFER	627	0	0	0	0	288	915
1997	ANDERSON	QUEEN CITY AQUIFER	631	0	0	0	0	288	919
1998	ANDERSON	QUEEN CITY AQUIFER	674	0	0	0	0	252	926
1999	ANDERSON	QUEEN CITY AQUIFER	636	0	0	0	0	259	895
2000	ANDERSON	QUEEN CITY AQUIFER	190	0	0	0	7	269	466

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2001	ANDERSON	QUEEN CITY AQUIFER	217	0	0	0	7	132	356
2002	ANDERSON	QUEEN CITY AQUIFER	220	0	0	0	6	132	358
2003	ANDERSON	QUEEN CITY AQUIFER	212	0	0	0	1	120	333
2004	ANDERSON	QUEEN CITY AQUIFER	205	0	0	0	2	118	325
2005	ANDERSON	QUEEN CITY AQUIFER	220	0	0	0	4	28	252
2006	ANDERSON	QUEEN CITY AQUIFER	838	0	0	0	0	30	868
2007	ANDERSON	QUEEN CITY AQUIFER	695	0	0	0	21	30	746
2008	ANDERSON	QUEEN CITY AQUIFER	773	0	0	0	13	21	807
2009	ANDERSON	QUEEN CITY AQUIFER	818	0	0	0	31	22	871
2010	ANDERSON	QUEEN CITY AQUIFER	872	0	0	0	130	21	1,023
2011	ANDERSON	QUEEN CITY AQUIFER	899	0	0	0	229	21	1,149
2012	ANDERSON	QUEEN CITY AQUIFER	825	0	0	0	207	18	1,050
1980	ANDERSON	SPARTA AQUIFER	256	0	84	0	0	62	402
1984	ANDERSON	SPARTA AQUIFER	197	0	0	0	0	87	284
1985	ANDERSON	SPARTA AQUIFER	192	0	0	0	0	91	283
1986	ANDERSON	SPARTA AQUIFER	189	0	0	0	0	91	280
1988	ANDERSON	SPARTA AQUIFER	0	0	0	0	0	97	97
1989	ANDERSON	SPARTA AQUIFER	0	0	0	0	0	100	100
1990	ANDERSON	SPARTA AQUIFER	70	0	0	0	0	101	171
1991	ANDERSON	SPARTA AQUIFER	39	0	0	0	0	103	142
1992	ANDERSON	SPARTA AQUIFER	100	0	0	0	0	124	224
1993	ANDERSON	SPARTA AQUIFER	155	0	0	0	0	122	277
1994	ANDERSON	SPARTA AQUIFER	167	0	0	0	0	108	275
1995	ANDERSON	SPARTA AQUIFER	140	0	0	0	0	108	248
1996	ANDERSON	SPARTA AQUIFER	231	0	0	0	0	108	339
1997	ANDERSON	SPARTA AQUIFER	233	0	0	0	0	108	341
1998	ANDERSON	SPARTA AQUIFER	249	0	0	0	0	94	343
1999	ANDERSON	SPARTA AQUIFER	235	0	0	0	0	97	332
2000	ANDERSON	SPARTA AQUIFER	70	0	0	0	0	97	167
2001	ANDERSON	SPARTA AQUIFER	64	0	0	0	0	49	113
2002	ANDERSON	SPARTA AQUIFER	65	0	0	0	0	50	115
2003	ANDERSON	SPARTA AQUIFER	64	0	0	0	0	45	109
2004	ANDERSON	SPARTA AQUIFER	62	0	0	0	0	0	62
2005	ANDERSON	SPARTA AQUIFER	66	0	0	0	0	0	66
2006	ANDERSON	SPARTA AQUIFER	271	0	0	0	0	0	271
2007	ANDERSON	SPARTA AQUIFER	224	0	0	0	0	0	224
2008	ANDERSON	SPARTA AQUIFER	249	0	0	0	0	0	249
2009	ANDERSON	SPARTA AQUIFER	264	0	0	0	0	0	264
2010	ANDERSON	SPARTA AQUIFER	281	0	0	0	0	0	281
2011	ANDERSON	SPARTA AQUIFER	290	0	0	0	0	0	290
2012	ANDERSON	SPARTA AQUIFER	266	0	0	0	0	0	266
2008	ANDERSON	UNKNOWN	0	0	11	0	0	0	11
2009	ANDERSON	UNKNOWN	0	0	30	0	0	0	30
2010	ANDERSON	UNKNOWN	0	0	50	0	0	0	50
2011	ANDERSON	UNKNOWN	0	0	43	0	0	0	43
1980	ANGELINA	CARRIZO-WILCOX AQUIFER	8,244	21,296	0	0	0	0	29,540
1984	ANGELINA	CARRIZO-WILCOX AQUIFER	7,989	19,284	0	0	0	0	27,273
1985	ANGELINA	CARRIZO-WILCOX AQUIFER	8,222	19,120	0	0	0	0	27,342
1986	ANGELINA	CARRIZO-WILCOX AQUIFER	7,955	18,582	0	0	0	0	26,537
1987	ANGELINA	CARRIZO-WILCOX AQUIFER	7,673	18,561	0	0	0	0	26,234
1988	ANGELINA	CARRIZO-WILCOX AQUIFER	7,644	16,199	0	0	0	0	23,843
1989	ANGELINA	CARRIZO-WILCOX AQUIFER	7,845	23,578	0	0	0	0	31,423
1990	ANGELINA	CARRIZO-WILCOX AQUIFER	8,354	14,668	0	0	0	0	23,022
1991	ANGELINA	CARRIZO-WILCOX AQUIFER	8,201	13,565	22	0	0	0	21,788
1992	ANGELINA	CARRIZO-WILCOX AQUIFER	9,013	12,404	22	0	0	0	21,439
1993	ANGELINA	CARRIZO-WILCOX AQUIFER	8,816	11,999	22	0	0	0	20,837
1994	ANGELINA	CARRIZO-WILCOX AQUIFER	9,023	12,030	22	0	0	0	21,075
1995	ANGELINA	CARRIZO-WILCOX AQUIFER	9,132	12,552	22	0	0	0	21,706
1996	ANGELINA	CARRIZO-WILCOX AQUIFER	10,161	11,771	22	0	0	0	21,954
1997	ANGELINA	CARRIZO-WILCOX AQUIFER	10,705	11,262	22	0	0	0	21,989
1998	ANGELINA	CARRIZO-WILCOX AQUIFER	12,198	10,922	22	0	0	0	23,142
1999	ANGELINA	CARRIZO-WILCOX AQUIFER	12,266	10,715	22	0	0	0	23,003
2000	ANGELINA	CARRIZO-WILCOX AQUIFER	13,114	12,306	0	0	0	39	25,459
2001	ANGELINA	CARRIZO-WILCOX AQUIFER	12,435	8,995	0	0	0	38	21,468
2002	ANGELINA	CARRIZO-WILCOX AQUIFER	11,995	8,345	0	0	0	36	20,376
2003	ANGELINA	CARRIZO-WILCOX AQUIFER	11,793	9,137	0	0	0	34	20,964
2004	ANGELINA	CARRIZO-WILCOX AQUIFER	11,840	1,914	0	0	0	33	13,787
2005	ANGELINA	CARRIZO-WILCOX AQUIFER	12,984	610	0	0	0	7	13,601
2006	ANGELINA	CARRIZO-WILCOX AQUIFER	12,379	782	0	0	0	7	13,168
2007	ANGELINA	CARRIZO-WILCOX AQUIFER	11,641	20	0	0	0	7	11,668
2008	ANGELINA	CARRIZO-WILCOX AQUIFER	11,767	16	0	0	0	8	11,791
2009	ANGELINA	CARRIZO-WILCOX AQUIFER	11,355	16	0	0	0	8	11,379
2010	ANGELINA	CARRIZO-WILCOX AQUIFER	10,842	0	0	0	0	10	10,852
2011	ANGELINA	CARRIZO-WILCOX AQUIFER	11,894	0	0	0	0	10	11,904
2012	ANGELINA	CARRIZO-WILCOX AQUIFER	10,695	0	0	0	0	8	10,703
1980	ANGELINA	OTHER AQUIFER	2,645	0	0	0	191	70	2,906
1984	ANGELINA	OTHER AQUIFER	2,263	1,002	0	0	191	146	3,602
1985	ANGELINA	OTHER AQUIFER	2,322	892	0	0	153	95	3,462

Groundwater Pumping Estimates from Texas Water Development Board
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1986	ANGELINA	OTHER AQUIFER	2,289	871	0	0	136	85	3,381
1987	ANGELINA	OTHER AQUIFER	2,013	853	0	0	136	88	3,090
1988	ANGELINA	OTHER AQUIFER	2,103	912	0	0	136	100	3,251
1989	ANGELINA	OTHER AQUIFER	2,328	831	0	0	0	88	3,247
1990	ANGELINA	OTHER AQUIFER	2,561	851	0	0	0	87	3,499
1991	ANGELINA	OTHER AQUIFER	2,542	777	0	0	0	88	3,407
1992	ANGELINA	OTHER AQUIFER	2,582	791	0	0	0	124	3,497
1993	ANGELINA	OTHER AQUIFER	2,417	774	0	0	30	122	3,343
1994	ANGELINA	OTHER AQUIFER	2,247	800	0	0	30	100	3,177
1995	ANGELINA	OTHER AQUIFER	2,180	777	0	0	30	100	3,087
1996	ANGELINA	OTHER AQUIFER	2,348	756	0	0	30	91	3,225
1997	ANGELINA	OTHER AQUIFER	2,197	687	0	0	30	89	3,003
1998	ANGELINA	OTHER AQUIFER	2,503	41	0	0	30	100	2,674
1999	ANGELINA	OTHER AQUIFER	2,517	1,023	0	0	30	116	3,686
2000	ANGELINA	OTHER AQUIFER	2,218	709	0	0	0	0	2,927
2001	ANGELINA	OTHER AQUIFER	2,217	761	0	0	0	0	2,978
2002	ANGELINA	OTHER AQUIFER	2,292	904	0	0	0	0	3,196
2003	ANGELINA	OTHER AQUIFER	2,299	918	0	0	0	0	3,217
2004	ANGELINA	OTHER AQUIFER	2,944	798	0	0	0	0	3,742
2005	ANGELINA	OTHER AQUIFER	2,128	799	0	0	0	0	2,927
2006	ANGELINA	OTHER AQUIFER	2,250	864	0	0	0	0	3,114
2007	ANGELINA	OTHER AQUIFER	2,180	971	0	0	0	0	3,151
2008	ANGELINA	OTHER AQUIFER	2,240	890	0	0	0	0	3,130
2009	ANGELINA	OTHER AQUIFER	2,207	902	0	0	0	0	3,109
2010	ANGELINA	OTHER AQUIFER	127	75	0	0	0	0	202
2011	ANGELINA	OTHER AQUIFER	440	81	0	0	0	0	521
2012	ANGELINA	OTHER AQUIFER	351	69	0	0	0	0	420
1980	ANGELINA	QUEEN CITY AQUIFER	150	0	0	0	186	23	359
1984	ANGELINA	QUEEN CITY AQUIFER	214	0	0	0	186	48	448
1985	ANGELINA	QUEEN CITY AQUIFER	187	0	0	0	149	47	383
1986	ANGELINA	QUEEN CITY AQUIFER	136	0	0	0	132	42	310
1987	ANGELINA	QUEEN CITY AQUIFER	105	0	0	0	132	44	281
1988	ANGELINA	QUEEN CITY AQUIFER	60	0	0	0	132	49	241
1989	ANGELINA	QUEEN CITY AQUIFER	224	0	0	0	0	44	268
1990	ANGELINA	QUEEN CITY AQUIFER	134	0	0	0	0	44	178
1991	ANGELINA	QUEEN CITY AQUIFER	143	0	0	0	0	45	188
1992	ANGELINA	QUEEN CITY AQUIFER	92	0	0	0	0	63	155
1993	ANGELINA	QUEEN CITY AQUIFER	75	0	0	0	0	62	137
1994	ANGELINA	QUEEN CITY AQUIFER	67	0	0	0	0	51	118
1995	ANGELINA	QUEEN CITY AQUIFER	31	0	0	0	0	51	82
1996	ANGELINA	QUEEN CITY AQUIFER	76	0	0	0	0	46	122
1997	ANGELINA	QUEEN CITY AQUIFER	59	0	0	0	0	45	104
1998	ANGELINA	QUEEN CITY AQUIFER	67	0	0	0	0	51	118
1999	ANGELINA	QUEEN CITY AQUIFER	68	0	0	0	0	59	127
2000	ANGELINA	QUEEN CITY AQUIFER	2	0	0	0	0	58	60
2001	ANGELINA	QUEEN CITY AQUIFER	7	0	0	0	0	57	64
2002	ANGELINA	QUEEN CITY AQUIFER	8	0	0	0	0	54	62
2003	ANGELINA	QUEEN CITY AQUIFER	8	0	0	0	0	50	58
2004	ANGELINA	QUEEN CITY AQUIFER	8	0	0	0	0	0	8
2005	ANGELINA	QUEEN CITY AQUIFER	8	0	0	0	0	0	8
1980	ANGELINA	SPARTA AQUIFER	150	0	0	0	186	24	360
1984	ANGELINA	SPARTA AQUIFER	214	0	0	0	186	49	449
1985	ANGELINA	SPARTA AQUIFER	187	0	0	0	148	47	382
1986	ANGELINA	SPARTA AQUIFER	136	0	0	0	132	42	310
1987	ANGELINA	SPARTA AQUIFER	105	0	0	0	132	44	281
1988	ANGELINA	SPARTA AQUIFER	60	0	0	0	132	49	241
1989	ANGELINA	SPARTA AQUIFER	224	0	0	0	0	44	268
1990	ANGELINA	SPARTA AQUIFER	134	0	0	0	0	44	178
1991	ANGELINA	SPARTA AQUIFER	143	0	0	0	0	45	188
1992	ANGELINA	SPARTA AQUIFER	92	0	0	0	0	63	155
1993	ANGELINA	SPARTA AQUIFER	75	0	0	0	0	62	137
1994	ANGELINA	SPARTA AQUIFER	67	0	0	0	0	51	118
1995	ANGELINA	SPARTA AQUIFER	31	0	0	0	0	51	82
1996	ANGELINA	SPARTA AQUIFER	76	0	0	0	0	46	122
1997	ANGELINA	SPARTA AQUIFER	59	0	0	0	0	45	104
1998	ANGELINA	SPARTA AQUIFER	67	0	0	0	0	51	118
1999	ANGELINA	SPARTA AQUIFER	68	0	0	0	0	59	127
2000	ANGELINA	SPARTA AQUIFER	2	0	0	0	0	58	60
2001	ANGELINA	SPARTA AQUIFER	0	0	0	0	0	57	57
2002	ANGELINA	SPARTA AQUIFER	0	0	0	0	0	54	54
2003	ANGELINA	SPARTA AQUIFER	0	0	0	0	0	50	50
2004	ANGELINA	SPARTA AQUIFER	0	0	0	0	0	33	33
2005	ANGELINA	SPARTA AQUIFER	0	0	0	0	0	7	7
2006	ANGELINA	SPARTA AQUIFER	88	0	0	0	0	7	95
2007	ANGELINA	SPARTA AQUIFER	73	0	0	0	0	7	80
2008	ANGELINA	SPARTA AQUIFER	81	0	0	0	0	8	89
2009	ANGELINA	SPARTA AQUIFER	96	0	0	0	0	8	104
2010	ANGELINA	SPARTA AQUIFER	112	0	0	0	0	10	122

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2011	ANGELINA	SPARTA AQUIFER	130	0	0	0	0	10	140
2012	ANGELINA	SPARTA AQUIFER	85	0	0	0	0	8	93
2008	ANGELINA	UNKNOWN	0	0	71	0	0	0	71
2009	ANGELINA	UNKNOWN	0	0	43	0	0	0	43
2010	ANGELINA	UNKNOWN	0	0	15	0	0	0	15
2011	ANGELINA	UNKNOWN	0	0	10	0	0	0	10
2012	ANGELINA	UNKNOWN	0	0	27	0	0	0	27
2000	ANGELINA	YEGUA-JACKSON AQUIFER	0	0	0	0	30	76	106
2001	ANGELINA	YEGUA-JACKSON AQUIFER	0	0	0	0	9	74	83
2002	ANGELINA	YEGUA-JACKSON AQUIFER	0	0	0	0	9	70	79
2003	ANGELINA	YEGUA-JACKSON AQUIFER	0	0	0	0	25	67	92
2004	ANGELINA	YEGUA-JACKSON AQUIFER	0	0	0	0	109	133	242
2005	ANGELINA	YEGUA-JACKSON AQUIFER	0	0	0	0	209	26	235
2006	ANGELINA	YEGUA-JACKSON AQUIFER	455	0	0	0	186	27	668
2007	ANGELINA	YEGUA-JACKSON AQUIFER	377	0	0	0	0	28	405
2008	ANGELINA	YEGUA-JACKSON AQUIFER	421	0	0	0	0	33	454
2009	ANGELINA	YEGUA-JACKSON AQUIFER	498	0	0	0	214	31	743
2010	ANGELINA	YEGUA-JACKSON AQUIFER	2,468	1,384	0	0	238	40	4,130
2011	ANGELINA	YEGUA-JACKSON AQUIFER	2,376	975	0	0	265	39	3,655
2012	ANGELINA	YEGUA-JACKSON AQUIFER	1,872	790	0	0	274	33	2,969
1980	BOWIE	BLOSSOM AQUIFER	45	0	0	0	0	20	65
1984	BOWIE	BLOSSOM AQUIFER	59	0	0	0	0	22	81
1985	BOWIE	BLOSSOM AQUIFER	59	0	0	0	0	19	78
1986	BOWIE	BLOSSOM AQUIFER	48	0	0	0	0	21	69
1987	BOWIE	BLOSSOM AQUIFER	49	0	0	0	0	20	69
1988	BOWIE	BLOSSOM AQUIFER	46	0	0	0	0	20	66
1989	BOWIE	BLOSSOM AQUIFER	52	0	0	0	0	20	72
1990	BOWIE	BLOSSOM AQUIFER	66	0	0	0	0	22	88
1991	BOWIE	BLOSSOM AQUIFER	69	0	0	0	0	22	91
1992	BOWIE	BLOSSOM AQUIFER	63	0	0	0	0	18	81
1993	BOWIE	BLOSSOM AQUIFER	66	0	0	0	0	19	85
1994	BOWIE	BLOSSOM AQUIFER	66	0	0	0	0	21	87
1995	BOWIE	BLOSSOM AQUIFER	104	0	0	0	0	20	124
1996	BOWIE	BLOSSOM AQUIFER	106	0	0	0	0	27	133
1997	BOWIE	BLOSSOM AQUIFER	105	0	0	0	0	18	123
1998	BOWIE	BLOSSOM AQUIFER	99	0	0	0	0	19	118
1999	BOWIE	BLOSSOM AQUIFER	86	0	0	0	0	20	106
2000	BOWIE	BLOSSOM AQUIFER	62	0	0	0	0	20	82
2001	BOWIE	BLOSSOM AQUIFER	53	0	0	0	0	7	60
2002	BOWIE	BLOSSOM AQUIFER	62	0	0	0	0	7	69
2003	BOWIE	BLOSSOM AQUIFER	78	0	0	0	0	7	85
2004	BOWIE	BLOSSOM AQUIFER	75	0	0	0	0	0	75
2005	BOWIE	BLOSSOM AQUIFER	81	0	0	0	0	0	81
1980	BOWIE	CARRIZO-WILCOX AQUIFER	1,653	42	0	0	0	286	1,981
1984	BOWIE	CARRIZO-WILCOX AQUIFER	1,492	45	0	0	0	301	1,838
1985	BOWIE	CARRIZO-WILCOX AQUIFER	1,586	44	0	0	0	258	1,888
1986	BOWIE	CARRIZO-WILCOX AQUIFER	1,584	39	18	0	0	298	1,939
1987	BOWIE	CARRIZO-WILCOX AQUIFER	1,234	22	18	0	0	274	1,548
1988	BOWIE	CARRIZO-WILCOX AQUIFER	1,488	7	17	0	0	275	1,787
1989	BOWIE	CARRIZO-WILCOX AQUIFER	1,636	5	0	0	0	283	1,924
1990	BOWIE	CARRIZO-WILCOX AQUIFER	1,340	27	0	0	0	319	1,686
1991	BOWIE	CARRIZO-WILCOX AQUIFER	1,394	17	0	0	0	321	1,732
1992	BOWIE	CARRIZO-WILCOX AQUIFER	1,286	1	0	0	0	262	1,549
1993	BOWIE	CARRIZO-WILCOX AQUIFER	1,351	17	0	0	0	280	1,648
1994	BOWIE	CARRIZO-WILCOX AQUIFER	1,194	16	0	0	0	311	1,521
1995	BOWIE	CARRIZO-WILCOX AQUIFER	945	15	0	0	0	296	1,256
1996	BOWIE	CARRIZO-WILCOX AQUIFER	760	16	0	0	0	395	1,171
1997	BOWIE	CARRIZO-WILCOX AQUIFER	725	17	0	0	0	258	1,000
1998	BOWIE	CARRIZO-WILCOX AQUIFER	682	3	0	0	0	267	952
1999	BOWIE	CARRIZO-WILCOX AQUIFER	592	3	0	0	0	287	882
2000	BOWIE	CARRIZO-WILCOX AQUIFER	977	3	0	0	0	293	1,273
2001	BOWIE	CARRIZO-WILCOX AQUIFER	1,103	3	0	0	0	173	1,279
2002	BOWIE	CARRIZO-WILCOX AQUIFER	1,119	15	0	0	0	163	1,297
2003	BOWIE	CARRIZO-WILCOX AQUIFER	1,075	20	0	0	0	160	1,255
2004	BOWIE	CARRIZO-WILCOX AQUIFER	1,054	12	0	0	0	0	1,066
2005	BOWIE	CARRIZO-WILCOX AQUIFER	1,126	25	0	0	0	0	1,151
2006	BOWIE	CARRIZO-WILCOX AQUIFER	991	25	0	0	0	0	1,016
2007	BOWIE	CARRIZO-WILCOX AQUIFER	838	35	0	0	0	0	873
2008	BOWIE	CARRIZO-WILCOX AQUIFER	910	43	0	0	0	0	953
2009	BOWIE	CARRIZO-WILCOX AQUIFER	951	29	0	0	0	0	980
2010	BOWIE	CARRIZO-WILCOX AQUIFER	1,008	31	0	0	1,246	0	2,285
2011	BOWIE	CARRIZO-WILCOX AQUIFER	1,084	26	0	0	762	0	1,872
2012	BOWIE	CARRIZO-WILCOX AQUIFER	996	31	0	0	1,382	0	2,409
1980	BOWIE	NACATOCH AQUIFER	802	3	0	0	515	176	1,496
1984	BOWIE	NACATOCH AQUIFER	729	0	0	0	1,374	223	2,326
1985	BOWIE	NACATOCH AQUIFER	694	0	0	0	1,239	191	2,124
1986	BOWIE	NACATOCH AQUIFER	568	0	0	0	1,834	221	2,623
1987	BOWIE	NACATOCH AQUIFER	587	0	0	0	1,500	201	2,288

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1988	BOWIE	NACATOCH AQUIFER	542	0	0	0	1,425	203	2,170
1989	BOWIE	NACATOCH AQUIFER	620	0	0	0	774	210	1,604
1990	BOWIE	NACATOCH AQUIFER	799	0	0	0	938	236	1,973
1991	BOWIE	NACATOCH AQUIFER	838	0	0	0	0	237	1,075
1992	BOWIE	NACATOCH AQUIFER	773	0	0	0	0	193	966
1993	BOWIE	NACATOCH AQUIFER	806	0	0	0	422	206	1,434
1994	BOWIE	NACATOCH AQUIFER	763	0	0	0	78	229	1,070
1995	BOWIE	NACATOCH AQUIFER	972	0	0	0	55	218	1,245
1996	BOWIE	NACATOCH AQUIFER	950	0	0	0	45	291	1,286
1997	BOWIE	NACATOCH AQUIFER	936	0	0	0	40	190	1,166
1998	BOWIE	NACATOCH AQUIFER	881	0	0	0	48	196	1,125
1999	BOWIE	NACATOCH AQUIFER	765	0	0	0	50	211	1,026
2000	BOWIE	NACATOCH AQUIFER	679	0	0	0	0	215	894
2001	BOWIE	NACATOCH AQUIFER	698	0	0	0	0	91	789
2002	BOWIE	NACATOCH AQUIFER	674	0	0	0	0	86	760
2003	BOWIE	NACATOCH AQUIFER	729	0	0	0	0	85	814
2004	BOWIE	NACATOCH AQUIFER	702	0	0	0	255	219	1,176
2005	BOWIE	NACATOCH AQUIFER	758	0	0	0	240	52	1,050
2006	BOWIE	NACATOCH AQUIFER	904	0	0	0	5	53	962
2007	BOWIE	NACATOCH AQUIFER	751	0	0	0	55	35	841
2008	BOWIE	NACATOCH AQUIFER	833	0	0	0	71	23	927
2009	BOWIE	NACATOCH AQUIFER	878	0	0	0	455	26	1,359
2010	BOWIE	NACATOCH AQUIFER	911	0	0	0	452	65	1,428
2011	BOWIE	NACATOCH AQUIFER	986	0	0	0	278	67	1,331
2012	BOWIE	NACATOCH AQUIFER	920	0	0	0	504	42	1,466
1980	BOWIE	OTHER AQUIFER	286	0	0	0	515	81	882
1984	BOWIE	OTHER AQUIFER	104	3	0	0	1,374	47	1,528
1985	BOWIE	OTHER AQUIFER	121	3	0	0	1,239	41	1,404
1986	BOWIE	OTHER AQUIFER	115	0	0	0	1,834	47	1,996
1987	BOWIE	OTHER AQUIFER	126	0	0	0	1,500	43	1,669
1988	BOWIE	OTHER AQUIFER	86	0	0	0	1,425	43	1,554
1989	BOWIE	OTHER AQUIFER	98	0	16	0	774	45	933
1990	BOWIE	OTHER AQUIFER	278	0	16	0	938	51	1,283
1991	BOWIE	OTHER AQUIFER	289	0	21	0	0	51	361
1992	BOWIE	OTHER AQUIFER	287	0	21	0	0	42	350
1993	BOWIE	OTHER AQUIFER	275	0	21	0	422	45	763
1994	BOWIE	OTHER AQUIFER	214	0	21	0	0	50	285
1995	BOWIE	OTHER AQUIFER	289	0	25	0	0	48	362
1996	BOWIE	OTHER AQUIFER	278	0	30	0	0	64	372
1997	BOWIE	OTHER AQUIFER	289	0	30	0	0	42	361
1998	BOWIE	OTHER AQUIFER	272	0	30	0	0	43	345
1999	BOWIE	OTHER AQUIFER	236	0	30	0	0	47	313
2000	BOWIE	OTHER AQUIFER	200	0	0	0	0	48	248
2001	BOWIE	OTHER AQUIFER	101	0	0	0	0	16	117
2002	BOWIE	OTHER AQUIFER	112	0	0	0	0	15	127
2003	BOWIE	OTHER AQUIFER	59	0	0	0	0	15	74
2004	BOWIE	OTHER AQUIFER	54	0	0	0	3,439	39	3,532
2005	BOWIE	OTHER AQUIFER	58	0	0	0	3,238	9	3,305
2006	BOWIE	OTHER AQUIFER	267	0	0	0	70	10	347
2007	BOWIE	OTHER AQUIFER	221	0	0	0	750	6	977
2008	BOWIE	OTHER AQUIFER	246	0	0	0	955	35	1,236
2009	BOWIE	OTHER AQUIFER	259	0	0	0	6,145	40	6,444
2010	BOWIE	OTHER AQUIFER	276	0	0	0	6,098	17	6,391
2011	BOWIE	OTHER AQUIFER	299	0	0	0	3,749	17	4,065
2012	BOWIE	OTHER AQUIFER	279	0	0	0	6,801	11	7,091
2008	BOWIE	UNKNOWN	0	0	0	0	0	0	0
2009	BOWIE	UNKNOWN	0	0	0	0	0	0	0
2010	BOWIE	UNKNOWN	0	0	0	0	0	0	0
2011	BOWIE	UNKNOWN	0	0	0	0	0	0	0
1980	CAMP	CARRIZO-WILCOX AQUIFER	1,327	0	119	0	0	111	1,557
1984	CAMP	CARRIZO-WILCOX AQUIFER	1,547	178	61	0	130	92	2,008
1985	CAMP	CARRIZO-WILCOX AQUIFER	1,560	179	63	0	128	79	2,009
1986	CAMP	CARRIZO-WILCOX AQUIFER	1,495	181	59	0	86	94	1,915
1987	CAMP	CARRIZO-WILCOX AQUIFER	1,560	0	56	0	86	90	1,792
1988	CAMP	CARRIZO-WILCOX AQUIFER	1,598	0	57	0	86	88	1,829
1989	CAMP	CARRIZO-WILCOX AQUIFER	1,515	0	53	0	54	93	1,715
1990	CAMP	CARRIZO-WILCOX AQUIFER	1,585	0	53	0	70	110	1,818
1991	CAMP	CARRIZO-WILCOX AQUIFER	1,683	0	11	0	70	110	1,874
1992	CAMP	CARRIZO-WILCOX AQUIFER	1,263	0	11	0	71	128	1,473
1993	CAMP	CARRIZO-WILCOX AQUIFER	1,364	0	11	0	21	135	1,531
1994	CAMP	CARRIZO-WILCOX AQUIFER	1,471	0	11	0	9	154	1,645
1995	CAMP	CARRIZO-WILCOX AQUIFER	1,284	0	18	0	9	158	1,469
1996	CAMP	CARRIZO-WILCOX AQUIFER	1,254	0	18	0	12	157	1,441
1997	CAMP	CARRIZO-WILCOX AQUIFER	1,414	0	18	0	12	134	1,578
1998	CAMP	CARRIZO-WILCOX AQUIFER	1,409	0	18	0	12	139	1,578
1999	CAMP	CARRIZO-WILCOX AQUIFER	1,272	0	18	0	12	142	1,444
2000	CAMP	CARRIZO-WILCOX AQUIFER	1,432	0	0	0	0	149	1,581
2001	CAMP	CARRIZO-WILCOX AQUIFER	1,355	0	0	0	0	234	1,589

Groundwater Pumping Estimates from Texas Water Development Board
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2002	CAMP	CARRIZO-WILCOX AQUIFER	1,340	430	0	0	0	164	1,934
2003	CAMP	CARRIZO-WILCOX AQUIFER	1,356	36	0	0	0	153	1,545
2004	CAMP	CARRIZO-WILCOX AQUIFER	1,442	0	0	0	0	381	1,823
2005	CAMP	CARRIZO-WILCOX AQUIFER	1,531	0	0	0	0	372	1,903
2006	CAMP	CARRIZO-WILCOX AQUIFER	1,578	0	0	0	0	394	1,972
2007	CAMP	CARRIZO-WILCOX AQUIFER	1,442	0	0	0	0	381	1,823
2008	CAMP	CARRIZO-WILCOX AQUIFER	1,507	0	0	0	3	380	1,890
2009	CAMP	CARRIZO-WILCOX AQUIFER	1,655	0	0	0	0	378	2,033
2010	CAMP	CARRIZO-WILCOX AQUIFER	1,801	0	0	0	0	783	2,584
2011	CAMP	CARRIZO-WILCOX AQUIFER	1,783	0	0	0	0	782	2,565
2012	CAMP	CARRIZO-WILCOX AQUIFER	1,676	0	0	0	0	738	2,414
1980	CAMP	QUEEN CITY AQUIFER	168	0	37	0	0	166	371
1984	CAMP	QUEEN CITY AQUIFER	200	20	21	0	15	137	393
1985	CAMP	QUEEN CITY AQUIFER	202	20	21	0	14	119	376
1986	CAMP	QUEEN CITY AQUIFER	188	20	20	0	10	141	379
1987	CAMP	QUEEN CITY AQUIFER	213	0	19	0	10	135	377
1988	CAMP	QUEEN CITY AQUIFER	204	0	19	0	10	133	366
1989	CAMP	QUEEN CITY AQUIFER	228	0	18	0	6	140	392
1990	CAMP	QUEEN CITY AQUIFER	165	0	18	0	8	165	356
1991	CAMP	QUEEN CITY AQUIFER	163	0	4	0	8	166	341
1992	CAMP	QUEEN CITY AQUIFER	159	0	4	0	8	192	363
1993	CAMP	QUEEN CITY AQUIFER	161	0	4	0	2	202	369
1994	CAMP	QUEEN CITY AQUIFER	152	0	4	0	8	231	395
1995	CAMP	QUEEN CITY AQUIFER	128	0	6	0	8	238	380
1996	CAMP	QUEEN CITY AQUIFER	142	0	6	0	11	236	395
1997	CAMP	QUEEN CITY AQUIFER	153	0	6	0	11	202	372
1998	CAMP	QUEEN CITY AQUIFER	152	0	6	0	11	209	378
1999	CAMP	QUEEN CITY AQUIFER	138	0	6	0	11	215	370
2000	CAMP	QUEEN CITY AQUIFER	5	0	0	0	0	223	228
2001	CAMP	QUEEN CITY AQUIFER	5	0	0	0	0	352	357
2002	CAMP	QUEEN CITY AQUIFER	5	0	0	0	0	248	253
2003	CAMP	QUEEN CITY AQUIFER	5	0	0	0	0	230	235
2004	CAMP	QUEEN CITY AQUIFER	5	0	0	0	0	0	5
2005	CAMP	QUEEN CITY AQUIFER	5	0	0	0	0	0	5
2006	CAMP	QUEEN CITY AQUIFER	1	0	0	0	0	0	1
2007	CAMP	QUEEN CITY AQUIFER	1	0	0	0	0	0	1
2008	CAMP	QUEEN CITY AQUIFER	1	0	0	0	0	0	1
2009	CAMP	QUEEN CITY AQUIFER	1	0	0	0	0	0	1
2010	CAMP	QUEEN CITY AQUIFER	1	0	0	0	0	0	1
2011	CAMP	QUEEN CITY AQUIFER	1	0	0	0	0	0	1
2012	CAMP	QUEEN CITY AQUIFER	1	0	0	0	0	0	1
2008	CAMP	UNKNOWN	0	0	3	0	0	0	3
2009	CAMP	UNKNOWN	0	0	3	0	0	0	3
2010	CAMP	UNKNOWN	0	0	2	0	0	0	2
2011	CAMP	UNKNOWN	0	0	5	0	0	0	5
1980	CASS	CARRIZO-WILCOX AQUIFER	3,047	0	902	0	0	79	4,028
1984	CASS	CARRIZO-WILCOX AQUIFER	3,291	11	567	3	0	183	4,055
1985	CASS	CARRIZO-WILCOX AQUIFER	3,266	11	629	1	0	159	4,066
1986	CASS	CARRIZO-WILCOX AQUIFER	3,172	11	756	3	0	157	4,099
1987	CASS	CARRIZO-WILCOX AQUIFER	3,162	2	689	0	0	156	4,009
1988	CASS	CARRIZO-WILCOX AQUIFER	3,103	1	792	0	0	168	4,064
1989	CASS	CARRIZO-WILCOX AQUIFER	3,051	1	767	1	0	173	3,993
1990	CASS	CARRIZO-WILCOX AQUIFER	2,780	1	767	0	0	174	3,722
1991	CASS	CARRIZO-WILCOX AQUIFER	2,500	0	819	0	0	178	3,497
1992	CASS	CARRIZO-WILCOX AQUIFER	1,981	0	819	0	0	177	2,977
1993	CASS	CARRIZO-WILCOX AQUIFER	1,818	0	819	0	6	165	2,808
1994	CASS	CARRIZO-WILCOX AQUIFER	1,801	0	819	0	0	176	2,796
1995	CASS	CARRIZO-WILCOX AQUIFER	1,898	0	822	0	0	164	2,884
1996	CASS	CARRIZO-WILCOX AQUIFER	1,754	0	822	0	0	170	2,746
1997	CASS	CARRIZO-WILCOX AQUIFER	1,796	0	822	0	0	154	2,772
1998	CASS	CARRIZO-WILCOX AQUIFER	1,751	0	481	0	0	166	2,398
1999	CASS	CARRIZO-WILCOX AQUIFER	1,649	0	741	0	0	188	2,578
2000	CASS	CARRIZO-WILCOX AQUIFER	1,210	0	0	0	0	173	1,383
2001	CASS	CARRIZO-WILCOX AQUIFER	1,150	0	0	0	0	115	1,265
2002	CASS	CARRIZO-WILCOX AQUIFER	1,132	0	0	0	0	113	1,245
2003	CASS	CARRIZO-WILCOX AQUIFER	1,256	0	0	0	0	105	1,361
2004	CASS	CARRIZO-WILCOX AQUIFER	1,283	0	0	0	0	143	1,426
2005	CASS	CARRIZO-WILCOX AQUIFER	1,382	0	0	0	0	18	1,400
2006	CASS	CARRIZO-WILCOX AQUIFER	1,248	0	0	0	0	18	1,266
2007	CASS	CARRIZO-WILCOX AQUIFER	1,131	0	0	0	0	18	1,149
2008	CASS	CARRIZO-WILCOX AQUIFER	1,502	0	0	0	0	12	1,514
2009	CASS	CARRIZO-WILCOX AQUIFER	1,294	0	0	0	0	13	1,307
2010	CASS	CARRIZO-WILCOX AQUIFER	1,643	0	0	0	0	27	1,670
2011	CASS	CARRIZO-WILCOX AQUIFER	1,380	0	0	0	0	28	1,408
2012	CASS	CARRIZO-WILCOX AQUIFER	1,351	0	0	0	0	19	1,370
1980	CASS	QUEEN CITY AQUIFER	394	0	316	0	0	249	959
1984	CASS	QUEEN CITY AQUIFER	450	0	0	0	0	167	617
1985	CASS	QUEEN CITY AQUIFER	487	0	0	0	0	146	633

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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1986	CASS	QUEEN CITY AQUIFER	471	0	0	0	0	144	615
1987	CASS	QUEEN CITY AQUIFER	462	0	0	0	0	144	606
1988	CASS	QUEEN CITY AQUIFER	469	0	0	0	0	154	623
1989	CASS	QUEEN CITY AQUIFER	484	0	0	0	0	160	644
1990	CASS	QUEEN CITY AQUIFER	713	0	0	0	0	160	873
1991	CASS	QUEEN CITY AQUIFER	720	0	0	0	0	163	883
1992	CASS	QUEEN CITY AQUIFER	714	0	0	0	0	163	877
1993	CASS	QUEEN CITY AQUIFER	743	0	0	0	6	153	902
1994	CASS	QUEEN CITY AQUIFER	714	0	0	0	9	164	887
1995	CASS	QUEEN CITY AQUIFER	777	0	0	0	8	153	938
1996	CASS	QUEEN CITY AQUIFER	784	0	0	0	11	158	953
1997	CASS	QUEEN CITY AQUIFER	783	0	0	0	11	143	937
1998	CASS	QUEEN CITY AQUIFER	763	0	0	0	11	154	928
1999	CASS	QUEEN CITY AQUIFER	719	0	0	0	11	175	905
2000	CASS	QUEEN CITY AQUIFER	118	0	0	0	0	161	279
2001	CASS	QUEEN CITY AQUIFER	84	0	0	0	0	74	158
2002	CASS	QUEEN CITY AQUIFER	74	0	0	0	0	73	147
2003	CASS	QUEEN CITY AQUIFER	22	0	0	0	0	68	90
2004	CASS	QUEEN CITY AQUIFER	21	0	0	0	0	31	52
2005	CASS	QUEEN CITY AQUIFER	29	0	0	0	0	4	33
2006	CASS	QUEEN CITY AQUIFER	36	0	0	0	0	4	40
2007	CASS	QUEEN CITY AQUIFER	31	0	0	0	0	4	35
2008	CASS	QUEEN CITY AQUIFER	33	0	0	0	0	8	41
2009	CASS	QUEEN CITY AQUIFER	33	0	0	0	0	8	41
2010	CASS	QUEEN CITY AQUIFER	40	0	0	0	0	8	48
2011	CASS	QUEEN CITY AQUIFER	16	0	0	0	0	8	24
2012	CASS	QUEEN CITY AQUIFER	13	0	0	0	0	6	19
2000	CASS	UNKNOWN	0	0	0	0	0	0	0
2001	CASS	UNKNOWN	0	0	0	0	0	0	0
2002	CASS	UNKNOWN	0	0	0	0	0	0	0
2008	CASS	UNKNOWN	0	0	0	0	0	0	0
2009	CASS	UNKNOWN	0	0	5	0	0	0	5
2010	CASS	UNKNOWN	0	0	10	0	0	0	10
2011	CASS	UNKNOWN	0	0	8	0	0	0	8
1980	CHEROKEE	CARRIZO-WILCOX AQUIFER	4,850	0	0	333	25	0	5,208
1984	CHEROKEE	CARRIZO-WILCOX AQUIFER	4,636	0	117	408	58	252	5,471
1985	CHEROKEE	CARRIZO-WILCOX AQUIFER	4,878	0	120	218	36	269	5,521
1986	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,020	0	111	293	45	247	5,716
1987	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,450	0	89	510	45	233	6,327
1988	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,574	0	80	439	45	220	6,358
1989	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,408	0	53	347	48	226	6,082
1990	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,099	0	53	343	50	301	5,846
1991	CHEROKEE	CARRIZO-WILCOX AQUIFER	4,521	0	81	262	41	298	5,203
1992	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,349	0	81	136	41	407	6,014
1993	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,357	4	81	166	6	453	6,067
1994	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,714	0	81	162	7	423	6,387
1995	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,761	0	81	133	7	389	6,371
1996	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,588	2	81	131	7	424	6,233
1997	CHEROKEE	CARRIZO-WILCOX AQUIFER	5,907	0	81	108	7	340	6,443
1998	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,560	0	81	118	7	335	7,101
1999	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,302	0	81	115	7	335	6,840
2000	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,565	7	0	132	14	303	7,021
2001	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,468	9	0	128	12	307	6,924
2002	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,134	5	0	86	7	296	6,528
2003	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,234	6	0	119	4	246	6,609
2004	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,886	23	0	115	10	104	7,138
2005	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,759	23	0	124	23	39	6,968
2006	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,583	10	0	136	19	41	6,789
2007	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,120	9	0	155	106	40	6,430
2008	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,120	10	0	127	57	39	6,353
2009	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,261	5	0	167	64	34	6,531
2010	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,530	5	0	121	88	38	6,782
2011	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,984	0	0	181	4	38	7,207
2012	CHEROKEE	CARRIZO-WILCOX AQUIFER	6,191	0	0	170	123	34	6,518
2000	CHEROKEE	OTHER AQUIFER	0	0	0	0	2	88	90
2001	CHEROKEE	OTHER AQUIFER	0	0	0	0	1	89	90
2002	CHEROKEE	OTHER AQUIFER	0	0	0	0	2	86	88
2003	CHEROKEE	OTHER AQUIFER	0	0	0	0	1	72	73
2004	CHEROKEE	OTHER AQUIFER	0	0	0	0	1	70	71
2005	CHEROKEE	OTHER AQUIFER	0	0	0	0	3	26	29
2006	CHEROKEE	OTHER AQUIFER	81	0	0	0	2	27	110
2007	CHEROKEE	OTHER AQUIFER	67	0	0	0	13	26	106
2008	CHEROKEE	OTHER AQUIFER	76	0	0	0	7	26	109
2009	CHEROKEE	OTHER AQUIFER	110	0	0	0	8	23	141
2010	CHEROKEE	OTHER AQUIFER	145	0	0	0	11	26	182
2011	CHEROKEE	OTHER AQUIFER	157	0	0	0	0	26	183
2012	CHEROKEE	OTHER AQUIFER	145	0	0	0	15	23	183
1980	CHEROKEE	QUEEN CITY AQUIFER	428	0	53	0	25	380	886

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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1984	CHEROKEE	QUEEN CITY AQUIFER	205	0	0	0	59	252	516
1985	CHEROKEE	QUEEN CITY AQUIFER	194	0	0	0	36	269	499
1986	CHEROKEE	QUEEN CITY AQUIFER	125	0	0	0	45	247	417
1987	CHEROKEE	QUEEN CITY AQUIFER	73	0	0	0	45	233	351
1988	CHEROKEE	QUEEN CITY AQUIFER	126	0	0	0	45	220	391
1989	CHEROKEE	QUEEN CITY AQUIFER	247	0	0	0	48	226	521
1990	CHEROKEE	QUEEN CITY AQUIFER	113	0	0	0	50	301	464
1991	CHEROKEE	QUEEN CITY AQUIFER	111	0	0	0	41	298	450
1992	CHEROKEE	QUEEN CITY AQUIFER	178	0	0	0	41	407	626
1993	CHEROKEE	QUEEN CITY AQUIFER	97	0	0	0	6	453	556
1994	CHEROKEE	QUEEN CITY AQUIFER	77	0	0	0	19	423	519
1995	CHEROKEE	QUEEN CITY AQUIFER	82	0	0	0	20	389	491
1996	CHEROKEE	QUEEN CITY AQUIFER	80	0	0	0	20	424	524
1997	CHEROKEE	QUEEN CITY AQUIFER	83	0	0	0	20	340	443
1998	CHEROKEE	QUEEN CITY AQUIFER	92	0	0	0	20	335	447
1999	CHEROKEE	QUEEN CITY AQUIFER	89	0	0	0	20	335	444
2000	CHEROKEE	QUEEN CITY AQUIFER	94	0	0	0	16	215	325
2001	CHEROKEE	QUEEN CITY AQUIFER	82	0	0	0	13	217	312
2002	CHEROKEE	QUEEN CITY AQUIFER	117	0	0	0	21	210	348
2003	CHEROKEE	QUEEN CITY AQUIFER	88	0	0	0	12	174	274
2004	CHEROKEE	QUEEN CITY AQUIFER	147	0	0	0	11	383	541
2005	CHEROKEE	QUEEN CITY AQUIFER	158	0	0	0	26	142	326
2006	CHEROKEE	QUEEN CITY AQUIFER	448	0	0	0	21	149	618
2007	CHEROKEE	QUEEN CITY AQUIFER	413	0	0	0	119	145	677
2008	CHEROKEE	QUEEN CITY AQUIFER	434	0	0	0	64	142	640
2009	CHEROKEE	QUEEN CITY AQUIFER	504	0	0	0	72	124	700
2010	CHEROKEE	QUEEN CITY AQUIFER	632	0	0	0	99	140	871
2011	CHEROKEE	QUEEN CITY AQUIFER	677	0	0	0	4	140	821
2012	CHEROKEE	QUEEN CITY AQUIFER	643	0	0	0	139	124	906
1980	CHEROKEE	SPARTA AQUIFER	6	0	28	0	0	204	238
1984	CHEROKEE	SPARTA AQUIFER	2	0	0	0	0	81	83
1985	CHEROKEE	SPARTA AQUIFER	3	0	0	0	0	88	91
1986	CHEROKEE	SPARTA AQUIFER	2	0	0	0	0	80	82
1987	CHEROKEE	SPARTA AQUIFER	2	0	0	0	0	76	78
1988	CHEROKEE	SPARTA AQUIFER	2	0	0	0	0	72	74
1989	CHEROKEE	SPARTA AQUIFER	2	0	0	0	0	74	76
1990	CHEROKEE	SPARTA AQUIFER	3	0	0	0	0	99	102
1991	CHEROKEE	SPARTA AQUIFER	3	0	0	0	0	98	101
1992	CHEROKEE	SPARTA AQUIFER	27	0	0	0	0	134	161
1993	CHEROKEE	SPARTA AQUIFER	6	0	0	0	0	149	155
1994	CHEROKEE	SPARTA AQUIFER	1	0	0	0	2	139	142
1995	CHEROKEE	SPARTA AQUIFER	0	0	0	0	2	128	130
1996	CHEROKEE	SPARTA AQUIFER	0	0	0	0	2	140	142
1997	CHEROKEE	SPARTA AQUIFER	0	0	0	0	2	112	114
1998	CHEROKEE	SPARTA AQUIFER	0	0	0	0	2	110	112
1999	CHEROKEE	SPARTA AQUIFER	0	0	0	0	2	110	112
2000	CHEROKEE	SPARTA AQUIFER	0	0	0	0	1	100	101
2001	CHEROKEE	SPARTA AQUIFER	0	0	0	0	1	101	102
2002	CHEROKEE	SPARTA AQUIFER	0	0	0	0	0	97	97
2003	CHEROKEE	SPARTA AQUIFER	0	0	0	0	0	81	81
2004	CHEROKEE	SPARTA AQUIFER	0	0	0	0	1	0	1
2005	CHEROKEE	SPARTA AQUIFER	0	0	0	0	1	0	1
2006	CHEROKEE	SPARTA AQUIFER	81	0	0	0	1	0	82
2007	CHEROKEE	SPARTA AQUIFER	67	0	0	0	7	0	74
2008	CHEROKEE	SPARTA AQUIFER	76	0	0	0	4	0	80
2009	CHEROKEE	SPARTA AQUIFER	110	0	0	0	4	0	114
2010	CHEROKEE	SPARTA AQUIFER	145	0	0	0	6	0	151
2011	CHEROKEE	SPARTA AQUIFER	157	0	0	0	0	0	157
2012	CHEROKEE	SPARTA AQUIFER	145	0	0	0	8	0	153
2008	CHEROKEE	UNKNOWN	0	0	101	0	0	0	101
2009	CHEROKEE	UNKNOWN	0	0	77	0	0	0	77
2010	CHEROKEE	UNKNOWN	0	0	53	0	0	0	53
2011	CHEROKEE	UNKNOWN	0	0	30	0	0	0	30
2012	CHEROKEE	UNKNOWN	0	0	3	0	0	0	3
1980	FRANKLIN	CARRIZO-WILCOX AQUIFER	305	0	552	0	0	342	1,199
1984	FRANKLIN	CARRIZO-WILCOX AQUIFER	265	0	631	0	0	423	1,319
1985	FRANKLIN	CARRIZO-WILCOX AQUIFER	302	0	768	0	0	446	1,516
1986	FRANKLIN	CARRIZO-WILCOX AQUIFER	318	0	1,222	0	0	413	1,953
1987	FRANKLIN	CARRIZO-WILCOX AQUIFER	331	0	1,117	0	0	395	1,843
1988	FRANKLIN	CARRIZO-WILCOX AQUIFER	450	0	1,153	0	0	410	2,013
1989	FRANKLIN	CARRIZO-WILCOX AQUIFER	456	0	706	0	0	378	1,540
1990	FRANKLIN	CARRIZO-WILCOX AQUIFER	383	0	706	0	0	521	1,610
1991	FRANKLIN	CARRIZO-WILCOX AQUIFER	282	0	1,399	0	0	516	2,197
1992	FRANKLIN	CARRIZO-WILCOX AQUIFER	275	0	1,399	0	0	637	2,311
1993	FRANKLIN	CARRIZO-WILCOX AQUIFER	162	0	1,399	0	3	668	2,232
1994	FRANKLIN	CARRIZO-WILCOX AQUIFER	310	0	1,408	0	2	582	2,302
1995	FRANKLIN	CARRIZO-WILCOX AQUIFER	125	0	1,354	0	2	572	2,053
1996	FRANKLIN	CARRIZO-WILCOX AQUIFER	178	0	1,354	0	3	567	2,102

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1997	FRANKLIN	CARRIZO-WILCOX AQUIFER	92	0	895	0	3	460	1,450
1998	FRANKLIN	CARRIZO-WILCOX AQUIFER	122	0	894	0	3	452	1,471
1999	FRANKLIN	CARRIZO-WILCOX AQUIFER	289	0	895	0	3	484	1,671
2000	FRANKLIN	CARRIZO-WILCOX AQUIFER	198	0	0	0	0	449	647
2001	FRANKLIN	CARRIZO-WILCOX AQUIFER	176	0	0	0	0	249	425
2002	FRANKLIN	CARRIZO-WILCOX AQUIFER	64	0	0	0	0	229	293
2003	FRANKLIN	CARRIZO-WILCOX AQUIFER	70	0	0	0	0	225	295
2004	FRANKLIN	CARRIZO-WILCOX AQUIFER	41	0	0	0	0	217	258
2005	FRANKLIN	CARRIZO-WILCOX AQUIFER	51	0	0	0	0	428	479
2006	FRANKLIN	CARRIZO-WILCOX AQUIFER	52	0	0	0	0	426	478
2007	FRANKLIN	CARRIZO-WILCOX AQUIFER	42	0	0	0	33	335	410
2008	FRANKLIN	CARRIZO-WILCOX AQUIFER	45	0	0	0	0	444	489
2009	FRANKLIN	CARRIZO-WILCOX AQUIFER	34	0	0	0	0	440	474
2010	FRANKLIN	CARRIZO-WILCOX AQUIFER	22	0	0	0	0	517	539
2011	FRANKLIN	CARRIZO-WILCOX AQUIFER	22	0	0	0	0	516	538
2012	FRANKLIN	CARRIZO-WILCOX AQUIFER	18	0	0	0	0	495	513
2008	FRANKLIN	UNKNOWN	0	0	2	0	0	0	2
2009	FRANKLIN	UNKNOWN	0	0	1	0	0	0	1
2010	FRANKLIN	UNKNOWN	0	0	1	0	0	0	1
2011	FRANKLIN	UNKNOWN	0	0	15	0	0	0	15
2012	FRANKLIN	UNKNOWN	0	0	1	0	0	0	1
1980	GREGG	CARRIZO-WILCOX AQUIFER	690	250	152	1	0	47	1,140
1984	GREGG	CARRIZO-WILCOX AQUIFER	700	196	2,672	1	0	45	3,614
1985	GREGG	CARRIZO-WILCOX AQUIFER	688	186	129	1	0	36	1,040
1986	GREGG	CARRIZO-WILCOX AQUIFER	629	186	66	1	0	36	918
1987	GREGG	CARRIZO-WILCOX AQUIFER	372	161	66	1	0	33	633
1988	GREGG	CARRIZO-WILCOX AQUIFER	461	161	61	1	0	38	722
1989	GREGG	CARRIZO-WILCOX AQUIFER	368	161	29	1	0	41	600
1990	GREGG	CARRIZO-WILCOX AQUIFER	409	161	29	1	0	40	640
1991	GREGG	CARRIZO-WILCOX AQUIFER	513	161	11	1	0	41	727
1992	GREGG	CARRIZO-WILCOX AQUIFER	605	161	0	1	0	46	813
1993	GREGG	CARRIZO-WILCOX AQUIFER	627	161	0	1	20	43	852
1994	GREGG	CARRIZO-WILCOX AQUIFER	628	161	0	1	25	38	853
1995	GREGG	CARRIZO-WILCOX AQUIFER	583	161	0	19	25	38	826
1996	GREGG	CARRIZO-WILCOX AQUIFER	603	161	0	64	25	38	891
1997	GREGG	CARRIZO-WILCOX AQUIFER	552	162	0	113	25	40	892
1998	GREGG	CARRIZO-WILCOX AQUIFER	502	24	0	1	25	36	588
1999	GREGG	CARRIZO-WILCOX AQUIFER	563	24	0	101	25	44	757
2000	GREGG	CARRIZO-WILCOX AQUIFER	1,189	0	0	42	0	42	1,273
2001	GREGG	CARRIZO-WILCOX AQUIFER	1,158	0	0	258	0	36	1,452
2002	GREGG	CARRIZO-WILCOX AQUIFER	1,170	0	0	25	0	31	1,226
2003	GREGG	CARRIZO-WILCOX AQUIFER	1,242	0	0	267	0	24	1,533
2004	GREGG	CARRIZO-WILCOX AQUIFER	1,268	1	0	194	0	47	1,510
2005	GREGG	CARRIZO-WILCOX AQUIFER	3,567	0	0	242	7	23	3,839
2006	GREGG	CARRIZO-WILCOX AQUIFER	3,240	0	0	242	19	19	3,520
2007	GREGG	CARRIZO-WILCOX AQUIFER	1,648	0	0	242	0	23	1,913
2008	GREGG	CARRIZO-WILCOX AQUIFER	1,787	0	0	243	0	11	2,041
2009	GREGG	CARRIZO-WILCOX AQUIFER	1,855	3	0	242	0	12	2,112
2010	GREGG	CARRIZO-WILCOX AQUIFER	3,114	3	0	242	0	14	3,373
2011	GREGG	CARRIZO-WILCOX AQUIFER	2,448	3	0	242	13	15	2,721
2012	GREGG	CARRIZO-WILCOX AQUIFER	1,788	2	0	243	3	11	2,047
2006	GREGG	OTHER AQUIFER	22	0	0	0	0	0	22
2007	GREGG	OTHER AQUIFER	18	0	0	0	0	0	18
2008	GREGG	OTHER AQUIFER	20	0	0	0	0	0	20
2009	GREGG	OTHER AQUIFER	63	0	0	0	0	0	63
2010	GREGG	OTHER AQUIFER	106	0	0	0	0	0	106
2011	GREGG	OTHER AQUIFER	83	0	0	0	0	0	83
2012	GREGG	OTHER AQUIFER	83	0	0	0	0	0	83
1980	GREGG	QUEEN CITY AQUIFER	340	28	153	0	0	62	583
1984	GREGG	QUEEN CITY AQUIFER	258	0	1,312	0	0	57	1,627
1985	GREGG	QUEEN CITY AQUIFER	221	0	0	0	0	46	267
1986	GREGG	QUEEN CITY AQUIFER	208	0	90	0	0	46	344
1987	GREGG	QUEEN CITY AQUIFER	168	0	0	0	0	42	210
1989	GREGG	QUEEN CITY AQUIFER	192	0	0	0	0	53	245
1990	GREGG	QUEEN CITY AQUIFER	203	0	0	0	0	52	255
1991	GREGG	QUEEN CITY AQUIFER	211	0	0	0	0	53	264
1992	GREGG	QUEEN CITY AQUIFER	317	0	0	0	0	60	377
1993	GREGG	QUEEN CITY AQUIFER	275	0	0	0	0	56	331
1994	GREGG	QUEEN CITY AQUIFER	283	0	0	0	0	49	332
1995	GREGG	QUEEN CITY AQUIFER	518	0	0	0	0	49	567
1996	GREGG	QUEEN CITY AQUIFER	526	0	0	0	0	49	575
1997	GREGG	QUEEN CITY AQUIFER	532	0	0	0	0	52	584
1998	GREGG	QUEEN CITY AQUIFER	484	0	0	0	0	47	531
1999	GREGG	QUEEN CITY AQUIFER	542	0	0	0	0	57	599
2000	GREGG	QUEEN CITY AQUIFER	31	0	0	0	0	53	84
2001	GREGG	QUEEN CITY AQUIFER	31	0	0	0	0	38	69
2002	GREGG	QUEEN CITY AQUIFER	32	0	0	0	0	32	64
2003	GREGG	QUEEN CITY AQUIFER	32	0	0	0	0	24	56

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2004	GREGG	QUEEN CITY AQUIFER	31	0	0	0	0	1	32
2005	GREGG	QUEEN CITY AQUIFER	33	0	0	0	2	0	35
2006	GREGG	QUEEN CITY AQUIFER	36	0	0	0	5	0	41
2007	GREGG	QUEEN CITY AQUIFER	29	0	0	0	0	0	29
2008	GREGG	QUEEN CITY AQUIFER	33	0	0	0	0	9	42
2009	GREGG	QUEEN CITY AQUIFER	102	0	0	0	0	10	112
2010	GREGG	QUEEN CITY AQUIFER	174	0	0	0	0	12	186
2011	GREGG	QUEEN CITY AQUIFER	136	0	0	0	3	12	151
2012	GREGG	QUEEN CITY AQUIFER	136	0	0	0	1	8	145
2008	GREGG	UNKNOWN	0	0	104	0	0	0	104
2009	GREGG	UNKNOWN	0	0	106	0	0	0	106
2010	GREGG	UNKNOWN	0	0	107	0	0	0	107
2011	GREGG	UNKNOWN	0	0	31	0	0	0	31
2012	GREGG	UNKNOWN	0	0	32	0	0	0	32
1980	HARRISON	CARRIZO-WILCOX AQUIFER	2,398	72	468	0	0	191	3,129
1984	HARRISON	CARRIZO-WILCOX AQUIFER	2,577	116	330	0	20	289	3,332
1985	HARRISON	CARRIZO-WILCOX AQUIFER	2,558	136	261	0	95	236	3,286
1986	HARRISON	CARRIZO-WILCOX AQUIFER	2,624	144	248	0	95	59	3,170
1987	HARRISON	CARRIZO-WILCOX AQUIFER	2,696	125	211	0	95	257	3,384
1988	HARRISON	CARRIZO-WILCOX AQUIFER	2,753	131	182	0	95	69	3,230
1989	HARRISON	CARRIZO-WILCOX AQUIFER	2,427	122	181	0	32	71	2,833
1990	HARRISON	CARRIZO-WILCOX AQUIFER	2,505	102	195	0	50	71	2,923
1991	HARRISON	CARRIZO-WILCOX AQUIFER	2,529	110	195	0	50	73	2,957
1992	HARRISON	CARRIZO-WILCOX AQUIFER	2,519	57	167	0	50	56	2,849
1993	HARRISON	CARRIZO-WILCOX AQUIFER	2,471	155	198	0	39	57	2,920
1994	HARRISON	CARRIZO-WILCOX AQUIFER	2,614	142	196	0	34	59	3,045
1995	HARRISON	CARRIZO-WILCOX AQUIFER	2,661	104	207	0	34	60	3,066
1996	HARRISON	CARRIZO-WILCOX AQUIFER	2,571	102	207	0	39	53	2,972
1997	HARRISON	CARRIZO-WILCOX AQUIFER	2,558	110	208	0	39	59	2,974
1998	HARRISON	CARRIZO-WILCOX AQUIFER	2,702	123	197	0	34	66	3,122
1999	HARRISON	CARRIZO-WILCOX AQUIFER	2,534	123	197	0	34	72	2,960
2000	HARRISON	CARRIZO-WILCOX AQUIFER	3,852	173	3	0	39	65	4,132
2001	HARRISON	CARRIZO-WILCOX AQUIFER	3,657	211	3	0	37	35	3,943
2002	HARRISON	CARRIZO-WILCOX AQUIFER	3,913	179	6	0	42	32	4,172
2003	HARRISON	CARRIZO-WILCOX AQUIFER	3,763	169	4	0	29	30	3,995
2004	HARRISON	CARRIZO-WILCOX AQUIFER	3,697	130	4	0	125	40	3,996
2005	HARRISON	CARRIZO-WILCOX AQUIFER	4,005	151	5	0	112	77	4,350
2006	HARRISON	CARRIZO-WILCOX AQUIFER	4,224	239	3	0	95	65	4,626
2007	HARRISON	CARRIZO-WILCOX AQUIFER	3,451	251	3	0	124	66	3,895
2008	HARRISON	CARRIZO-WILCOX AQUIFER	3,575	219	3	0	0	55	3,852
2009	HARRISON	CARRIZO-WILCOX AQUIFER	3,464	8,735	4	0	708	62	12,973
2010	HARRISON	CARRIZO-WILCOX AQUIFER	3,712	111	4	0	626	50	4,503
2011	HARRISON	CARRIZO-WILCOX AQUIFER	4,090	145	5	0	642	50	4,932
2012	HARRISON	CARRIZO-WILCOX AQUIFER	3,918	146	4	0	411	43	4,522
2006	HARRISON	OTHER AQUIFER	32	0	0	0	0	0	32
2007	HARRISON	OTHER AQUIFER	27	0	0	0	0	0	27
2008	HARRISON	OTHER AQUIFER	30	0	0	0	0	0	30
2009	HARRISON	OTHER AQUIFER	27	0	0	0	0	0	27
2010	HARRISON	OTHER AQUIFER	25	0	0	0	0	0	25
2011	HARRISON	OTHER AQUIFER	27	0	0	0	0	0	27
2012	HARRISON	OTHER AQUIFER	26	0	0	0	0	0	26
1980	HARRISON	QUEEN CITY AQUIFER	345	8	309	0	0	133	795
1984	HARRISON	QUEEN CITY AQUIFER	375	0	48	0	0	115	538
1985	HARRISON	QUEEN CITY AQUIFER	334	0	0	0	0	95	429
1986	HARRISON	QUEEN CITY AQUIFER	346	0	0	0	0	23	369
1987	HARRISON	QUEEN CITY AQUIFER	376	0	0	0	0	102	478
1988	HARRISON	QUEEN CITY AQUIFER	344	0	0	0	0	28	372
1989	HARRISON	QUEEN CITY AQUIFER	265	0	0	0	0	28	293
1990	HARRISON	QUEEN CITY AQUIFER	296	0	0	0	0	28	324
1991	HARRISON	QUEEN CITY AQUIFER	326	0	0	0	0	28	354
1992	HARRISON	QUEEN CITY AQUIFER	333	0	0	0	0	21	354
1993	HARRISON	QUEEN CITY AQUIFER	321	0	0	0	0	21	342
1994	HARRISON	QUEEN CITY AQUIFER	317	0	0	0	0	21	338
1995	HARRISON	QUEEN CITY AQUIFER	272	0	0	0	0	21	293
1996	HARRISON	QUEEN CITY AQUIFER	218	0	0	0	0	18	236
1997	HARRISON	QUEEN CITY AQUIFER	170	0	0	0	0	20	190
1998	HARRISON	QUEEN CITY AQUIFER	179	0	0	0	0	23	202
1999	HARRISON	QUEEN CITY AQUIFER	169	0	0	0	0	24	193
2000	HARRISON	QUEEN CITY AQUIFER	105	0	0	0	0	22	127
2001	HARRISON	QUEEN CITY AQUIFER	103	0	0	0	0	13	116
2002	HARRISON	QUEEN CITY AQUIFER	90	0	0	0	0	11	101
2003	HARRISON	QUEEN CITY AQUIFER	108	0	0	0	0	11	119
2004	HARRISON	QUEEN CITY AQUIFER	104	0	0	0	0	0	104
2005	HARRISON	QUEEN CITY AQUIFER	112	0	0	0	0	0	112
2006	HARRISON	QUEEN CITY AQUIFER	146	0	0	0	0	0	146
2007	HARRISON	QUEEN CITY AQUIFER	121	0	0	0	0	0	121
2008	HARRISON	QUEEN CITY AQUIFER	135	0	0	0	0	0	135
2009	HARRISON	QUEEN CITY AQUIFER	122	0	0	0	0	0	122

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2010	HARRISON	QUEEN CITY AQUIFER	111	0	0	0	0	0	111
2011	HARRISON	QUEEN CITY AQUIFER	124	0	0	0	0	0	124
2012	HARRISON	QUEEN CITY AQUIFER	116	0	0	0	0	0	116
2008	HARRISON	UNKNOWN	0	0	707	0	0	0	707
2009	HARRISON	UNKNOWN	0	0	801	0	0	0	801
2010	HARRISON	UNKNOWN	0	0	894	0	0	0	894
2011	HARRISON	UNKNOWN	0	0	624	0	0	0	624
2012	HARRISON	UNKNOWN	0	0	490	0	0	0	490
1980	HENDERSON	CARRIZO-WILCOX AQUIFER	2,658	0	304	0	100	386	3,448
1984	HENDERSON	CARRIZO-WILCOX AQUIFER	3,677	0	925	0	20	470	5,092
1985	HENDERSON	CARRIZO-WILCOX AQUIFER	3,708	0	906	0	70	462	5,146
1986	HENDERSON	CARRIZO-WILCOX AQUIFER	3,444	0	819	8	70	632	4,973
1987	HENDERSON	CARRIZO-WILCOX AQUIFER	3,691	0	411	1	70	379	4,552
1988	HENDERSON	CARRIZO-WILCOX AQUIFER	3,874	0	456	0	70	594	4,994
1989	HENDERSON	CARRIZO-WILCOX AQUIFER	3,704	0	102	0	20	607	4,433
1990	HENDERSON	CARRIZO-WILCOX AQUIFER	3,104	0	199	0	21	613	3,937
1991	HENDERSON	CARRIZO-WILCOX AQUIFER	2,944	0	200	1	21	625	3,791
1992	HENDERSON	CARRIZO-WILCOX AQUIFER	2,930	0	374	0	21	473	3,798
1993	HENDERSON	CARRIZO-WILCOX AQUIFER	3,329	0	374	1	20	451	4,175
1994	HENDERSON	CARRIZO-WILCOX AQUIFER	3,451	0	387	1	20	464	4,323
1995	HENDERSON	CARRIZO-WILCOX AQUIFER	3,629	0	475	0	20	459	4,583
1996	HENDERSON	CARRIZO-WILCOX AQUIFER	3,643	0	475	0	20	563	4,701
1997	HENDERSON	CARRIZO-WILCOX AQUIFER	3,447	1	492	0	20	434	4,394
1998	HENDERSON	CARRIZO-WILCOX AQUIFER	3,771	0	153	0	20	499	4,443
1999	HENDERSON	CARRIZO-WILCOX AQUIFER	3,767	0	474	0	20	490	4,751
2000	HENDERSON	CARRIZO-WILCOX AQUIFER	5,081	0	2	0	0	485	5,568
2001	HENDERSON	CARRIZO-WILCOX AQUIFER	4,953	0	0	0	0	294	5,247
2002	HENDERSON	CARRIZO-WILCOX AQUIFER	4,934	0	2	0	2	80	5,018
2003	HENDERSON	CARRIZO-WILCOX AQUIFER	4,601	0	2	0	22	242	4,867
2004	HENDERSON	CARRIZO-WILCOX AQUIFER	4,639	0	2	0	38	266	4,945
2005	HENDERSON	CARRIZO-WILCOX AQUIFER	5,066	187	2	0	40	327	5,622
2006	HENDERSON	CARRIZO-WILCOX AQUIFER	4,883	180	2	0	116	311	5,492
2007	HENDERSON	CARRIZO-WILCOX AQUIFER	4,607	169	2	0	136	313	5,227
2008	HENDERSON	CARRIZO-WILCOX AQUIFER	4,865	124	2	0	151	381	5,523
2009	HENDERSON	CARRIZO-WILCOX AQUIFER	5,392	124	2	0	0	192	5,710
2010	HENDERSON	CARRIZO-WILCOX AQUIFER	5,688	122	2	0	80	299	6,191
2011	HENDERSON	CARRIZO-WILCOX AQUIFER	6,255	122	2	0	30	299	6,708
2012	HENDERSON	CARRIZO-WILCOX AQUIFER	5,738	122	2	0	109	247	6,218
2006	HENDERSON	NACATOCH AQUIFER	7	0	0	0	0	0	7
2007	HENDERSON	NACATOCH AQUIFER	6	0	0	0	0	0	6
2008	HENDERSON	NACATOCH AQUIFER	6	0	0	0	0	0	6
2009	HENDERSON	NACATOCH AQUIFER	9	0	0	0	0	0	9
2010	HENDERSON	NACATOCH AQUIFER	13	0	0	0	0	0	13
2011	HENDERSON	NACATOCH AQUIFER	14	0	0	0	0	0	14
2012	HENDERSON	NACATOCH AQUIFER	12	0	0	0	0	0	12
1980	HENDERSON	OTHER AQUIFER	29	0	0	147	0	88	264
1984	HENDERSON	OTHER AQUIFER	37	0	0	104	0	107	248
1985	HENDERSON	OTHER AQUIFER	36	0	0	117	0	105	258
1986	HENDERSON	OTHER AQUIFER	30	0	0	113	0	144	287
1987	HENDERSON	OTHER AQUIFER	34	0	0	85	0	87	206
1988	HENDERSON	OTHER AQUIFER	38	0	0	16	0	136	190
1989	HENDERSON	OTHER AQUIFER	44	0	0	0	0	139	183
1990	HENDERSON	OTHER AQUIFER	40	0	0	0	0	140	180
1991	HENDERSON	OTHER AQUIFER	48	0	0	0	0	143	191
1992	HENDERSON	OTHER AQUIFER	23	0	0	0	0	108	131
1993	HENDERSON	OTHER AQUIFER	26	0	0	0	0	103	129
1994	HENDERSON	OTHER AQUIFER	25	0	0	0	0	106	131
1995	HENDERSON	OTHER AQUIFER	27	0	0	0	0	105	132
1996	HENDERSON	OTHER AQUIFER	33	0	0	0	0	129	162
1997	HENDERSON	OTHER AQUIFER	32	0	0	0	0	100	132
1998	HENDERSON	OTHER AQUIFER	35	0	0	0	0	115	150
1999	HENDERSON	OTHER AQUIFER	35	0	0	0	0	113	148
2000	HENDERSON	OTHER AQUIFER	46	0	0	0	0	111	157
2001	HENDERSON	OTHER AQUIFER	34	0	0	0	0	71	105
2002	HENDERSON	OTHER AQUIFER	35	0	0	0	0	20	55
2003	HENDERSON	OTHER AQUIFER	32	0	0	0	0	59	91
2004	HENDERSON	OTHER AQUIFER	32	0	0	0	0	61	93
2005	HENDERSON	OTHER AQUIFER	45	0	0	0	0	75	120
2006	HENDERSON	OTHER AQUIFER	264	0	0	0	0	72	336
2007	HENDERSON	OTHER AQUIFER	204	0	0	0	0	72	276
2008	HENDERSON	OTHER AQUIFER	233	0	0	0	0	104	337
2009	HENDERSON	OTHER AQUIFER	321	0	0	0	0	24	345
2010	HENDERSON	OTHER AQUIFER	391	0	0	0	0	65	456
2011	HENDERSON	OTHER AQUIFER	431	0	0	0	0	65	496
2012	HENDERSON	OTHER AQUIFER	384	0	0	0	0	54	438
1980	HENDERSON	QUEEN CITY AQUIFER	268	0	0	0	0	265	533
1984	HENDERSON	QUEEN CITY AQUIFER	172	0	0	0	0	323	495
1985	HENDERSON	QUEEN CITY AQUIFER	164	0	0	0	0	318	482

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1986	HENDERSON	QUEEN CITY AQUIFER	158	0	0	0	0	435	593
1987	HENDERSON	QUEEN CITY AQUIFER	154	0	0	0	0	262	416
1988	HENDERSON	QUEEN CITY AQUIFER	154	0	0	0	0	410	564
1989	HENDERSON	QUEEN CITY AQUIFER	178	0	0	0	0	420	598
1990	HENDERSON	QUEEN CITY AQUIFER	465	0	0	0	0	424	889
1991	HENDERSON	QUEEN CITY AQUIFER	512	0	0	0	0	431	943
1992	HENDERSON	QUEEN CITY AQUIFER	540	0	0	0	0	327	867
1993	HENDERSON	QUEEN CITY AQUIFER	635	0	0	0	0	311	946
1994	HENDERSON	QUEEN CITY AQUIFER	539	0	0	0	0	321	860
1995	HENDERSON	QUEEN CITY AQUIFER	452	0	0	0	0	318	770
1996	HENDERSON	QUEEN CITY AQUIFER	474	0	0	0	0	391	865
1997	HENDERSON	QUEEN CITY AQUIFER	611	0	0	0	0	301	912
1998	HENDERSON	QUEEN CITY AQUIFER	668	0	0	0	0	347	1,015
1999	HENDERSON	QUEEN CITY AQUIFER	668	0	0	0	0	340	1,008
2000	HENDERSON	QUEEN CITY AQUIFER	264	0	0	0	0	335	599
2001	HENDERSON	QUEEN CITY AQUIFER	264	0	0	0	0	153	417
2002	HENDERSON	QUEEN CITY AQUIFER	259	0	0	0	0	42	301
2003	HENDERSON	QUEEN CITY AQUIFER	328	0	0	0	1	126	455
2004	HENDERSON	QUEEN CITY AQUIFER	330	0	0	0	1	104	435
2005	HENDERSON	QUEEN CITY AQUIFER	345	0	0	0	1	128	474
2006	HENDERSON	QUEEN CITY AQUIFER	387	0	0	0	3	122	512
2007	HENDERSON	QUEEN CITY AQUIFER	336	0	0	0	3	122	461
2008	HENDERSON	QUEEN CITY AQUIFER	368	0	0	0	4	17	389
2009	HENDERSON	QUEEN CITY AQUIFER	451	0	0	0	150	240	841
2010	HENDERSON	QUEEN CITY AQUIFER	354	0	0	0	53	147	554
2011	HENDERSON	QUEEN CITY AQUIFER	528	0	0	0	20	149	697
2012	HENDERSON	QUEEN CITY AQUIFER	450	0	0	0	72	123	645
2008	HENDERSON	UNKNOWN	0	0	45	0	0	0	45
2009	HENDERSON	UNKNOWN	0	0	56	0	0	0	56
2010	HENDERSON	UNKNOWN	0	0	66	0	0	0	66
2011	HENDERSON	UNKNOWN	0	0	52	0	0	0	52
1980	HOPKINS	CARRIZO-WILCOX AQUIFER	583	0	73	0	0	1,496	2,152
1984	HOPKINS	CARRIZO-WILCOX AQUIFER	908	0	0	0	0	1,670	2,578
1985	HOPKINS	CARRIZO-WILCOX AQUIFER	1,023	0	67	0	0	1,666	2,756
1986	HOPKINS	CARRIZO-WILCOX AQUIFER	1,016	0	138	0	0	1,485	2,639
1987	HOPKINS	CARRIZO-WILCOX AQUIFER	1,072	0	127	0	0	1,517	2,716
1988	HOPKINS	CARRIZO-WILCOX AQUIFER	1,052	0	133	0	0	1,246	2,431
1989	HOPKINS	CARRIZO-WILCOX AQUIFER	1,038	0	187	0	0	1,322	2,547
1990	HOPKINS	CARRIZO-WILCOX AQUIFER	962	0	120	0	0	2,253	3,335
1991	HOPKINS	CARRIZO-WILCOX AQUIFER	909	0	147	0	0	2,297	3,353
1992	HOPKINS	CARRIZO-WILCOX AQUIFER	1,128	0	143	0	0	2,670	3,941
1993	HOPKINS	CARRIZO-WILCOX AQUIFER	1,494	0	144	0	0	2,569	4,207
1994	HOPKINS	CARRIZO-WILCOX AQUIFER	1,579	0	145	0	0	2,800	4,524
1995	HOPKINS	CARRIZO-WILCOX AQUIFER	1,729	0	145	0	0	2,605	4,479
1996	HOPKINS	CARRIZO-WILCOX AQUIFER	1,692	0	145	0	0	2,536	4,373
1997	HOPKINS	CARRIZO-WILCOX AQUIFER	1,609	0	143	0	0	2,417	4,169
1998	HOPKINS	CARRIZO-WILCOX AQUIFER	1,792	0	78	0	0	1,873	3,743
1999	HOPKINS	CARRIZO-WILCOX AQUIFER	1,604	0	78	0	0	1,849	3,531
2000	HOPKINS	CARRIZO-WILCOX AQUIFER	1,619	0	67	0	0	1,825	3,511
2001	HOPKINS	CARRIZO-WILCOX AQUIFER	1,601	0	67	0	0	1,009	2,677
2002	HOPKINS	CARRIZO-WILCOX AQUIFER	1,873	0	67	0	0	997	2,937
2003	HOPKINS	CARRIZO-WILCOX AQUIFER	1,897	0	67	0	0	995	2,959
2004	HOPKINS	CARRIZO-WILCOX AQUIFER	1,859	0	67	0	0	810	2,736
2005	HOPKINS	CARRIZO-WILCOX AQUIFER	1,605	0	67	0	0	1,849	3,521
2006	HOPKINS	CARRIZO-WILCOX AQUIFER	1,745	0	67	0	241	1,960	4,013
2007	HOPKINS	CARRIZO-WILCOX AQUIFER	1,564	0	17	0	201	1,509	3,291
2008	HOPKINS	CARRIZO-WILCOX AQUIFER	1,493	0	0	0	16	1,636	3,145
2009	HOPKINS	CARRIZO-WILCOX AQUIFER	1,579	0	0	0	210	1,544	3,333
2010	HOPKINS	CARRIZO-WILCOX AQUIFER	1,412	0	0	0	2,317	1,469	5,198
2011	HOPKINS	CARRIZO-WILCOX AQUIFER	1,776	0	0	0	315	1,487	3,578
2012	HOPKINS	CARRIZO-WILCOX AQUIFER	1,652	0	0	0	880	1,462	3,994
1980	HOPKINS	NACATOCH AQUIFER	276	0	0	0	0	175	451
1984	HOPKINS	NACATOCH AQUIFER	230	0	0	0	0	196	426
1985	HOPKINS	NACATOCH AQUIFER	213	0	0	0	0	106	319
1986	HOPKINS	NACATOCH AQUIFER	247	0	0	0	0	95	342
1987	HOPKINS	NACATOCH AQUIFER	264	0	0	0	0	97	361
1988	HOPKINS	NACATOCH AQUIFER	295	0	0	0	0	79	374
1989	HOPKINS	NACATOCH AQUIFER	263	0	0	0	0	84	347
1990	HOPKINS	NACATOCH AQUIFER	326	0	0	0	0	143	469
1991	HOPKINS	NACATOCH AQUIFER	338	0	0	0	0	146	484
1992	HOPKINS	NACATOCH AQUIFER	334	0	0	0	0	170	504
1993	HOPKINS	NACATOCH AQUIFER	365	0	0	0	0	164	529
1994	HOPKINS	NACATOCH AQUIFER	402	0	0	0	0	179	581
1995	HOPKINS	NACATOCH AQUIFER	444	0	0	0	0	166	610
1996	HOPKINS	NACATOCH AQUIFER	438	0	0	0	0	162	600
1997	HOPKINS	NACATOCH AQUIFER	354	0	0	0	0	155	509
1998	HOPKINS	NACATOCH AQUIFER	394	0	0	0	0	120	514
1999	HOPKINS	NACATOCH AQUIFER	353	0	0	0	0	119	472

Groundwater Pumping Estimates from Texas Water Development Board
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2000	HOPKINS	NACATOCH AQUIFER	350	0	0	0	0	117	467
2001	HOPKINS	NACATOCH AQUIFER	353	0	0	0	0	35	388
2002	HOPKINS	NACATOCH AQUIFER	354	0	0	0	0	35	389
2003	HOPKINS	NACATOCH AQUIFER	356	0	0	0	0	34	390
2004	HOPKINS	NACATOCH AQUIFER	359	0	0	0	0	131	490
2005	HOPKINS	NACATOCH AQUIFER	415	0	0	0	0	299	714
2006	HOPKINS	NACATOCH AQUIFER	480	0	0	0	0	316	796
2007	HOPKINS	NACATOCH AQUIFER	405	0	0	0	0	243	648
2008	HOPKINS	NACATOCH AQUIFER	414	0	0	0	0	635	1,049
2009	HOPKINS	NACATOCH AQUIFER	459	0	0	0	0	600	1,059
2010	HOPKINS	NACATOCH AQUIFER	494	0	0	0	0	521	1,015
2011	HOPKINS	NACATOCH AQUIFER	509	0	0	0	0	532	1,041
2012	HOPKINS	NACATOCH AQUIFER	590	0	0	0	0	523	1,113
1980	HOPKINS	OTHER AQUIFER	31	0	0	0	0	0	31
1984	HOPKINS	OTHER AQUIFER	87	0	0	0	0	0	87
1985	HOPKINS	OTHER AQUIFER	44	0	0	0	0	0	44
1986	HOPKINS	OTHER AQUIFER	100	0	0	0	0	0	100
1987	HOPKINS	OTHER AQUIFER	110	0	0	0	0	0	110
1988	HOPKINS	OTHER AQUIFER	98	0	0	0	0	0	98
1989	HOPKINS	OTHER AQUIFER	107	0	0	0	0	0	107
1990	HOPKINS	OTHER AQUIFER	106	0	0	0	0	0	106
1991	HOPKINS	OTHER AQUIFER	107	0	0	0	0	0	107
1992	HOPKINS	OTHER AQUIFER	107	0	0	0	0	0	107
1993	HOPKINS	OTHER AQUIFER	79	0	0	0	0	0	79
1994	HOPKINS	OTHER AQUIFER	84	0	0	0	0	0	84
1995	HOPKINS	OTHER AQUIFER	92	0	0	0	0	0	92
1996	HOPKINS	OTHER AQUIFER	94	0	0	0	0	0	94
1997	HOPKINS	OTHER AQUIFER	92	0	0	0	0	0	92
1998	HOPKINS	OTHER AQUIFER	102	0	0	0	0	0	102
1999	HOPKINS	OTHER AQUIFER	92	0	0	0	0	0	92
2000	HOPKINS	OTHER AQUIFER	15	0	0	0	0	0	15
2001	HOPKINS	OTHER AQUIFER	11	0	0	0	0	0	11
2002	HOPKINS	OTHER AQUIFER	12	0	0	0	0	0	12
2003	HOPKINS	OTHER AQUIFER	11	0	0	0	0	0	11
2004	HOPKINS	OTHER AQUIFER	11	0	0	0	0	0	11
2005	HOPKINS	OTHER AQUIFER	12	0	0	0	0	0	12
2008	HOPKINS	UNKNOWN	0	0	747	0	0	0	747
2009	HOPKINS	UNKNOWN	0	0	745	0	0	0	745
2010	HOPKINS	UNKNOWN	0	0	742	0	0	0	742
2011	HOPKINS	UNKNOWN	0	0	754	0	0	0	754
1980	HOUSTON	CARRIZO-WILCOX AQUIFER	641	0	0	0	0	45	686
1984	HOUSTON	CARRIZO-WILCOX AQUIFER	586	0	0	0	0	70	656
1985	HOUSTON	CARRIZO-WILCOX AQUIFER	633	0	0	0	0	72	705
1986	HOUSTON	CARRIZO-WILCOX AQUIFER	577	0	0	0	0	53	630
1987	HOUSTON	CARRIZO-WILCOX AQUIFER	702	0	0	0	1	61	764
1988	HOUSTON	CARRIZO-WILCOX AQUIFER	722	0	0	0	0	65	787
1989	HOUSTON	CARRIZO-WILCOX AQUIFER	566	0	0	0	0	66	632
1990	HOUSTON	CARRIZO-WILCOX AQUIFER	390	0	0	0	0	67	457
1991	HOUSTON	CARRIZO-WILCOX AQUIFER	196	0	0	0	0	68	264
1992	HOUSTON	CARRIZO-WILCOX AQUIFER	195	0	0	0	0	67	262
1993	HOUSTON	CARRIZO-WILCOX AQUIFER	340	0	0	0	0	64	404
1994	HOUSTON	CARRIZO-WILCOX AQUIFER	803	0	0	0	35	69	907
1995	HOUSTON	CARRIZO-WILCOX AQUIFER	856	0	0	0	30	62	948
1996	HOUSTON	CARRIZO-WILCOX AQUIFER	917	0	0	0	41	62	1,020
1997	HOUSTON	CARRIZO-WILCOX AQUIFER	897	0	0	0	41	54	992
1998	HOUSTON	CARRIZO-WILCOX AQUIFER	911	0	0	0	41	61	1,013
1999	HOUSTON	CARRIZO-WILCOX AQUIFER	965	0	0	0	41	64	1,070
2000	HOUSTON	CARRIZO-WILCOX AQUIFER	948	0	0	0	115	65	1,128
2001	HOUSTON	CARRIZO-WILCOX AQUIFER	1,072	0	0	0	85	40	1,197
2002	HOUSTON	CARRIZO-WILCOX AQUIFER	1,050	0	0	0	151	39	1,240
2003	HOUSTON	CARRIZO-WILCOX AQUIFER	1,250	0	0	0	54	38	1,342
2004	HOUSTON	CARRIZO-WILCOX AQUIFER	1,059	0	0	0	114	67	1,240
2005	HOUSTON	CARRIZO-WILCOX AQUIFER	1,092	0	0	0	165	31	1,288
2006	HOUSTON	CARRIZO-WILCOX AQUIFER	854	0	0	0	205	26	1,085
2007	HOUSTON	CARRIZO-WILCOX AQUIFER	1,171	0	0	0	269	23	1,463
2008	HOUSTON	CARRIZO-WILCOX AQUIFER	1,766	0	0	0	66	30	1,862
2009	HOUSTON	CARRIZO-WILCOX AQUIFER	1,624	0	0	0	89	30	1,743
2010	HOUSTON	CARRIZO-WILCOX AQUIFER	1,659	0	0	0	48	28	1,735
2011	HOUSTON	CARRIZO-WILCOX AQUIFER	2,229	0	0	0	30	29	2,288
2012	HOUSTON	CARRIZO-WILCOX AQUIFER	1,963	0	0	0	246	18	2,227
1980	HOUSTON	OTHER AQUIFER	909	0	0	0	0	202	1,111
1984	HOUSTON	OTHER AQUIFER	1,490	10	78	0	0	274	1,852
1985	HOUSTON	OTHER AQUIFER	1,399	5	125	0	0	278	1,807
1986	HOUSTON	OTHER AQUIFER	1,433	5	119	0	1	207	1,765
1987	HOUSTON	OTHER AQUIFER	1,256	0	108	0	0	237	1,601
1988	HOUSTON	OTHER AQUIFER	1,046	0	111	0	1	250	1,408
1989	HOUSTON	OTHER AQUIFER	1,112	0	103	0	0	254	1,469
1990	HOUSTON	OTHER AQUIFER	1,256	0	103	0	0	259	1,618

Groundwater Pumping Estimates from Texas Water Development Board
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1991	HOUSTON	OTHER AQUIFER	1,241	0	143	0	0	265	1,649
1992	HOUSTON	OTHER AQUIFER	1,224	0	143	0	0	259	1,626
1993	HOUSTON	OTHER AQUIFER	1,022	0	140	0	0	246	1,408
1994	HOUSTON	OTHER AQUIFER	901	0	140	0	0	265	1,306
1995	HOUSTON	OTHER AQUIFER	943	0	140	0	0	239	1,322
1996	HOUSTON	OTHER AQUIFER	965	0	140	0	0	239	1,344
1997	HOUSTON	OTHER AQUIFER	981	0	140	0	0	210	1,331
1998	HOUSTON	OTHER AQUIFER	997	0	140	0	0	237	1,374
1999	HOUSTON	OTHER AQUIFER	1,055	0	140	0	0	249	1,444
2000	HOUSTON	OTHER AQUIFER	1,212	0	0	0	32	253	1,497
2001	HOUSTON	OTHER AQUIFER	1,297	0	0	0	24	146	1,467
2002	HOUSTON	OTHER AQUIFER	1,299	0	0	0	42	141	1,482
2003	HOUSTON	OTHER AQUIFER	1,303	0	0	0	15	142	1,460
2004	HOUSTON	OTHER AQUIFER	1,225	0	0	0	19	123	1,367
2005	HOUSTON	OTHER AQUIFER	1,216	0	0	0	28	56	1,300
2006	HOUSTON	OTHER AQUIFER	1,224	0	0	0	34	47	1,305
2007	HOUSTON	OTHER AQUIFER	1,234	0	0	0	45	43	1,322
2008	HOUSTON	OTHER AQUIFER	1,285	0	0	0	11	51	1,347
2009	HOUSTON	OTHER AQUIFER	1,268	0	0	0	15	51	1,334
2010	HOUSTON	OTHER AQUIFER	1,251	0	0	0	73	53	1,377
2011	HOUSTON	OTHER AQUIFER	208	0	0	0	45	56	309
2012	HOUSTON	OTHER AQUIFER	195	0	0	0	373	35	603
1980	HOUSTON	QUEEN CITY AQUIFER	131	0	0	0	0	112	243
1984	HOUSTON	QUEEN CITY AQUIFER	165	1	0	0	14	115	295
1985	HOUSTON	QUEEN CITY AQUIFER	167	1	0	0	12	117	297
1986	HOUSTON	QUEEN CITY AQUIFER	168	1	0	0	12	87	268
1987	HOUSTON	QUEEN CITY AQUIFER	166	0	0	0	12	100	278
1988	HOUSTON	QUEEN CITY AQUIFER	174	0	0	0	12	105	291
1989	HOUSTON	QUEEN CITY AQUIFER	165	0	0	0	12	107	284
1990	HOUSTON	QUEEN CITY AQUIFER	163	0	0	0	12	109	284
1991	HOUSTON	QUEEN CITY AQUIFER	158	0	0	0	12	112	282
1992	HOUSTON	QUEEN CITY AQUIFER	147	0	0	0	12	109	268
1993	HOUSTON	QUEEN CITY AQUIFER	142	0	0	0	101	104	347
1994	HOUSTON	QUEEN CITY AQUIFER	147	0	0	0	35	112	294
1995	HOUSTON	QUEEN CITY AQUIFER	145	0	0	0	30	101	276
1996	HOUSTON	QUEEN CITY AQUIFER	145	0	0	0	41	101	287
1997	HOUSTON	QUEEN CITY AQUIFER	135	0	0	0	41	89	265
1998	HOUSTON	QUEEN CITY AQUIFER	137	0	0	0	41	100	278
1999	HOUSTON	QUEEN CITY AQUIFER	145	0	0	0	41	105	291
2000	HOUSTON	QUEEN CITY AQUIFER	118	0	0	0	147	107	372
2001	HOUSTON	QUEEN CITY AQUIFER	126	0	0	0	109	49	284
2002	HOUSTON	QUEEN CITY AQUIFER	127	0	0	0	192	47	366
2003	HOUSTON	QUEEN CITY AQUIFER	133	0	0	0	68	48	249
2004	HOUSTON	QUEEN CITY AQUIFER	115	0	0	0	152	37	304
2005	HOUSTON	QUEEN CITY AQUIFER	115	0	0	0	221	17	353
2006	HOUSTON	QUEEN CITY AQUIFER	93	0	0	0	273	14	380
2007	HOUSTON	QUEEN CITY AQUIFER	94	0	0	0	359	13	466
2008	HOUSTON	QUEEN CITY AQUIFER	92	0	0	0	88	11	191
2009	HOUSTON	QUEEN CITY AQUIFER	122	0	0	0	119	11	252
2010	HOUSTON	QUEEN CITY AQUIFER	94	0	0	0	64	19	177
2011	HOUSTON	QUEEN CITY AQUIFER	98	0	0	0	40	20	158
2012	HOUSTON	QUEEN CITY AQUIFER	93	0	0	0	328	13	434
1980	HOUSTON	SPARTA AQUIFER	38	0	0	0	0	315	353
1984	HOUSTON	SPARTA AQUIFER	86	6	32	0	12	387	523
1985	HOUSTON	SPARTA AQUIFER	79	3	33	0	12	392	519
1986	HOUSTON	SPARTA AQUIFER	78	3	32	0	12	292	417
1987	HOUSTON	SPARTA AQUIFER	77	0	29	0	12	334	452
1988	HOUSTON	SPARTA AQUIFER	82	0	30	0	12	352	476
1989	HOUSTON	SPARTA AQUIFER	72	0	27	0	12	358	469
1990	HOUSTON	SPARTA AQUIFER	95	0	27	0	11	365	498
1991	HOUSTON	SPARTA AQUIFER	101	0	38	0	11	372	522
1992	HOUSTON	SPARTA AQUIFER	90	0	38	0	11	365	504
1993	HOUSTON	SPARTA AQUIFER	94	0	37	0	0	346	477
1994	HOUSTON	SPARTA AQUIFER	102	0	37	0	76	371	586
1995	HOUSTON	SPARTA AQUIFER	95	0	37	0	65	335	532
1996	HOUSTON	SPARTA AQUIFER	94	0	37	0	88	335	554
1997	HOUSTON	SPARTA AQUIFER	90	0	37	0	88	295	510
1998	HOUSTON	SPARTA AQUIFER	91	0	37	0	88	333	549
1999	HOUSTON	SPARTA AQUIFER	97	0	37	0	88	350	572
2000	HOUSTON	SPARTA AQUIFER	6	0	0	0	314	299	619
2001	HOUSTON	SPARTA AQUIFER	7	0	0	0	234	177	418
2002	HOUSTON	SPARTA AQUIFER	7	0	0	0	413	171	591
2003	HOUSTON	SPARTA AQUIFER	7	0	0	0	147	172	326
2004	HOUSTON	SPARTA AQUIFER	7	0	0	0	76	174	257
2005	HOUSTON	SPARTA AQUIFER	8	0	0	0	110	79	197
2006	HOUSTON	SPARTA AQUIFER	31	0	0	0	137	67	235
2007	HOUSTON	SPARTA AQUIFER	26	0	0	0	180	60	266
2008	HOUSTON	SPARTA AQUIFER	35	0	0	0	44	68	147

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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2009	HOUSTON	SPARTA AQUIFER	116	0	0	0	59	68	243
2010	HOUSTON	SPARTA AQUIFER	324	0	0	0	32	78	434
2011	HOUSTON	SPARTA AQUIFER	1,357	0	0	0	20	81	1,458
2012	HOUSTON	SPARTA AQUIFER	1,282	0	0	0	164	52	1,498
2008	HOUSTON	UNKNOWN	0	0	7	0	0	0	7
2009	HOUSTON	UNKNOWN	0	0	10	0	0	0	10
2010	HOUSTON	UNKNOWN	0	0	13	0	0	0	13
2011	HOUSTON	UNKNOWN	0	0	120	0	0	0	120
2012	HOUSTON	UNKNOWN	0	0	66	0	0	0	66
2000	HOUSTON	YEGUA-JACKSON AQUIFER	0	0	0	0	0	56	56
2001	HOUSTON	YEGUA-JACKSON AQUIFER	0	0	0	0	0	19	19
2002	HOUSTON	YEGUA-JACKSON AQUIFER	0	0	0	0	0	18	18
2003	HOUSTON	YEGUA-JACKSON AQUIFER	0	0	0	0	0	18	18
2004	HOUSTON	YEGUA-JACKSON AQUIFER	0	0	0	0	0	18	18
2005	HOUSTON	YEGUA-JACKSON AQUIFER	0	0	0	0	0	8	8
2006	HOUSTON	YEGUA-JACKSON AQUIFER	43	0	0	0	0	7	50
2007	HOUSTON	YEGUA-JACKSON AQUIFER	36	0	0	0	0	6	42
2008	HOUSTON	YEGUA-JACKSON AQUIFER	40	0	0	0	0	0	40
2009	HOUSTON	YEGUA-JACKSON AQUIFER	160	0	0	0	0	0	160
2010	HOUSTON	YEGUA-JACKSON AQUIFER	500	0	0	0	0	12	512
2011	HOUSTON	YEGUA-JACKSON AQUIFER	546	0	0	0	0	13	559
2012	HOUSTON	YEGUA-JACKSON AQUIFER	462	0	0	0	0	8	470
1980	MARION	CARRIZO-WILCOX AQUIFER	527	9	7	0	0	22	565
1984	MARION	CARRIZO-WILCOX AQUIFER	520	14	0	0	0	31	565
1985	MARION	CARRIZO-WILCOX AQUIFER	547	25	69	0	0	24	665
1986	MARION	CARRIZO-WILCOX AQUIFER	499	25	65	0	0	19	608
1987	MARION	CARRIZO-WILCOX AQUIFER	494	18	61	0	0	21	594
1988	MARION	CARRIZO-WILCOX AQUIFER	503	33	60	0	0	23	619
1989	MARION	CARRIZO-WILCOX AQUIFER	518	34	56	0	0	23	631
1990	MARION	CARRIZO-WILCOX AQUIFER	370	26	56	0	0	23	475
1991	MARION	CARRIZO-WILCOX AQUIFER	399	35	53	0	0	23	510
1992	MARION	CARRIZO-WILCOX AQUIFER	364	0	53	0	0	25	442
1993	MARION	CARRIZO-WILCOX AQUIFER	440	0	53	0	55	27	575
1994	MARION	CARRIZO-WILCOX AQUIFER	439	0	53	0	63	25	580
1995	MARION	CARRIZO-WILCOX AQUIFER	483	0	83	1	59	20	646
1996	MARION	CARRIZO-WILCOX AQUIFER	474	0	83	1	55	22	635
1997	MARION	CARRIZO-WILCOX AQUIFER	472	0	83	74	55	26	710
1998	MARION	CARRIZO-WILCOX AQUIFER	527	0	83	88	55	19	772
1999	MARION	CARRIZO-WILCOX AQUIFER	402	0	83	100	55	21	661
2000	MARION	CARRIZO-WILCOX AQUIFER	657	1	0	99	0	144	901
2001	MARION	CARRIZO-WILCOX AQUIFER	686	1	0	96	0	18	801
2002	MARION	CARRIZO-WILCOX AQUIFER	654	0	0	0	0	17	671
2003	MARION	CARRIZO-WILCOX AQUIFER	628	0	0	82	0	17	727
2004	MARION	CARRIZO-WILCOX AQUIFER	642	0	0	60	0	50	752
2005	MARION	CARRIZO-WILCOX AQUIFER	720	0	0	82	0	6	808
2006	MARION	CARRIZO-WILCOX AQUIFER	812	0	0	79	0	6	897
2007	MARION	CARRIZO-WILCOX AQUIFER	693	0	0	73	0	6	772
2008	MARION	CARRIZO-WILCOX AQUIFER	714	0	0	74	0	4	792
2009	MARION	CARRIZO-WILCOX AQUIFER	621	0	0	81	0	4	706
2010	MARION	CARRIZO-WILCOX AQUIFER	394	0	0	91	0	12	497
2011	MARION	CARRIZO-WILCOX AQUIFER	556	0	0	75	0	12	643
2012	MARION	CARRIZO-WILCOX AQUIFER	469	0	0	82	0	7	558
2006	MARION	OTHER AQUIFER	12	0	0	0	0	0	12
2007	MARION	OTHER AQUIFER	10	0	0	0	0	0	10
2008	MARION	OTHER AQUIFER	11	0	0	0	0	0	11
2009	MARION	OTHER AQUIFER	7	0	0	0	0	0	7
2010	MARION	OTHER AQUIFER	3	0	0	0	0	0	3
2011	MARION	OTHER AQUIFER	3	0	0	0	0	0	3
2012	MARION	OTHER AQUIFER	2	0	0	0	0	0	2
1980	MARION	QUEEN CITY AQUIFER	352	0	6	0	0	40	398
1984	MARION	QUEEN CITY AQUIFER	303	0	0	0	0	57	360
1985	MARION	QUEEN CITY AQUIFER	303	0	0	0	0	44	347
1986	MARION	QUEEN CITY AQUIFER	284	0	0	0	0	35	319
1987	MARION	QUEEN CITY AQUIFER	255	0	0	0	0	40	295
1988	MARION	QUEEN CITY AQUIFER	272	0	0	0	0	43	315
1989	MARION	QUEEN CITY AQUIFER	283	0	0	0	0	42	325
1990	MARION	QUEEN CITY AQUIFER	391	0	0	0	0	42	433
1991	MARION	QUEEN CITY AQUIFER	381	0	0	0	0	43	424
1992	MARION	QUEEN CITY AQUIFER	314	0	0	0	0	48	362
1993	MARION	QUEEN CITY AQUIFER	364	0	0	0	0	52	416
1994	MARION	QUEEN CITY AQUIFER	338	0	0	0	0	48	386
1995	MARION	QUEEN CITY AQUIFER	273	0	0	0	0	39	312
1996	MARION	QUEEN CITY AQUIFER	267	1	0	0	0	44	312
1997	MARION	QUEEN CITY AQUIFER	279	3	0	0	0	53	335
1998	MARION	QUEEN CITY AQUIFER	312	3	0	0	0	39	354
1999	MARION	QUEEN CITY AQUIFER	237	3	0	0	0	44	284
2000	MARION	QUEEN CITY AQUIFER	138	3	0	0	0	290	431
2001	MARION	QUEEN CITY AQUIFER	121	3	0	0	0	38	162

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2002	MARION	QUEEN CITY AQUIFER	122	0	0	0	0	34	156
2003	MARION	QUEEN CITY AQUIFER	133	0	0	0	0	34	167
2004	MARION	QUEEN CITY AQUIFER	129	0	0	0	0	0	129
2005	MARION	QUEEN CITY AQUIFER	139	0	0	0	0	0	139
2006	MARION	QUEEN CITY AQUIFER	35	0	0	0	0	0	35
2007	MARION	QUEEN CITY AQUIFER	30	0	0	0	0	0	30
2008	MARION	QUEEN CITY AQUIFER	31	0	0	0	0	0	31
2009	MARION	QUEEN CITY AQUIFER	24	0	0	0	0	0	24
2010	MARION	QUEEN CITY AQUIFER	6	0	0	0	0	0	6
2011	MARION	QUEEN CITY AQUIFER	6	0	0	0	0	0	6
2012	MARION	QUEEN CITY AQUIFER	5	0	0	0	0	0	5
2000	MARION	UNKNOWN	0	0	0	0	0	0	0
2001	MARION	UNKNOWN	0	0	0	0	0	0	0
2002	MARION	UNKNOWN	0	0	0	0	0	0	0
2008	MARION	UNKNOWN	0	0	82	0	0	0	82
2009	MARION	UNKNOWN	0	0	96	0	0	0	96
2010	MARION	UNKNOWN	0	0	109	0	0	0	109
2011	MARION	UNKNOWN	0	0	87	0	0	0	87
2012	MARION	UNKNOWN	0	0	17	0	0	0	17
1980	MORRIS	CARRIZO-WILCOX AQUIFER	1,048	221	0	0	0	77	1,346
1984	MORRIS	CARRIZO-WILCOX AQUIFER	830	15	0	0	170	79	1,094
1985	MORRIS	CARRIZO-WILCOX AQUIFER	857	7	0	0	151	75	1,090
1986	MORRIS	CARRIZO-WILCOX AQUIFER	712	6	0	0	151	76	945
1987	MORRIS	CARRIZO-WILCOX AQUIFER	654	6	0	0	151	82	893
1988	MORRIS	CARRIZO-WILCOX AQUIFER	728	0	0	0	84	87	899
1989	MORRIS	CARRIZO-WILCOX AQUIFER	709	6,412	0	0	0	90	7,211
1990	MORRIS	CARRIZO-WILCOX AQUIFER	527	6,412	0	0	0	90	7,029
1991	MORRIS	CARRIZO-WILCOX AQUIFER	533	6,412	32	0	0	92	7,069
1992	MORRIS	CARRIZO-WILCOX AQUIFER	513	40	32	0	0	136	721
1993	MORRIS	CARRIZO-WILCOX AQUIFER	503	32	32	0	0	128	695
1994	MORRIS	CARRIZO-WILCOX AQUIFER	446	31	32	0	0	102	611
1995	MORRIS	CARRIZO-WILCOX AQUIFER	512	34	32	0	0	113	691
1996	MORRIS	CARRIZO-WILCOX AQUIFER	500	31	32	0	0	107	670
1997	MORRIS	CARRIZO-WILCOX AQUIFER	621	30	32	0	0	85	768
1998	MORRIS	CARRIZO-WILCOX AQUIFER	638	30	32	0	0	91	791
1999	MORRIS	CARRIZO-WILCOX AQUIFER	490	32	32	0	0	102	656
2000	MORRIS	CARRIZO-WILCOX AQUIFER	559	88	0	0	0	104	751
2001	MORRIS	CARRIZO-WILCOX AQUIFER	562	25	0	0	0	43	630
2002	MORRIS	CARRIZO-WILCOX AQUIFER	552	21	0	0	0	53	626
2003	MORRIS	CARRIZO-WILCOX AQUIFER	508	76	0	0	0	62	646
2004	MORRIS	CARRIZO-WILCOX AQUIFER	499	79	0	0	0	141	719
2005	MORRIS	CARRIZO-WILCOX AQUIFER	548	196	0	0	0	63	807
2006	MORRIS	CARRIZO-WILCOX AQUIFER	625	72	0	0	0	68	765
2007	MORRIS	CARRIZO-WILCOX AQUIFER	550	77	0	0	0	68	695
2008	MORRIS	CARRIZO-WILCOX AQUIFER	585	20	0	0	0	52	657
2009	MORRIS	CARRIZO-WILCOX AQUIFER	645	23	0	0	0	58	726
2010	MORRIS	CARRIZO-WILCOX AQUIFER	691	23	0	0	0	78	792
2011	MORRIS	CARRIZO-WILCOX AQUIFER	685	23	0	0	0	82	790
2012	MORRIS	CARRIZO-WILCOX AQUIFER	621	19	0	0	0	57	697
2006	MORRIS	OTHER AQUIFER	6	0	0	0	0	0	6
2007	MORRIS	OTHER AQUIFER	5	0	0	0	0	0	5
2008	MORRIS	OTHER AQUIFER	5	0	0	0	0	0	5
2009	MORRIS	OTHER AQUIFER	6	0	0	0	0	0	6
2010	MORRIS	OTHER AQUIFER	7	0	0	0	0	0	7
2011	MORRIS	OTHER AQUIFER	6	0	0	0	0	0	6
2012	MORRIS	OTHER AQUIFER	6	0	0	0	0	0	6
1980	MORRIS	QUEEN CITY AQUIFER	201	0	0	0	0	80	281
1984	MORRIS	QUEEN CITY AQUIFER	154	0	0	0	85	65	304
1985	MORRIS	QUEEN CITY AQUIFER	153	0	0	0	74	64	291
1986	MORRIS	QUEEN CITY AQUIFER	149	0	0	0	74	64	287
1987	MORRIS	QUEEN CITY AQUIFER	130	0	0	0	74	68	272
1988	MORRIS	QUEEN CITY AQUIFER	131	0	0	0	41	72	244
1989	MORRIS	QUEEN CITY AQUIFER	143	0	0	0	0	75	218
1990	MORRIS	QUEEN CITY AQUIFER	278	0	0	0	0	76	354
1991	MORRIS	QUEEN CITY AQUIFER	278	0	0	0	0	77	355
1992	MORRIS	QUEEN CITY AQUIFER	259	0	0	0	0	114	373
1993	MORRIS	QUEEN CITY AQUIFER	285	0	0	0	0	107	392
1994	MORRIS	QUEEN CITY AQUIFER	284	0	0	0	0	85	369
1995	MORRIS	QUEEN CITY AQUIFER	240	0	0	0	0	94	334
1996	MORRIS	QUEEN CITY AQUIFER	240	0	0	0	0	89	329
1997	MORRIS	QUEEN CITY AQUIFER	205	0	0	0	0	72	277
1998	MORRIS	QUEEN CITY AQUIFER	211	0	0	0	0	77	288
1999	MORRIS	QUEEN CITY AQUIFER	162	0	0	0	0	86	248
2000	MORRIS	QUEEN CITY AQUIFER	103	0	0	0	0	90	193
2001	MORRIS	QUEEN CITY AQUIFER	91	0	0	0	0	52	143
2002	MORRIS	QUEEN CITY AQUIFER	92	0	0	0	0	65	157
2003	MORRIS	QUEEN CITY AQUIFER	94	0	0	0	0	76	170
2004	MORRIS	QUEEN CITY AQUIFER	92	0	0	0	0	0	92

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2005	MORRIS	QUEEN CITY AQUIFER	98	0	0	0	0	0	98
2006	MORRIS	QUEEN CITY AQUIFER	23	0	0	0	0	0	23
2007	MORRIS	QUEEN CITY AQUIFER	19	0	0	0	0	0	19
2008	MORRIS	QUEEN CITY AQUIFER	21	0	0	0	0	0	21
2009	MORRIS	QUEEN CITY AQUIFER	24	0	0	0	0	0	24
2010	MORRIS	QUEEN CITY AQUIFER	27	0	0	0	0	0	27
2011	MORRIS	QUEEN CITY AQUIFER	25	0	0	0	0	0	25
2012	MORRIS	QUEEN CITY AQUIFER	25	0	0	0	0	0	25
2006	MORRIS	SPARTA AQUIFER	6	0	0	0	0	0	6
2007	MORRIS	SPARTA AQUIFER	5	0	0	0	0	0	5
2008	MORRIS	SPARTA AQUIFER	5	0	0	0	0	0	5
2009	MORRIS	SPARTA AQUIFER	6	0	0	0	0	0	6
2010	MORRIS	SPARTA AQUIFER	7	0	0	0	0	0	7
2011	MORRIS	SPARTA AQUIFER	6	0	0	0	0	0	6
2012	MORRIS	SPARTA AQUIFER	6	0	0	0	0	0	6
2008	MORRIS	UNKNOWN	0	0	0	0	0	0	0
2009	MORRIS	UNKNOWN	0	0	0	0	0	0	0
2010	MORRIS	UNKNOWN	0	0	0	0	0	0	0
2011	MORRIS	UNKNOWN	0	0	0	0	0	0	0
1980	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	6,558	21	0	0	0	432	7,011
1984	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	6,701	0	0	0	19	381	7,101
1985	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	6,874	0	0	0	39	277	7,190
1986	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,148	0	0	0	40	290	7,478
1987	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,260	0	0	0	40	280	7,580
1988	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,806	0	0	0	40	281	8,127
1989	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,922	0	0	0	138	292	8,352
1990	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,481	0	0	0	140	349	7,970
1991	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,235	0	0	0	140	349	7,724
1992	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,744	0	0	0	140	350	8,234
1993	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	8,250	0	0	0	980	360	9,590
1994	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,861	0	0	0	1,117	391	9,369
1995	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	8,532	0	0	0	1,016	352	9,900
1996	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,218	0	0	0	1,016	472	8,706
1997	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,351	0	0	0	1,016	329	8,696
1998	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,152	0	0	0	1,016	295	8,463
1999	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,113	0	0	0	1,016	320	8,449
2000	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,801	0	0	0	186	333	8,320
2001	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,678	20	0	0	419	320	8,437
2002	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,288	31	0	0	187	321	7,827
2003	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	6,665	20	0	0	395	278	7,358
2004	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,140	11	0	0	281	340	7,772
2005	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	7,461	32	0	0	206	83	7,782
2006	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	6,924	27	0	0	248	92	7,291
2007	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	5,911	110	0	0	143	77	6,241
2008	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	6,157	31	0	0	145	82	6,415
2009	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	5,258	24	0	0	226	84	5,592
2010	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	5,871	30	0	0	141	184	6,226
2011	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	6,268	36	0	0	298	182	6,784
2012	NACOGDOCHES	CARRIZO-WILCOX AQUIFER	5,336	25	0	0	31	170	5,562
1980	NACOGDOCHES	OTHER AQUIFER	34	0	0	0	0	51	85
1984	NACOGDOCHES	OTHER AQUIFER	22	0	0	0	0	45	67
1985	NACOGDOCHES	OTHER AQUIFER	16	0	0	0	0	33	49
1986	NACOGDOCHES	OTHER AQUIFER	21	0	0	0	0	35	56
1987	NACOGDOCHES	OTHER AQUIFER	26	0	0	0	0	33	59
1988	NACOGDOCHES	OTHER AQUIFER	21	0	0	0	0	32	53
1989	NACOGDOCHES	OTHER AQUIFER	23	0	0	0	0	35	58
1990	NACOGDOCHES	OTHER AQUIFER	16	0	0	0	0	41	57
1991	NACOGDOCHES	OTHER AQUIFER	15	0	0	0	0	41	56
1992	NACOGDOCHES	OTHER AQUIFER	14	0	0	0	0	41	55
1993	NACOGDOCHES	OTHER AQUIFER	13	0	0	0	0	42	55
1994	NACOGDOCHES	OTHER AQUIFER	9	0	0	0	0	46	55
1995	NACOGDOCHES	OTHER AQUIFER	22	0	0	0	0	41	63
1996	NACOGDOCHES	OTHER AQUIFER	22	0	0	0	0	55	77
1997	NACOGDOCHES	OTHER AQUIFER	5	0	0	0	0	38	43
1998	NACOGDOCHES	OTHER AQUIFER	5	0	0	0	0	34	39
1999	NACOGDOCHES	OTHER AQUIFER	5	0	0	0	0	37	42
2000	NACOGDOCHES	OTHER AQUIFER	1	0	0	0	0	39	40
2001	NACOGDOCHES	OTHER AQUIFER	1	0	0	0	0	37	38
2002	NACOGDOCHES	OTHER AQUIFER	1	0	0	0	0	37	38
2003	NACOGDOCHES	OTHER AQUIFER	1	0	0	0	0	32	33
2004	NACOGDOCHES	OTHER AQUIFER	1	0	0	0	0	31	32
2005	NACOGDOCHES	OTHER AQUIFER	1	0	0	0	0	8	9
2006	NACOGDOCHES	OTHER AQUIFER	56	0	0	0	0	8	64
2007	NACOGDOCHES	OTHER AQUIFER	46	0	0	0	0	7	53
2008	NACOGDOCHES	OTHER AQUIFER	51	0	0	0	0	7	58
2009	NACOGDOCHES	OTHER AQUIFER	63	0	0	0	0	8	71
2010	NACOGDOCHES	OTHER AQUIFER	74	0	0	0	0	17	91
2011	NACOGDOCHES	OTHER AQUIFER	63	0	0	0	0	17	80

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2012	NACOGDOCHES	OTHER AQUIFER	61	0	0	0	0	15	76
1980	NACOGDOCHES	QUEEN CITY AQUIFER	96	0	0	0	0	144	240
1984	NACOGDOCHES	QUEEN CITY AQUIFER	62	0	0	0	0	127	189
1985	NACOGDOCHES	QUEEN CITY AQUIFER	46	0	0	0	0	92	138
1986	NACOGDOCHES	QUEEN CITY AQUIFER	59	0	0	0	0	97	156
1987	NACOGDOCHES	QUEEN CITY AQUIFER	72	0	0	0	0	93	165
1988	NACOGDOCHES	QUEEN CITY AQUIFER	59	0	0	0	0	93	152
1989	NACOGDOCHES	QUEEN CITY AQUIFER	64	0	0	0	0	97	161
1990	NACOGDOCHES	QUEEN CITY AQUIFER	43	0	0	0	0	116	159
1991	NACOGDOCHES	QUEEN CITY AQUIFER	41	0	0	0	0	116	157
1992	NACOGDOCHES	QUEEN CITY AQUIFER	38	0	0	0	0	116	154
1993	NACOGDOCHES	QUEEN CITY AQUIFER	37	0	0	0	0	119	156
1994	NACOGDOCHES	QUEEN CITY AQUIFER	24	0	0	0	0	129	153
1995	NACOGDOCHES	QUEEN CITY AQUIFER	61	0	0	0	0	116	177
1996	NACOGDOCHES	QUEEN CITY AQUIFER	60	0	0	0	0	156	216
1997	NACOGDOCHES	QUEEN CITY AQUIFER	14	0	0	0	0	109	123
1998	NACOGDOCHES	QUEEN CITY AQUIFER	14	0	0	0	0	98	112
1999	NACOGDOCHES	QUEEN CITY AQUIFER	14	0	0	0	0	106	120
2000	NACOGDOCHES	QUEEN CITY AQUIFER	2	0	0	0	0	110	112
2001	NACOGDOCHES	QUEEN CITY AQUIFER	2	0	0	0	0	106	108
2002	NACOGDOCHES	QUEEN CITY AQUIFER	2	0	0	0	0	106	108
2003	NACOGDOCHES	QUEEN CITY AQUIFER	2	0	0	0	0	92	94
2004	NACOGDOCHES	QUEEN CITY AQUIFER	2	0	0	0	0	124	126
2005	NACOGDOCHES	QUEEN CITY AQUIFER	2	0	0	0	0	30	32
2006	NACOGDOCHES	QUEEN CITY AQUIFER	159	0	0	0	0	34	193
2007	NACOGDOCHES	QUEEN CITY AQUIFER	131	0	0	0	0	28	159
2008	NACOGDOCHES	QUEEN CITY AQUIFER	146	0	0	0	0	30	176
2009	NACOGDOCHES	QUEEN CITY AQUIFER	177	0	0	0	0	31	208
2010	NACOGDOCHES	QUEEN CITY AQUIFER	210	0	0	0	0	67	277
2011	NACOGDOCHES	QUEEN CITY AQUIFER	178	0	0	0	0	66	244
2012	NACOGDOCHES	QUEEN CITY AQUIFER	171	0	0	0	0	62	233
1980	NACOGDOCHES	SPARTA AQUIFER	108	0	0	0	0	162	270
1984	NACOGDOCHES	SPARTA AQUIFER	70	0	0	0	0	142	212
1985	NACOGDOCHES	SPARTA AQUIFER	52	0	0	0	0	104	156
1986	NACOGDOCHES	SPARTA AQUIFER	66	0	0	0	0	109	175
1987	NACOGDOCHES	SPARTA AQUIFER	81	0	0	0	0	105	186
1988	NACOGDOCHES	SPARTA AQUIFER	67	0	0	0	0	105	172
1989	NACOGDOCHES	SPARTA AQUIFER	72	0	0	0	0	109	181
1990	NACOGDOCHES	SPARTA AQUIFER	49	0	0	0	0	131	180
1991	NACOGDOCHES	SPARTA AQUIFER	47	0	0	0	0	131	178
1992	NACOGDOCHES	SPARTA AQUIFER	43	0	0	0	0	131	174
1993	NACOGDOCHES	SPARTA AQUIFER	42	0	0	0	0	135	177
1994	NACOGDOCHES	SPARTA AQUIFER	27	0	0	0	0	147	174
1995	NACOGDOCHES	SPARTA AQUIFER	70	0	0	0	0	132	202
1996	NACOGDOCHES	SPARTA AQUIFER	69	0	0	0	0	177	246
1997	NACOGDOCHES	SPARTA AQUIFER	16	0	0	0	0	123	139
1998	NACOGDOCHES	SPARTA AQUIFER	16	0	0	0	0	110	126
1999	NACOGDOCHES	SPARTA AQUIFER	15	0	0	0	0	120	135
2000	NACOGDOCHES	SPARTA AQUIFER	2	0	0	0	0	125	127
2001	NACOGDOCHES	SPARTA AQUIFER	2	0	0	0	0	120	122
2002	NACOGDOCHES	SPARTA AQUIFER	2	0	0	0	0	120	122
2003	NACOGDOCHES	SPARTA AQUIFER	2	0	0	0	0	104	106
2004	NACOGDOCHES	SPARTA AQUIFER	2	0	0	0	0	0	2
2005	NACOGDOCHES	SPARTA AQUIFER	2	0	0	0	0	0	2
2006	NACOGDOCHES	SPARTA AQUIFER	112	0	0	0	0	0	112
2007	NACOGDOCHES	SPARTA AQUIFER	93	0	0	0	0	0	93
2008	NACOGDOCHES	SPARTA AQUIFER	103	0	0	0	0	0	103
2009	NACOGDOCHES	SPARTA AQUIFER	125	0	0	0	0	0	125
2010	NACOGDOCHES	SPARTA AQUIFER	149	0	0	0	0	0	149
2011	NACOGDOCHES	SPARTA AQUIFER	125	0	0	0	0	0	125
2012	NACOGDOCHES	SPARTA AQUIFER	121	0	0	0	0	0	121
2008	NACOGDOCHES	UNKNOWN	0	0	345	0	0	0	345
2009	NACOGDOCHES	UNKNOWN	0	0	352	0	0	0	352
2010	NACOGDOCHES	UNKNOWN	0	0	359	0	0	0	359
2011	NACOGDOCHES	UNKNOWN	0	0	825	0	0	0	825
2012	NACOGDOCHES	UNKNOWN	0	0	683	0	0	0	683
2006	NACOGDOCHES	YEGUA-JACKSON AQUIFER	19	0	0	0	0	0	19
2007	NACOGDOCHES	YEGUA-JACKSON AQUIFER	15	0	0	0	0	0	15
2008	NACOGDOCHES	YEGUA-JACKSON AQUIFER	17	0	0	0	0	0	17
2009	NACOGDOCHES	YEGUA-JACKSON AQUIFER	21	0	0	0	0	0	21
2010	NACOGDOCHES	YEGUA-JACKSON AQUIFER	25	0	0	0	0	0	25
2011	NACOGDOCHES	YEGUA-JACKSON AQUIFER	21	0	0	0	0	0	21
2012	NACOGDOCHES	YEGUA-JACKSON AQUIFER	20	0	0	0	0	0	20
1980	PANOLA	CARRIZO-WILCOX AQUIFER	2,233	0	244	2	0	708	3,187
1984	PANOLA	CARRIZO-WILCOX AQUIFER	2,316	0	358	125	0	654	3,453
1985	PANOLA	CARRIZO-WILCOX AQUIFER	2,495	15	426	11	0	640	3,587
1986	PANOLA	CARRIZO-WILCOX AQUIFER	2,188	16	3,305	20	0	670	6,199
1987	PANOLA	CARRIZO-WILCOX AQUIFER	2,229	20	989	24	0	695	3,957

Groundwater Pumping Estimates from Texas Water Development Board
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1988	PANOLA	CARRIZO-WILCOX AQUIFER	2,290	20	1,047	16	0	705	4,078
1989	PANOLA	CARRIZO-WILCOX AQUIFER	2,203	19	1,078	17	0	747	4,064
1990	PANOLA	CARRIZO-WILCOX AQUIFER	2,212	59	1,078	17	0	858	4,224
1991	PANOLA	CARRIZO-WILCOX AQUIFER	2,184	14	1,044	155	0	869	4,266
1992	PANOLA	CARRIZO-WILCOX AQUIFER	2,381	20	1,051	0	0	812	4,264
1993	PANOLA	CARRIZO-WILCOX AQUIFER	2,324	20	1,064	0	0	815	4,223
1994	PANOLA	CARRIZO-WILCOX AQUIFER	2,322	20	1,064	0	0	1,090	4,496
1995	PANOLA	CARRIZO-WILCOX AQUIFER	2,395	20	1,045	0	0	1,059	4,519
1996	PANOLA	CARRIZO-WILCOX AQUIFER	2,306	0	1,944	0	0	1,126	5,376
1997	PANOLA	CARRIZO-WILCOX AQUIFER	2,268	0	1,947	0	0	1,128	5,343
1998	PANOLA	CARRIZO-WILCOX AQUIFER	2,186	0	1,947	0	0	1,118	5,251
1999	PANOLA	CARRIZO-WILCOX AQUIFER	2,219	0	1,947	0	0	1,216	5,382
2000	PANOLA	CARRIZO-WILCOX AQUIFER	2,743	0	7	0	0	1,238	3,988
2001	PANOLA	CARRIZO-WILCOX AQUIFER	2,808	921	7	0	0	1,264	5,000
2002	PANOLA	CARRIZO-WILCOX AQUIFER	2,564	473	7	0	0	1,254	4,298
2003	PANOLA	CARRIZO-WILCOX AQUIFER	2,588	513	7	0	0	1,249	4,357
2004	PANOLA	CARRIZO-WILCOX AQUIFER	2,589	424	7	0	0	1,270	4,290
2005	PANOLA	CARRIZO-WILCOX AQUIFER	2,546	498	8	0	0	320	3,372
2006	PANOLA	CARRIZO-WILCOX AQUIFER	3,148	185	7	0	18	333	3,691
2007	PANOLA	CARRIZO-WILCOX AQUIFER	2,689	338	7	0	31	327	3,392
2008	PANOLA	CARRIZO-WILCOX AQUIFER	2,444	260	1	0	64	304	3,073
2009	PANOLA	CARRIZO-WILCOX AQUIFER	2,637	408	1	0	31	314	3,391
2010	PANOLA	CARRIZO-WILCOX AQUIFER	5,203	0	483	0	346	136	6,168
2011	PANOLA	CARRIZO-WILCOX AQUIFER	3,617	0	562	0	383	139	4,701
2012	PANOLA	CARRIZO-WILCOX AQUIFER	3,256	0	518	0	137	96	4,007
2008	PANOLA	UNKNOWN	0	0	1,297	0	0	0	1,297
2009	PANOLA	UNKNOWN	0	0	1,319	0	0	0	1,319
2010	PANOLA	UNKNOWN	0	0	1,340	0	0	0	1,340
2011	PANOLA	UNKNOWN	0	0	629	0	0	0	629
2012	PANOLA	UNKNOWN	0	0	1,050	0	0	0	1,050
1980	RAINS	CARRIZO-WILCOX AQUIFER	166	0	0	0	0	149	315
1984	RAINS	CARRIZO-WILCOX AQUIFER	68	0	0	0	0	211	279
1985	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	197	197
1986	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	183	183
1987	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	200	200
1988	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	192	192
1989	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	202	202
1990	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	252	252
1991	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	251	251
1992	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	223	223
1993	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	217	217
1994	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	233	233
1995	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	233	233
1996	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	229	229
1997	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	227	227
1998	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	211	211
1999	RAINS	CARRIZO-WILCOX AQUIFER	0	0	0	0	0	220	220
2000	RAINS	CARRIZO-WILCOX AQUIFER	248	0	0	0	0	216	464
2001	RAINS	CARRIZO-WILCOX AQUIFER	265	0	0	0	0	200	465
2002	RAINS	CARRIZO-WILCOX AQUIFER	274	0	0	0	0	182	456
2003	RAINS	CARRIZO-WILCOX AQUIFER	288	0	0	0	0	190	478
2004	RAINS	CARRIZO-WILCOX AQUIFER	269	0	0	0	0	218	487
2005	RAINS	CARRIZO-WILCOX AQUIFER	296	0	0	0	0	28	324
2006	RAINS	CARRIZO-WILCOX AQUIFER	315	0	0	0	0	27	342
2007	RAINS	CARRIZO-WILCOX AQUIFER	261	0	0	0	58	24	343
2008	RAINS	CARRIZO-WILCOX AQUIFER	299	0	0	0	0	24	323
2009	RAINS	CARRIZO-WILCOX AQUIFER	276	0	0	0	0	24	300
2010	RAINS	CARRIZO-WILCOX AQUIFER	819	0	0	0	0	21	840
2011	RAINS	CARRIZO-WILCOX AQUIFER	544	0	0	0	7	21	572
2012	RAINS	CARRIZO-WILCOX AQUIFER	465	0	0	0	53	19	537
1980	RAINS	OTHER AQUIFER	55	0	0	0	0	49	104
1984	RAINS	OTHER AQUIFER	22	0	0	0	0	53	75
1985	RAINS	OTHER AQUIFER	0	0	0	0	0	49	49
1986	RAINS	OTHER AQUIFER	0	0	0	0	0	46	46
1987	RAINS	OTHER AQUIFER	0	0	0	0	0	50	50
1988	RAINS	OTHER AQUIFER	0	0	0	0	0	48	48
1989	RAINS	OTHER AQUIFER	0	0	0	0	0	51	51
1990	RAINS	OTHER AQUIFER	0	0	0	0	0	64	64
1992	RAINS	OTHER AQUIFER	0	0	0	0	0	57	57
1993	RAINS	OTHER AQUIFER	0	0	0	0	0	56	56
1994	RAINS	OTHER AQUIFER	0	0	0	0	0	60	60
1995	RAINS	OTHER AQUIFER	0	0	0	0	0	60	60
1996	RAINS	OTHER AQUIFER	0	0	0	0	0	59	59
1997	RAINS	OTHER AQUIFER	0	0	0	0	0	58	58
1998	RAINS	OTHER AQUIFER	0	0	0	0	0	54	54
1999	RAINS	OTHER AQUIFER	0	0	0	0	0	56	56
2000	RAINS	OTHER AQUIFER	29	0	0	0	0	54	83
2001	RAINS	OTHER AQUIFER	31	0	0	0	0	51	82

Groundwater Pumping Estimates from Texas Water Development Board
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2002	RAINS	OTHER AQUIFER	32	0	0	0	0	46	78
2003	RAINS	OTHER AQUIFER	33	0	0	0	0	48	81
2004	RAINS	OTHER AQUIFER	31	0	0	0	0	0	31
2005	RAINS	OTHER AQUIFER	34	0	0	0	0	0	34
2006	RAINS	OTHER AQUIFER	36	0	0	0	0	0	36
2007	RAINS	OTHER AQUIFER	30	0	0	0	0	0	30
2008	RAINS	OTHER AQUIFER	34	0	0	0	0	0	34
2009	RAINS	OTHER AQUIFER	32	0	0	0	0	0	32
2010	RAINS	OTHER AQUIFER	30	0	0	0	0	0	30
2011	RAINS	OTHER AQUIFER	28	0	0	0	0	0	28
2012	RAINS	OTHER AQUIFER	24	0	0	0	0	0	24
2008	RAINS	UNKNOWN	0	0	0	0	0	0	0
2009	RAINS	UNKNOWN	0	0	0	0	0	0	0
2010	RAINS	UNKNOWN	0	0	0	0	0	0	0
2011	RAINS	UNKNOWN	0	0	0	0	0	0	0
1980	RUSK	CARRIZO-WILCOX AQUIFER	4,725	0	562	0	0	558	5,845
1984	RUSK	CARRIZO-WILCOX AQUIFER	4,364	0	1,604	0	33	535	6,536
1985	RUSK	CARRIZO-WILCOX AQUIFER	5,459	0	2,286	0	38	479	8,262
1986	RUSK	CARRIZO-WILCOX AQUIFER	5,097	0	2,389	0	19	451	7,956
1987	RUSK	CARRIZO-WILCOX AQUIFER	4,944	0	1,928	0	19	430	7,321
1988	RUSK	CARRIZO-WILCOX AQUIFER	5,527	0	1,855	0	19	447	7,848
1989	RUSK	CARRIZO-WILCOX AQUIFER	5,295	0	1,890	0	32	455	7,672
1990	RUSK	CARRIZO-WILCOX AQUIFER	5,353	0	1,702	0	27	479	7,561
1991	RUSK	CARRIZO-WILCOX AQUIFER	5,225	0	1,142	18	27	487	6,899
1992	RUSK	CARRIZO-WILCOX AQUIFER	5,254	0	1,133	24	27	468	6,906
1993	RUSK	CARRIZO-WILCOX AQUIFER	5,514	0	1,106	23	149	479	7,271
1994	RUSK	CARRIZO-WILCOX AQUIFER	5,275	0	1,077	18	38	441	6,849
1995	RUSK	CARRIZO-WILCOX AQUIFER	5,968	0	1,093	20	151	391	7,623
1996	RUSK	CARRIZO-WILCOX AQUIFER	6,199	0	1,093	179	149	333	7,953
1997	RUSK	CARRIZO-WILCOX AQUIFER	5,863	0	1,105	14	149	346	7,477
1998	RUSK	CARRIZO-WILCOX AQUIFER	6,135	0	1,105	18	149	401	7,808
1999	RUSK	CARRIZO-WILCOX AQUIFER	5,621	0	1,105	18	149	433	7,326
2000	RUSK	CARRIZO-WILCOX AQUIFER	7,154	0	38	11	18	436	7,657
2001	RUSK	CARRIZO-WILCOX AQUIFER	6,526	184	7	12	49	221	6,999
2002	RUSK	CARRIZO-WILCOX AQUIFER	6,635	143	6	97	49	217	7,147
2003	RUSK	CARRIZO-WILCOX AQUIFER	6,724	150	6	99	73	201	7,253
2004	RUSK	CARRIZO-WILCOX AQUIFER	6,696	176	6	113	92	221	7,304
2005	RUSK	CARRIZO-WILCOX AQUIFER	6,644	210	3	0	92	231	7,180
2006	RUSK	CARRIZO-WILCOX AQUIFER	6,887	188	0	287	100	202	7,664
2007	RUSK	CARRIZO-WILCOX AQUIFER	6,137	71	0	356	25	216	6,805
2008	RUSK	CARRIZO-WILCOX AQUIFER	6,529	188	0	147	29	209	7,102
2009	RUSK	CARRIZO-WILCOX AQUIFER	6,347	196	0	183	0	194	6,920
2010	RUSK	CARRIZO-WILCOX AQUIFER	6,822	0	173	358	0	224	7,577
2011	RUSK	CARRIZO-WILCOX AQUIFER	8,226	0	160	1,023	172	223	9,804
2012	RUSK	CARRIZO-WILCOX AQUIFER	7,399	0	115	245	69	180	8,008
2001	RUSK	OTHER AQUIFER	0	0	0	0	0	0	0
2002	RUSK	OTHER AQUIFER	0	0	0	0	0	0	0
2006	RUSK	OTHER AQUIFER	44	0	0	0	0	0	44
2007	RUSK	OTHER AQUIFER	36	0	0	0	0	0	36
2008	RUSK	OTHER AQUIFER	40	0	0	0	0	0	40
2009	RUSK	OTHER AQUIFER	52	0	0	0	0	0	52
2010	RUSK	OTHER AQUIFER	64	0	0	0	0	0	64
2011	RUSK	OTHER AQUIFER	68	0	0	0	136	0	204
2012	RUSK	OTHER AQUIFER	64	0	0	2,132	54	0	2,250
1980	RUSK	QUEEN CITY AQUIFER	67	0	72	0	0	35	174
1984	RUSK	QUEEN CITY AQUIFER	32	0	86	0	0	31	149
1985	RUSK	QUEEN CITY AQUIFER	32	0	206	0	0	28	266
1986	RUSK	QUEEN CITY AQUIFER	25	0	195	0	0	27	247
1987	RUSK	QUEEN CITY AQUIFER	22	0	183	0	0	25	230
1988	RUSK	QUEEN CITY AQUIFER	30	0	165	0	0	26	221
1989	RUSK	QUEEN CITY AQUIFER	41	0	153	0	0	27	221
1990	RUSK	QUEEN CITY AQUIFER	39	0	153	0	0	28	220
1991	RUSK	QUEEN CITY AQUIFER	45	0	99	0	0	28	172
1992	RUSK	QUEEN CITY AQUIFER	44	0	99	0	0	27	170
1993	RUSK	QUEEN CITY AQUIFER	48	0	96	0	0	28	172
1994	RUSK	QUEEN CITY AQUIFER	32	0	96	0	0	26	154
1995	RUSK	QUEEN CITY AQUIFER	35	0	96	0	0	23	154
1996	RUSK	QUEEN CITY AQUIFER	26	0	96	0	0	20	142
1997	RUSK	QUEEN CITY AQUIFER	26	0	96	0	0	21	143
1998	RUSK	QUEEN CITY AQUIFER	27	0	96	0	0	24	147
1999	RUSK	QUEEN CITY AQUIFER	25	0	96	0	0	26	147
2000	RUSK	QUEEN CITY AQUIFER	5	0	0	0	0	26	31
2001	RUSK	QUEEN CITY AQUIFER	5	0	0	0	0	15	20
2002	RUSK	QUEEN CITY AQUIFER	4	0	0	0	0	14	18
2003	RUSK	QUEEN CITY AQUIFER	5	0	0	0	0	14	19
2004	RUSK	QUEEN CITY AQUIFER	4	0	0	0	0	0	4
2005	RUSK	QUEEN CITY AQUIFER	5	0	0	0	0	0	5
2008	RUSK	UNKNOWN	0	0	1,233	0	0	0	1,233

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2009	RUSK	UNKNOWN	0	0	1,059	0	0	0	1,059
2010	RUSK	UNKNOWN	0	0	885	0	0	0	885
2011	RUSK	UNKNOWN	0	0	387	0	0	0	387
2012	RUSK	UNKNOWN	0	0	310	0	0	0	310
1980	SABINE	CARRIZO-WILCOX AQUIFER	214	0	0	0	0	65	279
1984	SABINE	CARRIZO-WILCOX AQUIFER	81	0	0	0	0	64	145
1985	SABINE	CARRIZO-WILCOX AQUIFER	48	0	0	0	0	57	105
1986	SABINE	CARRIZO-WILCOX AQUIFER	46	0	0	0	0	60	106
1987	SABINE	CARRIZO-WILCOX AQUIFER	44	0	0	0	0	73	117
1988	SABINE	CARRIZO-WILCOX AQUIFER	46	0	0	0	50	75	171
1989	SABINE	CARRIZO-WILCOX AQUIFER	72	0	0	0	0	76	148
1990	SABINE	CARRIZO-WILCOX AQUIFER	77	0	0	0	0	84	161
1991	SABINE	CARRIZO-WILCOX AQUIFER	72	0	0	0	0	86	158
1992	SABINE	CARRIZO-WILCOX AQUIFER	82	0	0	0	0	74	156
1993	SABINE	CARRIZO-WILCOX AQUIFER	94	0	0	0	0	77	171
1994	SABINE	CARRIZO-WILCOX AQUIFER	102	0	0	0	0	28	130
1995	SABINE	CARRIZO-WILCOX AQUIFER	91	0	0	0	0	22	113
1996	SABINE	CARRIZO-WILCOX AQUIFER	97	0	0	0	0	20	117
1997	SABINE	CARRIZO-WILCOX AQUIFER	90	0	0	0	0	46	136
1998	SABINE	CARRIZO-WILCOX AQUIFER	116	0	0	0	0	97	213
1999	SABINE	CARRIZO-WILCOX AQUIFER	63	0	0	0	0	92	155
2000	SABINE	CARRIZO-WILCOX AQUIFER	245	0	0	0	0	116	361
2001	SABINE	CARRIZO-WILCOX AQUIFER	250	0	0	0	0	102	352
2002	SABINE	CARRIZO-WILCOX AQUIFER	292	0	0	0	0	103	395
2003	SABINE	CARRIZO-WILCOX AQUIFER	375	0	0	0	0	110	485
2004	SABINE	CARRIZO-WILCOX AQUIFER	352	0	0	0	0	85	437
2005	SABINE	CARRIZO-WILCOX AQUIFER	389	0	0	0	0	45	434
2006	SABINE	CARRIZO-WILCOX AQUIFER	107	0	0	0	0	46	153
2007	SABINE	CARRIZO-WILCOX AQUIFER	223	0	0	0	0	45	268
2008	SABINE	CARRIZO-WILCOX AQUIFER	200	0	0	0	0	55	255
2009	SABINE	CARRIZO-WILCOX AQUIFER	532	0	0	0	0	57	589
2010	SABINE	CARRIZO-WILCOX AQUIFER	177	0	0	0	0	7	184
2011	SABINE	CARRIZO-WILCOX AQUIFER	323	0	0	0	0	7	330
2012	SABINE	CARRIZO-WILCOX AQUIFER	279	0	0	0	0	6	285
2006	SABINE	GULF COAST AQUIFER	5	0	0	0	0	0	5
2007	SABINE	GULF COAST AQUIFER	4	0	0	0	0	0	4
2008	SABINE	GULF COAST AQUIFER	148	0	0	0	0	0	148
2009	SABINE	GULF COAST AQUIFER	11	0	0	0	0	0	11
2010	SABINE	GULF COAST AQUIFER	18	0	0	0	0	0	18
2011	SABINE	GULF COAST AQUIFER	20	0	0	0	0	0	20
2012	SABINE	GULF COAST AQUIFER	18	0	0	0	0	0	18
1980	SABINE	OTHER AQUIFER	415	132	0	0	0	42	589
1984	SABINE	OTHER AQUIFER	264	433	0	0	0	40	737
1985	SABINE	OTHER AQUIFER	273	417	0	0	0	36	726
1986	SABINE	OTHER AQUIFER	255	420	0	0	0	38	713
1987	SABINE	OTHER AQUIFER	274	457	0	0	0	46	777
1988	SABINE	OTHER AQUIFER	312	418	0	0	0	47	777
1989	SABINE	OTHER AQUIFER	322	432	0	0	0	48	802
1990	SABINE	OTHER AQUIFER	330	374	0	0	0	53	757
1991	SABINE	OTHER AQUIFER	319	364	0	0	0	54	737
1992	SABINE	OTHER AQUIFER	281	402	0	0	0	47	730
1993	SABINE	OTHER AQUIFER	294	455	0	0	0	49	798
1994	SABINE	OTHER AQUIFER	287	512	0	0	0	18	817
1995	SABINE	OTHER AQUIFER	271	451	0	0	0	14	736
1996	SABINE	OTHER AQUIFER	285	368	0	0	0	13	666
1997	SABINE	OTHER AQUIFER	276	374	0	0	0	29	679
1998	SABINE	OTHER AQUIFER	356	260	0	0	0	61	677
1999	SABINE	OTHER AQUIFER	192	158	0	0	0	58	408
2000	SABINE	OTHER AQUIFER	327	214	0	0	0	20	561
2001	SABINE	OTHER AQUIFER	270	225	0	0	0	4	499
2002	SABINE	OTHER AQUIFER	258	242	0	0	0	4	504
2003	SABINE	OTHER AQUIFER	218	140	0	0	0	4	362
2004	SABINE	OTHER AQUIFER	205	95	0	0	0	0	300
2005	SABINE	OTHER AQUIFER	306	130	0	0	0	0	436
2006	SABINE	OTHER AQUIFER	193	93	0	0	0	0	286
2007	SABINE	OTHER AQUIFER	194	93	0	0	0	0	287
2008	SABINE	OTHER AQUIFER	198	0	0	0	0	0	198
2009	SABINE	OTHER AQUIFER	30	0	0	0	0	0	30
2010	SABINE	OTHER AQUIFER	48	0	0	0	0	0	48
2011	SABINE	OTHER AQUIFER	52	0	0	0	0	0	52
2012	SABINE	OTHER AQUIFER	122	0	0	0	0	0	122
1980	SABINE	SPARTA AQUIFER	160	0	0	0	0	35	195
1984	SABINE	SPARTA AQUIFER	44	0	0	0	0	34	78
1985	SABINE	SPARTA AQUIFER	38	0	0	0	0	31	69
1986	SABINE	SPARTA AQUIFER	37	0	0	0	0	33	70
1987	SABINE	SPARTA AQUIFER	38	0	0	0	0	40	78
1988	SABINE	SPARTA AQUIFER	39	0	0	0	0	40	79
1989	SABINE	SPARTA AQUIFER	41	0	0	0	0	41	82

Groundwater Pumping Estimates from Texas Water Development Board
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1990	SABINE	SPARTA AQUIFER	42	0	0	0	0	45	87
1991	SABINE	SPARTA AQUIFER	40	0	0	0	0	46	86
1992	SABINE	SPARTA AQUIFER	42	0	0	0	0	40	82
1993	SABINE	SPARTA AQUIFER	45	0	0	0	0	41	86
1994	SABINE	SPARTA AQUIFER	46	0	0	0	0	15	61
1995	SABINE	SPARTA AQUIFER	31	0	0	0	0	12	43
1996	SABINE	SPARTA AQUIFER	31	0	0	0	0	11	42
1997	SABINE	SPARTA AQUIFER	30	0	0	0	0	25	55
1998	SABINE	SPARTA AQUIFER	39	0	0	0	0	52	91
1999	SABINE	SPARTA AQUIFER	21	0	0	0	0	50	71
2000	SABINE	SPARTA AQUIFER	3	0	0	0	0	63	66
2001	SABINE	SPARTA AQUIFER	3	0	0	0	0	52	55
2002	SABINE	SPARTA AQUIFER	3	0	0	0	0	52	55
2003	SABINE	SPARTA AQUIFER	3	0	0	0	0	56	59
2004	SABINE	SPARTA AQUIFER	3	0	0	0	0	27	30
2005	SABINE	SPARTA AQUIFER	3	0	0	0	0	15	18
2006	SABINE	SPARTA AQUIFER	15	0	0	0	0	15	30
2007	SABINE	SPARTA AQUIFER	12	0	0	0	0	15	27
2008	SABINE	SPARTA AQUIFER	14	0	0	0	0	27	41
2009	SABINE	SPARTA AQUIFER	34	0	0	0	0	28	62
2010	SABINE	SPARTA AQUIFER	56	0	0	0	0	3	59
2011	SABINE	SPARTA AQUIFER	61	0	0	0	0	3	64
2012	SABINE	SPARTA AQUIFER	57	0	0	0	0	2	59
2008	SABINE	UNKNOWN	0	0	138	0	0	0	138
2009	SABINE	UNKNOWN	0	0	201	0	0	0	201
2010	SABINE	UNKNOWN	0	0	264	0	0	0	264
2011	SABINE	UNKNOWN	0	0	222	0	0	0	222
2012	SABINE	UNKNOWN	0	0	37	0	0	0	37
2000	SABINE	YEGUA-JACKSON AQUIFER	0	0	0	0	0	53	53
2001	SABINE	YEGUA-JACKSON AQUIFER	0	0	0	0	0	50	50
2002	SABINE	YEGUA-JACKSON AQUIFER	0	0	0	0	0	51	51
2003	SABINE	YEGUA-JACKSON AQUIFER	0	0	0	0	0	54	54
2004	SABINE	YEGUA-JACKSON AQUIFER	0	0	0	0	0	118	118
2005	SABINE	YEGUA-JACKSON AQUIFER	0	0	0	0	0	62	62
2006	SABINE	YEGUA-JACKSON AQUIFER	127	0	0	0	0	63	190
2007	SABINE	YEGUA-JACKSON AQUIFER	105	0	0	0	0	62	167
2008	SABINE	YEGUA-JACKSON AQUIFER	117	0	0	0	0	30	147
2009	SABINE	YEGUA-JACKSON AQUIFER	294	0	0	0	0	31	325
2010	SABINE	YEGUA-JACKSON AQUIFER	706	0	0	0	0	8	714
2011	SABINE	YEGUA-JACKSON AQUIFER	608	0	0	0	0	8	616
2012	SABINE	YEGUA-JACKSON AQUIFER	581	0	0	0	0	6	587
1980	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	283	0	0	0	0	79	362
1984	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	131	0	0	0	0	67	198
1985	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	122	0	0	0	0	60	182
1986	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	134	0	0	0	0	68	202
1987	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	126	0	0	0	0	74	200
1988	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	135	0	0	0	100	76	311
1989	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	144	0	0	0	0	77	221
1990	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	140	0	0	0	0	85	225
1991	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	106	0	0	0	0	87	193
1992	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	88	0	0	0	0	93	181
1993	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	95	0	0	0	39	93	227
1994	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	99	3	0	0	75	31	208
1995	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	115	3	0	0	77	33	228
1996	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	87	3	0	0	77	29	196
1997	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	102	2	0	0	77	53	234
1998	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	106	2	0	0	77	103	288
1999	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	108	3	0	0	77	98	286
2000	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	241	3	0	0	112	128	484
2001	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	289	4	0	0	82	83	458
2002	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	294	4	0	0	82	84	464
2003	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	381	5	0	0	50	83	519
2004	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	276	3	0	0	50	131	460
2005	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	359	3	0	0	50	40	452
2006	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	309	3	0	0	63	40	415
2007	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	298	5	0	0	0	42	345
2008	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	329	4	0	0	0	109	442
2009	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	352	6	0	0	0	111	469
2010	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	386	5	0	0	0	27	418
2011	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	416	4	0	0	14	27	461
2012	SAN AUGUSTINE	CARRIZO-WILCOX AQUIFER	395	3	0	0	0	26	424
1980	SAN AUGUSTINE	OTHER AQUIFER	300	0	0	0	0	101	401
1984	SAN AUGUSTINE	OTHER AQUIFER	249	0	0	0	0	85	334
1985	SAN AUGUSTINE	OTHER AQUIFER	245	0	0	0	0	77	322
1986	SAN AUGUSTINE	OTHER AQUIFER	248	0	0	0	0	87	335
1987	SAN AUGUSTINE	OTHER AQUIFER	234	0	0	0	0	94	328
1988	SAN AUGUSTINE	OTHER AQUIFER	240	0	0	0	0	97	337
1989	SAN AUGUSTINE	OTHER AQUIFER	227	0	0	0	0	99	326

Groundwater Pumping Estimates from Texas Water Development Board
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1990	SAN AUGUSTINE	OTHER AQUIFER	217	0	0	0	0	110	327
1991	SAN AUGUSTINE	OTHER AQUIFER	176	0	0	0	0	113	289
1992	SAN AUGUSTINE	OTHER AQUIFER	197	0	0	0	0	120	317
1993	SAN AUGUSTINE	OTHER AQUIFER	220	0	0	0	0	121	341
1994	SAN AUGUSTINE	OTHER AQUIFER	231	0	0	0	0	40	271
1995	SAN AUGUSTINE	OTHER AQUIFER	250	0	0	0	0	44	294
1996	SAN AUGUSTINE	OTHER AQUIFER	240	0	0	0	0	38	278
1997	SAN AUGUSTINE	OTHER AQUIFER	253	0	0	0	0	69	322
1998	SAN AUGUSTINE	OTHER AQUIFER	264	0	0	0	0	134	398
1999	SAN AUGUSTINE	OTHER AQUIFER	267	0	0	0	0	128	395
2000	SAN AUGUSTINE	OTHER AQUIFER	411	0	0	0	0	167	578
2001	SAN AUGUSTINE	OTHER AQUIFER	338	0	0	0	0	160	498
2002	SAN AUGUSTINE	OTHER AQUIFER	342	0	0	0	0	160	502
2003	SAN AUGUSTINE	OTHER AQUIFER	310	0	0	0	0	159	469
2004	SAN AUGUSTINE	OTHER AQUIFER	305	0	0	0	0	40	345
2005	SAN AUGUSTINE	OTHER AQUIFER	316	0	0	0	0	12	328
2006	SAN AUGUSTINE	OTHER AQUIFER	194	0	0	0	0	12	206
2007	SAN AUGUSTINE	OTHER AQUIFER	188	0	0	0	0	13	201
2008	SAN AUGUSTINE	OTHER AQUIFER	98	0	0	0	0	0	98
2009	SAN AUGUSTINE	OTHER AQUIFER	109	0	0	0	0	0	109
2010	SAN AUGUSTINE	OTHER AQUIFER	119	0	0	0	0	7	126
2011	SAN AUGUSTINE	OTHER AQUIFER	124	0	0	0	0	7	131
2012	SAN AUGUSTINE	OTHER AQUIFER	118	0	0	0	0	6	124
1980	SAN AUGUSTINE	SPARTA AQUIFER	51	0	0	0	0	50	101
1984	SAN AUGUSTINE	SPARTA AQUIFER	59	0	0	0	0	43	102
1985	SAN AUGUSTINE	SPARTA AQUIFER	50	0	0	0	0	38	88
1986	SAN AUGUSTINE	SPARTA AQUIFER	58	0	0	0	0	43	101
1987	SAN AUGUSTINE	SPARTA AQUIFER	48	0	0	0	0	47	95
1988	SAN AUGUSTINE	SPARTA AQUIFER	42	0	0	0	0	48	90
1989	SAN AUGUSTINE	SPARTA AQUIFER	41	0	0	0	0	49	90
1990	SAN AUGUSTINE	SPARTA AQUIFER	37	0	0	0	0	54	91
1991	SAN AUGUSTINE	SPARTA AQUIFER	28	0	0	0	0	55	83
1992	SAN AUGUSTINE	SPARTA AQUIFER	29	0	0	0	0	58	87
1993	SAN AUGUSTINE	SPARTA AQUIFER	37	0	0	0	39	58	134
1994	SAN AUGUSTINE	SPARTA AQUIFER	47	0	0	0	0	19	66
1995	SAN AUGUSTINE	SPARTA AQUIFER	42	0	0	0	0	21	63
1996	SAN AUGUSTINE	SPARTA AQUIFER	32	0	0	0	0	18	50
1997	SAN AUGUSTINE	SPARTA AQUIFER	32	0	0	0	0	33	65
1998	SAN AUGUSTINE	SPARTA AQUIFER	33	0	0	0	0	64	97
1999	SAN AUGUSTINE	SPARTA AQUIFER	34	0	0	0	0	61	95
2000	SAN AUGUSTINE	SPARTA AQUIFER	29	0	0	0	0	80	109
2001	SAN AUGUSTINE	SPARTA AQUIFER	30	0	0	0	0	76	106
2002	SAN AUGUSTINE	SPARTA AQUIFER	31	0	0	0	0	77	108
2003	SAN AUGUSTINE	SPARTA AQUIFER	26	0	0	0	0	76	102
2004	SAN AUGUSTINE	SPARTA AQUIFER	25	0	0	0	0	159	184
2005	SAN AUGUSTINE	SPARTA AQUIFER	27	0	0	0	0	49	76
2006	SAN AUGUSTINE	SPARTA AQUIFER	95	0	0	0	0	49	144
2007	SAN AUGUSTINE	SPARTA AQUIFER	78	0	0	0	0	52	130
2008	SAN AUGUSTINE	SPARTA AQUIFER	85	0	0	0	0	0	85
2009	SAN AUGUSTINE	SPARTA AQUIFER	113	0	0	0	0	0	113
2010	SAN AUGUSTINE	SPARTA AQUIFER	142	0	0	0	0	27	169
2011	SAN AUGUSTINE	SPARTA AQUIFER	158	0	0	0	0	27	185
2012	SAN AUGUSTINE	SPARTA AQUIFER	150	0	0	0	0	25	175
2008	SAN AUGUSTINE	UNKNOWN	0	0	53	0	0	0	53
2009	SAN AUGUSTINE	UNKNOWN	0	0	167	0	0	0	167
2010	SAN AUGUSTINE	UNKNOWN	0	0	281	0	0	0	281
2011	SAN AUGUSTINE	UNKNOWN	0	0	984	0	0	0	984
2012	SAN AUGUSTINE	UNKNOWN	0	0	369	0	0	0	369
2006	SAN AUGUSTINE	YEGUA-JACKSON AQUIFER	110	0	0	0	0	0	110
2007	SAN AUGUSTINE	YEGUA-JACKSON AQUIFER	91	0	0	0	0	0	91
2008	SAN AUGUSTINE	YEGUA-JACKSON AQUIFER	99	0	0	0	0	0	99
2009	SAN AUGUSTINE	YEGUA-JACKSON AQUIFER	132	0	0	0	0	0	132
2010	SAN AUGUSTINE	YEGUA-JACKSON AQUIFER	166	0	0	0	0	0	166
2011	SAN AUGUSTINE	YEGUA-JACKSON AQUIFER	184	0	0	0	0	0	184
2012	SAN AUGUSTINE	YEGUA-JACKSON AQUIFER	175	0	0	0	0	0	175
1980	SHELBY	CARRIZO-WILCOX AQUIFER	2,015	23	0	0	0	748	2,786
1984	SHELBY	CARRIZO-WILCOX AQUIFER	2,661	2	0	0	5	584	3,252
1985	SHELBY	CARRIZO-WILCOX AQUIFER	1,891	4	0	0	12	561	2,468
1986	SHELBY	CARRIZO-WILCOX AQUIFER	1,645	4	0	0	13	588	2,250
1987	SHELBY	CARRIZO-WILCOX AQUIFER	1,753	0	0	0	13	664	2,430
1988	SHELBY	CARRIZO-WILCOX AQUIFER	1,439	0	0	0	39	684	2,162
1989	SHELBY	CARRIZO-WILCOX AQUIFER	1,591	0	0	0	11	721	2,323
1990	SHELBY	CARRIZO-WILCOX AQUIFER	1,600	52	0	0	12	785	2,449
1991	SHELBY	CARRIZO-WILCOX AQUIFER	1,673	66	0	0	12	801	2,552
1992	SHELBY	CARRIZO-WILCOX AQUIFER	1,875	63	0	0	12	779	2,729
1993	SHELBY	CARRIZO-WILCOX AQUIFER	1,681	49	0	0	29	781	2,540
1994	SHELBY	CARRIZO-WILCOX AQUIFER	1,568	57	0	0	32	1,107	2,764
1995	SHELBY	CARRIZO-WILCOX AQUIFER	1,501	45	0	0	29	1,137	2,712

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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1996	SHELBY	CARRIZO-WILCOX AQUIFER	1,478	50	0	0	29	1,161	2,718
1997	SHELBY	CARRIZO-WILCOX AQUIFER	1,494	57	0	0	29	1,201	2,781
1998	SHELBY	CARRIZO-WILCOX AQUIFER	1,623	62	0	0	29	1,231	2,945
1999	SHELBY	CARRIZO-WILCOX AQUIFER	1,716	71	0	0	29	1,329	3,145
2000	SHELBY	CARRIZO-WILCOX AQUIFER	2,351	64	0	0	26	1,393	3,834
2001	SHELBY	CARRIZO-WILCOX AQUIFER	1,975	48	0	0	20	1,048	3,091
2002	SHELBY	CARRIZO-WILCOX AQUIFER	1,927	36	0	0	24	1,051	3,038
2003	SHELBY	CARRIZO-WILCOX AQUIFER	1,913	14	0	0	22	1,074	3,023
2004	SHELBY	CARRIZO-WILCOX AQUIFER	1,931	1	0	0	20	1,099	3,051
2005	SHELBY	CARRIZO-WILCOX AQUIFER	2,155	1	0	0	23	562	2,741
2006	SHELBY	CARRIZO-WILCOX AQUIFER	2,062	1	0	0	27	588	2,678
2007	SHELBY	CARRIZO-WILCOX AQUIFER	1,888	0	0	0	20	579	2,487
2008	SHELBY	CARRIZO-WILCOX AQUIFER	1,757	0	0	0	25	530	2,312
2009	SHELBY	CARRIZO-WILCOX AQUIFER	2,046	0	0	0	0	571	2,617
2010	SHELBY	CARRIZO-WILCOX AQUIFER	2,484	0	0	0	0	459	2,943
2011	SHELBY	CARRIZO-WILCOX AQUIFER	2,910	0	0	0	13	452	3,375
2012	SHELBY	CARRIZO-WILCOX AQUIFER	2,731	0	0	0	8	437	3,176
2008	SHELBY	UNKNOWN	0	0	77	0	0	0	77
2009	SHELBY	UNKNOWN	0	0	359	0	0	0	359
2010	SHELBY	UNKNOWN	0	0	640	0	0	0	640
2011	SHELBY	UNKNOWN	0	0	1,380	0	0	0	1,380
2012	SHELBY	UNKNOWN	0	0	240	0	0	0	240
1980	SMITH	CARRIZO-WILCOX AQUIFER	16,100	10	329	0	25	90	16,554
1984	SMITH	CARRIZO-WILCOX AQUIFER	17,466	1,004	358	0	0	108	18,936
1985	SMITH	CARRIZO-WILCOX AQUIFER	17,215	1,020	506	0	0	91	18,832
1986	SMITH	CARRIZO-WILCOX AQUIFER	16,672	853	499	0	0	97	18,121
1987	SMITH	CARRIZO-WILCOX AQUIFER	17,175	744	465	0	0	91	18,475
1988	SMITH	CARRIZO-WILCOX AQUIFER	23,727	662	473	0	92	96	25,050
1989	SMITH	CARRIZO-WILCOX AQUIFER	16,878	637	441	0	20	99	18,075
1990	SMITH	CARRIZO-WILCOX AQUIFER	14,728	464	441	0	5	102	15,740
1991	SMITH	CARRIZO-WILCOX AQUIFER	14,744	390	435	0	5	104	15,678
1992	SMITH	CARRIZO-WILCOX AQUIFER	15,972	377	435	0	5	93	16,882
1993	SMITH	CARRIZO-WILCOX AQUIFER	17,194	328	422	0	57	87	18,088
1994	SMITH	CARRIZO-WILCOX AQUIFER	17,752	406	422	0	62	95	18,737
1995	SMITH	CARRIZO-WILCOX AQUIFER	19,503	418	161	0	56	89	20,227
1996	SMITH	CARRIZO-WILCOX AQUIFER	19,278	457	167	0	62	79	20,043
1997	SMITH	CARRIZO-WILCOX AQUIFER	18,764	406	167	0	62	79	19,478
1998	SMITH	CARRIZO-WILCOX AQUIFER	20,340	343	164	0	62	90	20,999
1999	SMITH	CARRIZO-WILCOX AQUIFER	20,937	387	165	0	62	100	21,651
2000	SMITH	CARRIZO-WILCOX AQUIFER	21,988	0	0	0	129	95	22,212
2001	SMITH	CARRIZO-WILCOX AQUIFER	21,336	0	0	0	86	49	21,471
2002	SMITH	CARRIZO-WILCOX AQUIFER	20,440	0	0	0	86	45	20,571
2003	SMITH	CARRIZO-WILCOX AQUIFER	20,815	263	0	0	79	42	21,199
2004	SMITH	CARRIZO-WILCOX AQUIFER	19,198	310	0	0	109	58	19,675
2005	SMITH	CARRIZO-WILCOX AQUIFER	19,771	289	0	0	103	152	20,315
2006	SMITH	CARRIZO-WILCOX AQUIFER	20,230	361	0	0	249	166	21,006
2007	SMITH	CARRIZO-WILCOX AQUIFER	19,611	453	0	0	0	168	20,232
2008	SMITH	CARRIZO-WILCOX AQUIFER	21,683	361	0	0	0	100	22,144
2009	SMITH	CARRIZO-WILCOX AQUIFER	11,334	196	0	0	251	128	11,909
2010	SMITH	CARRIZO-WILCOX AQUIFER	9,615	179	0	0	38	177	10,009
2011	SMITH	CARRIZO-WILCOX AQUIFER	12,990	154	0	0	180	178	13,502
2012	SMITH	CARRIZO-WILCOX AQUIFER	21,868	156	263	0	41	128	22,456
1992	SMITH	OTHER AQUIFER	0	58	0	0	0	0	58
1993	SMITH	OTHER AQUIFER	0	46	0	0	0	0	46
1994	SMITH	OTHER AQUIFER	0	49	0	0	0	0	49
1995	SMITH	OTHER AQUIFER	0	59	0	0	0	0	59
1996	SMITH	OTHER AQUIFER	0	40	0	0	0	0	40
1997	SMITH	OTHER AQUIFER	0	51	0	0	0	0	51
1998	SMITH	OTHER AQUIFER	0	7	0	0	0	0	7
1999	SMITH	OTHER AQUIFER	0	62	0	0	0	0	62
2000	SMITH	OTHER AQUIFER	0	57	0	0	0	0	57
2001	SMITH	OTHER AQUIFER	0	70	0	0	0	0	70
2002	SMITH	OTHER AQUIFER	0	71	0	0	0	0	71
2003	SMITH	OTHER AQUIFER	0	71	0	0	0	0	71
2008	SMITH	OTHER AQUIFER	0	133	0	0	0	0	133
2009	SMITH	OTHER AQUIFER	0	162	0	0	0	0	162
2010	SMITH	OTHER AQUIFER	0	180	0	0	0	0	180
2011	SMITH	OTHER AQUIFER	0	167	0	0	0	0	167
2012	SMITH	OTHER AQUIFER	0	120	0	0	0	0	120
1980	SMITH	QUEEN CITY AQUIFER	378	0	360	0	25	333	1,096
1984	SMITH	QUEEN CITY AQUIFER	343	44	147	0	0	403	937
1985	SMITH	QUEEN CITY AQUIFER	307	35	309	0	0	339	990
1986	SMITH	QUEEN CITY AQUIFER	312	32	273	0	0	367	984
1987	SMITH	QUEEN CITY AQUIFER	274	0	257	0	228	339	1,098
1988	SMITH	QUEEN CITY AQUIFER	288	0	266	0	91	358	1,003
1989	SMITH	QUEEN CITY AQUIFER	252	0	248	0	19	371	890
1990	SMITH	QUEEN CITY AQUIFER	518	0	248	0	5	381	1,152
1991	SMITH	QUEEN CITY AQUIFER	486	0	245	0	5	387	1,123

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1992	SMITH	QUEEN CITY AQUIFER	473	0	245	0	5	349	1,072
1993	SMITH	QUEEN CITY AQUIFER	507	0	238	0	57	326	1,128
1994	SMITH	QUEEN CITY AQUIFER	444	0	238	0	51	356	1,089
1995	SMITH	QUEEN CITY AQUIFER	680	0	90	0	44	332	1,146
1996	SMITH	QUEEN CITY AQUIFER	658	0	92	0	50	295	1,095
1997	SMITH	QUEEN CITY AQUIFER	589	0	92	0	50	295	1,026
1998	SMITH	QUEEN CITY AQUIFER	638	0	91	0	50	337	1,116
1999	SMITH	QUEEN CITY AQUIFER	658	0	92	0	50	372	1,172
2000	SMITH	QUEEN CITY AQUIFER	76	0	0	0	54	352	482
2001	SMITH	QUEEN CITY AQUIFER	75	0	0	0	34	201	310
2002	SMITH	QUEEN CITY AQUIFER	71	0	0	0	34	187	292
2003	SMITH	QUEEN CITY AQUIFER	74	0	0	0	31	175	280
2004	SMITH	QUEEN CITY AQUIFER	74	0	0	0	61	163	298
2005	SMITH	QUEEN CITY AQUIFER	83	0	0	0	57	430	570
2006	SMITH	QUEEN CITY AQUIFER	615	0	0	0	139	470	1,224
2007	SMITH	QUEEN CITY AQUIFER	517	0	0	0	0	476	993
2008	SMITH	QUEEN CITY AQUIFER	586	0	0	0	0	433	1,019
2009	SMITH	QUEEN CITY AQUIFER	941	0	0	0	141	327	1,409
2010	SMITH	QUEEN CITY AQUIFER	2,436	0	0	0	22	424	2,882
2011	SMITH	QUEEN CITY AQUIFER	2,415	0	0	0	101	427	2,943
2012	SMITH	QUEEN CITY AQUIFER	2,339	0	0	0	23	306	2,668
2000	SMITH	SPARTA AQUIFER	0	0	0	0	25	0	25
2001	SMITH	SPARTA AQUIFER	0	0	0	0	17	0	17
2002	SMITH	SPARTA AQUIFER	0	0	0	0	17	0	17
2003	SMITH	SPARTA AQUIFER	0	0	0	0	16	0	16
2004	SMITH	SPARTA AQUIFER	0	0	0	0	24	0	24
2005	SMITH	SPARTA AQUIFER	0	0	0	0	22	0	22
2006	SMITH	SPARTA AQUIFER	400	0	0	0	54	0	454
2007	SMITH	SPARTA AQUIFER	335	0	0	0	0	0	335
2008	SMITH	SPARTA AQUIFER	378	0	0	0	0	0	378
2009	SMITH	SPARTA AQUIFER	614	0	0	0	26	0	640
2010	SMITH	SPARTA AQUIFER	857	0	0	0	4	0	861
2011	SMITH	SPARTA AQUIFER	961	0	0	0	19	0	980
2012	SMITH	SPARTA AQUIFER	957	0	0	0	4	0	961
2008	SMITH	UNKNOWN	0	0	97	0	0	0	97
2009	SMITH	UNKNOWN	0	0	101	0	0	0	101
2010	SMITH	UNKNOWN	0	0	105	0	0	0	105
2011	SMITH	UNKNOWN	0	0	91	0	0	0	91
2012	SMITH	UNKNOWN	0	0	1	0	0	0	1
1980	TITUS	CARRIZO-WILCOX AQUIFER	422	316	0	62	0	356	1,156
1984	TITUS	CARRIZO-WILCOX AQUIFER	486	235	165	16	0	426	1,328
1985	TITUS	CARRIZO-WILCOX AQUIFER	409	290	359	2	0	362	1,422
1986	TITUS	CARRIZO-WILCOX AQUIFER	436	74	1,475	85	0	358	2,428
1987	TITUS	CARRIZO-WILCOX AQUIFER	448	145	319	4	0	376	1,292
1988	TITUS	CARRIZO-WILCOX AQUIFER	423	57	320	4	50	389	1,243
1989	TITUS	CARRIZO-WILCOX AQUIFER	446	242	318	31	0	400	1,437
1990	TITUS	CARRIZO-WILCOX AQUIFER	407	209	318	4	0	416	1,354
1991	TITUS	CARRIZO-WILCOX AQUIFER	405	115	1,736	4	0	424	2,684
1992	TITUS	CARRIZO-WILCOX AQUIFER	410	122	1,736	4	0	304	2,576
1993	TITUS	CARRIZO-WILCOX AQUIFER	430	112	1,729	4	0	322	2,597
1994	TITUS	CARRIZO-WILCOX AQUIFER	446	300	1,729	4	0	387	2,866
1995	TITUS	CARRIZO-WILCOX AQUIFER	487	120	1,729	0	0	375	2,711
1996	TITUS	CARRIZO-WILCOX AQUIFER	500	295	1,729	0	0	395	2,919
1997	TITUS	CARRIZO-WILCOX AQUIFER	527	223	1,729	0	0	356	2,835
1998	TITUS	CARRIZO-WILCOX AQUIFER	541	176	1,729	0	0	362	2,808
1999	TITUS	CARRIZO-WILCOX AQUIFER	535	199	1,729	0	0	383	2,846
2000	TITUS	CARRIZO-WILCOX AQUIFER	91	194	0	0	0	358	643
2001	TITUS	CARRIZO-WILCOX AQUIFER	92	104	0	0	0	184	380
2002	TITUS	CARRIZO-WILCOX AQUIFER	91	90	0	0	0	176	357
2003	TITUS	CARRIZO-WILCOX AQUIFER	92	104	0	0	0	154	350
2004	TITUS	CARRIZO-WILCOX AQUIFER	97	96	0	0	0	173	366
2005	TITUS	CARRIZO-WILCOX AQUIFER	102	93	0	0	0	183	378
2006	TITUS	CARRIZO-WILCOX AQUIFER	118	94	0	22	0	201	435
2007	TITUS	CARRIZO-WILCOX AQUIFER	100	80	0	0	0	157	337
2008	TITUS	CARRIZO-WILCOX AQUIFER	111	100	0	0	0	190	401
2009	TITUS	CARRIZO-WILCOX AQUIFER	115	91	0	0	46	198	450
2010	TITUS	CARRIZO-WILCOX AQUIFER	120	90	1	0	0	226	437
2011	TITUS	CARRIZO-WILCOX AQUIFER	141	90	1	0	109	224	565
2012	TITUS	CARRIZO-WILCOX AQUIFER	155	132	2	0	46	208	543
2002	TITUS	NACATOCH AQUIFER	63	0	0	0	0	0	63
2007	TITUS	NACATOCH AQUIFER	100	0	0	0	0	0	100
2008	TITUS	NACATOCH AQUIFER	100	0	0	0	0	0	100
2009	TITUS	NACATOCH AQUIFER	100	0	0	0	0	0	100
1980	TITUS	OTHER AQUIFER	128	0	0	0	0	59	187
1984	TITUS	OTHER AQUIFER	97	0	0	0	0	55	152
1985	TITUS	OTHER AQUIFER	125	0	0	0	0	46	171
1986	TITUS	OTHER AQUIFER	108	0	0	0	0	46	154
1987	TITUS	OTHER AQUIFER	48	0	0	0	0	48	96

Groundwater Pumping Estimates from Texas Water Development Board
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1988	TITUS	OTHER AQUIFER	46	0	0	0	0	50	96
1989	TITUS	OTHER AQUIFER	48	0	0	0	0	51	99
1990	TITUS	OTHER AQUIFER	96	0	0	0	0	53	149
1991	TITUS	OTHER AQUIFER	98	0	0	0	0	54	152
1992	TITUS	OTHER AQUIFER	100	0	0	0	0	39	139
1993	TITUS	OTHER AQUIFER	99	0	0	0	0	41	140
1994	TITUS	OTHER AQUIFER	102	0	0	0	0	49	151
1995	TITUS	OTHER AQUIFER	114	0	0	0	0	47	161
1996	TITUS	OTHER AQUIFER	117	0	0	0	0	50	167
1997	TITUS	OTHER AQUIFER	125	0	0	0	0	45	170
1998	TITUS	OTHER AQUIFER	128	0	0	0	0	46	174
1999	TITUS	OTHER AQUIFER	127	0	0	0	0	48	175
2000	TITUS	OTHER AQUIFER	8	0	0	0	0	45	53
2001	TITUS	OTHER AQUIFER	8	0	0	0	0	26	34
2002	TITUS	OTHER AQUIFER	9	0	0	0	0	25	34
2003	TITUS	OTHER AQUIFER	9	0	0	0	0	22	31
2004	TITUS	OTHER AQUIFER	9	0	0	0	0	0	9
2005	TITUS	OTHER AQUIFER	9	0	0	0	0	0	9
2008	TITUS	UNKNOWN	0	0	400	0	0	0	400
2009	TITUS	UNKNOWN	0	0	402	0	0	0	402
2010	TITUS	UNKNOWN	0	0	405	0	0	0	405
2011	TITUS	UNKNOWN	0	0	91	0	0	0	91
1988	TRINITY	GULF COAST AQUIFER	24	0	0	0	0	0	24
1989	TRINITY	GULF COAST AQUIFER	24	0	0	0	0	0	24
1990	TRINITY	GULF COAST AQUIFER	39	0	0	0	0	0	39
1991	TRINITY	GULF COAST AQUIFER	39	0	0	0	0	0	39
1992	TRINITY	GULF COAST AQUIFER	39	0	0	0	0	0	39
1993	TRINITY	GULF COAST AQUIFER	31	0	0	0	0	0	31
1994	TRINITY	GULF COAST AQUIFER	35	0	0	0	0	0	35
1995	TRINITY	GULF COAST AQUIFER	53	0	0	0	0	0	53
1996	TRINITY	GULF COAST AQUIFER	38	0	0	0	0	0	38
1997	TRINITY	GULF COAST AQUIFER	38	0	0	0	0	0	38
1998	TRINITY	GULF COAST AQUIFER	38	0	0	0	0	0	38
1999	TRINITY	GULF COAST AQUIFER	21	0	0	0	0	0	21
2000	TRINITY	GULF COAST AQUIFER	73	0	0	0	0	0	73
2001	TRINITY	GULF COAST AQUIFER	140	0	0	0	0	0	140
2002	TRINITY	GULF COAST AQUIFER	141	0	0	0	0	0	141
2003	TRINITY	GULF COAST AQUIFER	139	0	0	0	0	0	139
2004	TRINITY	GULF COAST AQUIFER	147	0	0	0	0	0	147
2005	TRINITY	GULF COAST AQUIFER	82	0	0	0	0	0	82
2006	TRINITY	GULF COAST AQUIFER	396	0	0	0	0	0	396
2007	TRINITY	GULF COAST AQUIFER	492	0	0	0	0	0	492
2008	TRINITY	GULF COAST AQUIFER	349	0	0	0	0	0	349
2009	TRINITY	GULF COAST AQUIFER	367	0	0	0	0	0	367
2010	TRINITY	GULF COAST AQUIFER	419	0	0	0	0	0	419
2011	TRINITY	GULF COAST AQUIFER	460	0	0	0	0	0	460
2012	TRINITY	GULF COAST AQUIFER	333	0	0	0	0	0	333
1980	TRINITY	OTHER AQUIFER	1,325	0	0	0	0	136	1,461
1984	TRINITY	OTHER AQUIFER	501	0	0	0	0	224	725
1985	TRINITY	OTHER AQUIFER	528	0	0	0	0	224	752
1986	TRINITY	OTHER AQUIFER	549	0	0	0	0	224	773
1987	TRINITY	OTHER AQUIFER	695	0	0	0	0	210	905
1988	TRINITY	OTHER AQUIFER	785	0	0	0	50	222	1,057
1989	TRINITY	OTHER AQUIFER	863	0	0	0	3	193	1,059
1990	TRINITY	OTHER AQUIFER	976	0	0	0	4	191	1,171
1991	TRINITY	OTHER AQUIFER	1,049	0	8	0	4	195	1,256
1992	TRINITY	OTHER AQUIFER	891	0	8	0	4	234	1,137
1993	TRINITY	OTHER AQUIFER	754	0	8	0	3	214	979
1994	TRINITY	OTHER AQUIFER	832	0	8	0	3	180	1,023
1995	TRINITY	OTHER AQUIFER	640	0	8	0	3	180	831
1996	TRINITY	OTHER AQUIFER	767	0	8	0	3	174	952
1997	TRINITY	OTHER AQUIFER	1,125	0	8	0	3	187	1,323
1998	TRINITY	OTHER AQUIFER	1,126	0	8	0	3	164	1,301
1999	TRINITY	OTHER AQUIFER	613	0	8	0	3	174	798
2000	TRINITY	OTHER AQUIFER	1,199	0	0	0	0	0	1,199
2001	TRINITY	OTHER AQUIFER	843	0	0	0	0	0	843
2002	TRINITY	OTHER AQUIFER	787	0	0	0	0	0	787
2003	TRINITY	OTHER AQUIFER	784	0	0	0	0	0	784
2004	TRINITY	OTHER AQUIFER	767	0	0	0	0	0	767
2005	TRINITY	OTHER AQUIFER	832	0	0	0	0	0	832
2006	TRINITY	OTHER AQUIFER	460	0	0	0	0	0	460
2007	TRINITY	OTHER AQUIFER	456	0	0	0	0	0	456
2008	TRINITY	OTHER AQUIFER	507	0	0	0	0	0	507
2009	TRINITY	OTHER AQUIFER	724	0	0	0	0	0	724
2010	TRINITY	OTHER AQUIFER	416	0	0	0	0	0	416
2011	TRINITY	OTHER AQUIFER	297	0	0	0	0	0	297
2012	TRINITY	OTHER AQUIFER	253	0	0	0	0	0	253
2000	TRINITY	TRINITY AQUIFER	0	0	0	0	0	0	0

Groundwater Pumping Estimates from Texas Water Development Board
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Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2001	TRINITY	TRINITY AQUIFER	0	0	0	0	0	0	0
2002	TRINITY	TRINITY AQUIFER	0	0	0	0	0	0	0
2003	TRINITY	TRINITY AQUIFER	0	0	0	0	0	0	0
2005	TRINITY	TRINITY AQUIFER	0	0	0	0	0	0	0
2006	TRINITY	TRINITY AQUIFER	0	0	0	0	50	0	50
2007	TRINITY	TRINITY AQUIFER	0	0	0	0	0	0	0
2009	TRINITY	TRINITY AQUIFER	0	0	0	0	0	0	0
2011	TRINITY	TRINITY AQUIFER	0	0	0	0	43	0	43
2012	TRINITY	TRINITY AQUIFER	0	0	0	0	42	0	42
2008	TRINITY	UNKNOWN	0	0	0	0	0	0	0
2009	TRINITY	UNKNOWN	0	0	0	0	0	0	0
2010	TRINITY	UNKNOWN	0	0	6	0	0	0	6
2011	TRINITY	UNKNOWN	0	0	3	0	0	0	3
2000	TRINITY	YEGUA-JACKSON AQUIFER	0	0	0	0	0	162	162
2001	TRINITY	YEGUA-JACKSON AQUIFER	0	0	0	0	0	88	88
2002	TRINITY	YEGUA-JACKSON AQUIFER	0	0	0	0	0	82	82
2003	TRINITY	YEGUA-JACKSON AQUIFER	0	0	0	0	0	91	91
2004	TRINITY	YEGUA-JACKSON AQUIFER	0	0	0	0	0	91	91
2005	TRINITY	YEGUA-JACKSON AQUIFER	0	0	0	0	0	28	28
2006	TRINITY	YEGUA-JACKSON AQUIFER	194	0	0	0	50	28	272
2007	TRINITY	YEGUA-JACKSON AQUIFER	162	0	0	0	0	23	185
2008	TRINITY	YEGUA-JACKSON AQUIFER	179	0	0	0	0	20	199
2009	TRINITY	YEGUA-JACKSON AQUIFER	186	0	0	0	0	19	205
2010	TRINITY	YEGUA-JACKSON AQUIFER	390	0	0	0	0	24	414
2011	TRINITY	YEGUA-JACKSON AQUIFER	472	0	0	0	43	23	538
2012	TRINITY	YEGUA-JACKSON AQUIFER	434	0	0	0	41	18	493
1980	UPSHUR	CARRIZO-WILCOX AQUIFER	2,388	296	1	0	0	55	2,740
1984	UPSHUR	CARRIZO-WILCOX AQUIFER	3,077	157	1	0	0	113	3,348
1985	UPSHUR	CARRIZO-WILCOX AQUIFER	3,113	99	0	0	0	98	3,310
1986	UPSHUR	CARRIZO-WILCOX AQUIFER	2,687	90	0	0	0	106	2,883
1987	UPSHUR	CARRIZO-WILCOX AQUIFER	2,819	121	0	0	0	101	3,041
1988	UPSHUR	CARRIZO-WILCOX AQUIFER	2,919	163	0	0	0	98	3,180
1989	UPSHUR	CARRIZO-WILCOX AQUIFER	2,869	157	0	0	0	98	3,124
1990	UPSHUR	CARRIZO-WILCOX AQUIFER	2,800	171	0	0	0	131	3,102
1991	UPSHUR	CARRIZO-WILCOX AQUIFER	2,775	188	1	0	0	130	3,094
1992	UPSHUR	CARRIZO-WILCOX AQUIFER	2,479	225	1	0	0	191	2,896
1993	UPSHUR	CARRIZO-WILCOX AQUIFER	2,664	206	1	0	11	208	3,090
1994	UPSHUR	CARRIZO-WILCOX AQUIFER	2,890	146	1	0	15	190	3,242
1995	UPSHUR	CARRIZO-WILCOX AQUIFER	2,911	150	1	0	15	167	3,244
1996	UPSHUR	CARRIZO-WILCOX AQUIFER	2,882	146	1	0	15	239	3,283
1997	UPSHUR	CARRIZO-WILCOX AQUIFER	3,054	164	1	0	15	150	3,384
1998	UPSHUR	CARRIZO-WILCOX AQUIFER	3,355	160	1	0	15	150	3,681
1999	UPSHUR	CARRIZO-WILCOX AQUIFER	3,350	129	1	0	15	154	3,649
2000	UPSHUR	CARRIZO-WILCOX AQUIFER	3,397	153	0	0	0	152	3,702
2001	UPSHUR	CARRIZO-WILCOX AQUIFER	3,315	183	0	0	0	98	3,596
2002	UPSHUR	CARRIZO-WILCOX AQUIFER	3,275	134	0	0	0	94	3,503
2003	UPSHUR	CARRIZO-WILCOX AQUIFER	3,340	100	0	0	0	95	3,535
2004	UPSHUR	CARRIZO-WILCOX AQUIFER	3,272	31	0	0	0	221	3,524
2005	UPSHUR	CARRIZO-WILCOX AQUIFER	3,638	35	0	0	0	128	3,801
2006	UPSHUR	CARRIZO-WILCOX AQUIFER	3,630	47	0	0	0	120	3,797
2007	UPSHUR	CARRIZO-WILCOX AQUIFER	3,060	38	0	0	100	106	3,304
2008	UPSHUR	CARRIZO-WILCOX AQUIFER	2,942	46	0	0	0	127	3,115
2009	UPSHUR	CARRIZO-WILCOX AQUIFER	2,982	36	0	0	0	135	3,153
2010	UPSHUR	CARRIZO-WILCOX AQUIFER	3,246	41	0	0	58	100	3,445
2011	UPSHUR	CARRIZO-WILCOX AQUIFER	3,519	32	0	0	54	101	3,706
2012	UPSHUR	CARRIZO-WILCOX AQUIFER	3,105	35	0	0	1	90	3,231
2004	UPSHUR	OTHER AQUIFER	0	0	0	0	0	43	43
2005	UPSHUR	OTHER AQUIFER	0	0	0	0	0	25	25
2006	UPSHUR	OTHER AQUIFER	0	0	0	0	0	24	24
2007	UPSHUR	OTHER AQUIFER	0	0	0	0	0	21	21
2008	UPSHUR	OTHER AQUIFER	0	0	0	0	0	13	13
2009	UPSHUR	OTHER AQUIFER	0	0	0	0	0	13	13
2010	UPSHUR	OTHER AQUIFER	0	0	0	0	0	15	15
2011	UPSHUR	OTHER AQUIFER	0	0	0	0	0	15	15
2012	UPSHUR	OTHER AQUIFER	0	0	0	0	0	14	14
1980	UPSHUR	QUEEN CITY AQUIFER	803	16	1	0	0	364	1,184
1984	UPSHUR	QUEEN CITY AQUIFER	694	0	0	0	0	341	1,035
1985	UPSHUR	QUEEN CITY AQUIFER	677	0	0	0	0	296	973
1986	UPSHUR	QUEEN CITY AQUIFER	631	0	0	0	0	316	947
1987	UPSHUR	QUEEN CITY AQUIFER	666	0	0	0	0	303	969
1988	UPSHUR	QUEEN CITY AQUIFER	601	0	0	0	0	296	897
1989	UPSHUR	QUEEN CITY AQUIFER	615	0	0	0	0	296	911
1990	UPSHUR	QUEEN CITY AQUIFER	843	0	0	0	0	399	1,242
1991	UPSHUR	QUEEN CITY AQUIFER	857	0	0	0	0	395	1,252
1992	UPSHUR	QUEEN CITY AQUIFER	850	0	0	0	0	580	1,430
1993	UPSHUR	QUEEN CITY AQUIFER	819	1	0	0	4	630	1,454
1994	UPSHUR	QUEEN CITY AQUIFER	781	0	0	0	0	578	1,359
1995	UPSHUR	QUEEN CITY AQUIFER	846	0	0	0	0	506	1,352

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1996	UPSHUR	QUEEN CITY AQUIFER	814	0	0	0	0	724	1,538
1997	UPSHUR	QUEEN CITY AQUIFER	836	0	0	0	0	453	1,289
1998	UPSHUR	QUEEN CITY AQUIFER	918	0	0	0	0	452	1,370
1999	UPSHUR	QUEEN CITY AQUIFER	917	0	0	0	0	463	1,380
2000	UPSHUR	QUEEN CITY AQUIFER	384	0	0	0	0	460	844
2001	UPSHUR	QUEEN CITY AQUIFER	408	0	0	0	0	297	705
2002	UPSHUR	QUEEN CITY AQUIFER	400	0	0	0	0	284	684
2003	UPSHUR	QUEEN CITY AQUIFER	389	0	0	0	0	288	677
2004	UPSHUR	QUEEN CITY AQUIFER	383	0	0	0	0	111	494
2005	UPSHUR	QUEEN CITY AQUIFER	396	0	0	0	0	64	460
2006	UPSHUR	QUEEN CITY AQUIFER	550	0	0	0	0	60	610
2007	UPSHUR	QUEEN CITY AQUIFER	495	0	0	0	100	53	648
2008	UPSHUR	QUEEN CITY AQUIFER	526	0	0	0	0	63	589
2009	UPSHUR	QUEEN CITY AQUIFER	561	0	0	0	0	67	628
2010	UPSHUR	QUEEN CITY AQUIFER	590	0	0	0	58	50	698
2011	UPSHUR	QUEEN CITY AQUIFER	585	0	0	0	54	50	689
2012	UPSHUR	QUEEN CITY AQUIFER	573	0	0	0	1	45	619
2008	UPSHUR	UNKNOWN	0	0	28	0	0	0	28
2009	UPSHUR	UNKNOWN	0	0	35	0	0	0	35
2010	UPSHUR	UNKNOWN	0	0	41	0	0	0	41
2011	UPSHUR	UNKNOWN	0	0	44	0	0	0	44
2012	UPSHUR	UNKNOWN	0	0	1	0	0	0	1
1980	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,644	684	1,795	0	0	627	5,750
1984	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,716	343	888	0	0	774	4,721
1985	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,631	191	1,291	0	0	664	4,777
1986	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,733	268	1,039	0	0	752	4,792
1987	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,731	422	947	0	0	677	4,777
1988	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,855	396	923	0	0	700	4,874
1989	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,808	415	778	0	0	721	4,722
1990	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,801	159	778	0	0	759	4,497
1991	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,819	156	1,061	0	0	769	4,805
1992	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,798	190	1,044	0	0	818	4,850
1993	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,911	339	1,044	0	19	787	5,100
1994	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,891	139	1,067	0	30	821	4,948
1995	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,033	255	1,074	0	19	848	5,229
1996	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,012	574	1,093	0	112	793	5,584
1997	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,326	178	1,093	0	91	844	5,532
1998	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,644	258	669	0	623	784	5,978
1999	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,504	292	673	0	146	838	5,453
2000	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,522	0	225	0	33	835	3,615
2001	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,071	0	73	0	33	305	3,482
2002	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,867	0	102	0	33	300	3,302
2003	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,916	0	252	0	0	314	3,482
2004	VAN ZANDT	CARRIZO-WILCOX AQUIFER	2,755	0	337	0	0	296	3,388
2005	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,871	0	220	0	0	501	4,592
2006	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,617	0	384	0	80	512	4,593
2007	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,257	0	156	0	0	332	3,745
2008	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,185	289	0	0	0	514	3,988
2009	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,076	253	0	0	33	543	3,905
2010	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,910	0	0	0	87	469	4,466
2011	VAN ZANDT	CARRIZO-WILCOX AQUIFER	4,410	189	0	0	143	470	5,212
2012	VAN ZANDT	CARRIZO-WILCOX AQUIFER	3,891	167	0	0	1	430	4,489
1980	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1984	VAN ZANDT	OTHER AQUIFER	6	0	0	0	0	10	16
1985	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1986	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1987	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1988	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1989	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1990	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1991	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1992	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1993	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1994	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1995	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1996	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1997	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1998	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
1999	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
2000	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	4	4
2001	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	2	2
2002	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	2	2
2003	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	2	2
2004	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	49	49
2005	VAN ZANDT	OTHER AQUIFER	0	0	0	0	0	83	83
2006	VAN ZANDT	OTHER AQUIFER	54	0	0	0	0	85	139
2007	VAN ZANDT	OTHER AQUIFER	45	0	0	0	0	55	100
2008	VAN ZANDT	OTHER AQUIFER	50	0	0	0	0	44	94

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

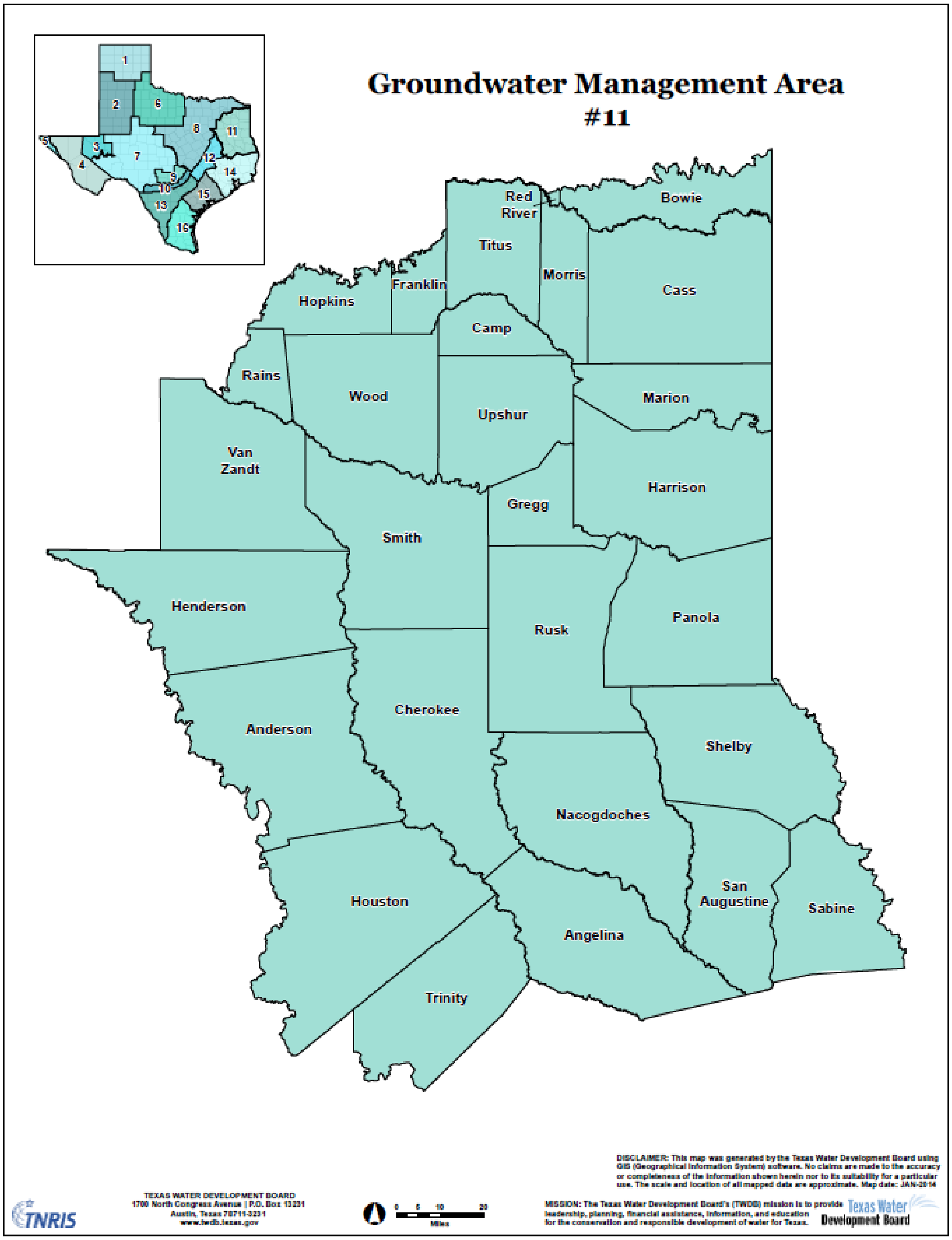
Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2009	VAN ZANDT	OTHER AQUIFER	102	0	0	0	0	47	149
2010	VAN ZANDT	OTHER AQUIFER	155	0	0	0	0	43	198
2011	VAN ZANDT	OTHER AQUIFER	168	0	0	0	0	43	211
2012	VAN ZANDT	OTHER AQUIFER	147	0	0	0	0	39	186
1980	VAN ZANDT	QUEEN CITY AQUIFER	71	0	0	0	0	101	172
1984	VAN ZANDT	QUEEN CITY AQUIFER	102	0	58	0	0	125	285
1985	VAN ZANDT	QUEEN CITY AQUIFER	112	0	239	0	0	107	458
1986	VAN ZANDT	QUEEN CITY AQUIFER	125	0	4	0	0	121	250
1987	VAN ZANDT	QUEEN CITY AQUIFER	122	0	3	0	0	109	234
1988	VAN ZANDT	QUEEN CITY AQUIFER	120	0	4	0	0	113	237
1989	VAN ZANDT	QUEEN CITY AQUIFER	56	0	3	0	0	116	175
1990	VAN ZANDT	QUEEN CITY AQUIFER	136	0	3	0	0	122	261
1991	VAN ZANDT	QUEEN CITY AQUIFER	145	0	24	0	0	124	293
1992	VAN ZANDT	QUEEN CITY AQUIFER	137	0	24	0	0	132	293
1993	VAN ZANDT	QUEEN CITY AQUIFER	127	0	24	0	0	127	278
1994	VAN ZANDT	QUEEN CITY AQUIFER	123	0	24	0	0	132	279
1995	VAN ZANDT	QUEEN CITY AQUIFER	0	0	24	0	0	137	161
1996	VAN ZANDT	QUEEN CITY AQUIFER	0	0	24	0	0	128	152
1997	VAN ZANDT	QUEEN CITY AQUIFER	0	0	24	0	0	136	160
1998	VAN ZANDT	QUEEN CITY AQUIFER	0	0	15	0	0	126	141
1999	VAN ZANDT	QUEEN CITY AQUIFER	0	0	14	0	0	135	149
2000	VAN ZANDT	QUEEN CITY AQUIFER	0	0	0	0	0	135	135
2001	VAN ZANDT	QUEEN CITY AQUIFER	0	0	0	0	0	37	37
2002	VAN ZANDT	QUEEN CITY AQUIFER	0	0	0	0	0	36	36
2003	VAN ZANDT	QUEEN CITY AQUIFER	0	0	0	0	0	38	38
2006	VAN ZANDT	QUEEN CITY AQUIFER	39	0	0	0	0	0	39
2007	VAN ZANDT	QUEEN CITY AQUIFER	33	0	0	0	0	0	33
2008	VAN ZANDT	QUEEN CITY AQUIFER	36	0	0	0	0	0	36
2009	VAN ZANDT	QUEEN CITY AQUIFER	73	0	0	0	0	0	73
2010	VAN ZANDT	QUEEN CITY AQUIFER	112	0	0	0	0	0	112
2011	VAN ZANDT	QUEEN CITY AQUIFER	121	0	0	0	0	0	121
2012	VAN ZANDT	QUEEN CITY AQUIFER	236	0	0	0	0	0	236
2008	VAN ZANDT	UNKNOWN	0	0	113	0	0	0	113
2009	VAN ZANDT	UNKNOWN	0	0	118	0	0	0	118
2010	VAN ZANDT	UNKNOWN	0	0	123	0	0	0	123
2011	VAN ZANDT	UNKNOWN	0	0	123	0	0	0	123
2012	VAN ZANDT	UNKNOWN	0	0	1	0	0	0	1
1980	WOOD	CARRIZO-WILCOX AQUIFER	3,301	22	4	0	0	136	3,463
1984	WOOD	CARRIZO-WILCOX AQUIFER	4,208	3	1,003	0	328	141	5,683
1985	WOOD	CARRIZO-WILCOX AQUIFER	4,220	3	1,547	0	382	133	6,285
1986	WOOD	CARRIZO-WILCOX AQUIFER	4,186	3	1,387	0	400	136	6,112
1987	WOOD	CARRIZO-WILCOX AQUIFER	4,486	41	1,319	0	187	142	6,175
1988	WOOD	CARRIZO-WILCOX AQUIFER	4,681	38	1,204	0	76	135	6,134
1989	WOOD	CARRIZO-WILCOX AQUIFER	4,483	8	1,121	0	195	141	5,948
1990	WOOD	CARRIZO-WILCOX AQUIFER	3,628	2	4	0	165	181	3,980
1991	WOOD	CARRIZO-WILCOX AQUIFER	3,542	4	0	0	165	180	3,891
1992	WOOD	CARRIZO-WILCOX AQUIFER	3,686	2	0	0	165	255	4,108
1993	WOOD	CARRIZO-WILCOX AQUIFER	3,769	0	0	0	71	251	4,091
1994	WOOD	CARRIZO-WILCOX AQUIFER	4,009	0	0	0	135	253	4,397
1995	WOOD	CARRIZO-WILCOX AQUIFER	4,149	0	0	0	131	255	4,535
1996	WOOD	CARRIZO-WILCOX AQUIFER	4,244	0	0	0	103	272	4,619
1997	WOOD	CARRIZO-WILCOX AQUIFER	4,593	0	0	0	103	225	4,921
1998	WOOD	CARRIZO-WILCOX AQUIFER	4,787	0	0	0	103	210	5,100
1999	WOOD	CARRIZO-WILCOX AQUIFER	4,500	0	0	0	103	226	4,829
2000	WOOD	CARRIZO-WILCOX AQUIFER	4,697	2	0	0	103	208	5,010
2001	WOOD	CARRIZO-WILCOX AQUIFER	4,830	0	0	0	78	171	5,079
2002	WOOD	CARRIZO-WILCOX AQUIFER	4,943	0	0	0	78	181	5,202
2003	WOOD	CARRIZO-WILCOX AQUIFER	5,138	193	0	0	81	181	5,593
2004	WOOD	CARRIZO-WILCOX AQUIFER	5,608	193	0	0	83	493	6,377
2005	WOOD	CARRIZO-WILCOX AQUIFER	5,819	460	0	0	82	80	6,441
2006	WOOD	CARRIZO-WILCOX AQUIFER	5,257	677	0	0	3	63	6,000
2007	WOOD	CARRIZO-WILCOX AQUIFER	5,041	629	0	0	56	50	5,776
2008	WOOD	CARRIZO-WILCOX AQUIFER	4,935	617	0	0	0	63	5,615
2009	WOOD	CARRIZO-WILCOX AQUIFER	6,235	617	0	0	0	67	6,919
2010	WOOD	CARRIZO-WILCOX AQUIFER	5,565	663	0	0	215	63	6,506
2011	WOOD	CARRIZO-WILCOX AQUIFER	5,792	663	0	0	163	63	6,681
2012	WOOD	CARRIZO-WILCOX AQUIFER	6,238	663	0	0	109	60	7,070
2004	WOOD	OTHER AQUIFER	0	0	0	0	0	35	35
2005	WOOD	OTHER AQUIFER	0	0	0	0	0	6	6
2006	WOOD	OTHER AQUIFER	0	0	0	0	0	4	4
2007	WOOD	OTHER AQUIFER	0	0	0	0	0	4	4
2008	WOOD	OTHER AQUIFER	0	0	0	0	0	4	4
2009	WOOD	OTHER AQUIFER	0	0	0	0	0	4	4
2010	WOOD	OTHER AQUIFER	0	0	0	0	0	4	4
2011	WOOD	OTHER AQUIFER	0	0	0	0	0	4	4
2012	WOOD	OTHER AQUIFER	0	0	0	0	0	4	4
1980	WOOD	QUEEN CITY AQUIFER	520	0	2,842	0	0	409	3,771
1984	WOOD	QUEEN CITY AQUIFER	165	0	2,616	0	137	424	3,342

Groundwater Pumping Estimates from Texas Water Development Board
Organized by County and Aquifer
All Values in AF/yr

Year	County	Aquifer	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
1985	WOOD	QUEEN CITY AQUIFER	161	0	3,182	0	128	400	3,871
1986	WOOD	QUEEN CITY AQUIFER	168	0	2,619	0	133	410	3,330
1987	WOOD	QUEEN CITY AQUIFER	170	0	2,258	0	63	427	2,918
1988	WOOD	QUEEN CITY AQUIFER	166	0	2,034	0	26	406	2,632
1989	WOOD	QUEEN CITY AQUIFER	165	0	2,040	0	65	426	2,696
1990	WOOD	QUEEN CITY AQUIFER	198	0	3,157	0	54	545	3,954
1991	WOOD	QUEEN CITY AQUIFER	214	0	2,841	0	54	542	3,651
1992	WOOD	QUEEN CITY AQUIFER	223	0	2,488	0	54	770	3,535
1993	WOOD	QUEEN CITY AQUIFER	233	0	2,535	0	23	757	3,548
1994	WOOD	QUEEN CITY AQUIFER	237	0	2,626	0	0	761	3,624
1995	WOOD	QUEEN CITY AQUIFER	309	0	560	0	0	766	1,635
1996	WOOD	QUEEN CITY AQUIFER	336	0	560	0	0	819	1,715
1997	WOOD	QUEEN CITY AQUIFER	246	0	488	0	0	676	1,410
1998	WOOD	QUEEN CITY AQUIFER	256	0	280	0	0	629	1,165
1999	WOOD	QUEEN CITY AQUIFER	241	0	280	0	0	678	1,199
2000	WOOD	QUEEN CITY AQUIFER	382	0	0	0	46	617	1,045
2001	WOOD	QUEEN CITY AQUIFER	331	0	0	0	34	510	875
2002	WOOD	QUEEN CITY AQUIFER	362	0	0	0	34	536	932
2003	WOOD	QUEEN CITY AQUIFER	378	0	0	0	36	539	953
2004	WOOD	QUEEN CITY AQUIFER	266	0	0	0	36	130	432
2005	WOOD	QUEEN CITY AQUIFER	264	0	0	0	28	21	313
2006	WOOD	QUEEN CITY AQUIFER	256	0	0	0	1	17	274
2007	WOOD	QUEEN CITY AQUIFER	130	0	0	0	24	13	167
2008	WOOD	QUEEN CITY AQUIFER	163	0	0	0	0	17	180
2009	WOOD	QUEEN CITY AQUIFER	172	0	0	0	0	18	190
2010	WOOD	QUEEN CITY AQUIFER	181	0	0	0	91	17	289
2011	WOOD	QUEEN CITY AQUIFER	131	0	0	0	69	17	217
2012	WOOD	QUEEN CITY AQUIFER	105	0	0	0	46	16	167
2004	WOOD	SPARTA AQUIFER	0	0	0	0	0	35	35
2005	WOOD	SPARTA AQUIFER	0	0	0	0	0	6	6
2006	WOOD	SPARTA AQUIFER	53	0	0	0	0	4	57
2007	WOOD	SPARTA AQUIFER	44	0	0	0	0	4	48
2008	WOOD	SPARTA AQUIFER	49	0	0	0	0	4	53
2009	WOOD	SPARTA AQUIFER	54	0	0	0	0	4	58
2010	WOOD	SPARTA AQUIFER	59	0	0	0	0	4	63
2011	WOOD	SPARTA AQUIFER	64	0	0	0	0	4	68
2012	WOOD	SPARTA AQUIFER	50	0	0	0	0	4	54
2008	WOOD	UNKNOWN	0	0	5	0	0	0	5
2009	WOOD	UNKNOWN	0	0	8	0	0	0	8
2010	WOOD	UNKNOWN	0	0	12	0	0	0	12
2011	WOOD	UNKNOWN	0	0	12	0	0	0	12
2012	WOOD	UNKNOWN	0	0	2	0	0	0	2

Appendix C

Graphical Comparison of TWDB Historic Pumping Estimates, Calibrated GAM Pumping Estimates and Modeled Available Groundwater for Groundwater Management Area 11


Groundwater Management Area
#11
1
2
6
8
11
5
3
7
12
4
9
14
10
15
13
16
Red River
Bowie
Titus
Morris
Cass
Franklin
Hopkins
Camp
Rains
Wood
Upshur
Marion
Van Zandt
Gregg
Harrison
Smith
Henderson
Rusk
Panola
Cherokee
Anderson
Shelby
Nacogdoches
Houston
San Augustine
Sabine
Angelina
Trinity
DISCLAIMER: This map was generated by the Texas Water Development Board using GIS (Geographical Information System) software. No claims are made to the accuracy or completeness of the information shown herein nor to its suitability for a particular use. The scale and location of all mapped data are approximate. Map date: JAN-2014
TNRIS
TEXAS WATER DEVELOPMENT BOARD
1700 North Congress Avenue | P.O. Box 13231
Austin, Texas 78711-3231
www.twdb.texas.gov
0
5
10
20
Miles
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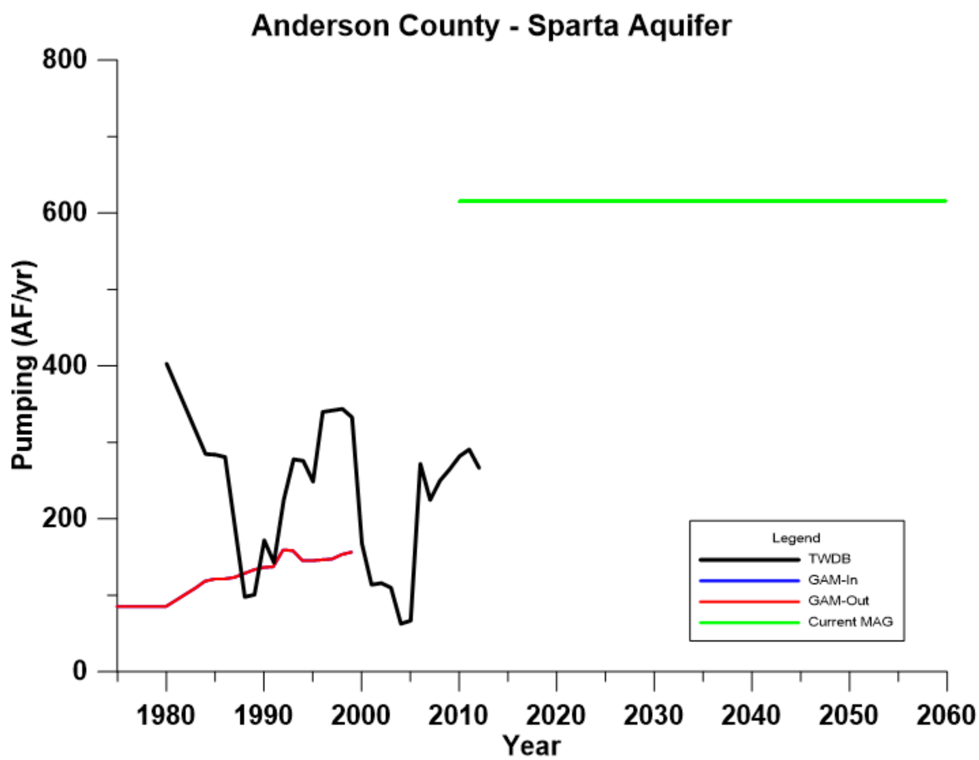
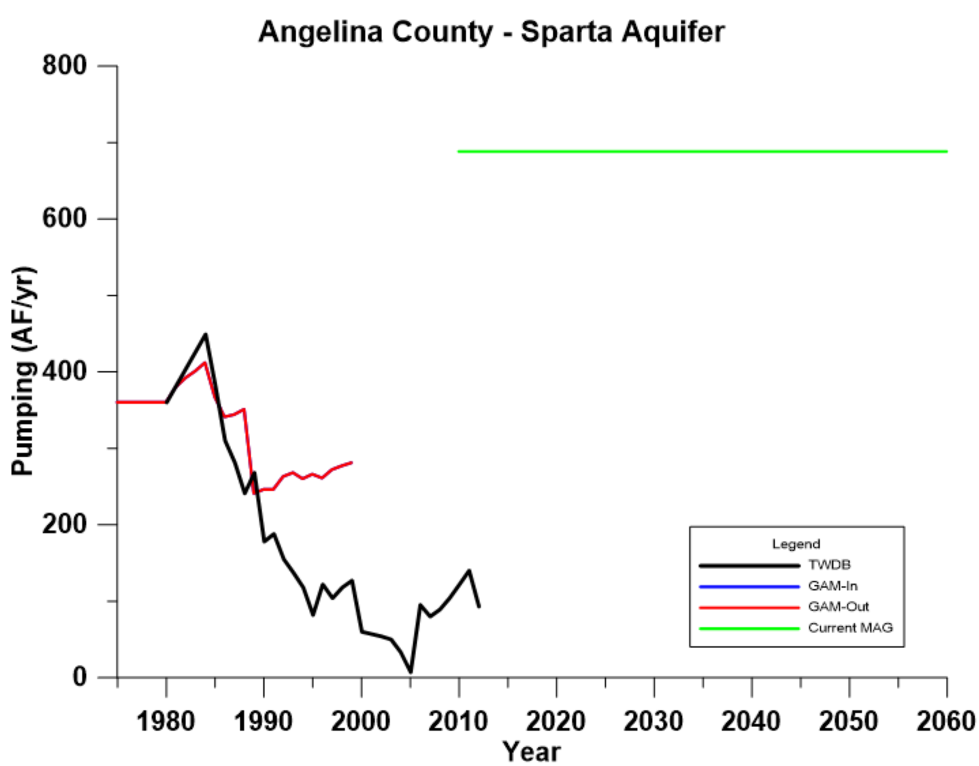
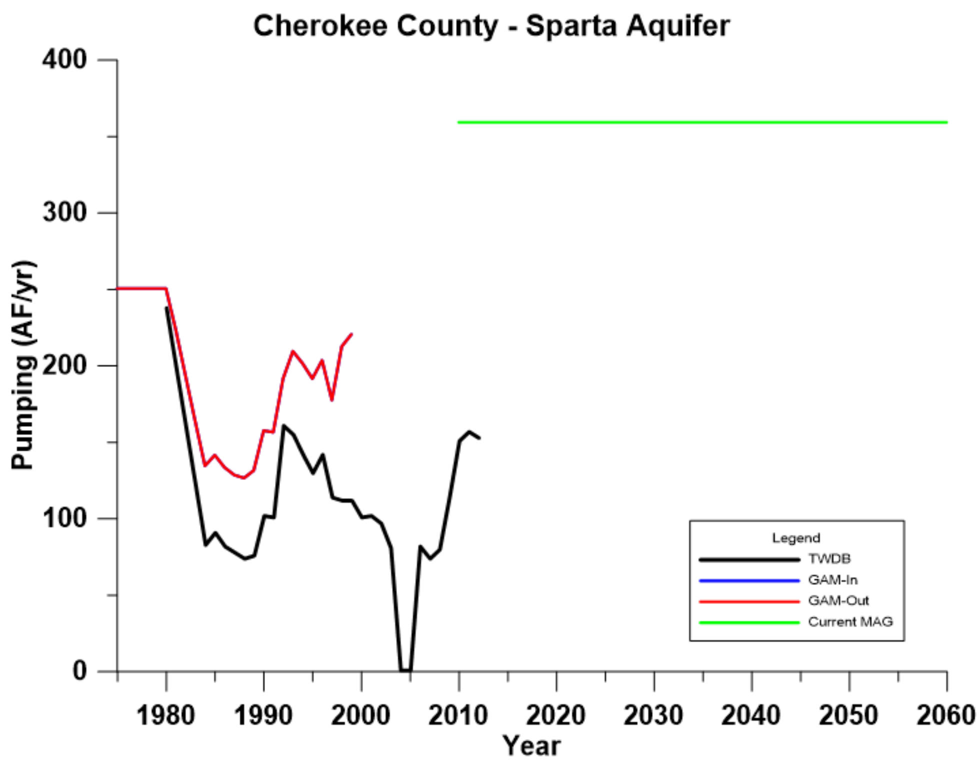
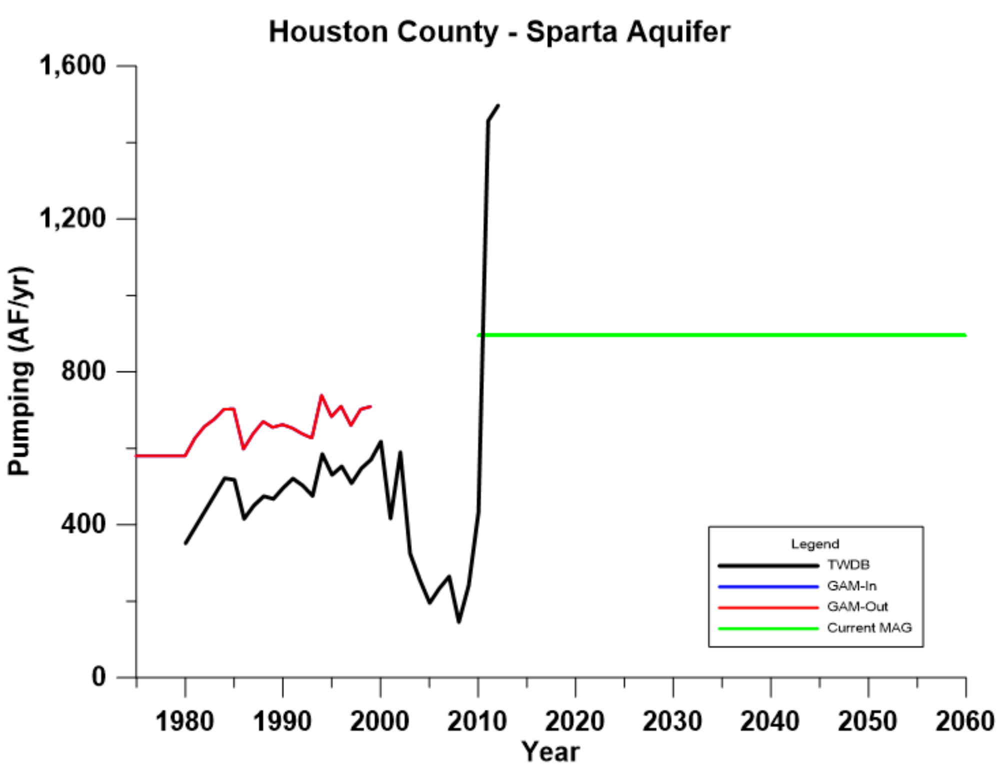
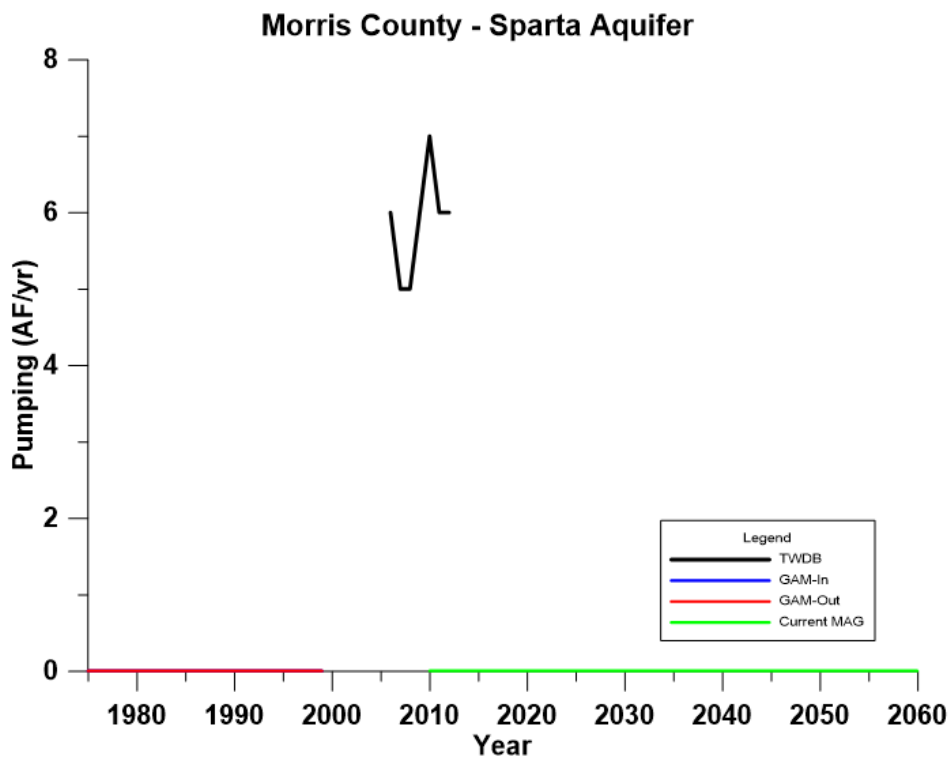
Texas Water
Development Board

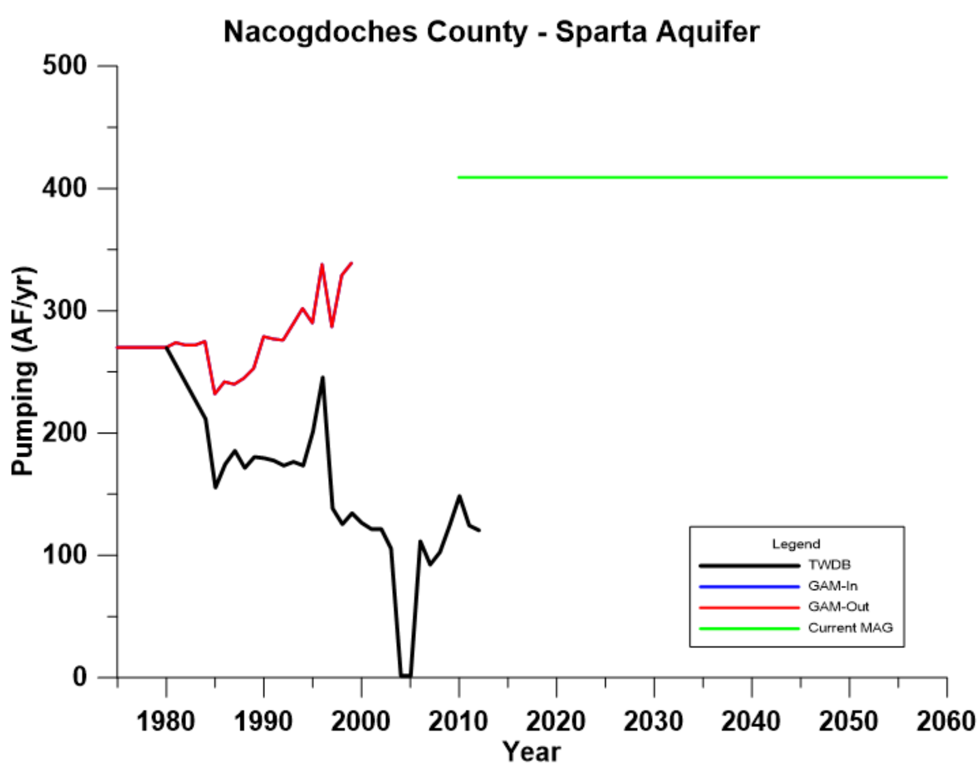

Anderson County - Sparta Aquifer
800
600
400
200
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

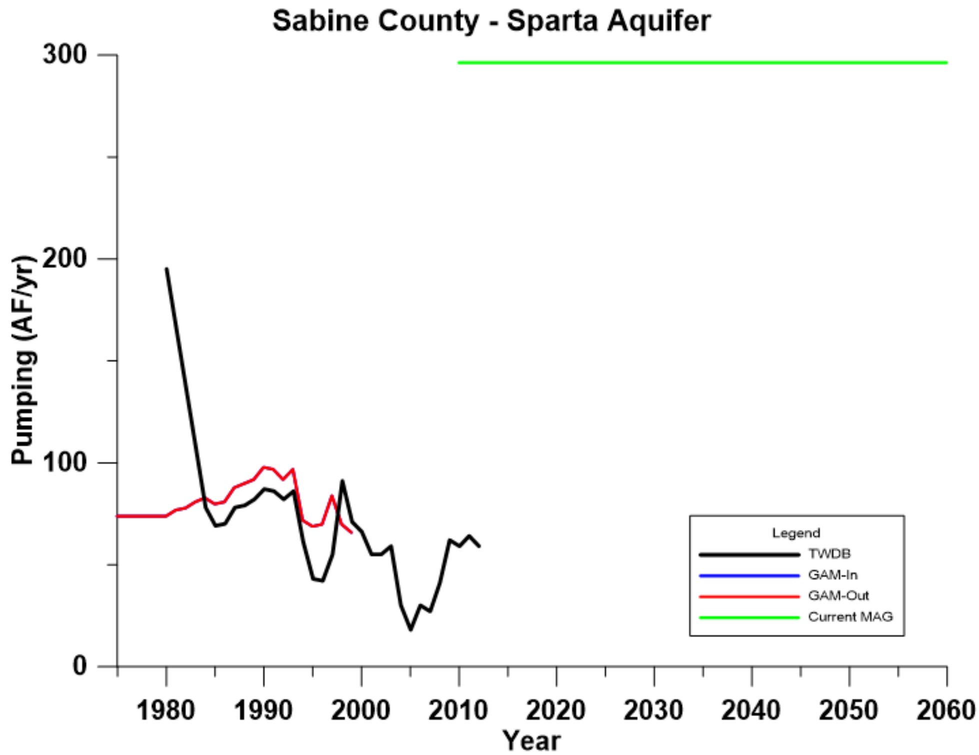

Angelina County - Sparta Aquifer
800
600
400
200
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

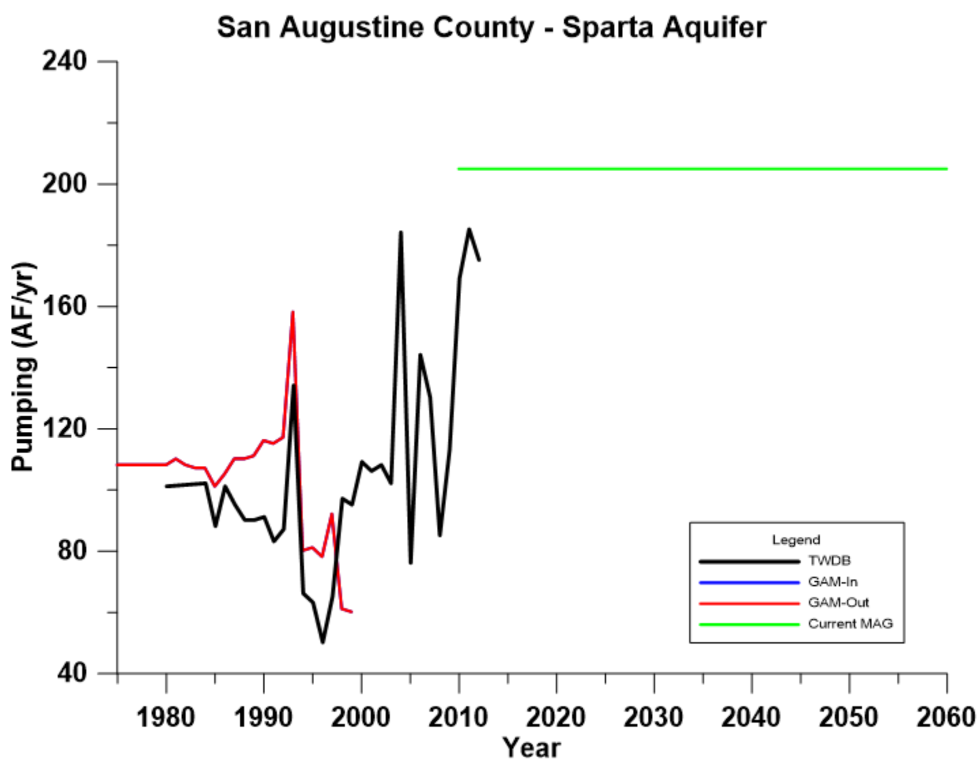

Cherokee County - Sparta Aquifer
400
300
200
100
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

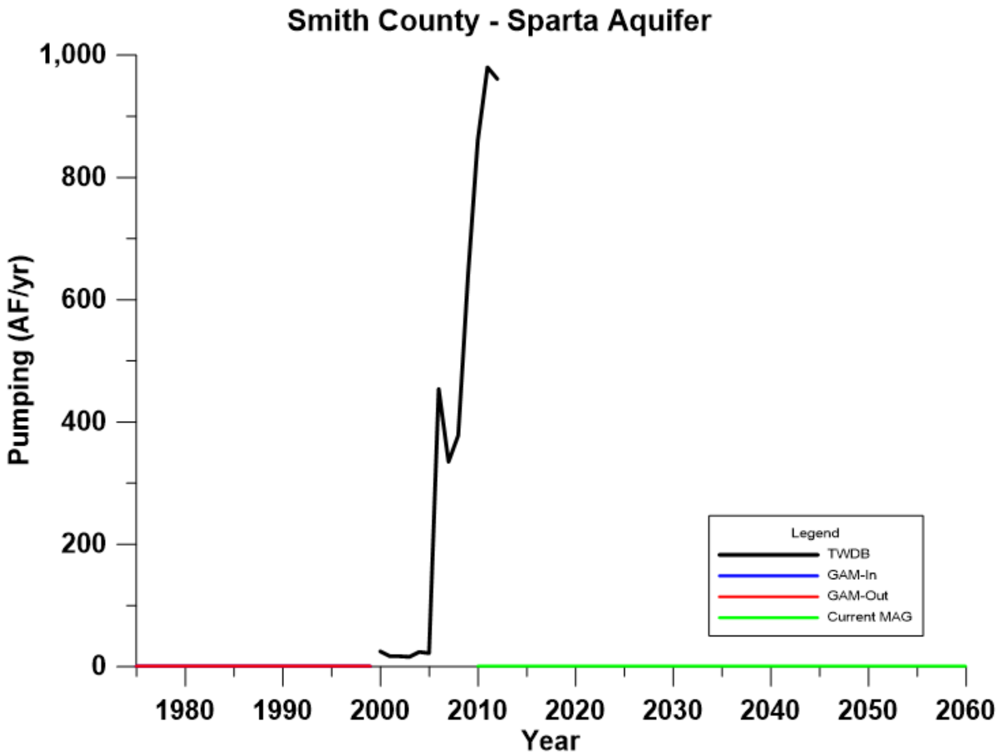

Houston County - Sparta Aquifer
1,600
1,200
800
400
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

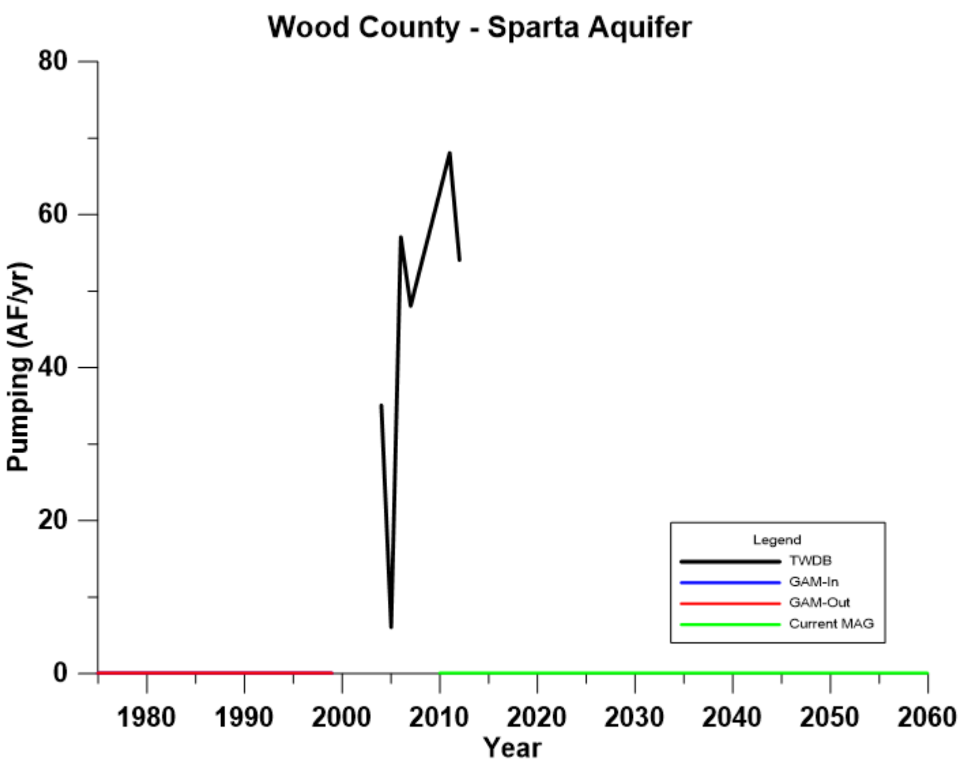

Morris County - Sparta Aquifer
Pumping (AF/yr)
8
6
4
2
0
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

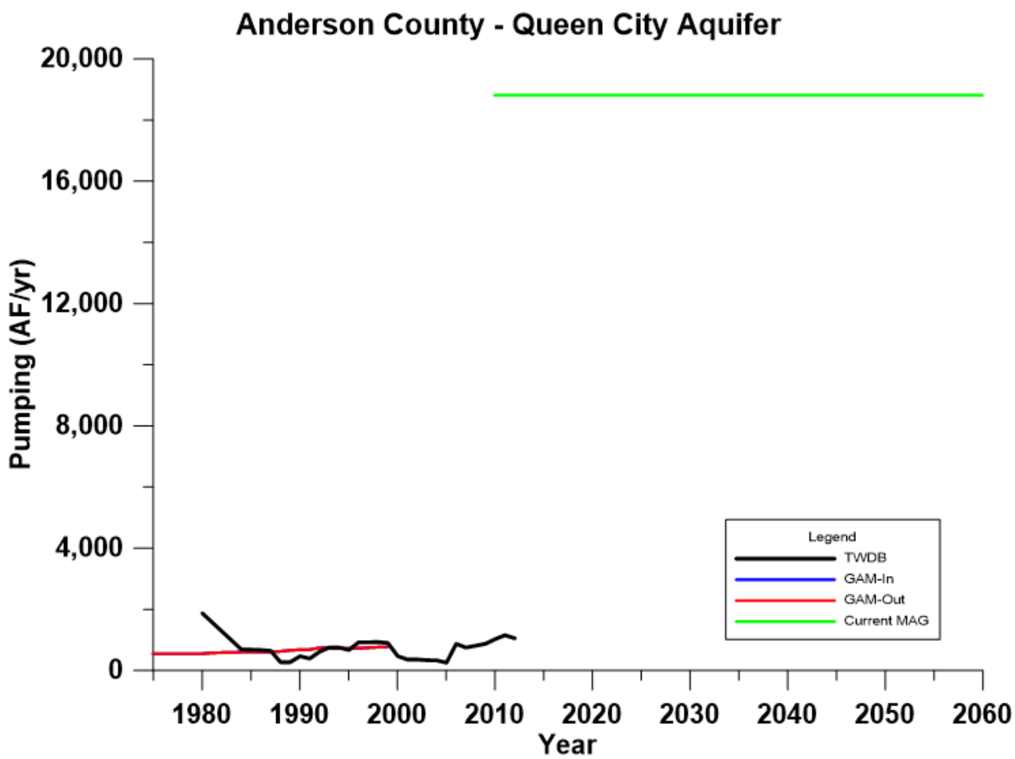

Nacogdoches County - Sparta Aquifer
Pumping (AF/yr)
500
400
300
200
100
0
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

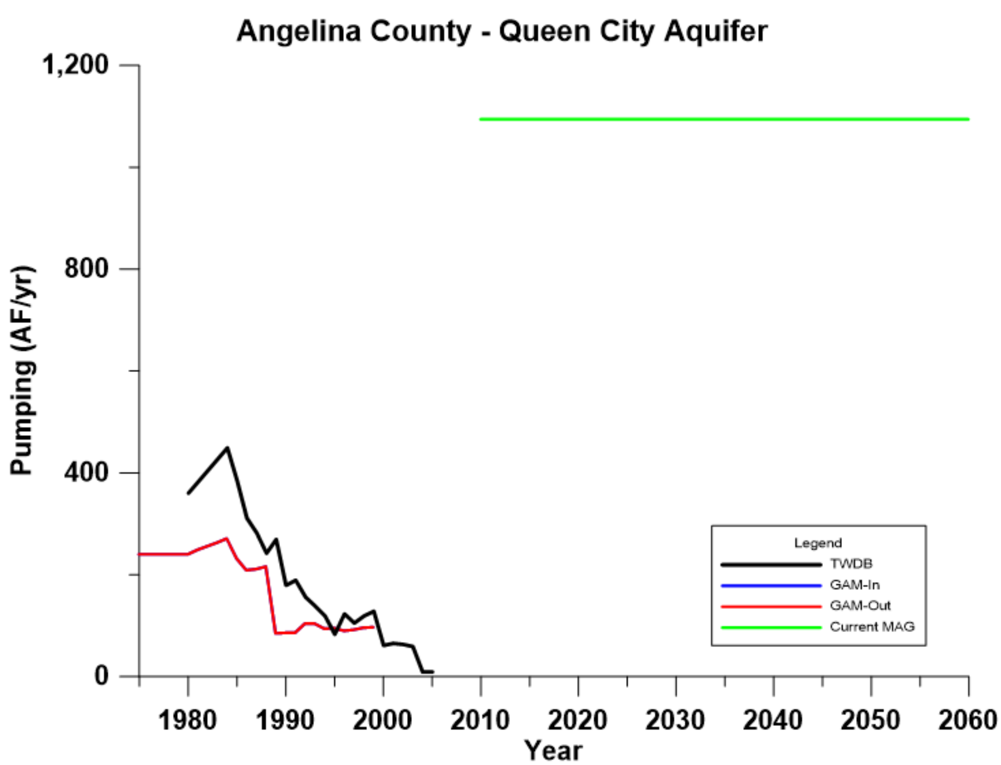

Sabine County - Sparta Aquifer
Pumping (AF/yr)
300
200
100
0
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

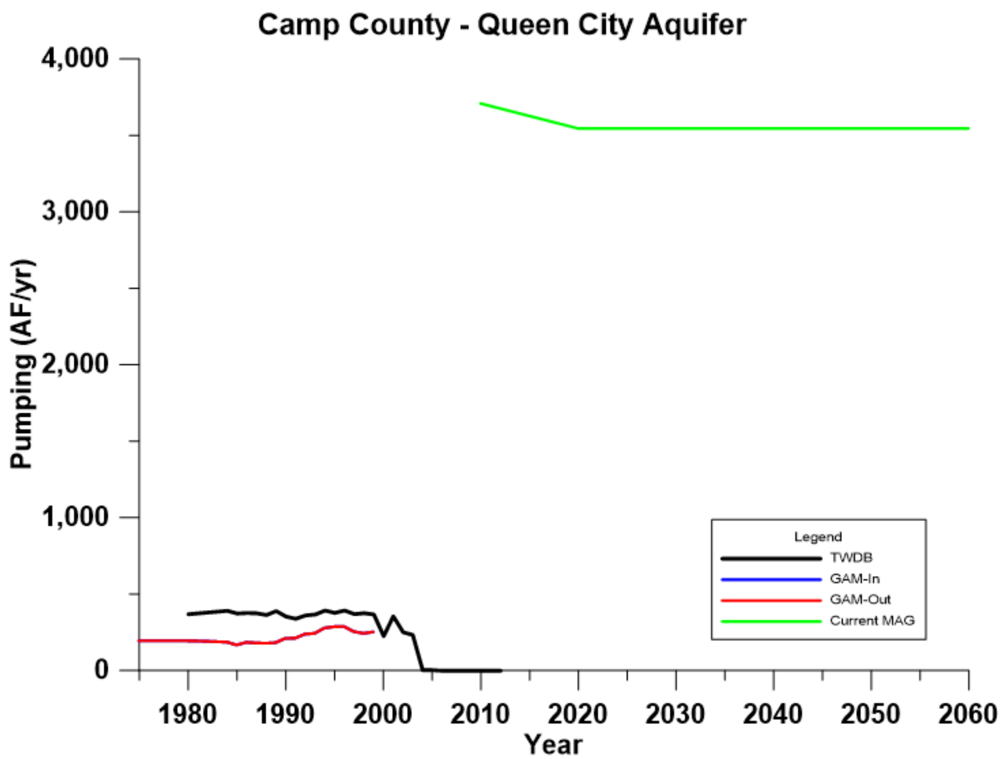

San Augustine County - Sparta Aquifer
Pumping (AF/yr)
240
200
160
120
80
40
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

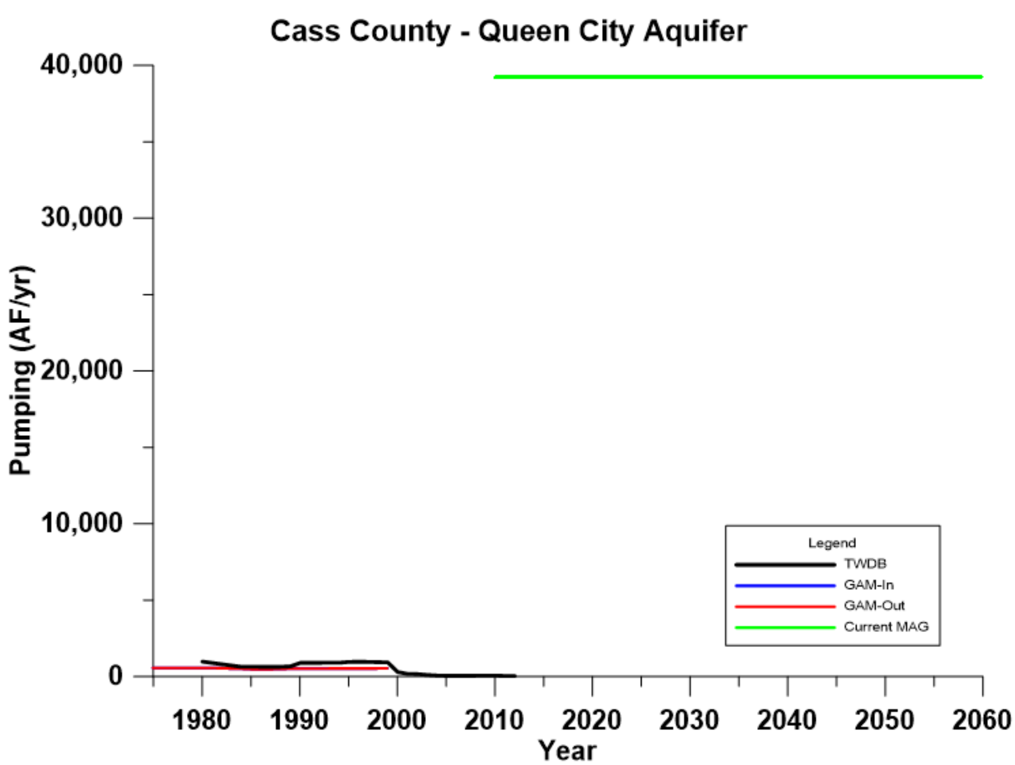

Smith County - Sparta Aquifer
1,000
800
600
400
200
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

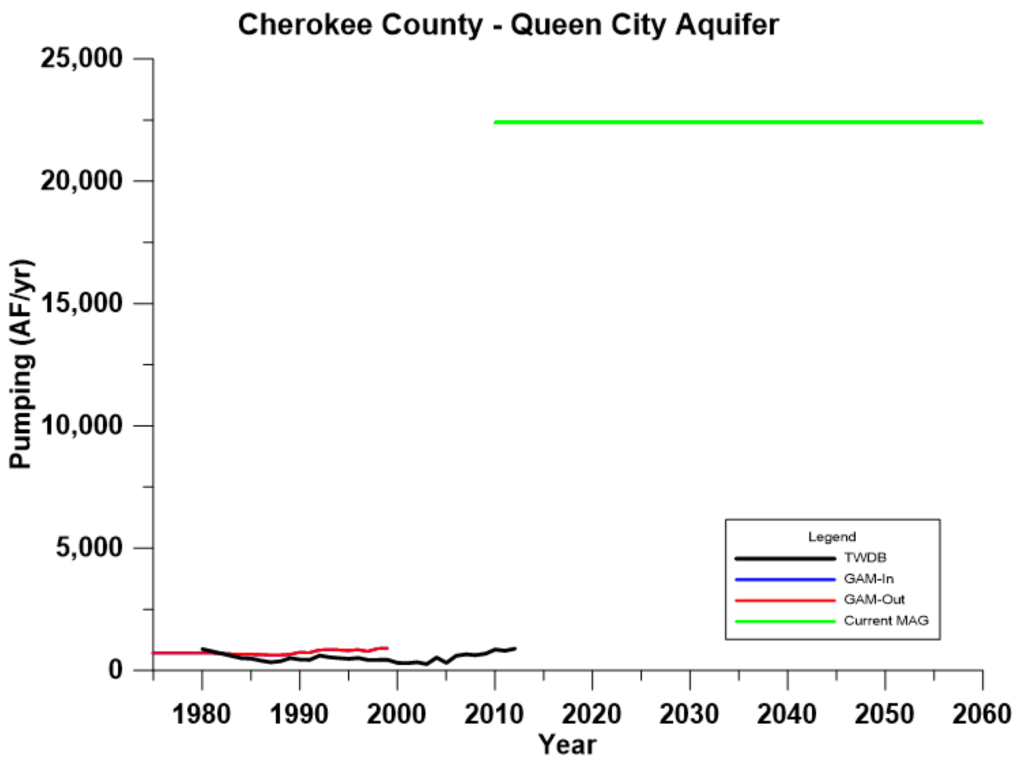

Wood County - Sparta Aquifer
80
60
40
20
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

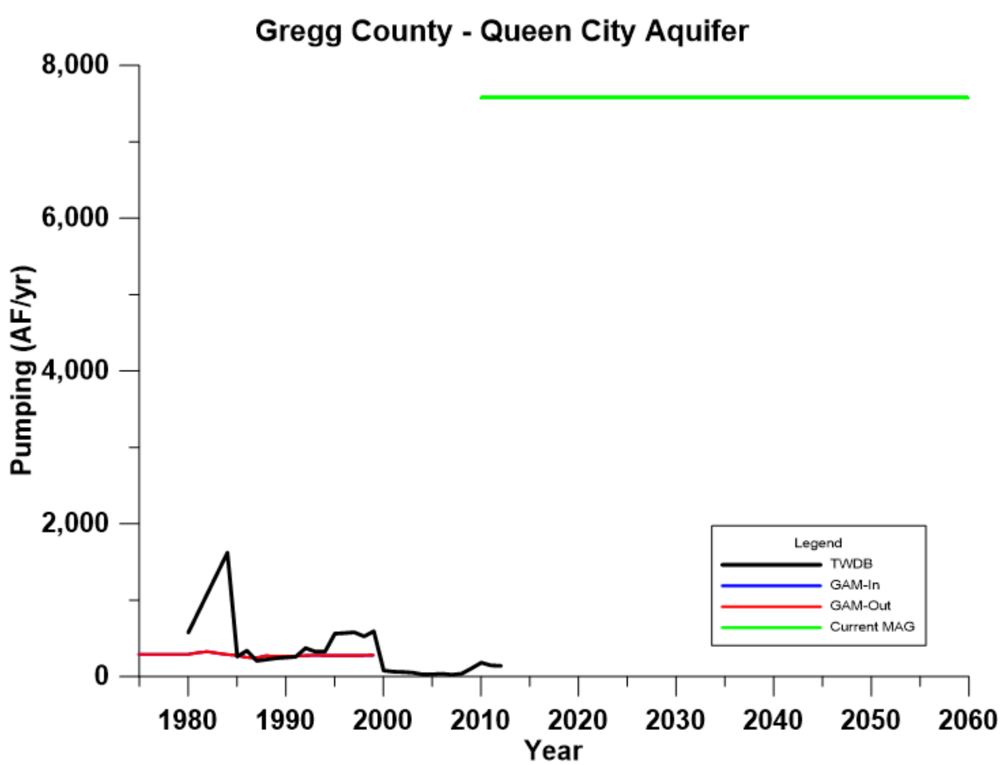

Anderson County - Queen City Aquifer
20,000
16,000
12,000
8,000
4,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

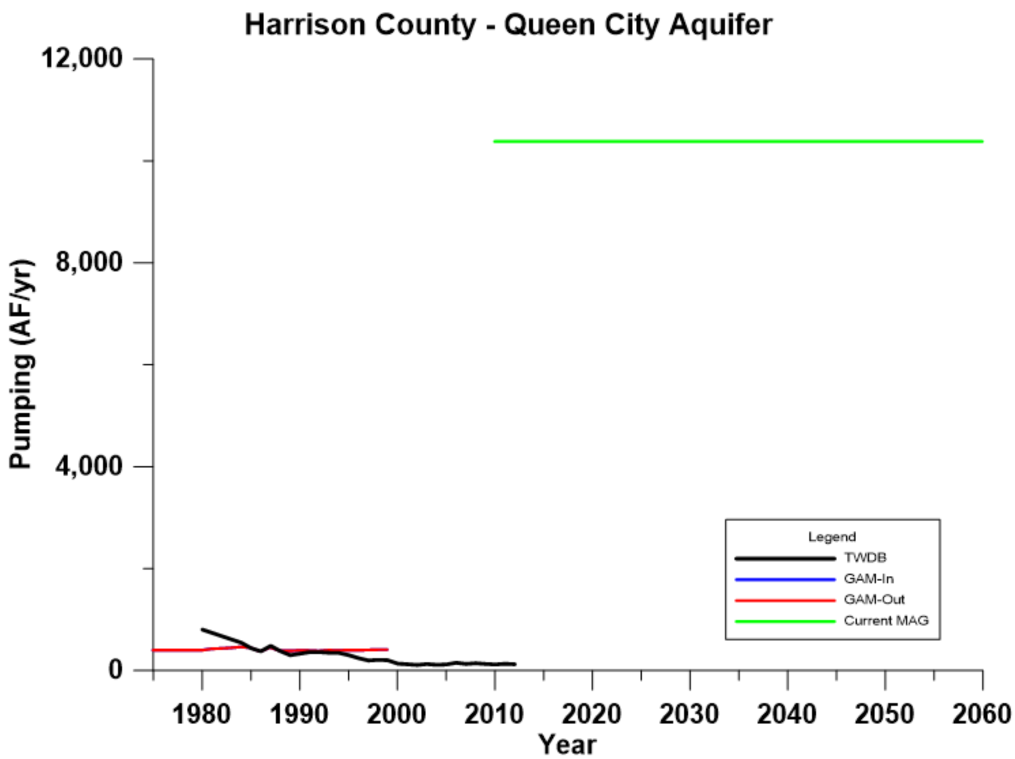

Angelina County - Queen City Aquifer
1,200
800
400
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

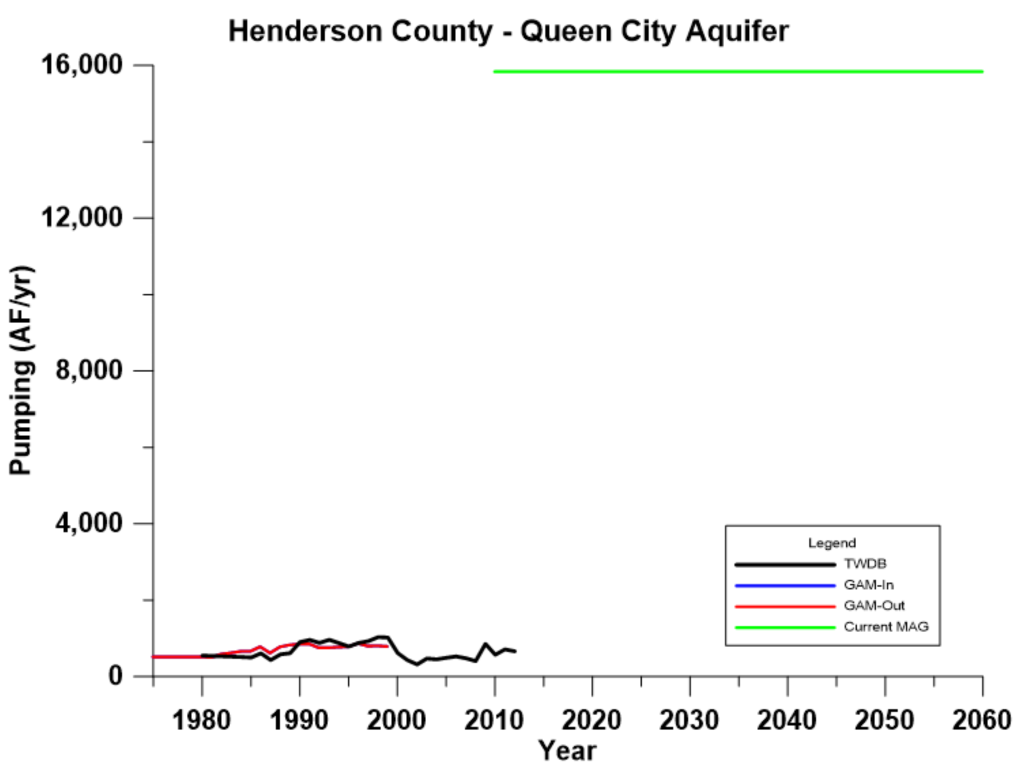

Camp County - Queen City Aquifer
Pumping (AF/yr)
4,000
3,000
2,000
1,000
0
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

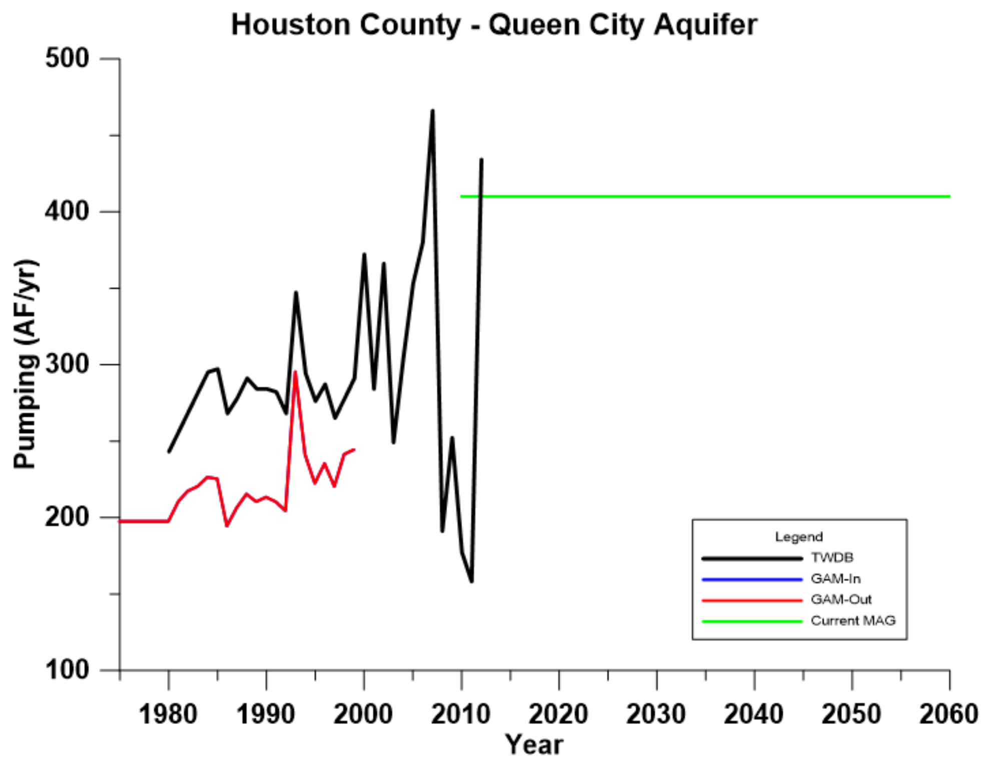

Cass County - Queen City Aquifer
Pumping (AF/yr)
40,000
30,000
20,000
10,000
0
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

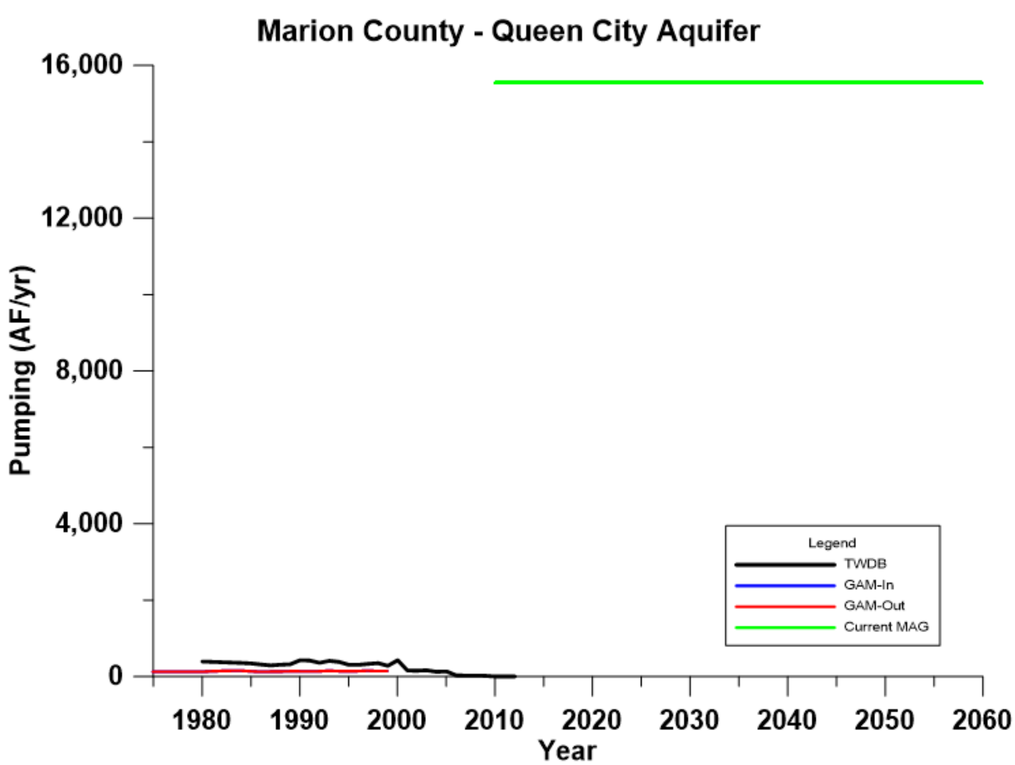

Cherokee County - Queen City Aquifer
25,000
20,000
15,000
10,000
5,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

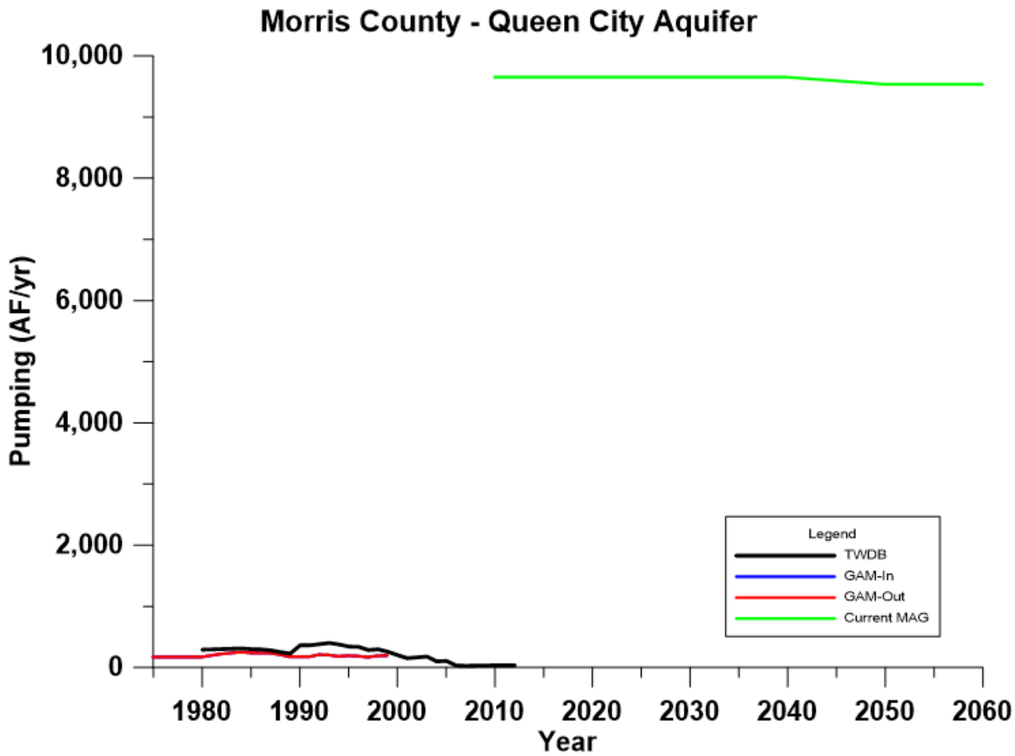

Gregg County - Queen City Aquifer
8,000
6,000
4,000
2,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

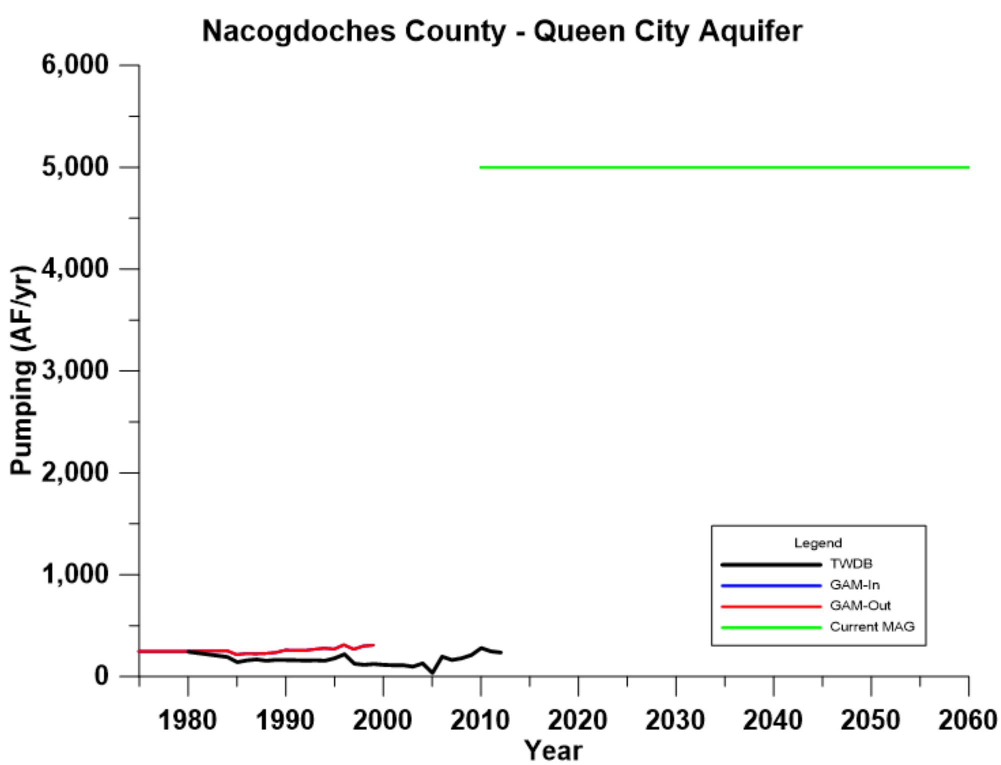

Harrison County - Queen City Aquifer
12,000
8,000
4,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

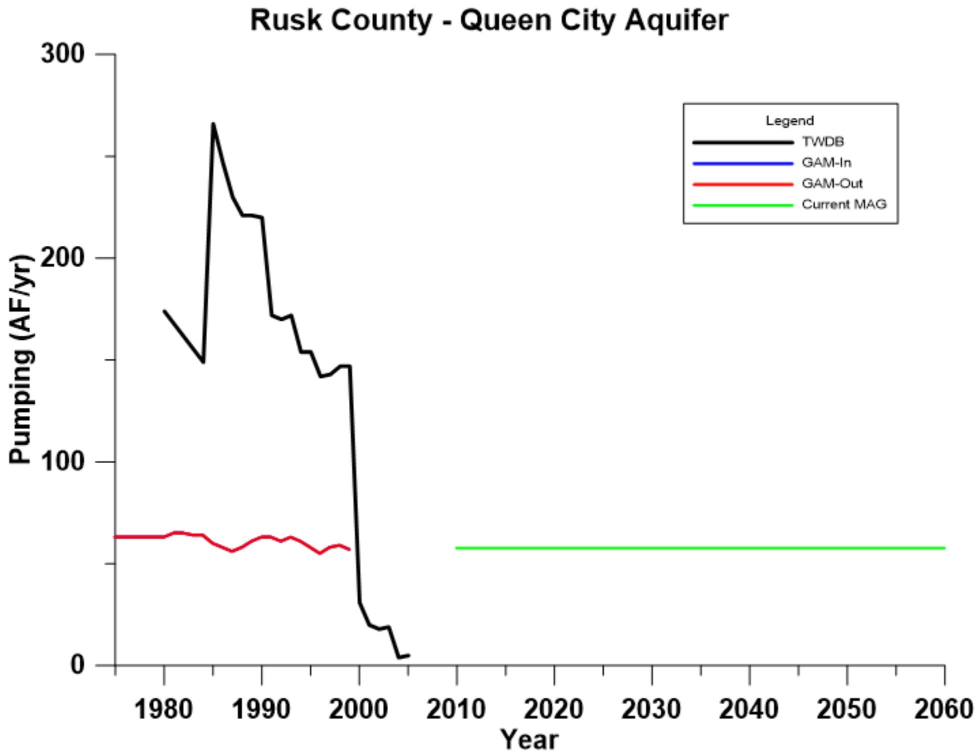

Henderson County - Queen City Aquifer
16,000
12,000
8,000
4,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

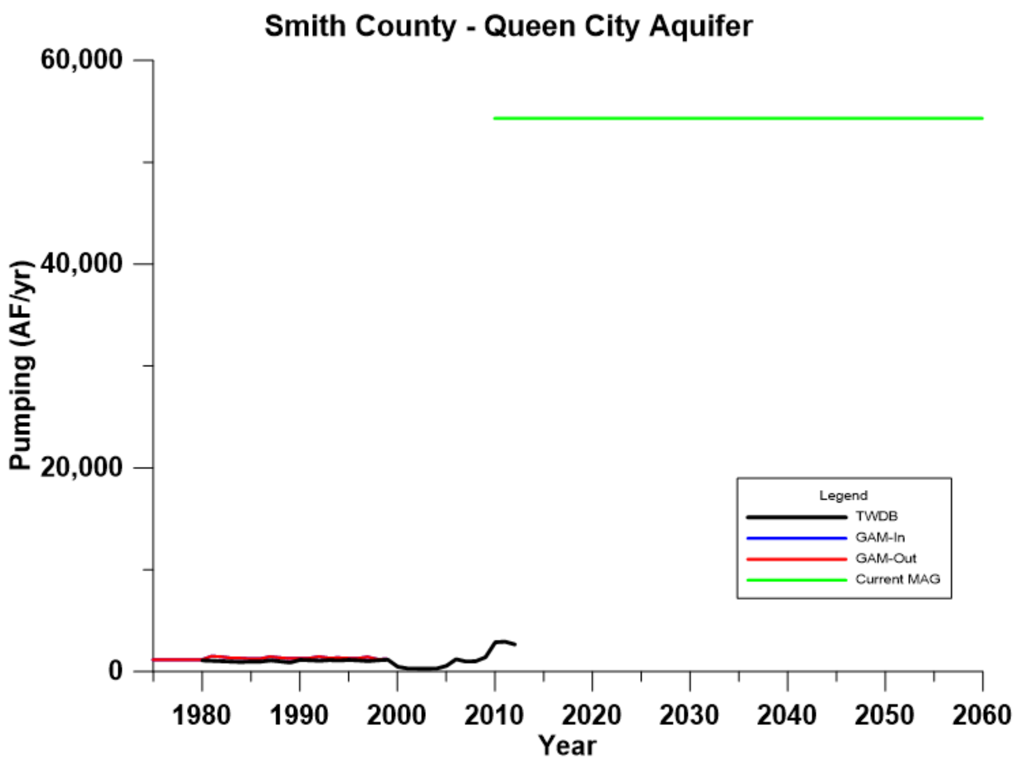

Houston County - Queen City Aquifer
500
400
300
200
100
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

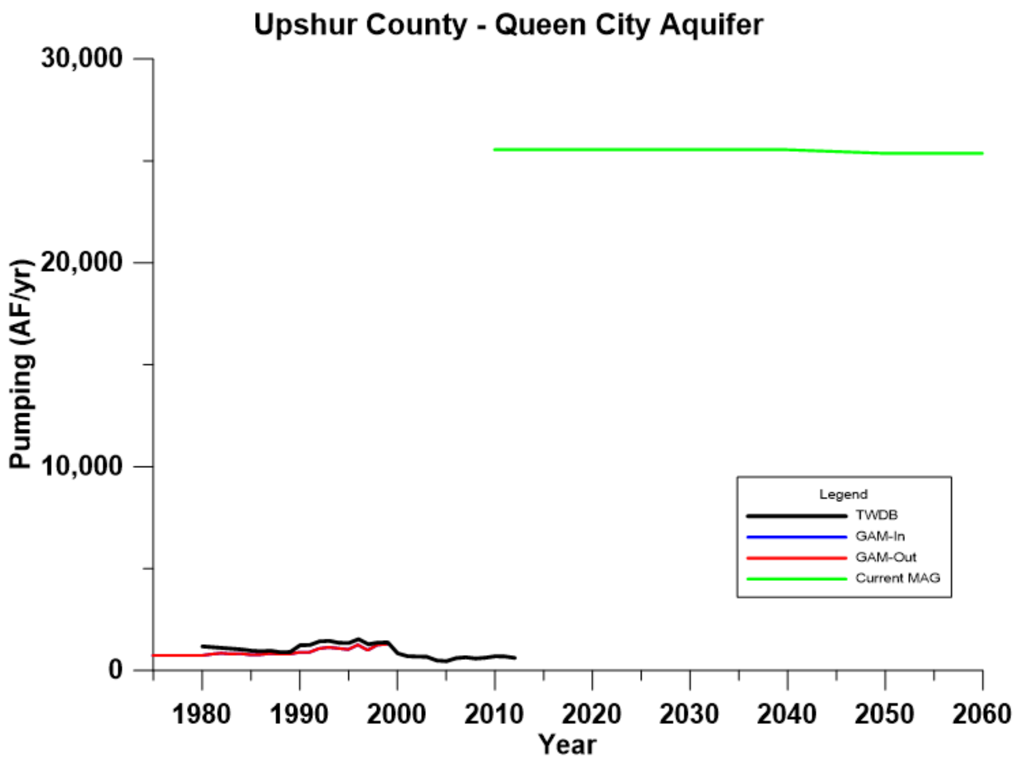

Marion County - Queen City Aquifer
16,000
12,000
8,000
4,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

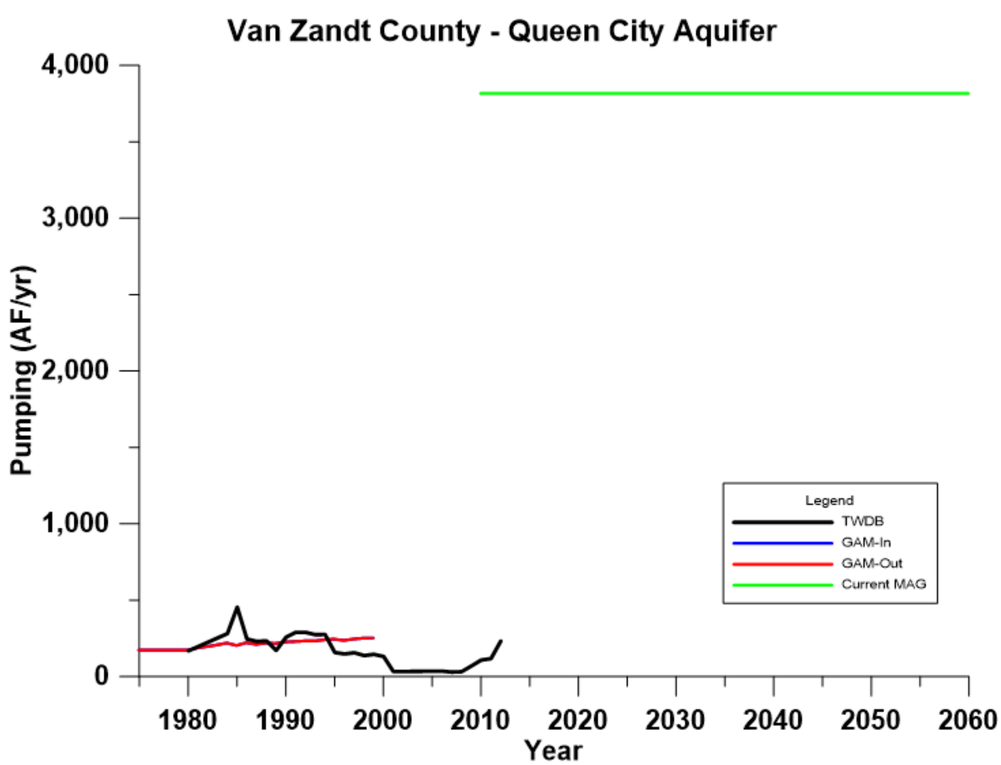

Morris County - Queen City Aquifer
10,000
8,000
6,000
4,000
2,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

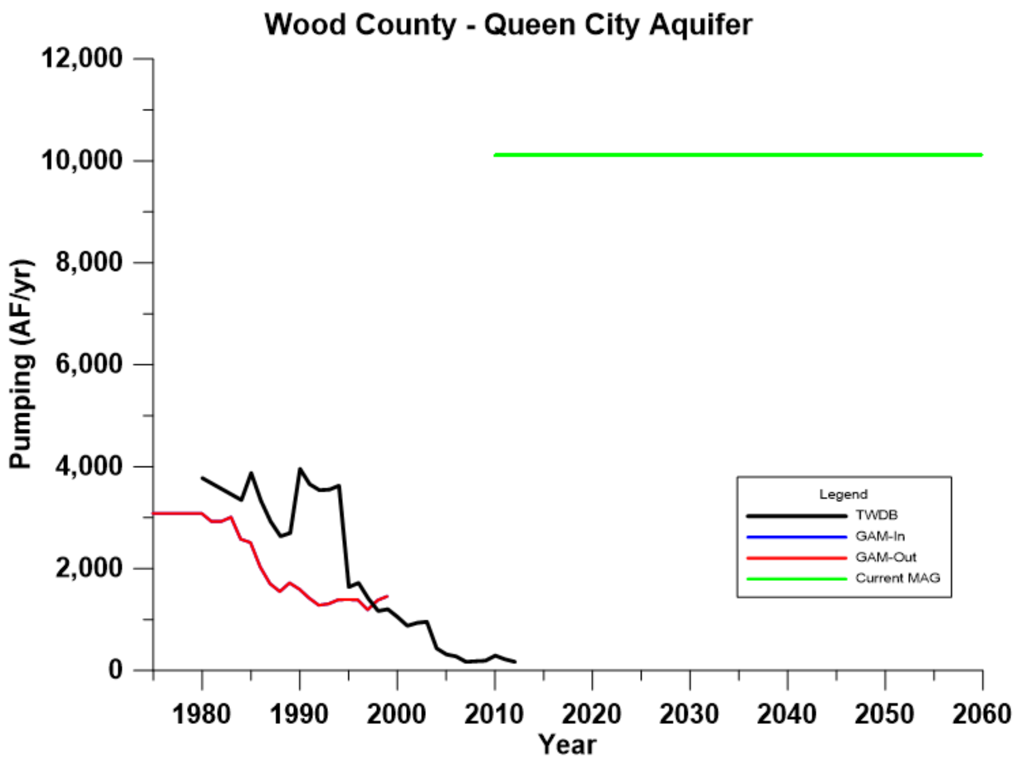

Nacogdoches County - Queen City Aquifer
6,000
5,000
4,000
3,000
2,000
1,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG


Rusk County - Queen City Aquifer
Legend
TWDB
GAM-In
GAM-Out
Current MAG
Pumping (AF/yr)
300
200
100
0
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year

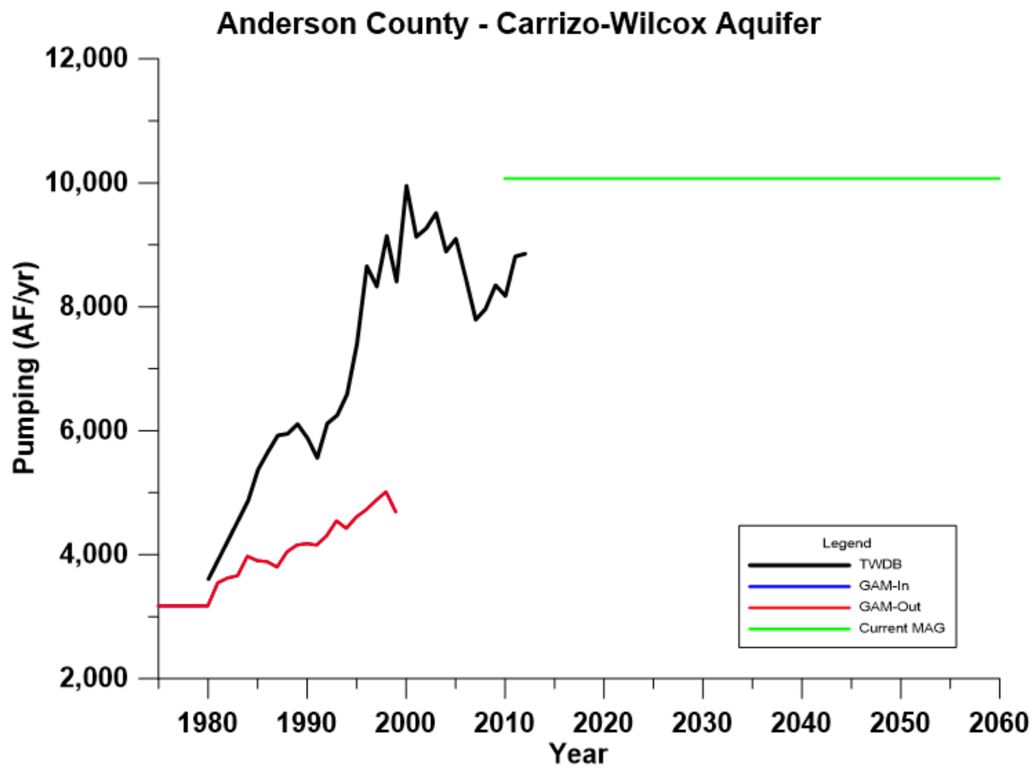

Smith County - Queen City Aquifer
Legend
TWDB
GAM-In
GAM-Out
Current MAG
Pumping (AF/yr)
60,000
40,000
20,000
0
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year

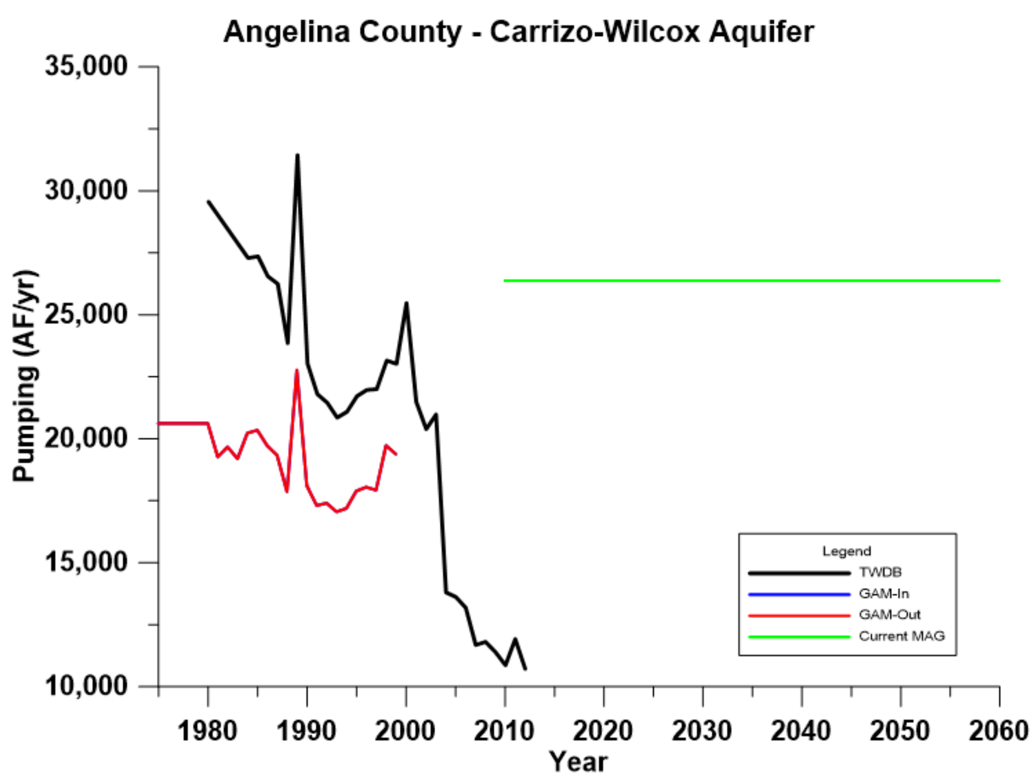

Upshur County - Queen City Aquifer
30,000
20,000
10,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

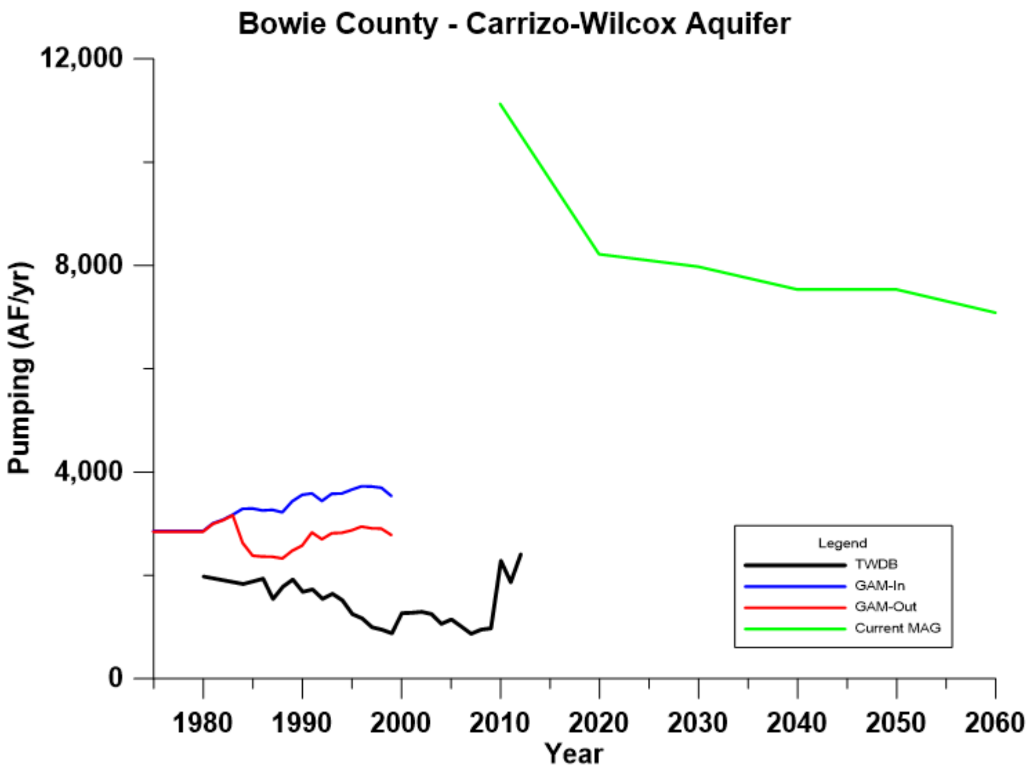

Van Zandt County - Queen City Aquifer
4,000
3,000
2,000
1,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

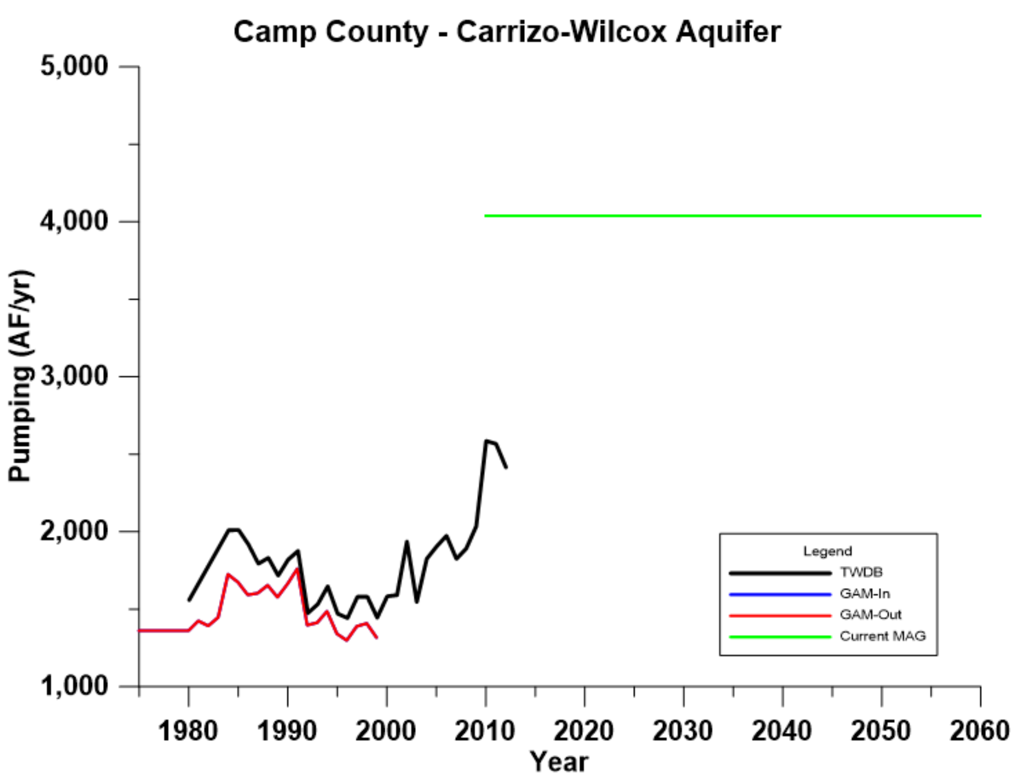


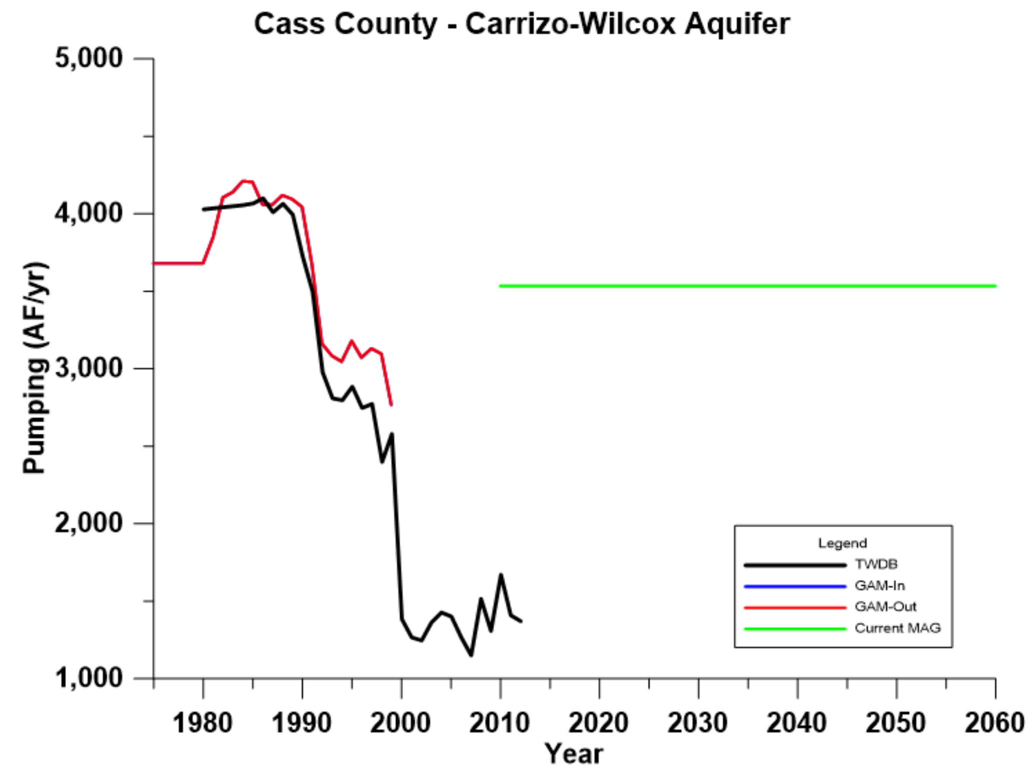
Wood County - Queen City Aquifer
12,000
10,000
8,000
6,000
4,000
2,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

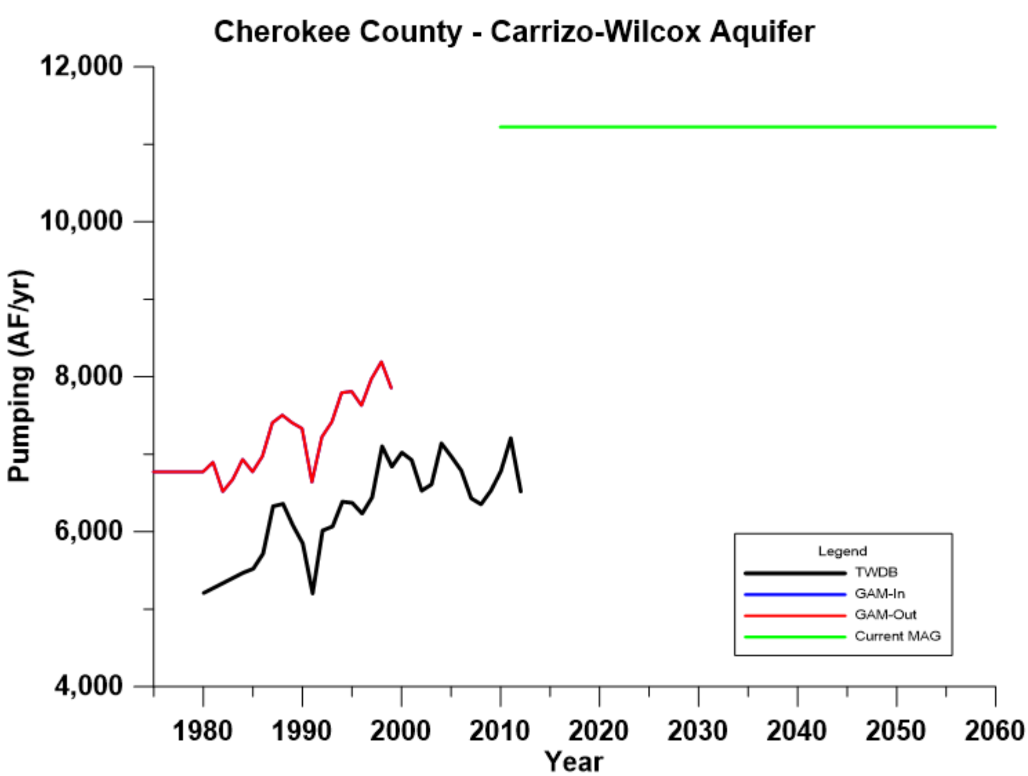

Anderson County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
12,000
10,000
8,000
6,000
4,000
2,000
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

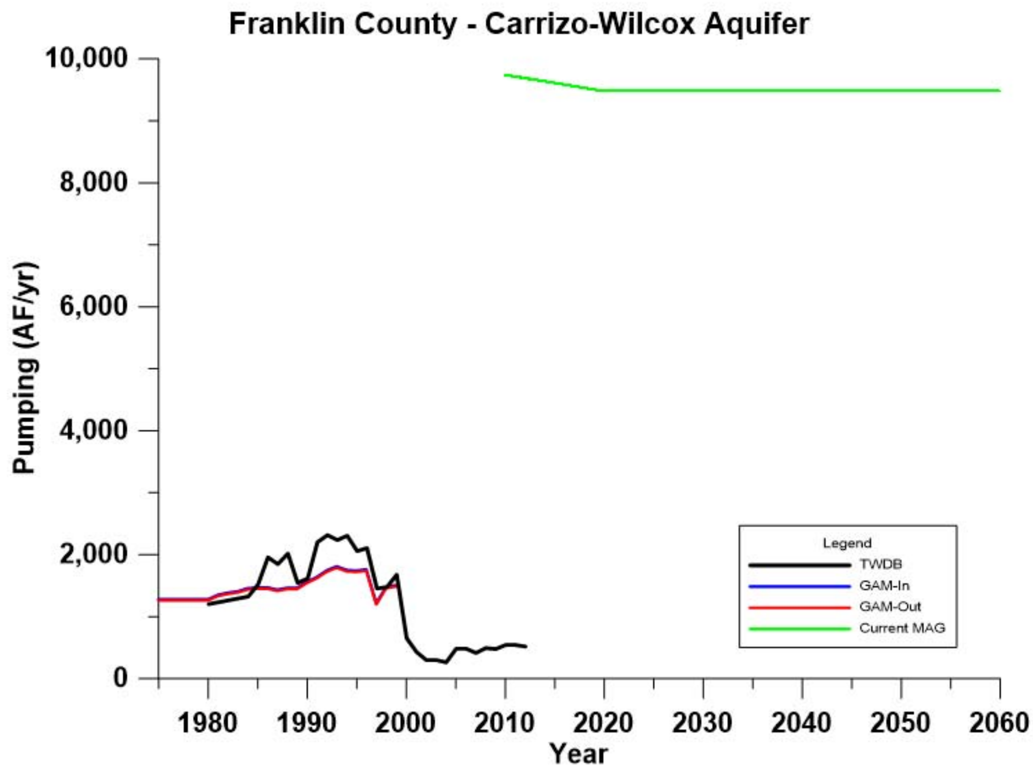

Angelina County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
35,000
30,000
25,000
20,000
15,000
10,000
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

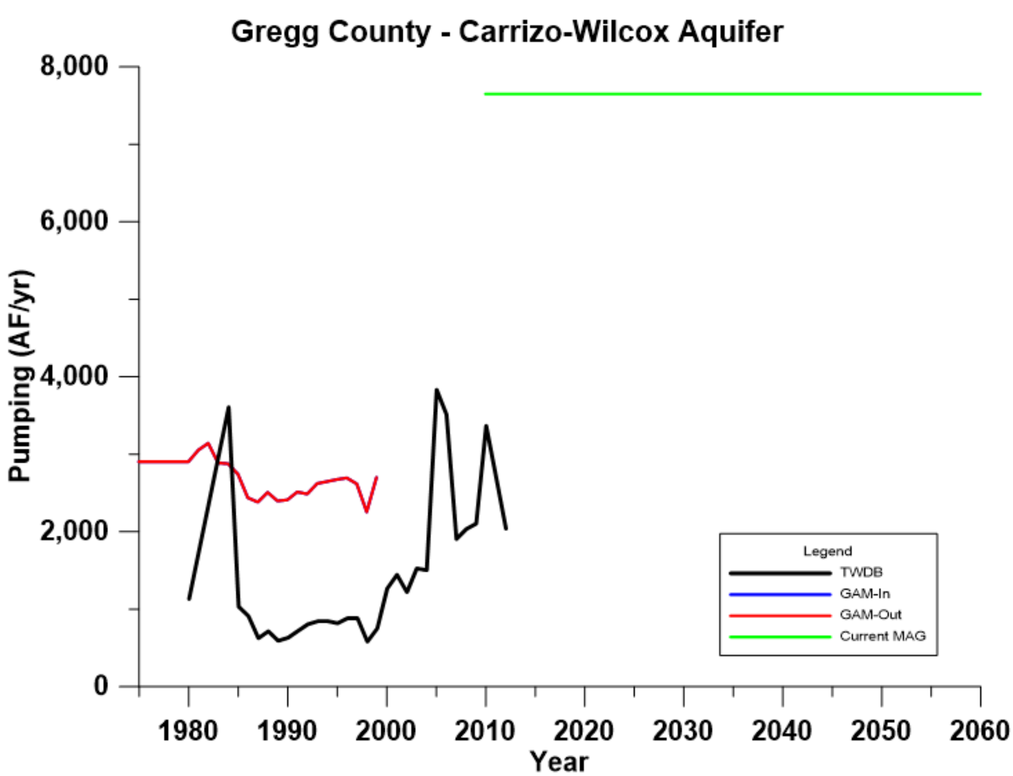

Bowie County - Carrizo-Wilcox Aquifer
12,000
8,000
4,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

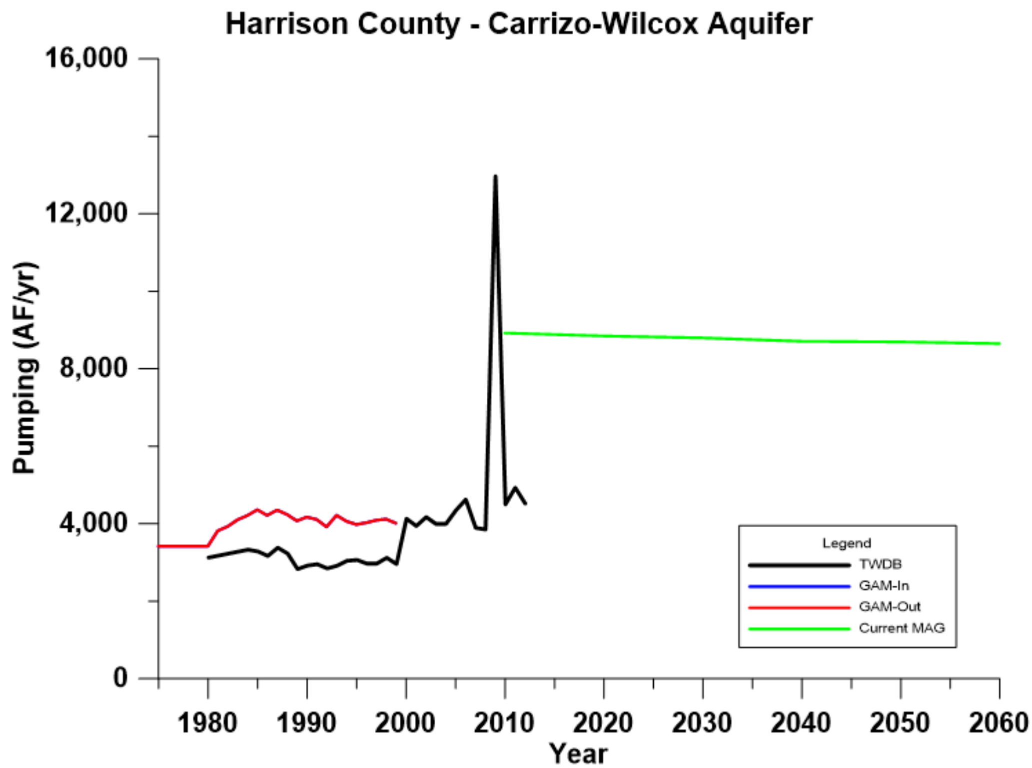

Camp County - Carrizo-Wilcox Aquifer
5,000
4,000
3,000
2,000
1,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

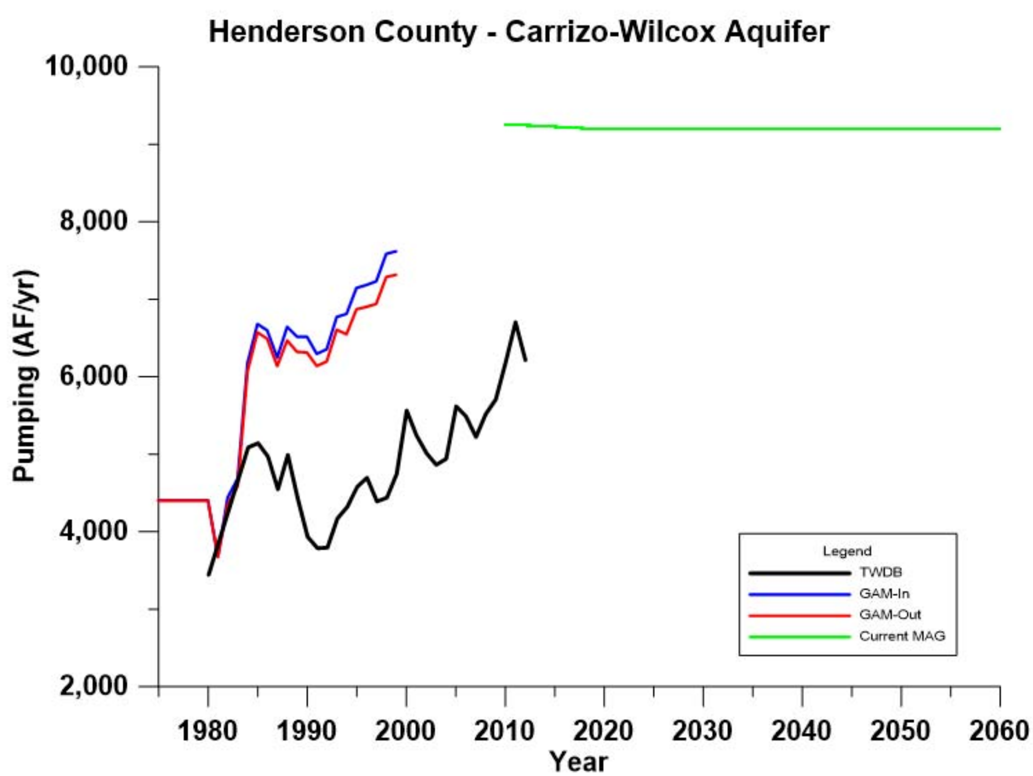

Cass County - Carrizo-Wilcox Aquifer
5,000
4,000
3,000
2,000
1,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

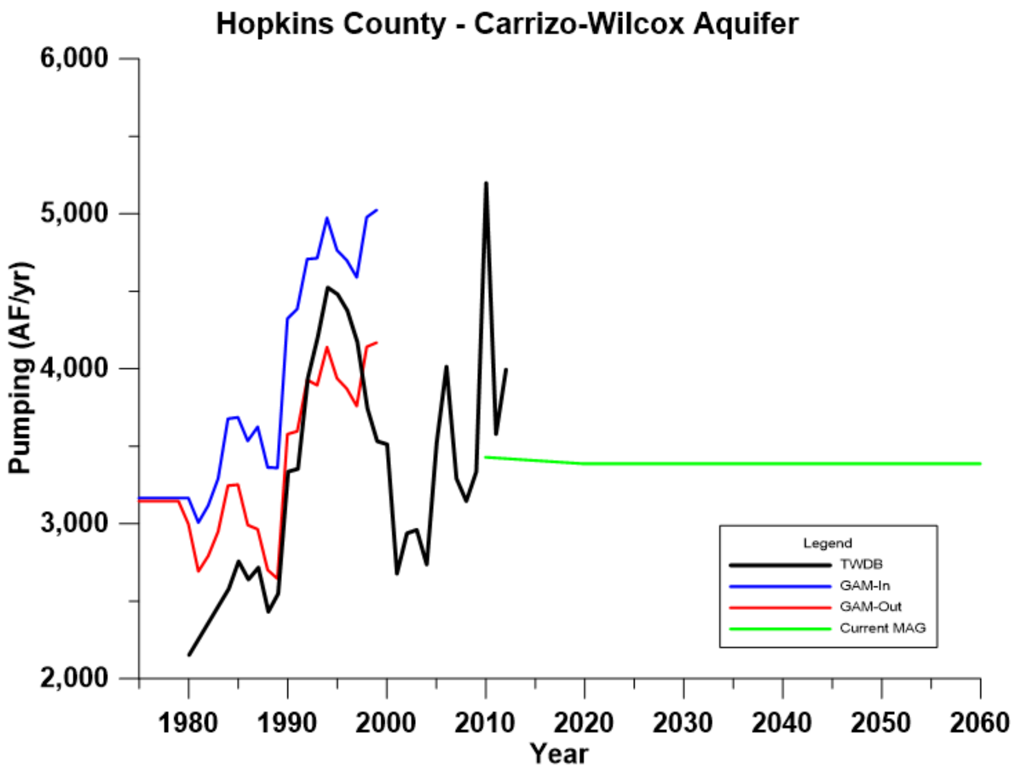

Cherokee County - Carrizo-Wilcox Aquifer
12,000
10,000
8,000
6,000
4,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

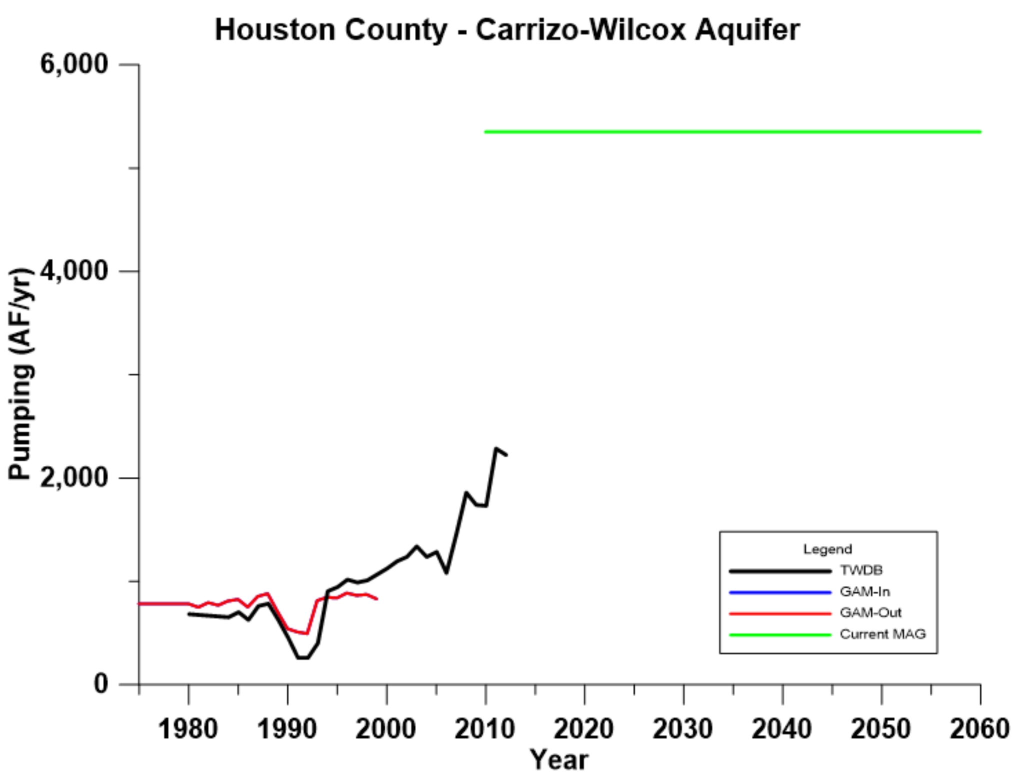

Franklin County - Carrizo-Wilcox Aquifer
10,000
8,000
6,000
4,000
2,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

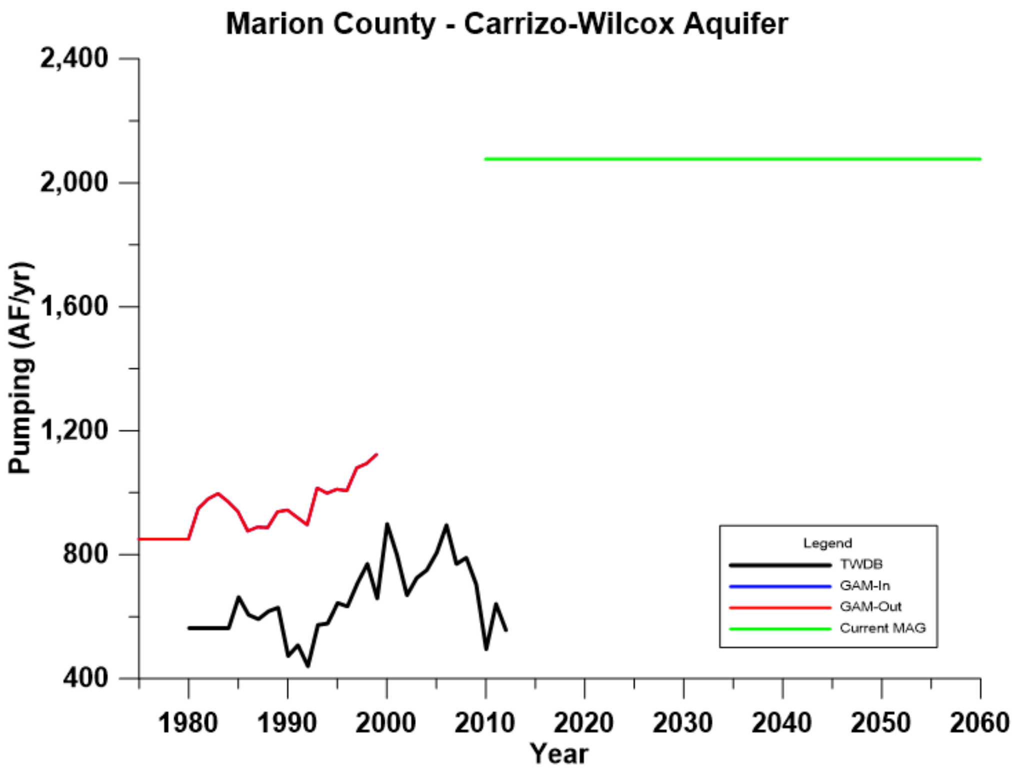

Gregg County - Carrizo-Wilcox Aquifer
8,000
6,000
4,000
2,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

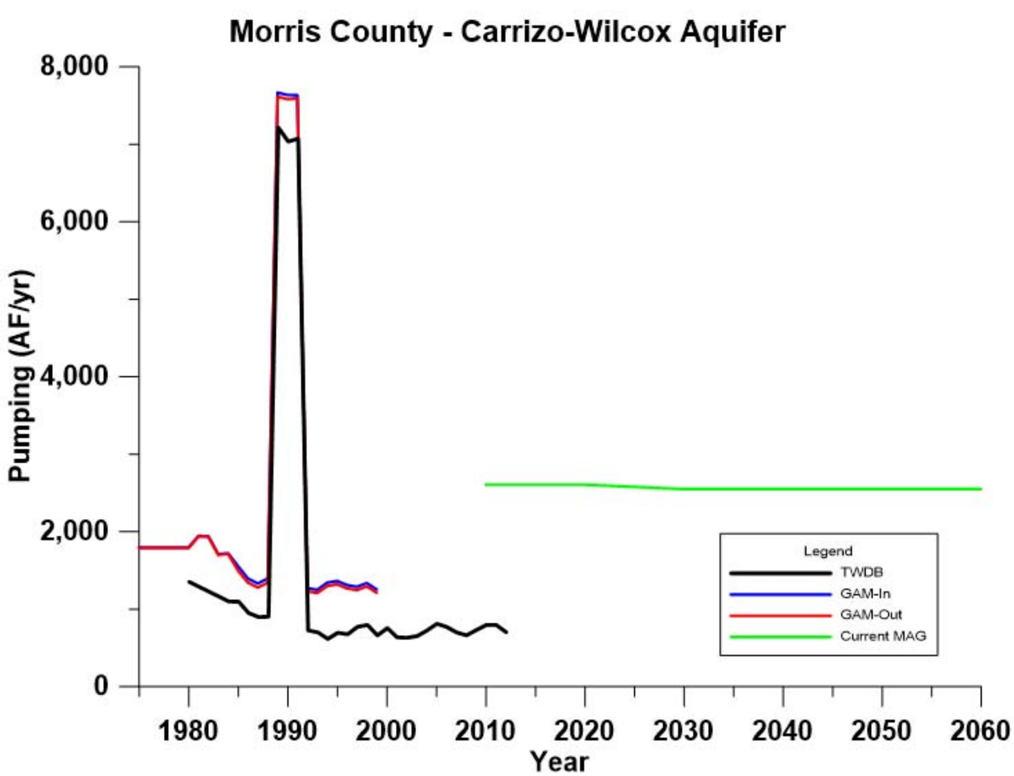

Harrison County - Carrizo-Wilcox Aquifer
16,000
12,000
8,000
4,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

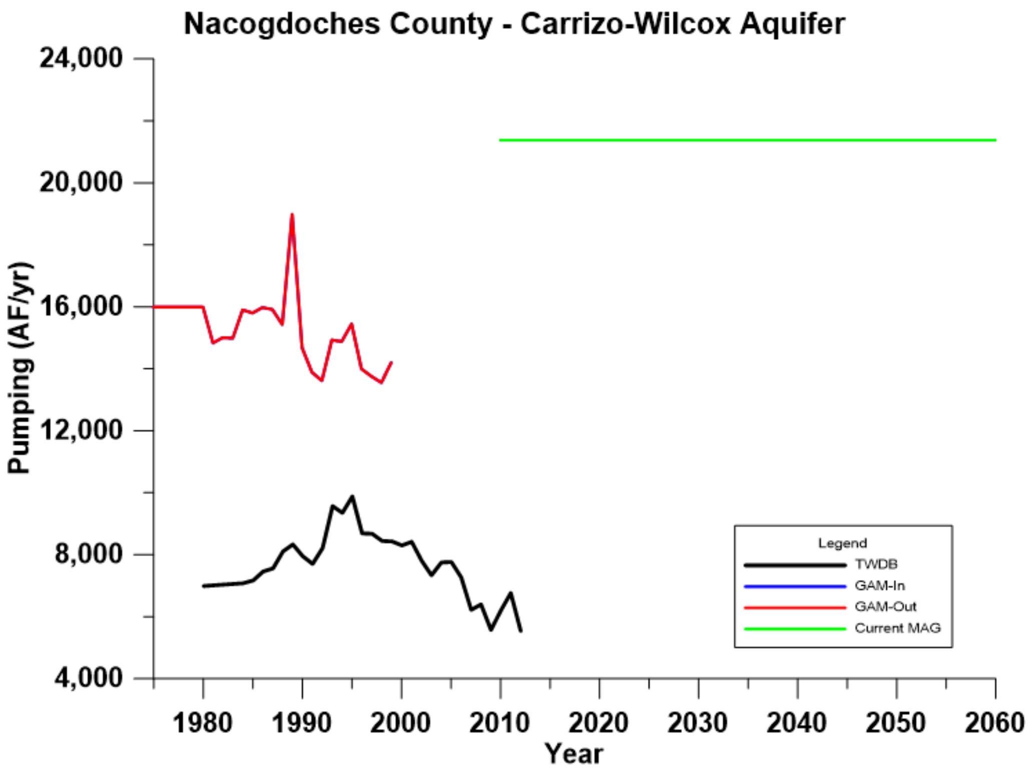

Henderson County - Carrizo-Wilcox Aquifer
10,000
8,000
6,000
4,000
2,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

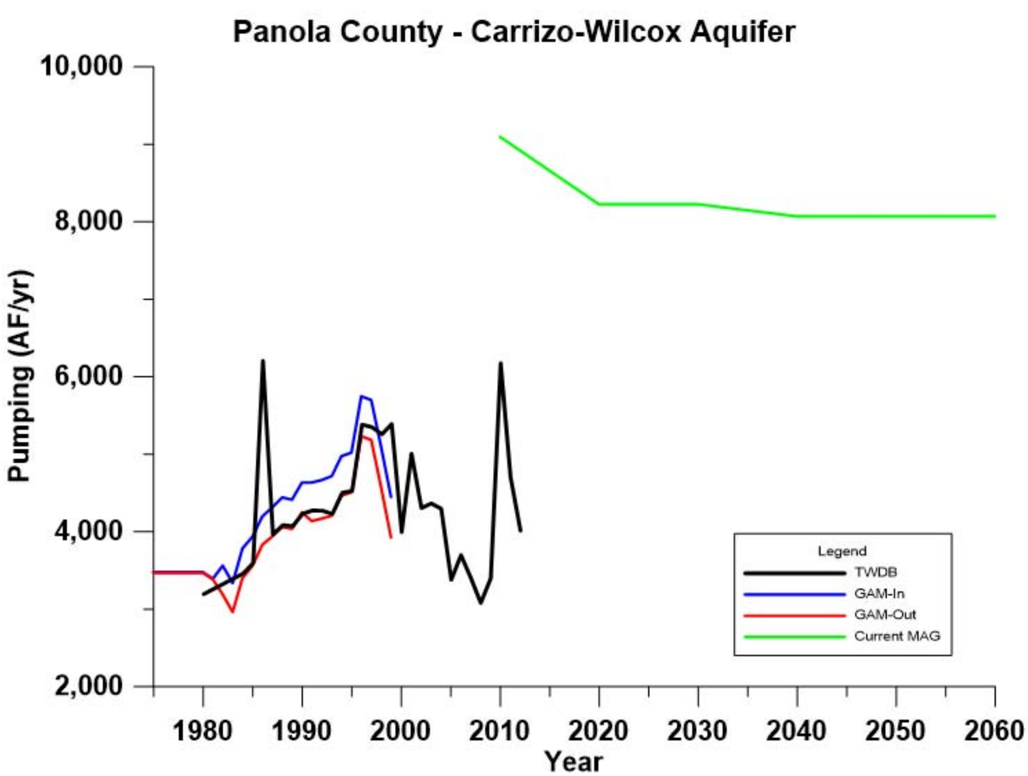

Hopkins County - Carrizo-Wilcox Aquifer
6,000
5,000
4,000
3,000
2,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

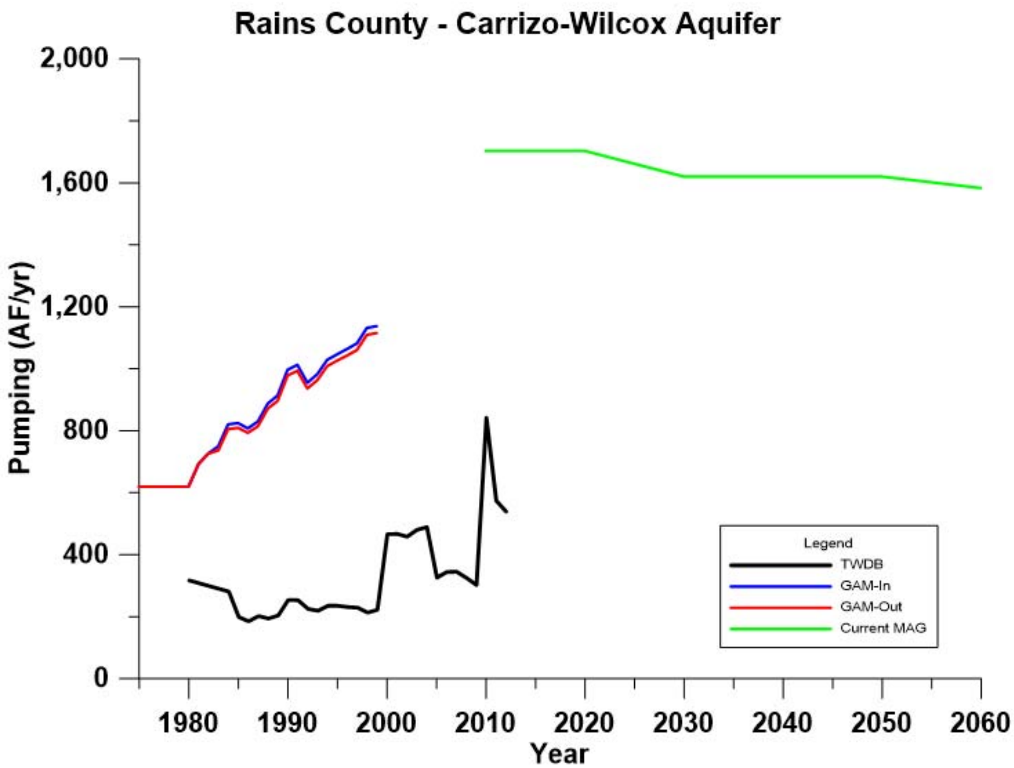

Houston County - Carrizo-Wilcox Aquifer
6,000
4,000
2,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG


Marion County - Carrizo-Wilcox Aquifer
2,400
2,000
1,600
1,200
800
400
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

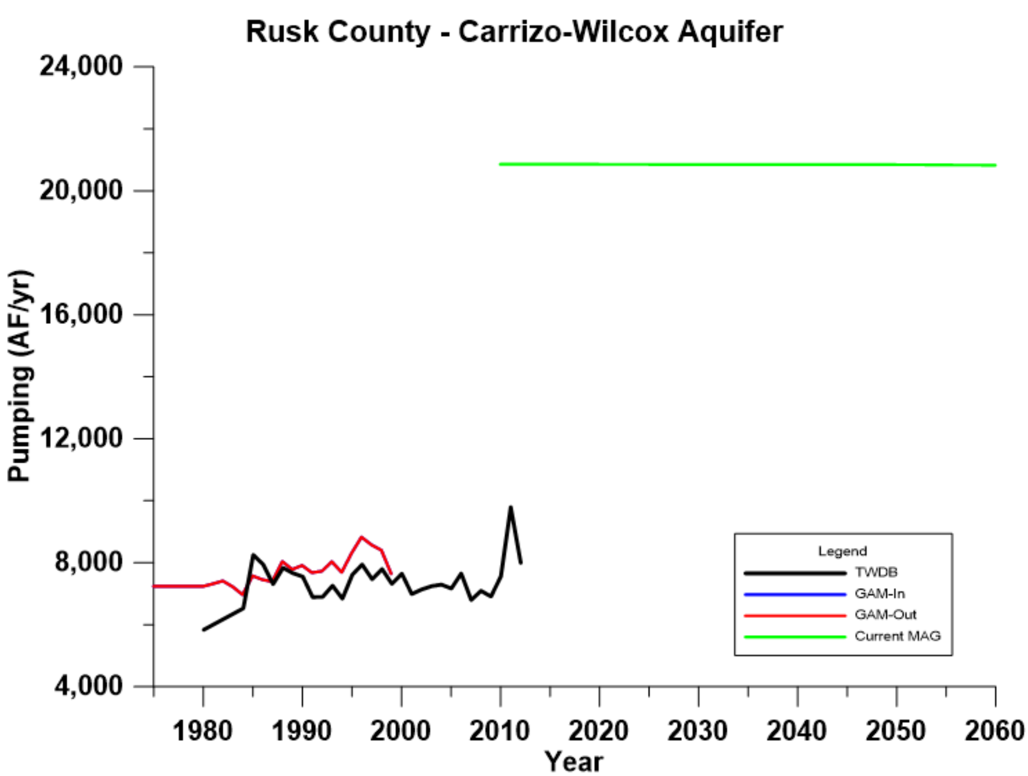

Morris County - Carrizo-Wilcox Aquifer
8,000
6,000
4,000
2,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG


Nacogdoches County - Carrizo-Wilcox Aquifer
24,000
20,000
16,000
12,000
8,000
4,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

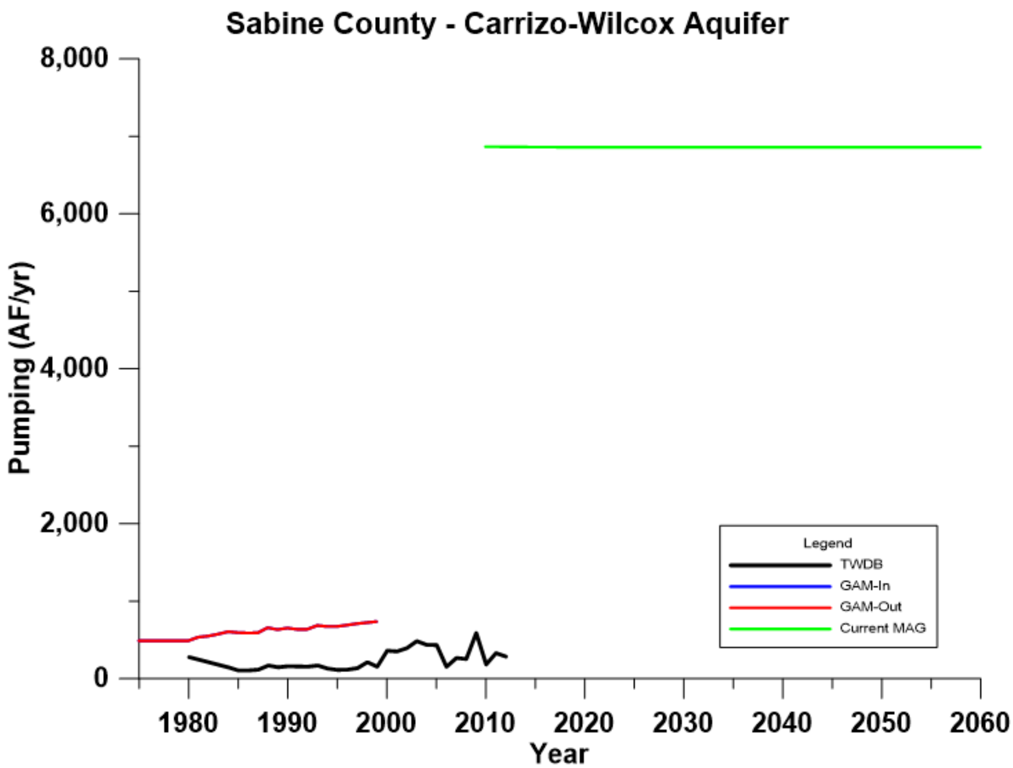

Panola County - Carrizo-Wilcox Aquifer
10,000
8,000
6,000
4,000
2,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

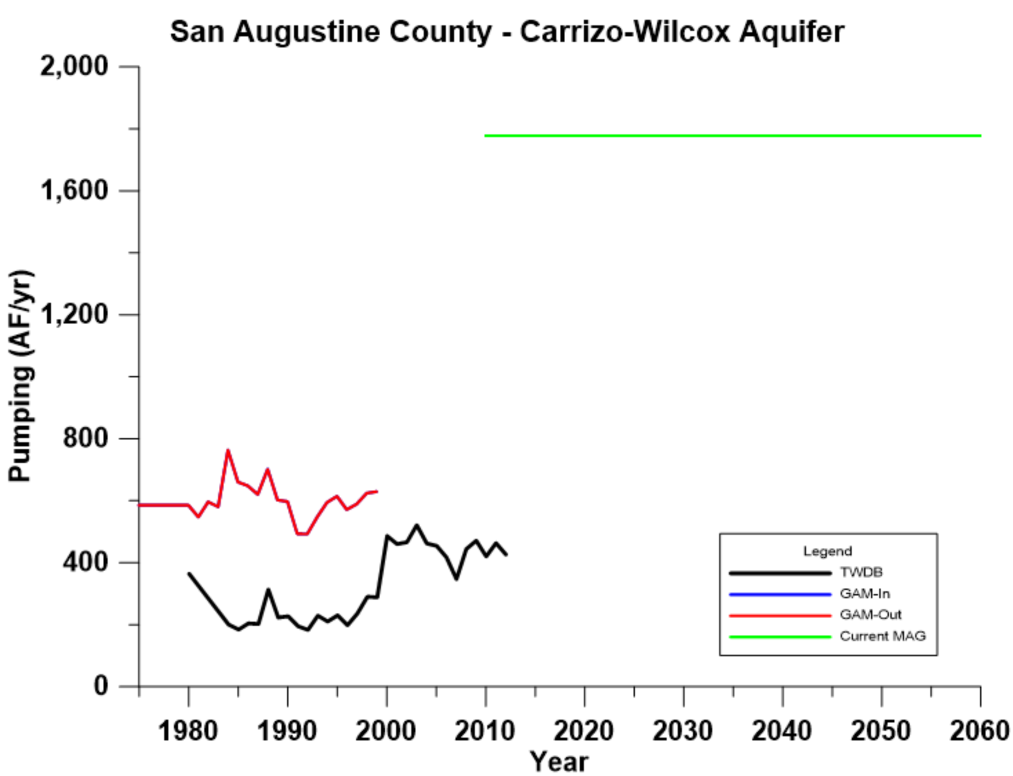


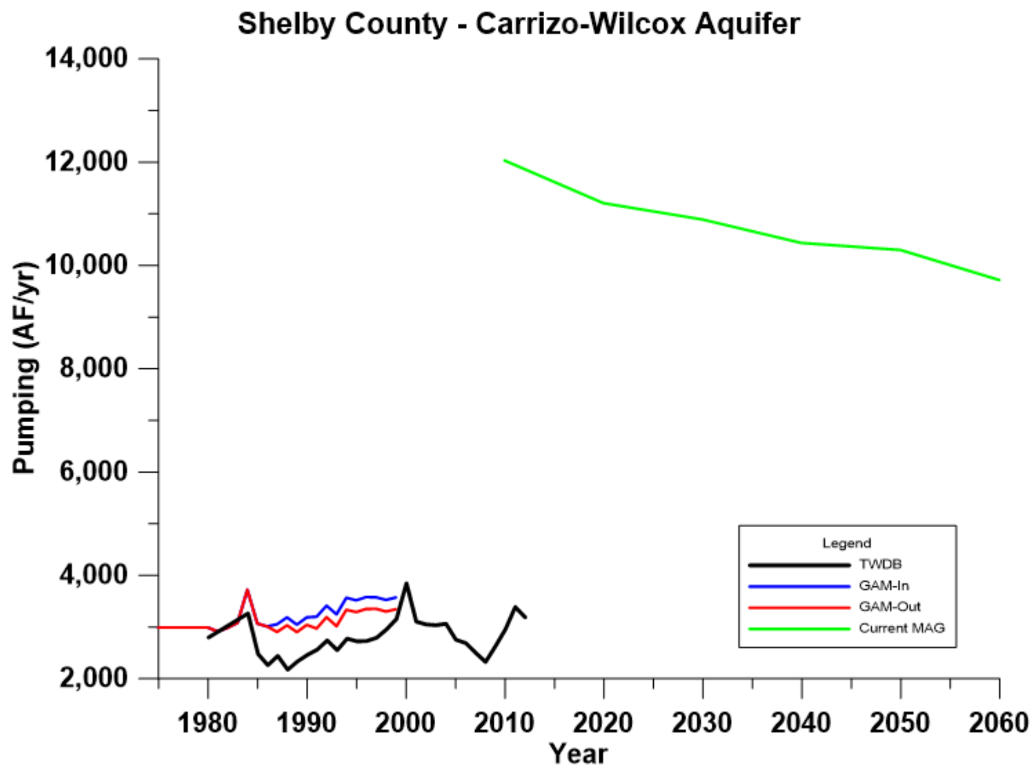
Rains County - Carrizo-Wilcox Aquifer
2,000
1,600
1,200
800
400
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

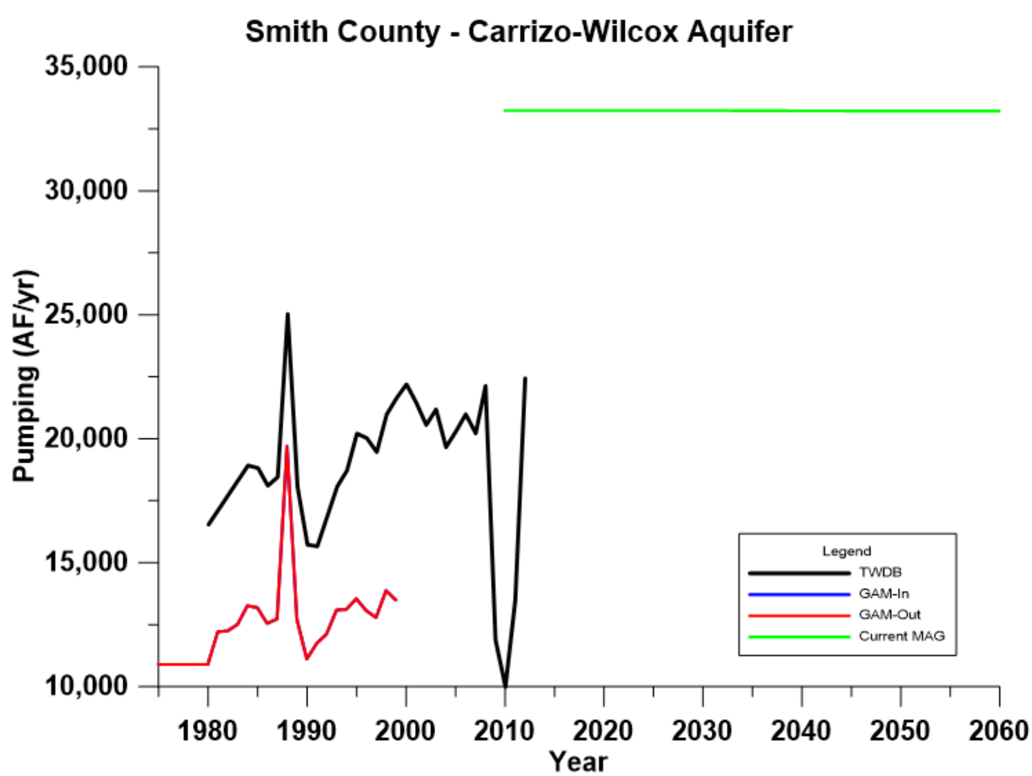


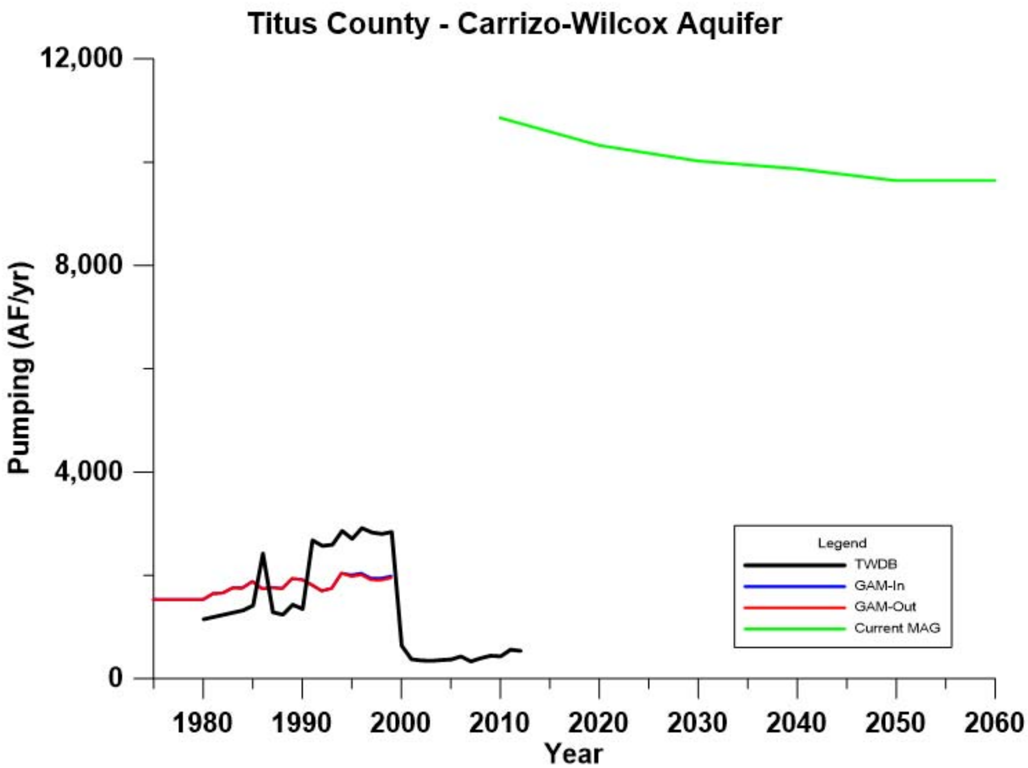
Rusk County - Carrizo-Wilcox Aquifer
24,000
20,000
16,000
12,000
8,000
4,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

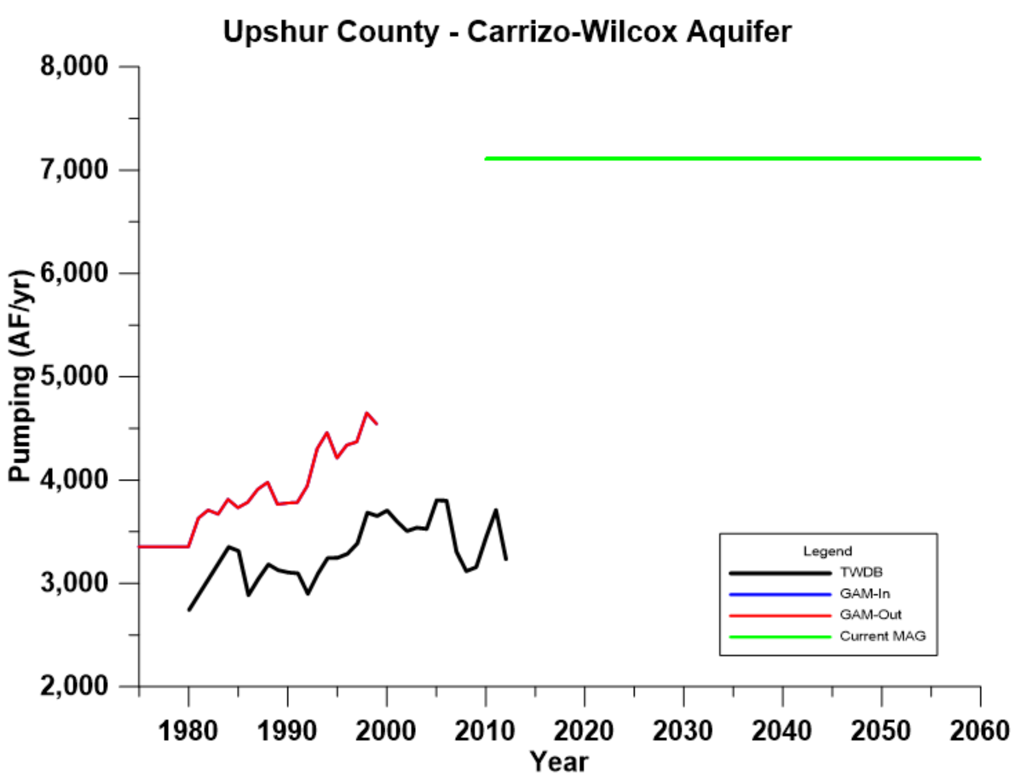

Sabine County - Carrizo-Wilcox Aquifer
8,000
6,000
4,000
2,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

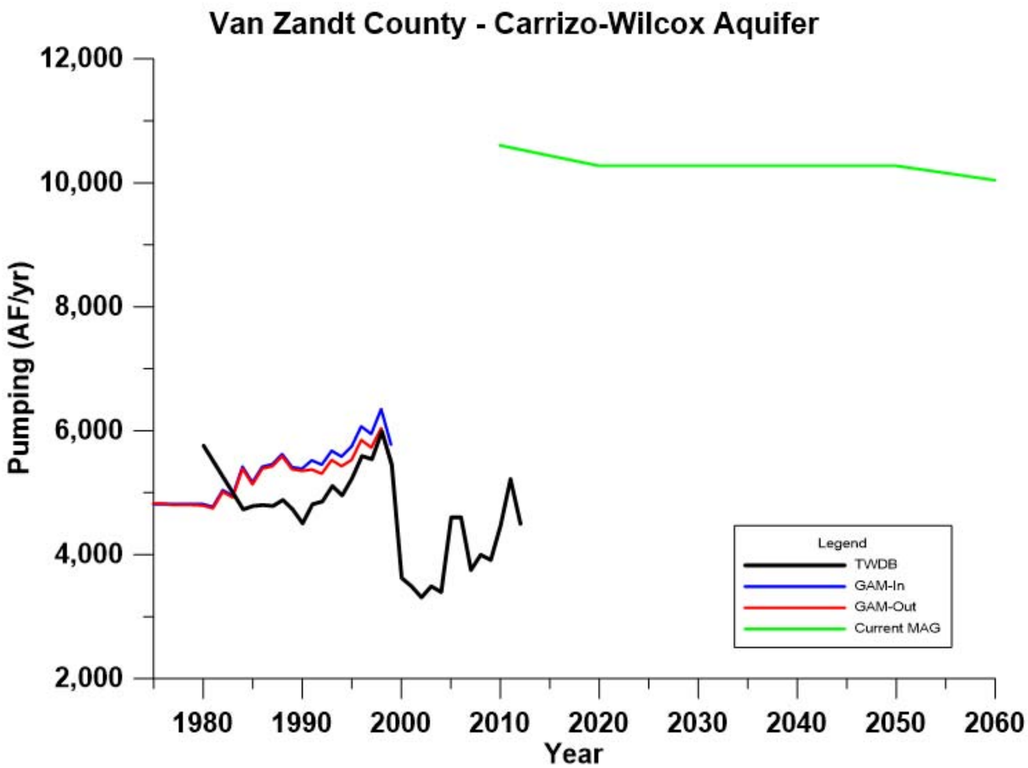

San Augustine County - Carrizo-Wilcox Aquifer
2,000
1,600
1,200
800
400
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

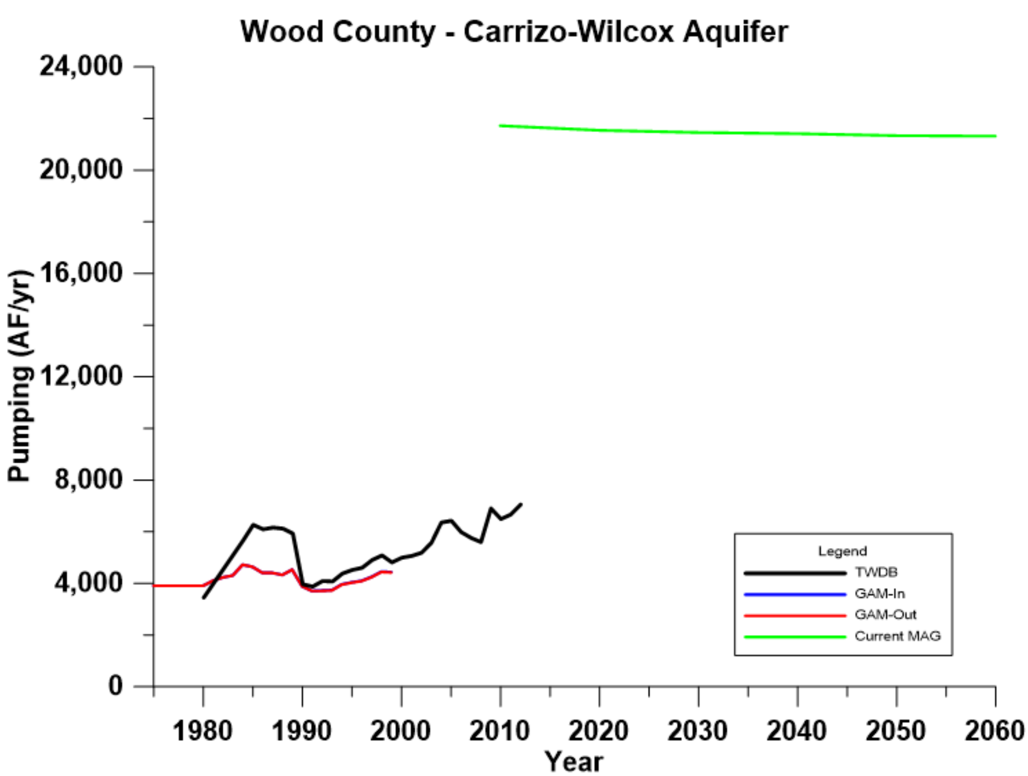

Shelby County - Carrizo-Wilcox Aquifer
14,000
12,000
10,000
8,000
6,000
4,000
2,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG


Smith County - Carrizo-Wilcox Aquifer
35,000
30,000
25,000
20,000
15,000
10,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG


Titus County - Carrizo-Wilcox Aquifer
12,000
8,000
4,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG


Upshur County - Carrizo-Wilcox Aquifer
8,000
7,000
6,000
5,000
4,000
3,000
2,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG


Van Zandt County - Carrizo-Wilcox Aquifer
12,000
10,000
8,000
6,000
4,000
2,000
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG


Wood County - Carrizo-Wilcox Aquifer
24,000
20,000
16,000
12,000
8,000
4,000
0
Pumping (AF/yr)
1980
1990
2000
2010
2020
2030
2040
2050
2060
Year
Legend
TWDB
GAM-In
GAM-Out
Current MAG

Appendix D

TWDB GAM Task 13-034: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 11

GAM Task 13-034: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 11

by Shirley Wade, Ph.D., P.G., Jerry Shi, Ph.D., P.G.,
and Chelsea Seiter-Weatherford
Texas Water Development Board
Groundwater Resources Division
(512) 936-0883
April 2, 2014

The seals appearing on this document were authorized by Shirley C. Wade, P.G. 525, Jianyou (Jerry) Shi, P.G. 11113, and Cynthia K. Ridgeway, P.G. 471 on April 2, 2014. Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by Chelsea Seiter-Weatherford under her direct supervision.

The total estimated recoverable storage in this report was calculated as follows: the Trinity Aquifer (Jerry Shi), the Nacatoch Aquifer (Chelsea Seiter-Weatherford), and the Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Gulf Coast aquifers (Shirley Wade).

GAM TASK 13-034: TOTAL ESTIMATED RECOVERABLE STORAGE FOR AQUIFERS IN GROUNDWATER MANAGEMENT AREA 11

by Shirley Wade, Ph.D., P.G., Jerry Shi, Ph.D., P.G.,
and Chelsea Seiter-Weatherford
Texas Water Development Board
Groundwater Resources Division
(512) 936-0883
April 2, 2014

EXECUTIVE SUMMARY:

Texas Water Code, §36.108 (d) (Texas Water Code, 2011) states that, before voting on the 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(24) (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 Trinity, Nacatoch, Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Gulf Coast aquifers within Groundwater Management Area 11. Tables 1 through 14 summarize the total estimated recoverable storage required by the statute. Figures 2 through 8 indicate the official extent of the aquifers in Groundwater Management Area 11 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 percent of the porosity-adjusted aquifer volume. In other words, we assume that only 25 to 75 percent of groundwater held within an aquifer can be removed by pumping.

The total recoverable storage was estimated for the portion of the aquifer within Groundwater Management Area 11 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 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 as the result of extracting groundwater from the aquifer.

METHODS:

To estimate the total recoverable storage of an aquifer, we first calculated the total storage in an aquifer within the official aquifer boundary. The total storage is the volume of groundwater removed by pumping that completely drains 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 in the aquifer outside the well. 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 between unconfined and confined aquifers. For an unconfined aquifer, the total storage is equal to the volume of groundwater removed by pumping that makes 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 related to confined aquifers and specific yield related to unconfined aquifers. 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)

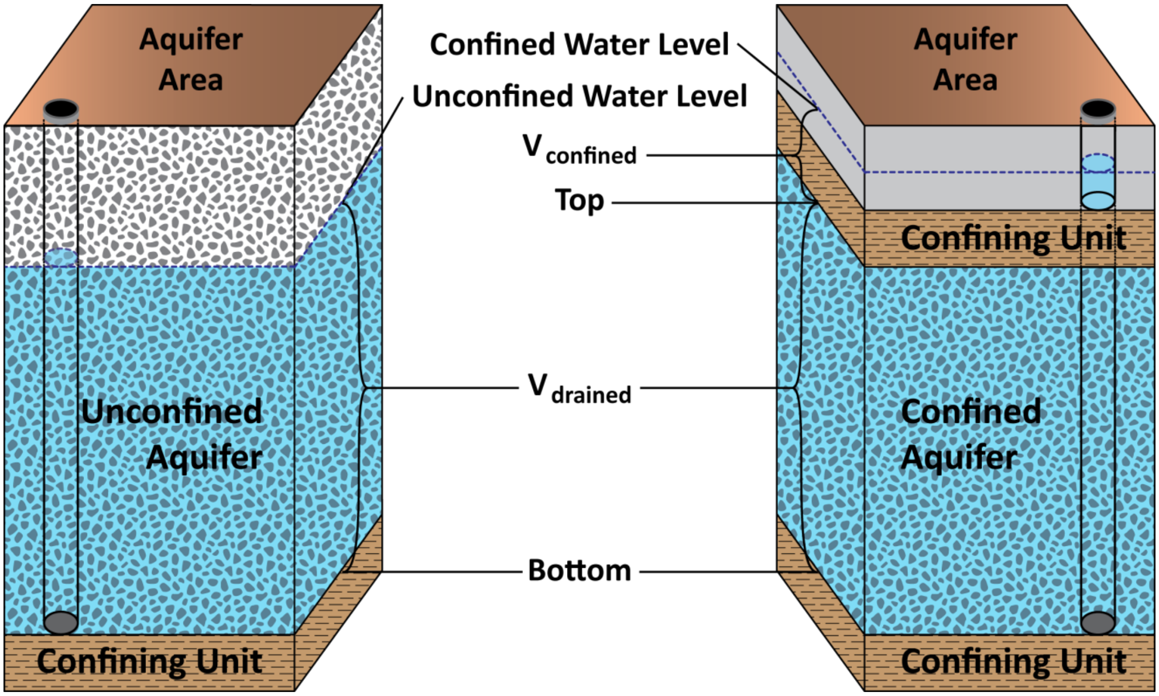


FIGURE 1. SCHEMATIC GRAPH SHOWING THE DIFFERENCE BETWEEN UNCONFINED AND CONFINED AQUIFERS.

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 Trinity, Nacatoch, Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Gulf Coast aquifers within Groundwater Management Area 11 we extracted this information from existing groundwater availability model input and output files on a cell-by-cell basis.

The recoverable storage for each of the aquifers listed above was the product of its total storage and an estimated factor ranging from 25 percent to 75 percent.

PARAMETERS AND ASSUMPTIONS:

Trinity Aquifer

- We used version 1.01 of the groundwater availability model for the northern part of the Trinity Aquifer and the Woodbine Aquifer to estimate the total recoverable storage for the Trinity Aquifer. The Woodbine Aquifer is not present in Groundwater

Management Area 11. See Bené and others (2004) for assumptions and limitations of the groundwater availability model.

- This groundwater availability model includes seven layers which generally represent the Woodbine Aquifer (Layer 1), the Washita and Fredericksburg Confining Unit (Layer 2), the Paluxy Aquifer Unit of the Trinity Aquifer (Layer 3), the Glen Rose Confining Unit of the Trinity Aquifer (Layer 4), the Hensell Sand Aquifer Unit of the Trinity Aquifer (Layer 5), the Twin Mountains Confining Units of the Trinity Aquifer (Layer 6), and the Hosston Aquifer Unit of the Trinity Aquifer (Layer 7). To develop the estimates for the total estimated recoverable storage, we used Layers 3 through 7 (the Trinity Aquifer).
- The down-dip boundary of the model is the Luling-Mexia-Talco Fault Zone, which probably allows minimal groundwater flow across the fault zone (Bené and others, 2004). The groundwater in the official extent of the northern portion of the Trinity Aquifer aquifers ranges from fresh to moderately saline (brackish) in composition (Bené and others, 2004).

Nacatoch Aquifer

- We used version 1.01 of the groundwater availability model for the Nacatoch Aquifer. See Beach and others (2009) for assumptions and limitations of the groundwater availability model for the Nacatoch Aquifer.
- This groundwater availability model includes two layers which represent the Midway Group, and alluvium and terrace deposits (Layer 1), and the Nacatoch Aquifer (Layer 2).
- The total estimated recoverable storage for the Nacatoch Aquifer was calculated using Layer 2.
- Groundwater in the Nacatoch Aquifer is generally fresh within Groundwater Management Area 11 (Beach and others, 2009). Groundwater with total dissolved solids of less than 1,000 milligrams per liter is defined as fresh. Groundwater with total dissolved solids between 1,000 to 10,000 milligrams per liter is defined as brackish, and groundwater with total dissolved solids between 10,000 and 35,000 milligrams per liter is defined as saline (George and others, 2011).

Carrizo-Wilcox, Queen City, and Sparta aquifers

- We used Version 2.01 of the groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. See Fryar and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers.
- The groundwater availability model includes eight layers that generally correspond to the Sparta Aquifer (Layer 1), the Weches Confining Unit (Layer 2), the Queen City Aquifer (Layer 3), the Reklaw Confining Unit (Layer 4), the Carrizo Aquifer (Layer 5), the Upper Wilcox Aquifer (Layer 6), the Middle Wilcox Aquifer (Layer 7), and the Lower Wilcox Aquifer (Layer 8).
- In the Sabine Uplift area, the Simsboro Formation (Middle Wilcox Aquifer) is not distinguishable and the Wilcox Group is informally divided into the Upper Wilcox and the Lower Wilcox aquifers (Fryar and others, 2003). In the current version of the groundwater availability model, layers 6 and 7 represent the Upper Wilcox and Lower Wilcox aquifers in this area. Layer 8 is included in the model in this area, but it is of nominal thickness and is not intended to represent the Lower Wilcox aquifer.

Yegua-Jackson Aquifer and the Catahoula Formation portion of the Gulf Coast Aquifer System

- We used version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer to estimate the total recoverable storages of the Yegua-Jackson Aquifer and parts of the Catahoula Formation. See Deeds and others (2010) for assumptions and limitations of the groundwater availability model.
- This groundwater availability model includes five layers which represent the outcrop section for the Yegua-Jackson Aquifer and the Catahoula Formation and other younger overlying units (Layer 1), the upper portion of the Jackson Group (Layer 2), the lower portion of the Jackson Group (Layer 3), the upper portion of the Yegua Group (Layer 4), and the lower portion of the Yegua Group (Layer 5). To develop the estimates for the total estimated recoverable storage in the Yegua-Jackson Aquifer, we used layers

1 through 5. However, we only used model cells in Layer 1 to evaluate the outcrop area of the Yegua-Jackson Aquifer.

- The down-dip boundary for the Yegua-Jackson Aquifer in this model was set to approximately coincide with the extent of the available geologic data, much deeper than any portion of the aquifer that is used for groundwater supply (Deeds and others, 2010). Consequently, the model extends into zones of brackish and saline groundwater. The groundwater in the official extent of the Yegua-Jackson Aquifer ranges from fresh to brackish in composition (Deeds and others, 2010).

Gulf Coast Aquifer System

- We used version 3.01 of the groundwater availability model for the northern portion of the Gulf Coast Aquifer system for this analysis. See Kasmarek (2013) for assumptions and limitations of the model.
- The model has four layers which represent the Chicot Aquifer (Layer 1), the Evangeline Aquifer (Layer 2), the Burkeville confining unit (Layer 3), and the Jasper Aquifer and parts of the Catahoula Formation in direct hydrologic communication with the Jasper Aquifer (Layer 4).
- The southeastern boundary of flow in each hydrogeologic unit of the model was set at the down-dip limit of freshwater (up to 10,000 milligrams per liter of total dissolved solids; Kasmarek, 2013).

RESULTS:

Tables 1 through 14 summarize the total estimated recoverable storage required by statute. The county and groundwater conservation district total storage estimates are rounded to two significant digits. Figures 2 through 8 indicate the extent of the groundwater availability models in Groundwater Management Area 11 from which the storage information was extracted.

TABLE 1. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE TRINITY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Henderson	500,000	125,000	375,000
Total	**500,000**	**125,000**	**375,000**

TABLE 2. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE TRINITY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Neches & Trinity Valleys GCD	500,000	125,000	375,000
Total	**500,000**	**125,000**	**375,000**

FIGURE 2 EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN TRINITY AND WOODBINE AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE TRINITY AQUIFER (TABLES 1 AND 2) WITHIN GROUNDWATER MANAGEMENT AREA 11.

TABLE 3. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE NACATOCH AQUIFER IN GROUNDWATER MANAGEMENT AREA 11. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Bowie	140,000	35,000	105,000
Henderson	9,800	2,450	7,350
Morris	2,900	725	2,175
Red River	11,000	2,750	8,250
Titus	15,000	3,750	11,250
Total	**178,700**	**44,675**	**134,025**

TABLE 4. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[1] FOR THE NACATOCH AQUIFER IN GROUNDWATER MANAGEMENT AREA 11. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

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	40,000	120,000
Neches & Trinity Valleys GCD	9,800	2,450	7,350
Total	**169,800**	**42,450**	**127,350**

[1] 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 two significant digits.

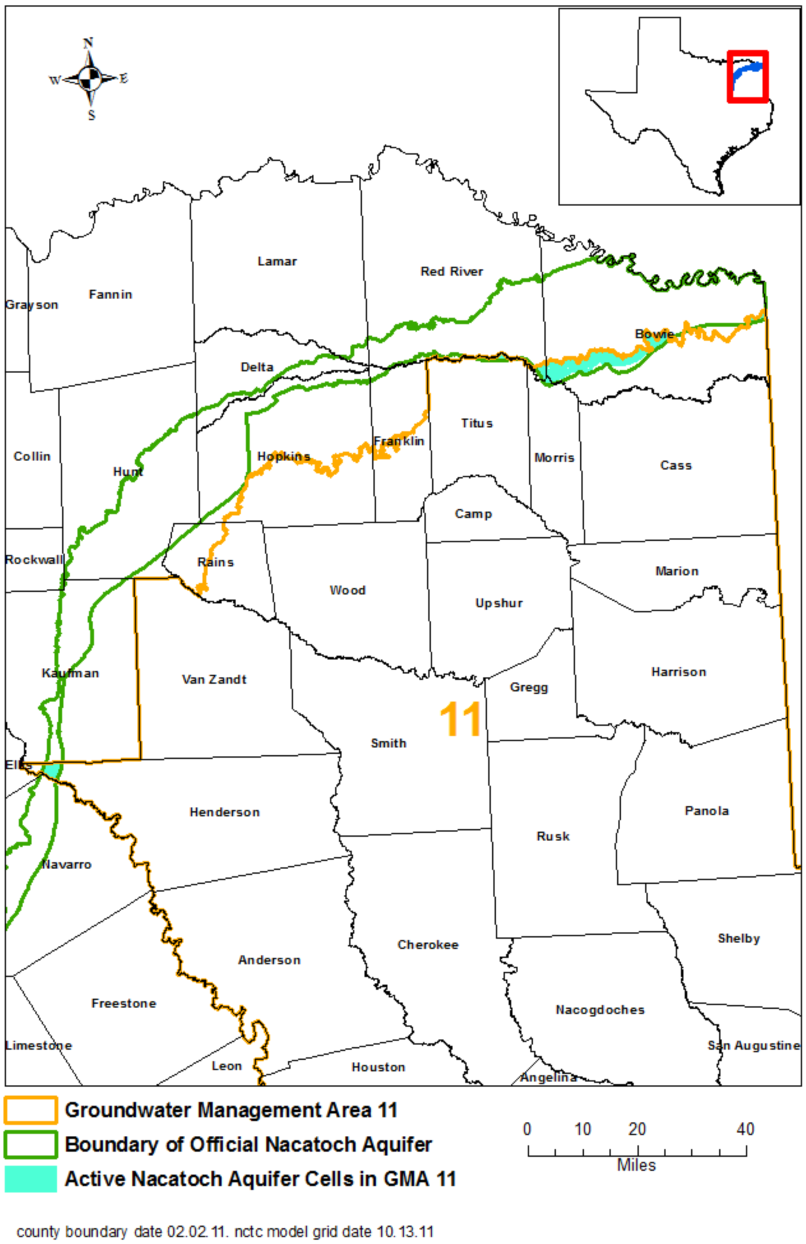


FIGURE 3. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NACATOCH AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE NACATOCH AQUIFER (TABLES 3 AND 4) WITHIN GROUNDWATER MANAGEMENT AREA 11.

TABLE 5. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE CARRIZO-WILCOX AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Anderson	170,000,000	42,500,000	127,500,000
Angelina	130,000,000	32,500,000	97,500,000
Bowie	6,400,000	1,600,000	4,800,000
Camp	15,000,000	3,750,000	11,250,000
Cass	60,000,000	15,000,000	45,000,000
Cherokee	200,000,000	50,000,000	150,000,000
Franklin	6,000,000	1,500,000	4,500,000
Gregg	21,000,000	5,250,000	15,750,000
Harrison	40,000,000	10,000,000	30,000,000
Henderson	66,000,000	16,500,000	49,500,000
Hopkins	7,000,000	1,750,000	5,250,000
Houston	390,000,000	97,500,000	292,500,000
Marion	25,000,000	6,250,000	18,750,000
Morris	16,000,000	4,000,000	12,000,000
Nacogdoches	210,000,000	52,500,000	157,500,000
Panola	33,000,000	8,250,000	24,750,000
Rains	3,200,000	800,000	2,400,000
Red River	33,000	8,250	24,750
Rusk	100,000,000	25,000,000	75,000,000
Sabine	78,000,000	19,500,000	58,500,000

County	***Total Storage (acre-feet)***	***25 percent of Total Storage (acre-feet)***	***75 percent of Total Storage (acre-feet)***
San Augustine	110,000,000	27,500,000	82,500,000
Shelby	85,000,000	21,250,000	63,750,000
Smith	100,000,000	25,000,000	75,000,000
Titus	13,000,000	3,250,000	9,750,000
Trinity	43,000,000	10,750,000	32,250,000
Upshur	45,000,000	11,250,000	33,750,000
Van Zandt	35,000,000	8,750,000	26,250,000
Wood	54,000,000	13,500,000	40,500,000
Total	**2,061,633,000**	**515,408,250**	**1,546,224,750**

TABLE 6. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT [2] FOR THE CARRIZO-WILCOX AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	890,000,000	222,500,000	667,500,000
Anderson County UWCD[3]	7,600,000	1,900,000	5,700,000
Deep East Texas GCD[4]	270,000,000	67,500,000	202,500,000
Neches & Trinity Valleys GCD	430,000,000	107,500,000	322,500,000
Panola County GCD	33,000,000	8,250,000	24,750,000
Pineywoods GCD	340,000,000	85,000,000	255,000,000
Rusk County GCD	100,000,000	25,000,000	75,000,000
Total	**2,070,600,000**	**517,650,000**	**1,552,950,000**

[2] 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 two significant digits.
[3] UWCD stands for Underground Water Conservation District
[4] Deep East Texas Groundwater Conservation District is pending confirmation.

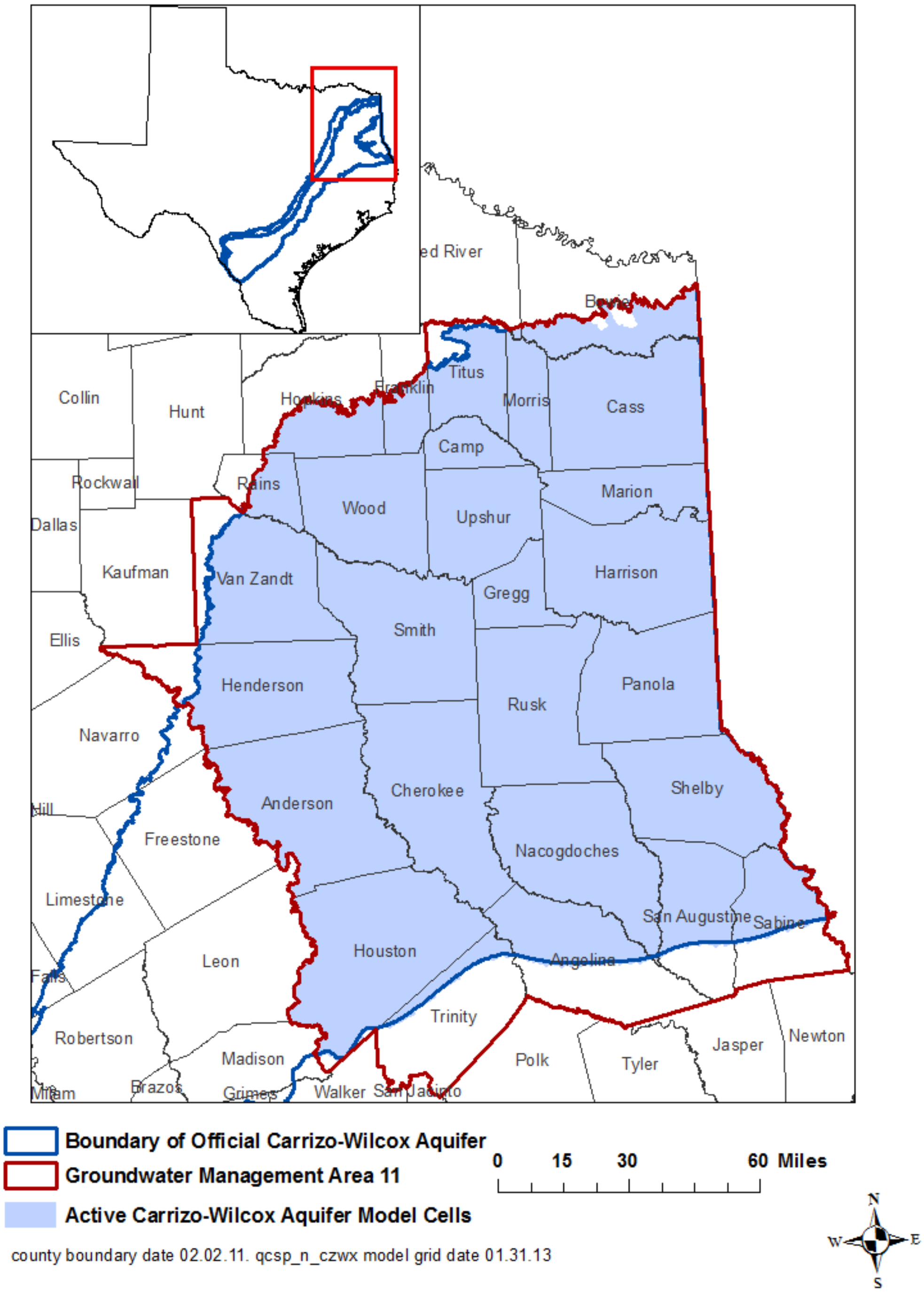


FIGURE 4. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PART OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE CARRIZO-WILCOX AQUIFER (TABLES 5 AND 6) WITHIN GROUNDWATER MANAGEMENT AREA 11.

TABLE 7. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE QUEEN CITY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Anderson	19,000,000	4,750,000	14,250,000
Angelina	2,000,000	500,000	1,500,000
Camp	600,000	150,000	450,000
Cass	8,000,000	2,000,000	6,000,000
Cherokee	15,000,000	3,750,000	11,250,000
Gregg	1,500,000	375,000	1,125,000
Harrison	1,200,000	300,000	900,000
Henderson	6,700,000	1,675,000	5,025,000
Houston	37,000,000	9,250,000	27,750,000
Marion	2,500,000	625,000	1,875,000
Morris	1,300,000	325,000	975,000
Nacogdoches	4,500,000	1,125,000	3,375,000
Rusk	58,000	14,500	43,500
Smith	23,000,000	5,750,000	17,250,000
Titus	63,000	15,750	47,250
Trinity	1,900,000	475,000	1,425,000
Upshur	7,800,000	1,950,000	5,850,000
Van Zandt	1,200,000	300,000	900,000
Wood	8,700,000	2,175,000	6,525,000
Total	**142,021,000**	**35,505,250**	**106,515,750**

TABLE 8. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[5] FOR THE QUEEN CITY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

Groundwater Conservation District (GCD)	***Total Storage (acre-feet)***	***25 percent of Total Storage (acre-feet)***	***75 percent of Total Storage (acre-feet)***
No District	95,000,000	23,750,000	71,250,000
Anderson County UWCD[6]	550,000	137,500	412,500
Neches & Trinity Valleys GCD	40,000,000	10,000,000	30,000,000
Pineywoods GCD	6,500,000	1,625,000	4,875,000
Rusk County GCD	58,000	14,500	43,500
Total	**142,108,000**	**35,527,000**	**106,581,000**

[5] 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 two significant digits.
[6] UWCD stands for Underground Water Conservation District

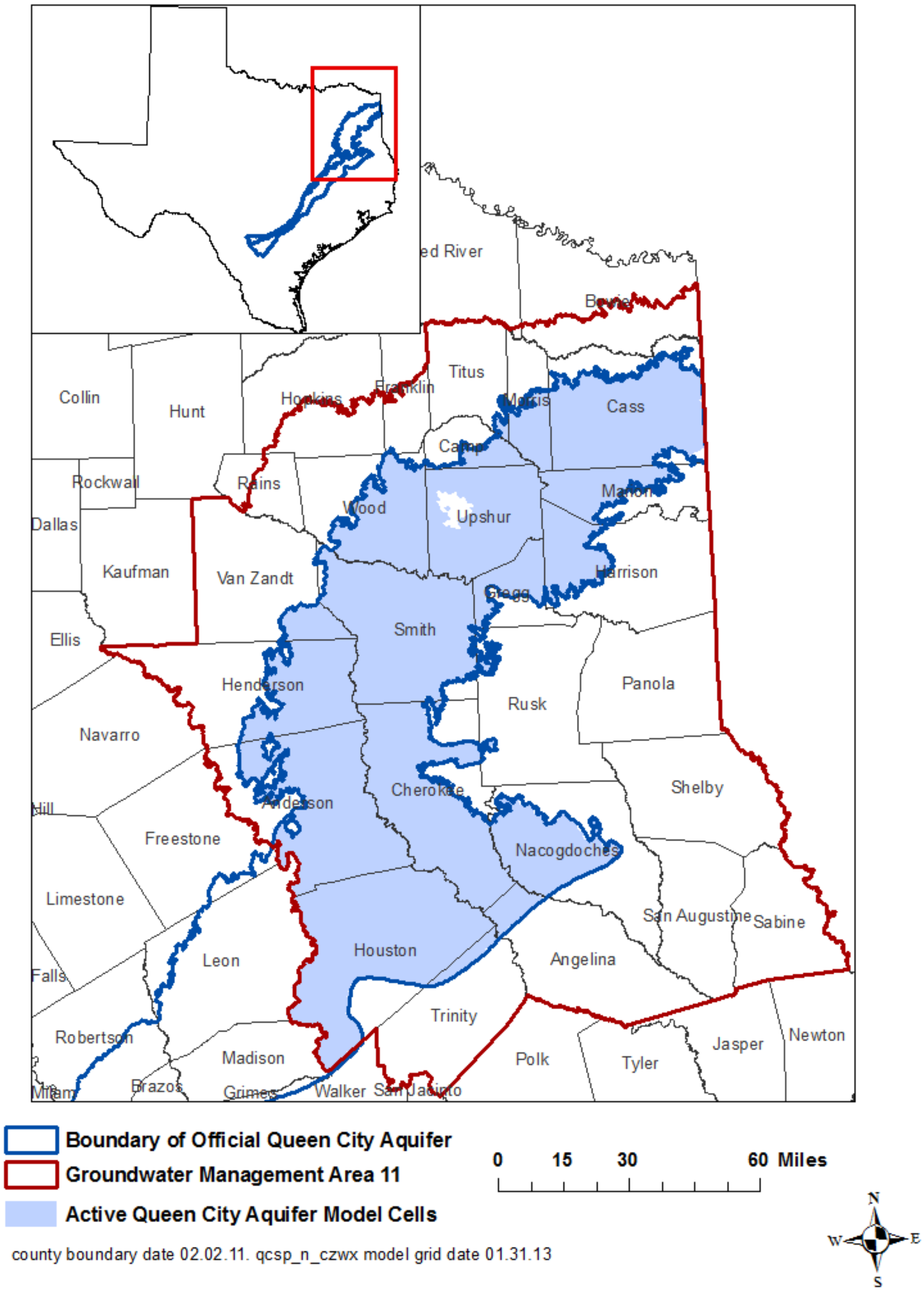


FIGURE 5. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PART OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE QUEEN CITY AQUIFER (TABLES 7 AND 8) WITHIN GROUNDWATER MANAGEMENT AREA 11.

TABLE 9. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE SPARTA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Anderson	640,000	160,000	480,000
Angelina	5,200,000	1,300,000	3,900,000
Cherokee	1,700,000	425,000	1,275,000
Houston	25,000,000	6,250,000	18,750,000
Nacogdoches	3,900,000	975,000	2,925,000
Sabine	6,000,000	1,500,000	4,500,000
San Augustine	6,800,000	1,700,000	5,100,000
Trinity	6,100,000	1,525,000	4,575,000
Total	**55,340,000**	**13,835,000**	**41,505,000**

TABLE 10. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[7] FOR THE SPARTA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	32,000,000	8,000,000	24,000,000
Deep East Texas GCD[8]	13,000,000	3,250,000	9,750,000
Neches & Trinity Valleys GCD	2,300,000	575,000	1,725,000
Pineywoods GCD	9,100,000	2,275,000	6,825,000
Total	**56,400,000**	**14,100,000**	**42,300,000**

[7] 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 two significant digits.
[8] Deep East Texas Groundwater Conservation District is pending confirmation.

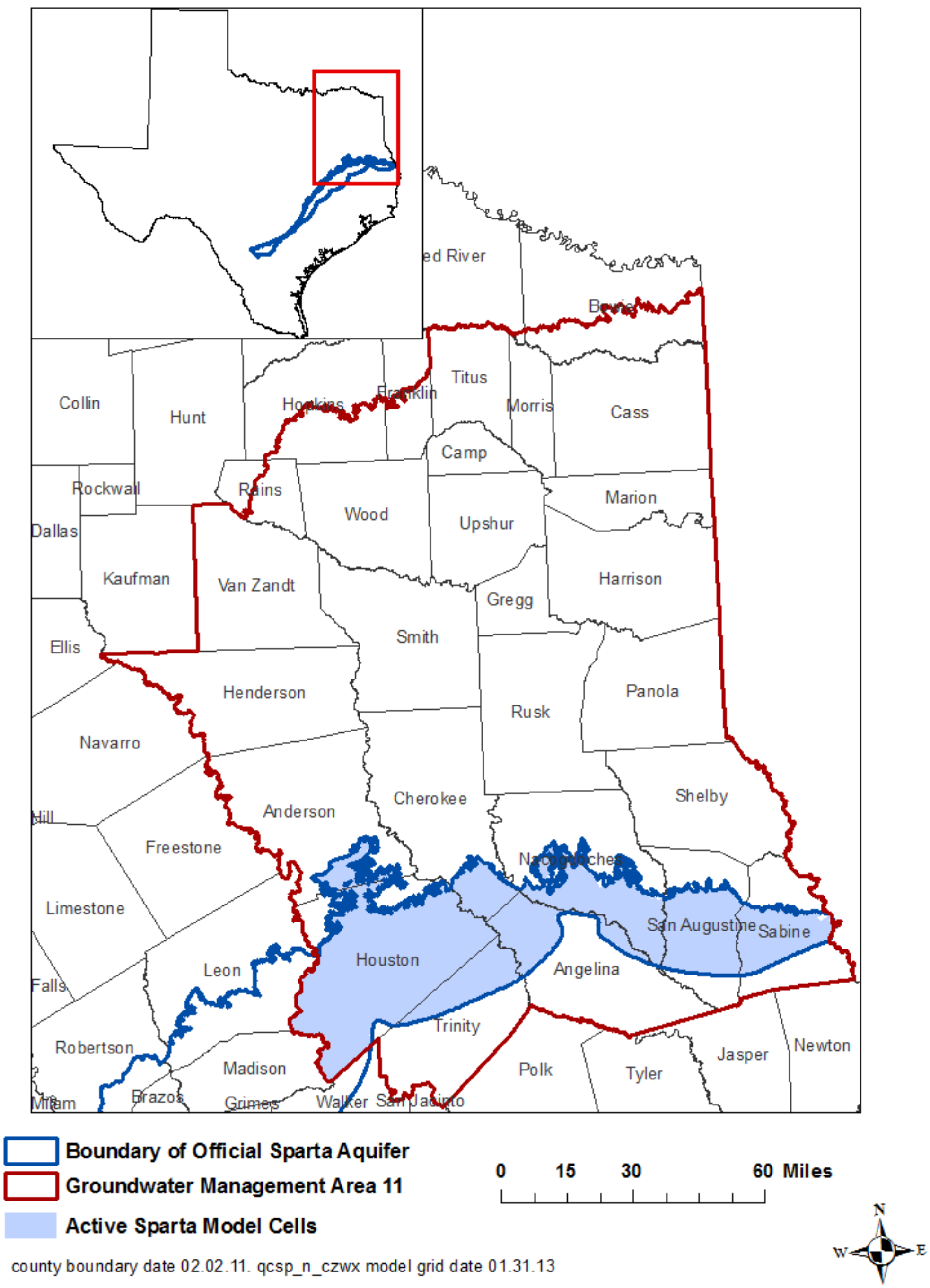


FIGURE 6. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CENTRAL PART OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE SPARTA AQUIFER (TABLES 9 AND 10) WITHIN GROUNDWATER MANAGEMENT AREA 11.

TABLE 11. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE YEGUA-JACKSON AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Angelina	72,000,000	18,000,000	54,000,000
Houston	21,000,000	5,250,000	15,750,000
Nacogdoches	1,400,000	350,000	1,050,000
Sabine	30,000,000	7,500,000	22,500,000
San Augustine	19,000,000	4,750,000	14,250,000
Trinity	83,000,000	20,750,000	62,250,000
Total	**226,400,000**	**56,600,000**	**169,800,000**

TABLE 12. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[9] FOR THE YEGUA-JACKSON AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25percent of Total Storage (acre-feet)*	*75percent of Total Storage (acre-feet)*
No District	100,000,000	25,000,000	75,000,000
Deep East Texas GCD[10]	49,000,000	12,250,000	36,750,000
Pineywoods GCD	74,000,000	18,500,000	55,500,000
Total	**223,000,000**	**55,750,000**	**167,250,000**

[9] The total estimated recoverable storages values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant digits.
[10] Deep East Texas Groundwater Conservation District is pending confirmation.

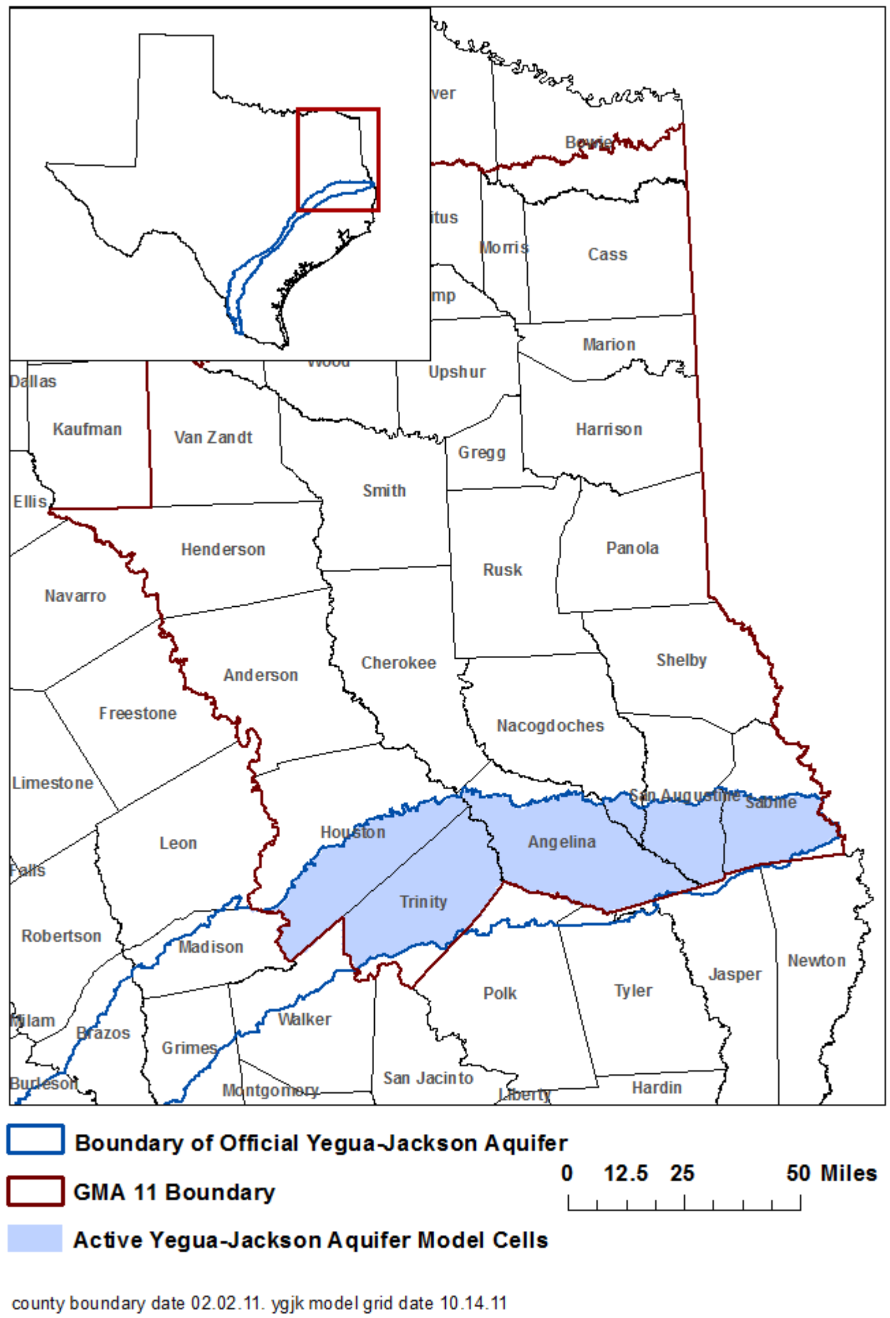


FIGURE 7. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE YEGUA-JACKSON AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLES 11 AND 12) FOR THE YEGUA-JACKSON AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 11.

TABLE 13. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE GULF COAST AQUIFER SYSTEM WITHIN GROUNDWATER MANAGEMENT AREA 11. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Angelina	27,000	6,750	20,250
Sabine	120,000	30,000	90,000
Trinity	1,300,000	325,000	975,000
Total	**1,447,000**	**361,750**	**1,085,250**

TABLE 14. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[11] FOR THE GULF COAST AQUIFER SYSTEM WITHIN GROUNDWATER MANAGEMENT AREA 11. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25percent of Total Storage (acre-feet)*	*75percent of Total Storage (acre-feet)*
No District	1,400,000	350,000	1,050,000
Pineywoods GCD	27,000	6,750	20,250
Total	**1,427,000**	**356,750**	**1,070,250**

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

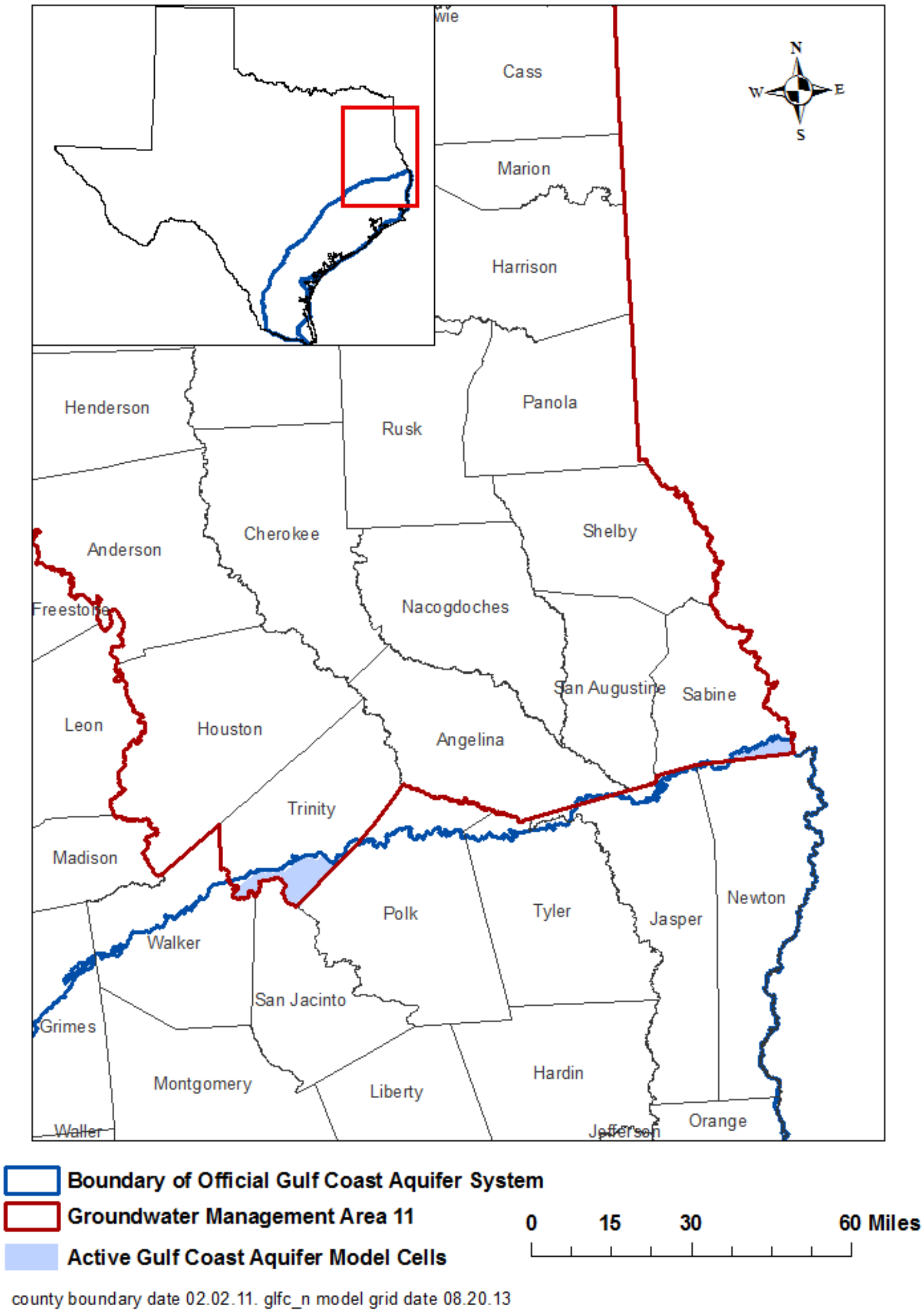


FIGURE 8. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE GULF COAST AQUIFER SYSTEM USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLES 13 AND 14) FOR THE GULF COAST AQUIFER SYSTEM WITHIN GROUNDWATER MANAGEMENT AREA 11.

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.

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Appendix E

Region D and Region I Socioeconomic Impact Reports from TWDB

June 4, 2010

Mr. Richard LeTourneau
Chairman, North East Texas
Regional Water Planning Group
P.O. Box 12071
Longview, Texas 75607

Re: Socioeconomic Impact Analysis of Not Meeting Water Needs for the 2011 North East Texas Regional Water Plan

Dear Chairman LeTourneau:

We have received your request for technical assistance to complete the socioeconomic impact analysis of not meeting water needs. In response, enclosed is a report that describes our methodology and presents the results. Section 1 provides an overview of the methodology, and Section 2 presents results at the regional level, and Appendix 2 show results for individual water user groups.

If you have any questions or comments, please feel free to contact me at (512) 463-7928 or by email at stuart.norvell@twdb.state.tx.us.

Sincerely,

Stuart D. Norvell
Manager, Water Planning Research and Analysis
Water Resources Planning Division

SN/ao

Enclosure

c. Temple Mckinnon, TWDB
S. Doug Shaw, TWDB

Socioeconomic Impacts of Projected Water Shortages for the Northeast Texas Regional Water Planning Area (Region D)

Prepared in Support of the 2011 Northeast Texas Regional Water Plan

Stuart D. Norvell, Managing Economist
Water Resources Planning Division
Texas Water Development Board
Austin, Texas

Doug Shaw, Agricultural Economist
Water Resources Planning Division
Texas Water Development Board
Austin, Texas

February, 2010

Table of Contents

Tables

Introduction

Water shortages during drought would likely curtail or eliminate economic activity in business and industries reliant on water. For example, without water farmers cannot irrigate; refineries cannot produce gasoline, and paper mills cannot make paper. Unreliable water supplies would not only have an immediate and real impact on existing businesses and industry, but they could also adversely affect economic development in Texas. From a social perspective, water supply reliability is critical as well. Shortages would disrupt activity in homes, schools and government and could adversely affect public health and safety. For all of the above reasons, it is important to analyze and understand how restricted water supplies during drought could affect communities throughout the state.

Administrative rules require that regional water planning groups evaluate the impacts of not meeting water needs as part of the regional water planning process, and rules direct TWDB staff to provide technical assistance: "*The executive administrator shall provide available technical assistance to the regional water planning groups, upon request, on water supply and demand analysis, including methods to evaluate the social and economic impacts of not meeting needs*" [(§357.7 (4)(A)]. Staff of the TWDB's Water Resources Planning Division designed and conducted this report in support of the Northeast Texas Regional Water Planning Group (Region D).

This document summarizes the results of our analysis and discusses the methodology used to generate the results. Section 1 outlines the overall methodology and discusses approaches and assumptions specific to each water use category (i.e., irrigation, livestock, mining, steam-electric, municipal and manufacturing). Section 2 presents the results for each category where shortages are reported at the regional planning area level and river basin level. Results for individual water user groups are not presented, but are available upon request.

1. Methodology

Section 1 provides a general overview of how economic and social impacts were measured. In addition, it summarizes important clarifications, assumptions and limitations of the study.

1.1 Economic Impacts of Water Shortages

1.1.1 General Approach

Economic analysis as it relates to water resources planning generally falls into two broad areas. Supply side analysis focuses on costs and alternatives of developing new water supplies or implementing programs that provide additional water from current supplies. Demand side analysis concentrates on impacts or benefits of providing water to people, businesses and the environment. Analysis in this report focuses strictly on demand side impacts. When analyzing the economic impacts of water shortages as defined in Texas water planning, three potential scenarios are possible:

1) Scenario 1 involves situations where there are physical shortages of raw surface or groundwater due to drought of record conditions. For example, City A relies on a reservoir with average conservation storage of 500 acre-feet per year and a firm yield of 100 acre feet. In 2010, the city uses about 50 acre-feet per year, but by 2030 their demands are expected to increase to 200 acre-feet. Thus, in 2030 the reservoir would not have enough water to meet the city's demands,

and people would experience a shortage of 100 acre-feet assuming drought of record conditions. Under normal or average climatic conditions, the reservoir would likely be able to provide reliable water supplies well beyond 2030.

2) Scenario 2 is a situation where despite drought of record conditions, water supply sources can meet existing use requirements; however, limitations in water infrastructure would preclude future water user groups from accessing these water supplies. For example, City B relies on a river that can provide 500 acre-feet per year during drought of record conditions and other constraints as dictated by planning assumptions. In 2010, the city is expected to use an estimated 100 acre-feet per year and by 2060 it would require no more than 400 acre-feet. But the intake and pipeline that currently transfers water from the river to the city's treatment plant has a capacity of only 200 acre-feet of water per year. Thus, the city's water supplies are adequate even under the most restrictive planning assumptions, but their conveyance system is too small. This implies that at some point – perhaps around 2030 - infrastructure limitations would constrain future population growth and any associated economic activity or impacts.

3) Scenario 3 involves water user groups that rely primarily on aquifers that are being depleted. In this scenario, projected and in some cases existing demands may be unsustainable as groundwater levels decline. Areas that rely on the Ogallala aquifer are a good example. In some communities in the region, irrigated agriculture forms a major base of the regional economy. With less irrigation water from the Ogallala, population and economic activity in the region could decline significantly assuming there are no offsetting developments.

Assessing the social and economic effects of each of the above scenarios requires various levels and methods of analysis and would generate substantially different results for a number of reasons; the most important of which has to do with the time frame of each scenario. Scenario 1 falls into the general category of static analysis. This means that models would measure impacts for a small interval of time such as a drought. Scenarios 2 and 3, on the other hand imply a dynamic analysis meaning that models are concerned with changes over a much longer time period.

Since administrative rules specify that planning analysis be evaluated under drought of record conditions (a static and random event), socioeconomic impact analysis developed by the TWDB for the state water plan is based on assumptions of Scenario 1. Estimated impacts under scenario 1 are point estimates for years in which needs are reported (2010, 2020, 2030, 2040, 2050 and 2060). They are independent and distinct "what if" scenarios for a particular year and shortages are assumed to be temporary events resulting from drought of record conditions. Estimated impacts measure what would happen if water user groups experience water shortages for a period of one year.

The TWDB recognize that dynamic models may be more appropriate for some water user groups; however, combining approaches on a statewide basis poses several problems. For one, it would require a complex array of analyses and models, and might require developing supply and demand forecasts under "normal" climatic conditions as opposed to drought of record conditions. Equally important is the notion that combining the approaches would produce inconsistent results across regions resulting in a so-called "apples to oranges" comparison.

A variety tools are available to estimate economic impacts, but by far, the most widely used today are input-output models (IO models) combined with social accounting matrices (SAMs). Referred to as IO/SAM models, these tools formed the basis for estimating economic impacts for agriculture (irrigation and livestock water uses) and industry (manufacturing, mining, steam-electric and commercial business activity for municipal water uses).

Since the planning horizon extends through 2060, economic variables in the baseline are adjusted in accordance with projected changes in demographic and economic activity. Growth rates for municipal water use sectors (i.e., commercial, residential and institutional) are based on TWDB population forecasts. Future values for manufacturing, agriculture, and mining and steam-electric activity are based on the same underlying economic forecasts used to estimate future water use for each category.

The following steps outline the overall process.

Step 1*: Generate IO/SAM Models and Develop Economic Baseline*

IO/SAM models were estimated using propriety software known as IMPLAN PRO™ (Impact for Planning Analysis). IMPLAN is a modeling system originally developed by the U.S. Forestry Service in the late 1970s. Today, the Minnesota IMPLAN Group (MIG Inc.) owns the copyright and distributes data and software. It is probably the most widely used economic impact model in existence. IMPLAN comes with databases containing the most recently available economic data from a variety of sources.[1] Using IMPLAN software and data, transaction tables conceptually similar to the one discussed previously were estimated for each county in the region and for the region as a whole. Each transaction table contains 528 economic sectors and allows one to estimate a variety of economic statistics including:

- **total sales -** total production measured by sales revenues;
- **intermediate sales -** sales to other businesses and industries within a given region;
- **final sales –** sales to end users in a region and exports out of a region**;**
- **employment -** number of full and part-time jobs (annual average) required by a given industry including self-employment;
- **regional income -** total payroll costs (wages and salaries plus benefits) paid by industries, corporate income, rental income and interest payments; and
- **business taxes -** sales, excise, fees, licenses and other taxes paid during normal operation of an industry (does not include income taxes).

TWDB analysts developed an economic baseline containing each of the above variables using year 2000 data. Since the planning horizon extends through 2060, economic variables in the baseline were allowed to change in accordance with projected changes in demographic and economic activity. Growth rates for municipal water use sectors (i.e., commercial, residential and institutional) are based on TWDB population forecasts. Projections for manufacturing, agriculture, and mining and steam-electric activity are based on the same underlying economic forecasts used to estimate future water use for each category. Monetary impacts in future years are reported in constant year 2006 dollars.

It is important to stress that employment, income and business taxes are the most useful variables when comparing the relative contribution of an economic sector to a regional economy. Total sales as reported in IO/SAM models are less desirable and can be misleading because they include sales to other industries in the region for use in the production of other goods. For example, if a mill buys grain from local farmers and uses it to produce feed, sales of both the processed feed and raw corn are counted as "output" in an IO model. Thus, total sales double-count or overstate the true economic value of goods

[1]The IMPLAN database consists of national level technology matrices based on benchmark input-output accounts generated by the U.S. Bureau of Economic Analysis and estimates of final demand, final payments, industry output and employment for various economic sectors. IMPLAN regional data (i.e. states, a counties or groups of counties within a state) are divided into two basic categories: 1) data on an industry basis including value-added, output and employment, and 2) data on a commodity basis including final demands and institutional sales. State-level data are balanced to national totals using a matrix ratio allocation system and county data are balanced to state totals.

and services produced in an economy. They are not consistent with commonly used measures of output such as Gross National Product (GNP), which counts only final sales.

Another important distinction relates to terminology. Throughout this report, the term *sector* refers to economic subdivisions used in the IMPLAN database and resultant input-output models (528 individual sectors based on Standard Industrial Classification Codes). In contrast, the phrase *water use category* refers to water user groups employed in state and regional water planning including irrigation, livestock, mining, municipal, manufacturing and steam electric. Each IMPLAN sector was assigned to a specific water use category.

Step 2: *Estimate Direct and Indirect Economic Impacts of Water Needs*

Direct impacts are reductions in output by sectors experiencing water shortages. For example, without adequate cooling and process water a refinery would have to curtail or cease operation, car washes may close, or farmers may not be able to irrigate and sales revenues fall. Indirect impacts involve changes in inter-industry transactions as supplying industries respond to decreased demands for their services, and how seemingly non-related businesses are affected by decreased incomes and spending due to direct impacts. For example, if a farmer ceases operations due to a lack of irrigation water, they would likely reduce expenditures on supplies such as fertilizer, labor and equipment, and businesses that provide these goods would suffer as well.

Direct impacts accrue to immediate businesses and industries that rely on water and without water industrial processes could suffer. However, output responses may vary depending upon the severity of shortages. A small shortage relative to total water use would likely have a minimal impact, but large shortages could be critical. For example, farmers facing small shortages might fallow marginally productive acreage to save water for more valuable crops. Livestock producers might employ emergency culling strategies, or they may consider hauling water by truck to fill stock tanks. In the case of manufacturing, a good example occurred in the summer of 1999 when Toyota Motor Manufacturing experienced water shortages at a facility near Georgetown, Kentucky.[2] As water levels in the Kentucky River fell to historic lows due to drought, plant managers sought ways to curtail water use such as reducing rinse operations to a bare minimum and recycling water by funneling it from paint shops to boilers. They even considered trucking in water at a cost of 10 times what they were paying. Fortunately, rains at the end of the summer restored river levels, and Toyota managed to implement cutbacks without affecting production, but it was a close call. If rains had not replenished the river, shortages could have severely reduced output.[3]

To account for uncertainty regarding the relative magnitude of impacts to farm and business operations, the following analysis employs the concept of elasticity. Elasticity is a number that shows how a change in one variable will affect another. In this case, it measures the relationship between a percentage reduction in water availability and a percentage reduction in output. For example, an elasticity of 1.0 indicates that a 1.0 percent reduction in water availability would result in a 1.0 percent reduction in economic output. An elasticity of 0.50 would indicate that for every 1.0 percent of unavailable water, output is reduced by 0.50 percent and so on. Output elasticities used in this study are:[4]

[2] Royal, W. "*High And Dry - Industrial Centers Face Water Shortages*." in Industry Week, Sept, 2000.

[3] The efforts described above are not planned programmatic or long-term operational changes. They are emergency measures that individuals might pursue to alleviate what they consider a temporary condition. Thus, they are not characteristic of long-term management strategies designed to ensure more dependable water supplies such as capital investments in conservation technology or development of new water supplies.

[4] Elasticities are based on one of the few empirical studies that analyze potential relationships between economic output and water shortages in the United States. The study, conducted in California, showed that a significant number of industries would suffer reduced output during water shortages. Using a survey based approach researchers posed two scenarios to different industries. In

- if water needs are 0 to 5 percent of total water demand, no corresponding reduction in output is assumed;

- if water needs are 5 to 30 percent of total water demand, for each additional one percent of water need that is not met, there is a corresponding 0.50 percent reduction in output;

- if water needs are 30 to 50 percent of total water demand, for each additional one percent of water need that is not met, there is a corresponding 0.75 percent reduction in output; and

- if water needs are greater than 50 percent of total water demand, for each additional one percent of water need that is not met, there is a corresponding 1.0 percent (i.e., a proportional reduction).

In some cases, elasticities are adjusted depending upon conditions specific to a given water user group.

Once output responses to water shortages were estimated, direct impacts to total sales, employment, regional income and business taxes were derived using regional level economic multipliers estimating using IO/SAM models. The formula for a given IMPLAN sector is:

$D_{i,t} = Q_{i,t} *_{,} S_{i,t} * E_Q * RFD_i * DM_{i(Q, L, I, T)}$

where:

$D_{i,t}$ = direct economic impact to sector *i* in period *t*

$Q_{i,t}$ = total sales for sector *i* in period *t* in an affected county

$RFD_{i,}$ = ratio of final demand to total sales for sector *i* for a given region

$S_{i,t}$ = water shortage as percentage of total water use in period *t*

E_Q = elasticity of output and water use

$DM_{i(L, I, T)}$ = direct output multiplier coefficients for labor (L), income (I) and taxes (T) for sector *i*.

Secondary impacts were derived using the same formula used to estimate direct impacts; however, indirect multiplier coefficients are used. Methods and assumptions specific to each water use sector are discussed in Sections 1.1.2 through 1.1.4.

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the first scenario, they asked how a 15 percent cutback in water supply lasting one year would affect operations. In the second scenario, they asked how a 30 percent reduction lasting one year would affect plant operations. In the case of a 15 percent shortage, reported output elasticities ranged from 0.00 to 0.76 with an average value of 0.25. For a 30 percent shortage, elasticities ranged from 0.00 to 1.39 with average of 0.47. For further information, see, California Urban Water Agencies, "*Cost of Industrial Water Shortages,*" Spectrum Economics, Inc. November, 1991.

General Assumptions and Clarification of the Methodology

As with any attempt to measure and quantify human activities at a societal level, assumptions are necessary and every model has limitations. Assumptions are needed to maintain a level of generality and simplicity such that models can be applied on several geographic levels and across different economic sectors. In terms of the general approach used here several clarifications and cautions are warranted:

1. Shortages as reported by regional planning groups are the starting point for socioeconomic analyses.

2. Estimated impacts are point estimates for years in which needs are reported (i.e., 2010, 2020, 2030, 2040, 2050 and 2060).They are independent and distinct "what if" scenarios for each particular year and water shortages are assumed to be temporary events resulting from severe drought conditions combined with infrastructure limitations. In other words, growth occurs and future shocks are imposed on an economy at 10-year intervals and resultant impacts are measured. Given, that reported figures are not cumulative in nature, it is inappropriate to sum impacts over the entire planning horizon. Doing so, would imply that the analysis predicts that drought of record conditions will occur every ten years in the future, which is not the case. Similarly, authors of this report recognize that in many communities needs are driven by population growth, and in the future total population will exceed the amount of water available due to infrastructure limitations, regardless of whether or not there is a drought. This implies that infrastructure limitations would constrain economic growth. However, since needs as defined by planning rules are based upon water supply and demand under the assumption of drought of record conditions, it improper to conduct economic analysis that focuses on growth related impacts over the planning horizon. Figures generated from such an analysis would presume a 50-year drought of record, which is unrealistic. Estimating lost economic activity related to constraints on population and commercial growth due to lack of water would require developing water supply and demand forecasts under "normal" or "most likely" future climatic conditions.

3. While useful for planning purposes, this study is not a benefit-cost analysis. Benefit cost analysis is a tool widely used to evaluate the economic feasibility of specific policies or projects as opposed to estimating economic impacts of unmet water needs. Nevertheless, one could include some impacts measured in this study as part of a benefit cost study if done so properly. Since this is not a benefit cost analysis, future impacts are not weighted differently. In other words, estimates are not discounted. If used as a measure of economic benefits, one should incorporate a measure of uncertainty into the analysis. In this type of analysis, a typical method of discounting future values is to assign probabilities of the drought of record recurring again in a given year, and weight monetary impacts accordingly. This analysis assumes a probability of one.

4. IO multipliers measure the strength of backward linkages to supporting industries (i.e., those who sell inputs to an affected sector). However, multipliers say nothing about forward linkages consisting of businesses that purchase goods from an affected sector for further processing. For example, ranchers in many areas sell most of their animals to local meat packers who process animals into a form that consumers ultimately see in grocery stores and restaurants. Multipliers do not capture forward linkages to meat packers, and since meat packers sell livestock purchased from ranchers as "final sales," multipliers for the ranching sector do fully account for all losses to a region's economy. Thus, as mentioned previously, in some cases closely linked sectors were moved from one water use category to another.

5. Cautions regarding interpretations of direct and secondary impacts are warranted. IO/SAM multipliers are based on "fixed-proportion production functions," which basically means that input use - including labor - moves in lockstep fashion with changes in levels of output. In a

scenario where output (i.e., sales) declines, losses in the immediate sector or supporting sectors could be much less than predicted by an IO/SAM model for several reasons. For one, businesses will likely expect to continue operating so they might maintain spending on inputs for future use; or they may be under contractual obligations to purchase inputs for an extended period regardless of external conditions. Also, employers may not lay-off workers given that experienced labor is sometimes scarce and skilled personnel may not be readily available when water shortages subside. Lastly people who lose jobs might find other employment in the region. As a result, direct losses for employment and secondary losses in sales and employment should be considered an upper bound. Similarly, since projected population losses are based on reduced employment in the region, they should be considered an upper bound as well.

6. IO models are static. Models and resultant multipliers are based upon the structure of the U.S. and regional economies in 2006. In contrast, water shortages are projected to occur well into the future. Thus, the analysis assumes that the general structure of the economy remains the same over the planning horizon, and the farther out into the future we go, this assumption becomes less reliable.

7. Impacts are annual estimates. If one were to assume that conditions persisted for more than one year, figures should be adjusted to reflect the extended duration. The drought of record in most regions of Texas lasted several years.

8. Monetary figures are reported in constant year 2006 dollars.

1.1.2 Impacts to Agriculture

Irrigated Crop Production

The first step in estimating impacts to irrigation required calculating gross sales for IMPLAN crop sectors. Default IMPLAN data do not distinguish irrigated production from dry-land production. Once gross sales were known other statistics such as employment and income were derived using IMPLAN direct multiplier coefficients. Gross sales for a given crop are based on two data sources:

1) county-level statistics collected and maintained by the TWDB and the USDA Farm Services Agency (FSA) including the number of irrigated acres by crop type and water application per acre, and

2) regional-level data published by the Texas Agricultural Statistics Service (TASS) including prices received for crops (marketing year averages), crop yields and crop acreages.

Crop categories used by the TWDB differ from those used in IMPLAN datasets. To maintain consistency, sales and other statistics are reported using IMPLAN crop classifications. Table 1 shows the TWDB crops included in corresponding IMPLAN sectors, and Table 2 summarizes acreage and estimated annual water use for each crop classification (five-year average from 2003-2007). Table 3 displays average (2003-2007) gross revenues per acre for IMPLAN crop categories.

Table 1: Crop Classifications Used in TWDB Water Use Survey and Corresponding IMPLAN Crop Sectors

IMPLAN Category	TWDB Category
Oilseeds	Soybeans and “other oil crops”
Grains	Grain sorghum, corn, wheat and “other grain crops”
Vegetable and melons	“Vegetables” and potatoes
Tree nuts	Pecans
Fruits	Citrus, vineyard and other orchard
Cotton	Cotton
Sugarcane and sugar beets	Sugarcane and sugar beets
All “other” crops	“Forage crops”, peanuts, alfalfa, hay and pasture, rice and “all other crops”

Table 2: Summary of Irrigated Crop Acreage and Water Demand for the Northeast Texas Regional Water Planning Area (average 2003-2007)

Sector	Acres (1000s)	Distribution of acres	Water use (1000s of AF)	Distribution of water use
Oilseeds	3	19%	3	16%
Grains	5	28%	5	25%
Vegetable and melons	<1	<1%	0	<1%
Fruits	<1	<1%	<1	<1%
All other crops	9	53%	12	59%
Total	17	100%	21	100%

Source: Water demand figures are a 5- year average (2003-2007) of the TWDB’s annual Irrigation Water Use Estimates. Statistics for irrigated crop acreage are based upon annual survey data collected by the TWDB and the Farm Service Agency. Values do not include acreage or water use for the TWDB categories classified by the Farm Services Agency as “failed acres,” “golf course” or “waste water.”

Table 3: Average Gross Sales Revenues per Acre for Irrigated Crops for the Northeast Texas Regional Water Planning Area (2003-2007)		
IMPLAN Sector	**Gross revenues per acre**	**Crops included in estimates**
Oilseeds	$202	Irrigated figure is based on five-year (2003-2007) average weighted by acreage for “irrigated soybeans” and “irrigated ‘other’ oil crops”.
Grains	$397	Based on five-year (2003-2007) average weighted by acreage for “irrigated grain sorghum,” “irrigated corn”, “irrigated wheat” and “irrigated ‘other’ grain crops.”
Vegetable and melons	$5,335	Based on five-year (2003-2007) average weighted by acreage for “irrigated shallow and deep root vegetables”, “irrigated Irish potatoes” and “irrigated melons.”
Fruits	$3,502	Based on five-year (2003-2007) average weighted by acreage for “irrigated citrus”, “irrigated vineyards” and “irrigated ‘other’ orchard.”
All Other Crops	$253	Irrigated figure is based on five-year (2003-2007) average weighted by acreage for “irrigated ‘forage’ crops”, “irrigated peanuts”, “irrigated alfalfa”, “irrigated ‘hay’ and pasture” and “irrigated ‘all other’ crops.”

*Figures are rounded. Source: Based on data from the Texas Agricultural Statistics Service, Texas Water Development Board, and Texas A&M University.

An important consideration when estimating impacts to irrigation was determining which crops are affected by water shortages. One approach is the so-called rationing model, which assumes that farmers respond to water supply cutbacks by fallowing the lowest value crops in the region first and the highest valued crops last until the amount of water saved equals the shortage.[5] For example, if farmer A grows vegetables (higher value) and farmer B grows wheat (lower value) and they both face a proportionate cutback in irrigation water, then farmer B will sell water to farmer A. Farmer B will fallow her irrigated acreage before farmer A fallows anything. Of course, this assumes that farmers can and do transfer enough water to allow this to happen. A different approach involves constructing farm-level profit maximization models that conform to widely-accepted economic theory that farmers make decisions based on marginal net returns. Such models have good predictive capability, but data requirements and complexity are high. Given that a detailed analysis for each region would require a substantial amount of farm-level data and analysis, the following investigation assumes that projected shortages are distributed equally across predominant crops in the region. Predominant in this case are crops that comprise at least one percent of total acreage in the region.

The following steps outline the overall process used to estimate direct impacts to irrigated agriculture:

1. *Distribute shortages across predominant crop types in the region*. Again, unmet water needs were distributed equally across crop sectors that constitute one percent or more of irrigated acreage.

2. *Estimate associated reductions in output for affected crop sectors*. Output reductions are based on elasticities discussed previously and on estimated values per acre for different crops. Values per acre stem from the same data used to estimate output for the year 2006 baseline. Using multipliers, we then generate estimates of forgone income, jobs, and tax revenues based on reductions in gross sales and final demand.

Livestock

The approach used for the livestock sector is basically the same as that used for crop production. As is the case with crops, livestock categorizations used by the TWDB differ from those used in IMPLAN datasets, and TWDB groupings were assigned to a given IMPLAN sector (Table 4). Then we:

1) *Distribute projected water needs equally among predominant livestock sectors and estimate lost output*: As is the case with irrigation, shortages are assumed to affect all livestock sectors equally; however, the category of "other" is not included given its small size. If water needs were small relative to total demands, we assume that producers would haul in water by truck to fill stock tanks. The cost per acre-foot ($24,000) is based on 2008 rates charged by various water haulers in Texas, and assumes that the average truck load is 6,500 gallons at a hauling distance of 60 miles.

3) *Estimate reduced output in forward processors for livestock sectors*. Reductions in output for livestock sectors are assumed to have a proportional impact on forward processors in the region such as meat packers. In other words, if the cows were gone, meat-packing plants or fluid milk manufacturers) would likely have little to process. This is not an unreasonable premise. Since the

[5] The rationing model was initially proposed by researchers at the University of California at Berkeley, and was then modified for use in a study conducted by the U.S. Environmental Protection Agency that evaluated how proposed water supply cutbacks recommended to protect water quality in the Bay/Delta complex in California would affect farmers in the Central Valley. See, Zilberman, D., Howitt, R. and Sunding, D. "*Economic Impacts of Water Quality Regulations in the San Francisco Bay and Delt*a." Western Consortium for Public Health. May 1993.

1950s, there has been a major trend towards specialized cattle feedlots, which in turn has decentralized cattle purchasing from livestock terminal markets to direct sales between producers and slaughterhouses. Today, the meat packing industry often operates large processing facilities near high concentrations of feedlots to increase capacity utilization.[6] As a result, packers are heavily dependent upon nearby feedlots. For example, a recent study by the USDA shows that on average meat packers obtain 64 percent of cattle from within 75 miles of their plant, 82 percent from within 150 miles and 92 percent from within 250 miles.[7]

Table 4: Description of Livestock Sectors

IMPLAN Category	TWDB Category
Cattle ranching and farming	Cattle, cow calf, feedlots and dairies
Poultry and egg production	Poultry production.
Other livestock	Livestock other than cattle and poultry (i.e., horses, goats, sheep, hogs)
Milk manufacturing	Fluid milk manufacturing, cheese manufacturing, ice cream manufacturing etc.
Meat packing	Meat processing present in the region from slaughter to final processing

1.1.3 Impacts to Municipal Water User Groups

Disaggregation of Municipal Water Demands

Estimating the economic impacts for the municipal water user groups is complicated for a number of reasons. For one, municipal use comprises a range of consumers including commercial businesses, institutions such as schools and government and households. However, reported water needs are not distributed among different municipal water users. In other words, how much of a municipal need is commercial and how much is residential (domestic)?

The amount of commercial water use as a percentage of total municipal demand was estimated based on "GED" coefficients (gallons per employee per day) published in secondary sources.[8] For example, if year 2006 baseline data for a given economic sector (e.g., amusement and recreation services) shows employment at 30 jobs and the GED coefficient is 200, then average daily water use by that sector is (30 x

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[6] Ferreira, W.N. "*Analysis of the Meat Processing Industry in the United States*." Clemson University Extension Economics Report ER211, January 2003.

[7] Ward, C.E. "*Summary of Results from USDA's Meatpacking Concentration Study*." Oklahoma Cooperative Extension Service, OSU Extension Facts WF-562.

[8] Sources for GED coefficients include: Gleick, P.H., Haasz, D., Henges-Jeck, C., Srinivasan, V., Wolff, G. Cushing, K.K., and Mann, A. "*Waste Not, Want Not*: *The Potential for Urban Water Conservation in California*." Pacific Institute. November 2003. U.S. Bureau of the Census. 1982 Census of Manufacturers: Water Use in Manufacturing. USGPO, Washington D.C. See also: "*U.S. Army Engineer Institute for Water Resources, IWR Report 88-R-6.*," Fort Belvoir, VA. See also, Joseph, E. S., 1982, "*Municipal and Industrial Water Demands of the Western United States*." Journal of the Water Resources Planning and Management Division, Proceedings of the American Society of Civil Engineers, v. 108, no. WR2, p. 204-216. See also, Baumann, D. D., Boland, J. J., and Sims, J. H., 1981, "*Evaluation of Water Conservation for Municipal and Industrial Water Supply*." U.S. Army Corps of Engineers, Institute for Water Resources, Contract no. 82-C1.

200 = 6,000 gallons) or 6.7 acre-feet per year. Water not attributed to commercial use is considered domestic, which includes single and multi-family residential consumption, institutional uses and all use designated as “county-other.” Based on our analysis, commercial water use is about 5 to 35 percent of municipal demand. Less populated rural counties occupy the lower end of the spectrum, while larger metropolitan counties are at the higher end.

After determining the distribution of domestic versus commercial water use, we developed methods for estimating impacts to the two groups.

Domestic Water Uses

Input output models are not well suited for measuring impacts of shortages for domestic water uses, which make up the majority of the municipal water use category. To estimate impacts associated with domestic water uses, municipal water demand and needs are subdivided into residential, and commercial and institutional use. Shortages associated with residential water uses are valued by estimating proxy demand functions for different water user groups allowing us to estimate the marginal value of water, which would vary depending upon the level of water shortages. The more severe the water shortage, the more costly it becomes. For instance, a 2 acre-foot shortage for a group of households that use 10 acre-feet per year would not be as severe as a shortage that amounted to 8 acre-feet. In the case of a 2 acre-foot shortage, households would probably have to eliminate some or all outdoor water use, which could have implicit and explicit economic costs including losses to the horticultural and landscaping industry. In the case of an 8 acre-foot shortage, people would have to forgo all outdoor water use and most indoor water consumption. Economic impacts would be much higher in the latter case because people, and would be forced to find emergency alternatives assuming alternatives were available.

To estimate the value of domestic water uses, TWDB staff developed marginal loss functions based on constant elasticity demand curves. This is a standard and well-established method used by economists to value resources such as water that have an explicit monetary cost.

A constant price elasticity of demand is estimated using a standard equation:

$$w = kc^{(-\varepsilon)}$$

where:

- w is equal to average monthly residential water use for a given water user group measured in thousands of gallons;
- k is a constant intercept;
- c is the average cost of water per 1,000 gallons; and
- ε is the price elasticity of demand.

Price elasticities (-0.30 for indoor water use and -0.50 for outdoor use) are based on a study by Bell et al.[9] that surveyed 1,400 water utilities in Texas that serve at least 1,000 people to estimate demand elasticity for several variables including price, income, weather etc. Costs of water and average use per month per household are based on data from the Texas Municipal League's annual water and

[9] Bell, D.R. and Griffin, R.C. “*Community Water Demand in Texas as a Century is Turned*.” Research contract report prepared for the Texas Water Development Board. May 2006.

wastewater rate surveys - specifically average monthly household expenditures on water and wastewater in different communities across the state. After examining variance in costs and usage, three different categories of water user groups based on population (population less than 5,000, cities with populations ranging from 5,000 to 99,999 and cities with populations exceeding 100,000) were selected to serve as proxy values for municipal water groups that meet the criteria (Table 5).[10]

Table 5: Water Use and Costs Parameters Used to Estimated Water Demand Functions
(average monthly costs per acre-foot for delivered water and average monthly use per household)

Community Population	Water	Wastewater	Total monthly cost	Avg. monthly use (gallons)
Less than or equal to 5,000	$1,335	$1,228	$2,563	6,204
5,000 to 100,000	$1,047	$1,162	$2,209	7,950
Great than or equal to 100,000	$718	$457	$1,190	8,409

Source: Based on annual water and wastewater rate surveys published by the Texas Municipal League.

As an example, Table 6 shows the economic impact per acre-foot of domestic water needs for municipal water user groups with population exceeding 100,000 people. There are several important assumptions incorporated in the calculations:

1) Reported values are net of the variable costs of treatment and distribution such as expenses for chemicals and electricity since using less water involves some savings to consumers and utilities alike; and for outdoor uses we do not include any value for wastewater.

2) Outdoor and "non-essential" water uses would be eliminated before indoor water consumption was affected, which is logical because most water utilities in Texas have drought contingency plans that generally specify curtailment or elimination of outdoor water use during droughts.[11] Determining how much water is used for outdoor purposes is based on several secondary sources. The first is a major study sponsored by the American Water Works Association, which surveyed cities in states including Colorado, Oregon, Washington, California, Florida and Arizona. On average across all cities surveyed 58 percent of single family residential water use was for outdoor activities. In cities with climates comparable to large metropolitan areas of Texas, the average was 40 percent.[12] Earlier findings of the U.S. Water Resources Council showed a national

[10] Ideally, one would want to estimate demand functions for each individual utility in the state. However, this would require an enormous amount of time and resources. For planning purposes, we believe the values generated from aggregate data are more than sufficient.

[11] In Texas, state law requires retail and wholesale water providers to prepare and submit plans to the Texas Commission on Environmental Quality (TCEQ). Plans must specify demand management measures for use during drought including curtailment of "non-essential water uses." Non-essential uses include, but are not limited to, landscape irrigation and water for swimming pools or fountains. For further information see the Texas Environmental Quality Code §288.20.

[12] See, Mayer, P.W., DeOreo, W.B., Opitz, E.M., Kiefer, J.C., Davis, W., Dziegielewski, D., Nelson, J.O. "*Residential End Uses of Water*." Research sponsored by the American Water Works Association and completed by Aquacraft, Inc. and Planning and Management Consultants, Ltd. (PMCL@CDM).

average of 33 percent. Similarly, the United States Environmental Protection Agency (USEPA) estimated that landscape watering accounts for 32 percent of total residential and commercial water use on annual basis.[13] A study conducted for the California Urban Water Agencies (CUWA) calculated average annual values ranging from 25 to 35 percent.[14] Unfortunately, there does not appear to be any comprehensive research that has estimated non-agricultural outdoor water use in Texas. As an approximation, an average annual value of 30 percent based on the above references was selected to serve as a rough estimate in this study.

3) As shortages approach 100 percent values become immense and theoretically infinite at 100 percent because at that point death would result, and willingness to pay for water is immeasurable. Thus, as shortages approach 80 percent of monthly consumption, we assume that households and non-water intensive commercial businesses (those that use water only for drinking and sanitation would have water delivered by tanker truck or commercial water delivery companies. Based on reports from water companies throughout the state, we estimate that the cost of trucking in water is around $21,000 to $27,000 per acre-feet assuming a hauling distance of between 20 to 60 miles. This is not an unreasonable assumption. The practice was widespread during the 1950s drought and recently during droughts in this decade. For example, in 2000 at the heels of three consecutive drought years Electra - a small town in North Texas - was down to its last 45 days worth of reservoir water when rain replenished the lake, and the city was able to refurbish old wells to provide supplemental groundwater. At the time, residents were forced to limit water use to 1,000 gallons per person per month - less than half of what most people use - and many were having water delivered to their homes by private contractors.[15] In 2003 citizens of Ballinger, Texas, were also faced with a dwindling water supply due to prolonged drought. After three years of drought, Lake Ballinger, which supplies water to more than 4,300 residents in Ballinger and to 600 residents in nearby Rowena, was almost dry. Each day, people lined up to get water from a well in nearby City Park. Trucks hauling trailers outfitted with large plastic and metal tanks hauled water to and from City Park to Ballinger.[16]

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[13] U.S. Environmental Protection Agency. *"Cleaner Water through Conservation*." USEPA Report no. 841-B-95-002. April, 1995.

[14] Planning and Management Consultants, Ltd. "*Evaluating Urban Water Conservation Programs: A Procedures Manual*." Prepared for the California Urban Water Agencies. February 1992.

[15] Zewe, C. "*Tap Threatens to Run Dry in Texas Town*." July 11, 2000. CNN Cable News Network.

[16] Associated Press, "*Ballinger Scrambles to Finish Pipeline before Lake Dries Up*." May 19, 2003.

Table 6: Economic Losses Associated with Domestic Water Shortages in Communities with Populations Exceeding 100,000 people

Water shortages as a percentage of total monthly household demands	No. of gallons remaining per household per day	No of gallons remaining per person per day	Economic loss (per acre-foot)	Economic loss (per gallon)
1%	278	93	$748	$0.00005
5%	266	89	$812	$0.0002
10%	252	84	$900	$0.0005
15%	238	79	$999	$0.0008
20%	224	75	$1,110	$0.0012
25%	210	70	$1,235	$0.0015
30%[a]	196	65	$1,699	$0.0020
35%	182	61	$3,825	$0.0085
40%	168	56	$4,181	$0.0096
45%	154	51	$4,603	$0.011
50%	140	47	$5,109	$0.012
55%	126	42	$5,727	$0.014
60%	112	37	$6,500	$0.017
65%	98	33	$7,493	$0.02
70%	84	28	$8,818	$0.02
75%	70	23	$10,672	$0.03
80%	56	19	$13,454	$0.04
85%	42	14	$18,091 ($24,000)[b]	$0.05 ($0.07)[b]
90%	28	9	$27,363 ($24,000)	$0.08 ($0.07)
95%	14	5	$55,182 ($24,000)	$0.17 ($0.07)
99%	3	0.9	$277,728 ($24,000)	$0.85 ($0.07)
99.9%	1	0.5	$2,781,377 ($24,000)	$8.53 ($0.07)
100%	0	0	Infinite ($24,000)	Infinite ($0.07)

[a] The first 30 percent of needs are assumed to be restrictions of outdoor water use; when needs reach 30 percent of total demands all outdoor water uses would be restricted. Needs greater than 30 percent include indoor use

[b] As shortages approach 100 percent the value approaches infinity assuming there are not alternatives available; however, we assume that communities would begin to have water delivered by tanker truck at an estimated cost of $24,000 per acre-foot when shortages breached 85 percent.

Commercial Businesses

Effects of water shortages on commercial sectors were estimated in a fashion similar to other business sectors meaning that water shortages would affect the ability of these businesses to operate. This is particularly true for "water intensive" commercial sectors that are need large amounts of water (in addition to potable and sanitary water) to provide their services. These include:

- car-washes,
- laundry and cleaning facilities,
- sports and recreation clubs and facilities including race tracks,
- amusement and recreation services,
- hospitals and medical facilities,
- hotels and lodging places, and
- eating and drinking establishments.

A key assumption is that commercial operations would not be affected until water shortages were at least 50 percent of total municipal demand. In other words, we assume that residential water consumers would reduce water use including all non-essential uses before businesses were affected.

An example will illustrate the breakdown of municipal water needs and the overall approach to estimating impacts of municipal needs. Assume City A experiences an unexpected shortage of 50 acre-feet per year when their demands are 200 acre-feet per year. Thus, shortages are only 25 percent of total municipal use and residents of City A could eliminate needs by restricting landscape irrigation. City B, on the other hand, has a deficit of 150 acre-feet in 2020 and a projected demand of 200 acre-feet. Thus, total shortages are 75 percent of total demand. Emergency outdoor and some indoor conservation measures could eliminate 50 acre-feet of projected needs, yet 50 acre-feet would still remain. To eliminate" the remaining 50 acre-feet water intensive commercial businesses would have to curtail operations or shut down completely.

Three other areas were considered when analyzing municipal water shortages: 1) lost revenues to water utilities, 2) losses to the horticultural and landscaping industries stemming for reduction in water available for landscape irrigation, and 3) lost revenues and related economic impacts associated with reduced water related recreation.

Water Utility Revenues

Estimating lost water utility revenues was straightforward. We relied on annual data from the "*Water and Wastewater Rate Survey*" published annually by the Texas Municipal League to calculate an average value per acre-foot for water and sewer. For water revenues, average retail water and sewer rates multiplied by total water needs served as a proxy. For lost wastewater, total unmet needs were adjusted for return flow factor of 0.60 and multiplied by average sewer rates for the region. Needs reported as "county-other" were excluded under the presumption that these consist primarily of self-supplied water uses. In addition, 15 percent of water demand and needs are considered non-billed or "unaccountable" water that comprises things such as leakages and water for municipal government functions (e.g., fire departments). Lost tax receipts are based on current rates for the "miscellaneous gross receipts tax, "which the state collects from utilities located in most incorporated cities or towns in Texas. We do not include lost water utility revenues when aggregating impacts of municipal water shortages to regional and state levels to prevent double counting.

Horticultural and Landscaping Industry

The horticultural and landscaping industry, also referred to as the "green Industry," consists of businesses that produce, distribute and provide services associated with ornamental plants, landscape and garden supplies and equipment. Horticultural industries often face big losses during drought. For example, the recent drought in the Southeast affecting the Carolinas and Georgia horticultural and landscaping businesses had a harsh year. Plant sales were down, plant mortality increased, and watering costs increased. Many businesses were forced to close locations, lay off employees, and even file for bankruptcy. University of Georgia economists put statewide losses for the industry at around $3.2 billion during the 3-year drought that ended in 2008.[17] Municipal restrictions on outdoor watering play a significant role. During drought, water restrictions coupled with persistent heat has a psychological effect on homeowners that reduces demands for landscaping products and services. Simply put, people were afraid to spend any money on new plants and landscaping.

In Texas, there do not appear to be readily available studies that analyze the economic effects of water shortages on the industry. However, authors of this report believe negative impacts do and would result in restricting landscape irrigation to municipal water consumers. The difficulty in measuring them is two-fold. First, as noted above, data and research for these types of impacts that focus on Texas are limited; and second, economic data provided by IMPLAN do not disaggregate different sectors of the green industry to a level that would allow for meaningful and defensible analysis.[18]

Recreational Impacts

Recreational businesses often suffer when water levels and flows in rivers, springs and reservoirs fall significantly during drought. During droughts, many boat docks and lake beaches are forced to close, leading to big losses for lakeside business owners and local communities. Communities adjacent to popular river and stream destinations such as Comal Springs and the Guadalupe River also see their business plummet when springs and rivers dry up. Although there are many examples of businesses that have suffered due to drought, dollar figures for drought-related losses to the recreation and tourism industry are not readily available, and very difficult to measure without extensive local surveys. Thus, while they are important, economic impacts are not measured in this study.

Table 7 summarizes impacts of municipal water shortages at differing levels of magnitude, and shows the ranges of economic costs or losses per acre-foot of shortage for each level.

[17] Williams, D. *"Georgia landscapers eye rebound from Southeast drought."* Atlanta Business Chronicle, Friday, June 19, 2009

[18] Economic impact analyses prepared by the TWDB for 2006 regional water plans did include estimates for the horticultural industry. However, year 2000 and prior IMPLAN data were disaggregated to a finer level. In the current dataset (2006), the sector previously listed as "Landscaping and Horticultural Services" (IMPLAN Sector 27) is aggregated into "Services to Buildings and Dwellings" (IMPLAN Sector 458).

Table 7: Impacts of Municipal Water Shortages at Different Magnitudes of Shortages		
Water shortages as percent of total municipal demands	Impacts	Economic costs per acre-foot*
0-30%	✓ Lost water utility revenues ✓ Restricted landscape irrigation and non-essential water uses	$730 - $2,040
30-50%	✓ Lost water utility revenues ✓ Elimination of landscape irrigation and non-essential water uses ✓ Rationing of indoor use	$2,040 - $10,970
>50%	✓ Lost water utility revenues ✓ Elimination of landscape irrigation and non-essential water uses ✓ Rationing of indoor use ✓ Restriction or elimination of commercial water use ✓ Importing water by tanker truck	$10,970 - varies
*Figures are rounded		

1.1.4 Industrial Water User Groups

Manufacturing

Impacts to manufacturing were estimated by distributing water shortages among industrial sectors at the county level. For example, if a planning group estimates that during a drought of record water supplies in County A would only meet 50 percent of total annual demands for manufactures in the county, we reduced output for each sector by 50 percent. Since projected manufacturing demands are based on TWDB Water Uses Survey data for each county, we only include IMPLAN sectors represented in the TWBD survey database. Some sectors in IMPLAN databases are not part of the TWDB database given that they use relatively small amounts of water - primarily for on-site sanitation and potable purposes. To maintain consistency between IMPLAN and TWDB databases, Standard Industrial Classification (SIC) codes both databases were cross referenced in county with shortages. Non-matches were excluded when calculating direct impacts.

Mining

The process of mining is very similar to that of manufacturing. We assume that within a given county, shortages would apply equally to relevant mining sectors, and IMPLAN sectors are cross referenced with TWDB data to ensure consistency.

In Texas, oil and gas extraction and sand and gravel (aggregates) operations are the primary mining industries that rely on large volumes of water. For sand and gravel, estimated output reductions are straightforward; however, oil and gas is more complicated for a number of reasons. IMPLAN does not necessarily report the physical extraction of minerals by geographic local, but rather the sales revenues reported by a particular corporation.

For example, at the state level revenues for IMPLAN sector 19 (oil and gas extraction) and sector 27 (drilling oil and gas wells) totals $257 billion. Of this, nearly $85 billion is attributed to Harris County. However, only a very small fraction (less than one percent) of actual production takes place in the county. To measure actual potential losses in well head capacity due to water shortages, we relied on county level production data from the Texas Railroad Commission (TRC) and average well-head market prices for crude and gas to estimate lost revenues in a given county. After which, we used to IMPLAN ratios to estimate resultant losses in income and employment.

Other considerations with respect to mining include:

1) Petroleum and gas extraction industry only uses water in significant amounts for secondary recovery. Known in the industry as enhanced or water flood extraction, secondary recovery involves pumping water down injection wells to increase underground pressure thereby pushing oil or gas into other wells. IMPLAN output numbers do not distinguish between secondary and non-secondary recovery. To account for the discrepancy, county-level TRC data that show the proportion of barrels produced using secondary methods were used to adjust IMPLAN data to reflect only the portion of sales attributed to secondary recovery.

2) A substantial portion of output from mining operations goes directly to businesses that are classified as manufacturing in our schema. Thus, multipliers measuring backward linkages for a given manufacturer might include impacts to a supplying mining operation. Care was taken not to double count in such situations if both a mining operation and a manufacturer were reported as having water shortages.

Steam-electric

At minimum without adequate cooling water, power plants cannot safely operate. As water availability falls below projected demands, water levels in lakes and rivers that provide cooling water would also decline. Low water levels could affect raw water intakes and outfalls at electrical generating units in several ways. For one, power plants are regulated by thermal emission guidelines that specify the maximum amount of heat that can go back into a river or lake via discharged cooling water. Low water levels could result in permit compliance issues due to reduced dilution and dispersion of heat and subsequent impacts on aquatic biota near outfalls.[19] However, the primary concern would be a loss of head (i.e., pressure) over intake structures that would decrease flows through intake tunnels. This would affect safety related pumps, increase operating costs and/or result in sustained shut-downs. Assuming plants did shutdown, they would not be able to generate electricity.

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[19] Section 316 (b) of the Clean Water Act requires that thermal wastewater discharges do not harm fish and other wildlife.

Among all water use categories steam-electric is unique and cautions are needed when applying methods used in this study. Measured changes to an economy using input-output models stem directly from changes in sales revenues. In the case of water shortages, one assumes that businesses will suffer lost output if process water is in short supply. For power generation facilities this is true as well. However, the electric services sector in IMPLAN represents a corporate entity that may own and operate several electrical generating units in a given region. If one unit became inoperable due to water shortages, plants in other areas or generation facilities that do not rely heavily on water such as gas powered turbines might be able to compensate for lost generating capacity. Utilities could also offset lost production via purchases on the spot market.[20] Thus, depending upon the severity of the shortages and conditions at a given electrical generating unit, energy supplies for local and regional communities could be maintained. But in general, without enough cooling water, utilities would have to throttle back plant operations, forcing them to buy or generate more costly power to meet customer demands.

Measuring impacts end users of electricity is not part of this study as it would require extensive local and regional level analysis of energy production and demand. To maintain consistency with other water user groups, impacts of steam-electric water shortages are measured in terms of lost revenues (and hence income) and jobs associated with shutting down electrical generating units.

1.2 Social Impacts of Water Shortages

As the name implies, the effects of water shortages can be social or economic. Distinctions between the two are both semantic and analytical in nature – more so analytic in the sense that social impacts are harder to quantify. Nevertheless, social effects associated with drought and water shortages are closely tied to economic impacts. For example, they might include:

- demographic effects such as changes in population,
- disruptions in institutional settings including activity in schools and government,
- conflicts between water users such as farmers and urban consumers,
- health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations),
- mental and physical stress (e.g., anxiety, depression, domestic violence),
- public safety issues from forest and range fires and reduced fire fighting capability,
- increased disease caused by wildlife concentrations,
- loss of aesthetic and property values, and
- reduced recreational opportunities.[21]

[20] Today, most utilities participate in large interstate "power pools" and can buy or sell electricity "on the grid" from other utilities or power marketers. Thus, assuming power was available to buy, and assuming that no contractual or physical limitations were in place such as transmission constraints; utilities could offset lost power that resulted from waters shortages with purchases via the power grid.

[21] Based on information from the website of the National Drought Mitigation Center at the University of Nebraska Lincoln. Available online at: http://www.drought.unl.edu/risk/impacts.htm. See also, Vanclay, F. "*Social Impact Assessment*." in Petts, J. (ed) International Handbook of Environmental Impact Assessment. 1999.

Social impacts measured in this study focus strictly on demographic effects including changes in population and school enrollment. Methods are based on demographic projection models developed by the Texas State Data Center and used by the TWDB for state and regional water planning. Basically, the social impact model uses results from the economic component of the study and assesses how changes in labor demand would affect migration patterns in a region. Declines in labor demand as measured using adjusted IMPLAN data are assumed to affect net economic migration in a given regional water planning area. Employment losses are adjusted to reflect the notion that some people would not relocate but would seek employment in the region and/or public assistance and wait for conditions to improve. Changes in school enrollment are simply the proportion of lost population between the ages of 5 and 17.

2. Results

Section 2 presents the results of the analysis at the regional level. Included are baseline economic data for each water use category, and estimated economics impacts of water shortages for water user groups with reported deficits. According to the 2011 *Northeast Texas Regional Water Plan*, during severe drought municipal and steam-electric water user groups would experience water shortages in the absence of new water management strategies.

2.1 Overview of Regional Economy

On an annual basis, the Northeast Texas regional economy generates nearly $27 billion in gross state product for Texas ($25 billion in income and $2 billion worth of business taxes) and supports 317,231 jobs (Table 8). Generating about $13 billion worth of income per year agriculture, manufacturing, and mining are the primary base economic sectors in the region.[22] Municipal sectors also generate substantial amounts of income and are major employers. However, while municipal sectors are the largest employer and source of wealth, many businesses that make up the municipal category such as restaurants and retail stores are non-basic industries meaning they exist to provide services to people who work would in base industries such as manufacturing, agriculture and mining. In other words, without base industries such agriculture, many municipal jobs in the region would not exist.

[22] Base industries are those that supply markets outside of the region. These industries are crucial to the local economy and are called the economic base of a region. Appendix A shows how IMPLAN's 529 sectors were allocated to water use category, and shows economic data for each sector.

Table 8: The Northeast Texas Regional Economy by Water User Group ($millions)*						
Water Use Category	Total sales	Intermediate sales	Final sales	Jobs	Income	Business taxes
Irrigation	$5.81	$2.44	$3.36	193	$2.88	$0.11
Livestock	$3,023.19	$1,484.70	$1,538.50	20,284	$509.63	$29.61
Manufacturing	$16,567.24	$2,542.98	$14,024.26	55,787	$4,008.66	$98.26
Mining	$13,982.68	$11,619.70	$2,362.97	12,748	$8,032.41	$854.58
Steam-electric	$615.14	$173.05	$442.09	1,439	$427.15	$72.90
Municipal	$19,500.64	$4,954.57	$14,546.07	226,780	$11,498.42	$1,120.28
Regional total	$53,694.70	$20,777.44	$32,917.25	317,231	$24,479.15	$2,175.74

[a] Appendix 1 displays data for individual IMPLAN sectors that make up each water use category. Based on data from the Texas Water Development Board, and year 2006 data from the Minnesota IMPLAN Group, Inc.

2.1 Impacts of Municipal Water Shortages

Water shortages are projected to occur in a significant number of communities throughout the region. Deficits range from approximately 2 to 100 percent of total annual water use. At the regional level, the estimated economic value of domestic water shortages totals $12 million in 2010 and $173 million in 2060 (Table 9). Due to curtailment of commercial business activity, municipal shortages would reduce gross state product (income plus taxes) by nearly $2 million in 2010 and $115 million in 2060.

Table 9: Economic Impacts of Water Shortages for Municipal Water User Groups ($millions)					
Decade	Monetary value of domestic water shortages	Lost income from reduced commercial business activity*	Lost state and local taxes from reduced commercial business activity	Lost jobs from reduced commercial business activity	Lost water utility revenues
2010	$12.46	$1.70	$0.06	15	$1.95
2020	$16.63	$5.47	$0.21	49	$3.10
2030	$21.72	$8.26	$0.30	70	$4.49
2040	$35.69	$15.90	$0.38	91	$6.37
2050	$63.29	$29.88	$0.78	184	$13.87
2060	$172.82	$113.00	$2.20	505	$29.50

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.3 Impacts of Steam-electric Water Shortages

Water shortages for electrical generating units are projected to occur in the counties of Titus, Hunt, Harrison and Lamar. These shortages would result in estimated losses of gross state product totaling $356 million dollars in 2010, and $2.1 billion in 2060 (Table 10).

Table 10: Economic Impacts of Water Shortages for Steam-electric Water User Groups ($millions)

Decade	Lost income due to reduced electrical generation	Lost state and local business tax revenues due to reduced electrical generation	Lost jobs due to reduced electrical generation
2010	$355.79	$51.07	1,209
2020	$509.28	$73.10	1,731
2030	$611.81	$87.82	2,080
2040	$855.10	$122.74	2,907
2050	$1,310.62	$188.12	4,455
2060	$1,847.21	$265.14	6,279

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.4 Social Impacts of Water Shortages

As discussed previously, estimated social impacts focus on changes in population and school enrollment in the region. In 2010, estimated population losses total 1,472 with corresponding reductions in school enrollment of 415 students (Table 11). In 2060, population in the region could decline by 8,171 and school enrollment would fall by 2,318.

Table 11: Social Impacts of Water Shortages (2010-2060)

Year	Population Losses	Declines in School Enrollment
2010	1,472	415
2020	2,144	608
2030	2,590	735
2040	3,611	1,024
2050	5,588	1,585
2060	8,171	2,318

2.5 Distribution of Impacts by Major River Basin

Administrative rules require that impacts are presented by both planning region and major river basin. To meet rule requirements, impacts were allocated among basins based on the distribution of water shortages in relevant basins. For example, if 50 percent of water shortages in River Basin A and 50 percent occur in River Basin B, then impacts were split equally among the two basins. Table 12 displays the results.

Table 12: Distribution of Impacts by Major River Basin (2010-2060)

Water Use	2010	2020	2030	2040	2050	2060
Municipal						
Cypress	3%	9%	13%	13%	8%	5%
Neches	0%	0%	0%	0%	1%	1%
Red	13%	11%	10%	8%	4%	2%
Sabine	25%	28%	30%	32%	53%	66%
Sulphur	59%	51%	47%	47%	35%	26%
Trinity	0%	0%	0%	0%	0%	1%
Steam-electric						
Cypress	0%	0%	0%	7%	32%	40%
Red	0%	0%	6%	12%	10%	10%
Sabine	100%	100%	94%	81%	58%	50%

Appendix 1: Economic Data for Individual IMPLAN Sectors for the Northeast Texas Regional Water Planning Area

Economic Data for Agricultural Water User Groups ($millions)									
Water Use Category	IMPLAN Sector	IMPLAN Code	Total Sales	Intermediate Sales	Final Sales	Jobs	Income	Business Taxes
Irrigation	Oilseed Farming	1	$0.64	$0.01	$0.63	23	$0.34	$0.01
Irrigation	Grain Farming	2	$2.22	$0.46	$1.75	130	$1.02	$0.04
Irrigation	Vegetable and Melon Farming	3	$0.03	$0.00	$0.03	1	$0.02	$0.00
Irrigation	Fruit Farming	5	$0.84	$0.26	$0.58	17	$0.48	$0.02
Irrigation	All "Other" Crop Farming	10	$2.08	$1.70	$0.38	22	$1.02	$0.04
	Total irrigation		**$5.81**	**$2.44**	**$3.36**	**193**	**$2.88**	**$0.11**
Livestock	Poultry processing	70	$1,127.04	$358.60	$768.44	5,019	$166.48	$7.66
Livestock	Cattle ranching and farming	11	$737.44	$511.34	$226.10	11,334	$58.26	$15.50
Livestock	Poultry and egg production	12	$441.75	$346.22	$95.54	1,813	$148.72	$1.50
Livestock	Rendering and meat byproduct processing	69	$289.77	$160.80	$128.97	515	$78.22	$2.25
Livestock	Dry- condensed- and evaporated dairy products	65	$119.97	$28.09	$91.88	149	$26.21	$0.77
Livestock	Fluid milk manufacturing	62	$108.80	$26.18	$82.63	189	$9.10	$0.54
Livestock	Creamery butter manufacturing	63	$75.33	$8.54	$66.79	158	$5.90	$0.33
Livestock	Animal- except poultry- slaughtering	67	$64.83	$17.33	$47.49	155	$11.52	$0.64
Livestock	Meat processed from carcasses	68	$35.92	$10.60	$25.32	85	$2.85	$0.15
Livestock	Animal production- except cattle and poultry	13	$16.36	$13.87	$2.49	853	$1.59	$0.25
Livestock	Ice cream and frozen dessert manufacturing	66	$5.99	$3.14	$2.85	14	$0.79	$0.03
	Total livestock		**$3,023.19**	**$1,484.70**	**$1,538.50**	**20,284**	**$509.63**	**$29.61**
	Total agriculture		**$3,029.00**	**$1,487.14**	**$1,541.86**	**20,477**	**$512.51**	**$29.72**

Based on year 2006 data from the Minnesota IMPLAN Group, Inc.

Economic Data for Mining and Steam-electric Water User Groups ($millions)									
Water Use Category	**IMPLAN Sector**	**IMPLAN Code**	**Total Sales**	**Intermediate Sales**	**Final Sales**	**Jobs**	**Income**	**Business Taxes**
Mining	Oil and gas extraction	19	$12,250.70	$11,377.07	$873.63	7,562	$7,019.74	$769.86
Mining	Coal mining	20	$370.11	$138.69	$231.42	641	$174.10	$30.73
Mining	Iron ore mining	21	$4.81	$0.00	$4.81	14	$1.71	$0.15
Mining	Sand- gravel- clay- and refractory mining	25	$16.46	$1.74	$14.73	52	$9.80	$0.62
Mining	Other nonmetallic mineral mining	26	$14.56	$1.46	$13.11	95	$5.60	$0.27
Mining	Drilling oil and gas wells	27	$619.84	$3.09	$616.74	976	$183.05	$24.13
Mining	Support activities for oil and gas operations	28	$702.66	$97.60	$605.07	3,382	$637.25	$28.69
Mining	Support activities for other mining	29	$3.53	$0.05	$3.48	26	$1.17	$0.14
	Total mining		**$13,982.68**	**$11,619.70**	**$2,362.97**	**12,748**	**$8,032.41**	**$854.58**
Steam-electric	**Power generation and supply**	**30**	**$615.14**	**$173.05**	**$442.09**	**1,439**	**$427.15**	**$72.90**
Based on year 2006 data from the Minnesota IMPLAN Group, Inc.								

Economic Data for Manufacturing Water User Groups ($millions)									
Water Use Category	**IMPLAN Sector**	**IMPLAN Code**	**Total Sales**	**Intermediate Sales**	**Final Sales**	**Jobs**	**Income**	**Business Taxes**
Manufacturing	Aircraft manufacturing	351	$2,505.75	$127.48	$2,378.27	4,977	$429.37	$8.98
Manufacturing	Iron and steel mills	203	$1,352.36	$97.41	$1,254.95	1,597	$274.45	$10.40
Manufacturing	Railroad rolling stock manufacturing	356	$978.70	$28.32	$950.38	2,656	$162.81	$3.56
Manufacturing	Aluminum sheet- plate- and foil manufacturing	211	$796.77	$21.63	$775.14	870	$122.82	$7.73
Manufacturing	New residential 1-unit structures- all	33	$735.42	$0.00	$735.42	4,989	$240.75	$3.79
Manufacturing	Construction machinery manufacturing	259	$651.24	$88.88	$562.36	951	$101.95	$3.07
Manufacturing	Ammunition manufacturing	256	$633.28	$2.51	$630.77	2,525	$230.10	$15.10
Manufacturing	Petrochemical manufacturing	147	$614.14	$281.38	$332.76	83	$24.47	$1.40
Manufacturing	Commercial and institutional buildings	38	$411.68	$0.00	$411.68	4,351	$206.26	$2.54
Manufacturing	Travel trailer and camper manufacturing	349	$307.85	$16.72	$291.13	1,558	$71.23	$0.99
Manufacturing	Farm machinery and equipment manufacturing	257	$306.39	$50.28	$256.10	710	$76.49	$0.79
Manufacturing	Industrial gas manufacturing	148	$293.03	$154.09	$138.95	276	$120.30	$1.83
Manufacturing	Automobile and light truck manufacturing	344	$292.35	$0.31	$292.04	215	$17.59	$0.57
Manufacturing	Soap and other detergent manufacturing	163	$268.23	$71.65	$196.58	306	$53.13	$1.20
Manufacturing	Broadcast and wireless communications equipment	307	$251.91	$59.72	$192.19	477	$33.18	$0.82
Manufacturing	Fabricated structural metal manufacturing	233	$249.07	$12.90	$236.17	1,031	$80.83	$1.30
Manufacturing	Motor vehicle parts manufacturing	350	$244.17	$19.63	$224.53	709	$47.47	$0.73
Manufacturing	Plastics plumbing fixtures and all other plastics	177	$210.34	$152.38	$57.96	1,077	$78.31	$1.35
Manufacturing	Paperboard container manufacturing	126	$198.08	$2.10	$195.98	671	$43.11	$1.67
Manufacturing	Other new construction	41	$179.47	$0.00	$179.47	1,996	$95.66	$0.75
Manufacturing	Sugar manufacturing	56	$167.81	$69.90	$97.90	308	$12.14	$0.66
Manufacturing	Logging	14	$161.21	$120.46	$40.75	648	$42.34	$1.43
Manufacturing	Machine shops	243	$161.17	$38.90	$122.27	1,175	$75.00	$1.20
Manufacturing	AC- refrigeration- and forced air heating	278	$147.38	$0.00	$147.38	501	$23.90	$0.59
Manufacturing	Oil and gas field machinery and equipment	261	$145.34	$5.41	$139.93	415	$32.45	$0.66
Manufacturing	Ferrous metal foundries	221	$133.16	$0.13	$133.03	579	$58.69	$1.31
	All other manufacturing		**$4,170.97**	**$1,120.79**	**$3,050.17**	**20,136**	**$1,253.87**	**$23.87**
	Total manufacturing		**$16,567.24**	**$2,542.98**	**$14,024.26**	**55,787**	**$4,008.66**	**$98.26**

Based on year 2006 data from the Minnesota IMPLAN Group, Inc.

Economic Data for Municipal Water User Groups ($millions)								
Water Use Category	IMPLAN Sector	IMPLAN Code	Total Sales	Intermediate Sales	Final Sales	Jobs	Income	Business Taxes
Manufacturing	Owner-occupied dwellings	509	$1,807.96	$0.00	$1,807.96	0	$1,400.57	$213.78
Manufacturing	Wholesale trade	390	$1,557.67	$745.76	$811.92	10,584	$820.08	$230.39
Manufacturing	State & Local Education	503	$996.46	$0.00	$996.46	27,388	$996.47	$0.00
Manufacturing	Monetary authorities and depository credit in	430	$895.44	$294.92	$600.52	4,448	$628.79	$11.45
Manufacturing	Hospitals	467	$821.38	$0.00	$821.38	7,287	$433.85	$5.54
Manufacturing	Food services and drinking places	481	$767.39	$97.99	$669.40	16,686	$303.65	$35.45
Manufacturing	Offices of physicians- dentists- and other he	465	$756.19	$0.00	$756.19	6,709	$534.38	$4.68
Manufacturing	Telecommunications	422	$726.78	$249.63	$477.14	1,439	$331.43	$56.33
Manufacturing	Truck transportation	394	$681.44	$368.98	$312.46	5,474	$300.10	$6.84
Manufacturing	Motor vehicle and parts dealers	401	$568.65	$61.83	$506.81	5,346	$292.98	$83.12
Manufacturing	State & Local Non-Education	504	$524.33	$0.00	$524.33	10,370	$524.33	$0.00
Manufacturing	General merchandise stores	410	$504.83	$53.21	$451.62	8,857	$230.75	$73.66
Manufacturing	Real estate	431	$359.85	$142.45	$217.40	2,035	$208.35	$44.20
Manufacturing	Nursing and residential care facilities	468	$339.28	$0.00	$339.28	8,031	$200.69	$4.73
Manufacturing	Federal Non-Military	506	$328.08	$0.00	$328.08	2,209	$328.08	$0.00
Manufacturing	Other State and local government enterprises	499	$305.70	$99.55	$206.16	1,537	$104.50	$0.04
Manufacturing	Building material and garden supply stores	404	$300.00	$46.52	$253.47	3,759	$139.36	$42.39
Manufacturing	Health and personal care stores	406	$264.57	$42.23	$222.35	2,689	$140.68	$40.88
Manufacturing	Home health care services	464	$257.05	$0.00	$257.05	7,229	$156.03	$0.92
Manufacturing	Management of companies and enterprises	451	$257.00	$241.68	$15.32	1,854	$119.18	$1.90
Manufacturing	Automotive repair and maintenance- except car	483	$242.19	$57.53	$184.66	3,205	$90.94	$18.03
Manufacturing	Food and beverage stores	405	$239.76	$32.06	$207.71	4,181	$122.20	$26.76
Manufacturing	Civic- social- professional and similar organ	493	$220.06	$77.32	$142.74	7,353	$93.14	$0.59
Manufacturing	Pipeline transportation	396	$218.03	$95.35	$122.68	273	$73.24	$15.51
Manufacturing	Legal services	437	$217.14	$137.81	$79.33	2,005	$133.41	$4.21
Manufacturing	Gasoline stations	407	$215.67	$32.75	$182.92	3,083	$116.04	$31.54
Manufacturing	All other municipal		$4,205.07	$1,634.57	$2,570.50	62,435	$2,186.63	$157.86
Manufacturing	**Total**		**$19,500.64**	**$4,954.57**	**$14,546.07**	**226,780**	**$11,498.42**	**$1,120.28**
Based on year 2006 data from the Minnesota IMPLAN Group, Inc.								

Appendix 2: Impacts by Water User Group Northeast Texas Regional Water Planning Area

Municipal ($millions)						
	2010	2020	2030	2040	2050	2060
Able Springs WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$2.14	$38.81
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$2.74	$9.09
Bi-County WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$1.35	$20.64
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$1.47	$4.61
Campbell WSC						
Monetary value of domestic water shortages	$0.14	$1.50	$3.00	$6.29	$14.68	$32.27
Lost income from reduced commercial business activity	$0.00	$0.00	$0.28	$0.59	$1.25	$2.30
Lost jobs due to reduced commercial business activity	0	0	11	24	50	92
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.04	$0.09	$0.19	$0.36
Lost utility revenues	$0.14	$0.29	$0.51	$0.85	$1.60	$2.78
Canton						
Monetary value of domestic water shortages	$0.00	$0.01	$0.03	$0.35	$6.50	$26.60
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$1.77	$10.26
Lost jobs due to reduced commercial business activity	0	0	0	0	56	323
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.25	$1.46
Lost utility revenues	$0.00	$0.01	$0.05	$0.35	$1.21	$2.63
Cash SUD						
Monetary value of domestic water shortages	$0.01	$0.41	$1.40	$4.82	$10.18	$18.29
Lost utility revenues	$0.02	$0.08	$0.18	$0.35	$0.75	$1.34
Celeste						
Monetary value of domestic water shortages	$0.00	$0.15	$0.48	$2.29	$3.11	$4.15
Lost utility revenues	$0.00	$0.23	$0.53	$0.76	$0.95	$1.15

Municipal cont. ($millions)						
	2010	2020	2030	2040	2050	2060
Central Bowie WSC						
Monetary value of domestic water shortages	$6.69	$6.34	$7.17	$9.90	$10.96	$11.93
Lost income from reduced commercial business activity	$0.00	$1.05	$1.29	$1.52	$1.76	$1.99
Lost jobs due to reduced commercial business activity	0	33	41	48	55	63
Lost state and local taxes from reduced commercial business activity	$0.00	$0.15	$0.18	$0.22	$0.25	$0.28
Lost utility revenues	$0.63	$0.73	$0.83	$0.93	$1.03	$1.14
Clarksville City						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.01	$0.01	$0.61
Lost utility revenues	$0.00	$0.00	$0.00	$0.01	$0.02	$1.05
Combined Consumers WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.08	$0.24	$0.49
Lost utility revenues	$0.00	$0.00	$0.00	$0.17	$0.47	$0.84
County-other (Bowie)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.12	$0.67
County-other (Harrison)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.06	$0.28	$0.72
County-other (Hunt)						
Monetary value of domestic water shortages	$0.33	$1.75	$1.94	$2.34	$2.30	$2.24
County-other (Rains)						
Monetary value of domestic water shortages	$0.25	$0.44	$0.58	$0.57	$0.56	$0.56
County-other (Van Zandt)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.18	$0.46
Crystal Systems, Inc.						
Monetary value of domestic water shortages	$0.35	$0.41	$0.44	$0.48	$0.45	$0.44
Lost utility revenues	$0.38	$0.44	$0.48	$0.52	$0.49	$0.48
Grand Saline						
Monetary value of domestic water shortages	$0.00	$0.00	$0.05	$0.14	$0.31	$2.21
Lost utility revenues	$0.00	$0.00	$0.07	$0.16	$0.27	$0.43

Municipal cont. ($millions)						
	2010	2020	2030	2040	2050	2060
Hickory Creek SUD						
Monetary value of domestic water shortages	$0.08	$0.26	$0.41	$0.43	$0.41	$0.39
Lost utility revenues	$0.12	$0.29	$0.40	$0.42	$0.40	$0.38
Hooks						
Monetary value of domestic water shortages	$4.29	$4.77	$5.29	$5.84	$6.62	$4.21
Lost income from reduced commercial business activity	$0.36	$0.40	$0.45	$0.49	$0.56	$0.65
Lost jobs due to reduced commercial business activity	15	16	18	20	22	26
Lost state and local taxes from reduced commercial business activity	$0.06	$0.06	$0.07	$0.08	$0.09	$0.10
Lost utility revenues	$0.20	$0.23	$0.25	$0.28	$0.32	$0.37
Liberty City WSC						
Monetary value of domestic water shortages	$0.07	$0.15	$0.23	$1.10	$1.41	$1.90
Lost utility revenues	$0.08	$0.15	$0.20	$0.23	$0.28	$0.34
Lindale						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.11	$0.34
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.14	$0.33
Lindale Rural WSC						
Monetary value of domestic water shortages	$0.00	$0.04	$0.09	$0.14	$0.22	$0.33
Lost utility revenues	$0.00	$0.07	$0.13	$0.17	$0.24	$0.33
Macedonia-Eylau MUD #1						
Monetary value of domestic water shortages	$0.04	$0.10	$0.14	$0.20	$0.19	$0.19
Lost utility revenues	$0.08	$0.18	$0.24	$0.31	$0.30	$0.30
Mineola						
Monetary value of domestic water shortages	$0.00	$0.00	$0.03	$0.05	$0.11	$0.18
Lost utility revenues	$0.00	$0.00	$0.05	$0.10	$0.18	$0.28
New Boston						
Monetary value of domestic water shortages	$0.13	$0.19	$0.26	$0.31	$0.31	$0.31
Lost utility revenues	$0.14	$0.19	$0.23	$0.27	$0.27	$0.27

Municipal cont. ($millions)						
	2010	2020	2030	2040	2050	2060
North Hunt WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.02	$0.05	$0.08	$0.14
Lost utility revenues	$0.00	$0.00	$0.05	$0.11	$0.18	$0.28
R P M WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.10	$1.75
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.08	$0.25
Redwater						
Monetary value of domestic water shortages	$0.00	$0.00	$0.02	$0.05	$0.12	$0.94
Lost utility revenues	$0.00	$0.00	$0.04	$0.06	$0.12	$0.20
Van						
Monetary value of domestic water shortages	$0.08	$0.10	$0.11	$0.12	$0.11	$0.10
Lost utility revenues	$0.16	$0.20	$0.22	$0.24	$0.22	$0.20
Wake Village						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.03	$0.10
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.04	$0.15
Waskom						
Monetary value of domestic water shortages	$0.00	$0.00	$0.02	$0.04	$0.10	$0.70
Lost utility revenues	$0.00	$0.00	$0.02	$0.05	$0.09	$0.14
West Gregg WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.01	$0.02	$0.02	$0.13
Lost utility revenues	$0.00	$0.01	$0.01	$0.02	$0.02	$0.14
Winona						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.02
Wolfe City						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01

Steam-electric ($millions)						
	2010	2020	2030	2040	2050	2060
Harrison County						
Reduced income from lost electrical generation	$0.00	$0.00	$0.00	$47.54	$175.50	$331.50
Reduced business taxes from lost electrical generation	$0.00	$0.00	$0.00	$6.82	$25.19	$47.58
Reduced jobs from lost electrical generation	0	0	0	162	597	1,127
Hunt County						
Reduced income from lost electrical generation	$355.79	$509.28	$595.39	$700.37	$828.37	$984.38
Reduced business taxes from lost electrical generation	$51.07	$73.10	$85.46	$100.53	$118.90	$141.29
Reduced jobs from lost electrical generation	1,209	1,731	2,024	2,381	2,816	3,346
Lamar County						
Reduced income from lost electrical generation	$0.00	$0.00	$16.41	$91.55	$163.14	$250.37
Reduced business taxes from lost electrical generation	$0.00	$0.00	$2.36	$13.14	$23.42	$35.94
Reduced jobs from lost electrical generation	0	0	56	311	555	851
Titus County						
Reduced income from lost electrical generation	$0.00	$0.00	$0.00	$15.63	$143.61	$280.96
Reduced business taxes from lost electrical generation	$0.00	$0.00	$0.00	$2.24	$20.61	$40.33
Reduced jobs from lost electrical generation	0	0	0	53	488	955

TEXAS WATER DEVELOPMENT BOARD

June 1, 2010

Mr. Kelley Holcomb
Chairman, East Texas Regional Water Planning Group
c/o General Manager, Angelina & Neches River Authority
P.O. Box 387
Lufkin, Texas 75902-0387

Re: Socioeconomic Impact Analysis of Not Meeting Water Needs for the 2011 East Texas Regional Water Plan

Dear Chairman Holcomb:

We have received your request for technical assistance to complete the socioeconomic impact analysis of not meeting water needs. In response, enclosed is a report that describes our methodology and presents the results. Section 1 provides an overview of the methodology, and Section 2 presents results for at the regional level, and Appendix 2 show results for individual water user groups.

If you have any questions or comments, please feel free to contact me at (512) 463-7928 or by email at stuart.norvell@twdb.state.tx.us.

Sincerely,

Stuart D. Norvell
Manager, Water Planning Research and Analysis
Water Resources Planning Division

SN/ao

Enclosure

c. Temple Mckinnon, TWDB
S. Doug Shaw, TWDB

Socioeconomic Impacts of Projected Water Shortages for the East Texas Regional Water Planning Area (Region I)

Prepared in Support of the 2011 East Texas Regional Water Plan

Stuart D. Norvell, Managing Economist
Water Resources Planning Division
Texas Water Development Board
Austin, Texas

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Water Resources Planning Division
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Austin, Texas

May 2010

Table of Contents

Introduction

Water shortages during drought would likely curtail or eliminate economic activity in business and industries reliant on water. For example, without water farmers cannot irrigate; refineries cannot produce gasoline, and paper mills cannot make paper. Unreliable water supplies would not only have an immediate and real impact on existing businesses and industry, but they could also adversely affect economic development in Texas. From a social perspective, water supply reliability is critical as well. Shortages would disrupt activity in homes, schools and government and could adversely affect public health and safety. For all of the above reasons, it is important to analyze and understand how restricted water supplies during drought could affect communities throughout the state.

Administrative rules require that regional water planning groups evaluate the impacts of not meeting water needs as part of the regional water planning process, and rules direct TWDB staff to provide technical assistance: "*The executive administrator shall provide available technical assistance to the regional water planning groups, upon request, on water supply and demand analysis, including methods to evaluate the social and economic impacts of not meeting needs*" [(§357.7 (4)(A)]. Staff of the TWDB's Water Resources Planning Division designed and conducted this report in support of the Northeast Texas Regional Water Planning Group (Region I).

This document summarizes the results of our analysis and discusses the methodology used to generate the results. Section 1 outlines the overall methodology and discusses approaches and assumptions specific to each water use category (i.e., irrigation, livestock, mining, steam-electric, municipal and manufacturing). Section 2 presents the results for each category where shortages are reported at the regional planning area level and river basin level. Results for individual water user groups are not presented, but are available upon request.

1. Methodology

Section 1 provides a general overview of how economic and social impacts were measured. In addition, it summarizes important clarifications, assumptions and limitations of the study.

1.1 Economic Impacts of Water Shortages

1.1.1 General Approach

Economic analysis as it relates to water resources planning generally falls into two broad areas. Supply side analysis focuses on costs and alternatives of developing new water supplies or implementing programs that provide additional water from current supplies. Demand side analysis concentrates on impacts or benefits of providing water to people, businesses and the environment. Analysis in this report focuses strictly on demand side impacts. When analyzing the economic impacts of water shortages as defined in Texas water planning, three potential scenarios are possible:

1) Scenario 1 involves situations where there are physical shortages of raw surface or groundwater due to drought of record conditions. For example, City A relies on a reservoir with average conservation storage of 500 acre-feet per year and a firm yield of 100 acre feet. In 2010, the city uses about 50 acre-feet per year, but by 2030 their demands are expected to increase to 200 acre-feet. Thus, in 2030 the reservoir would not have enough water to meet the city's demands,

and people would experience a shortage of 100 acre-feet assuming drought of record conditions. Under normal or average climatic conditions, the reservoir would likely be able to provide reliable water supplies well beyond 2030.

2) Scenario 2 is a situation where despite drought of record conditions, water supply sources can meet existing use requirements; however, limitations in water infrastructure would preclude future water user groups from accessing these water supplies. For example, City B relies on a river that can provide 500 acre-feet per year during drought of record conditions and other constraints as dictated by planning assumptions. In 2010, the city is expected to use an estimated 100 acre-feet per year and by 2060 it would require no more than 400 acre-feet. But the intake and pipeline that currently transfers water from the river to the city's treatment plant has a capacity of only 200 acre-feet of water per year. Thus, the city's water supplies are adequate even under the most restrictive planning assumptions, but their conveyance system is too small. This implies that at some point – perhaps around 2030 - infrastructure limitations would constrain future population growth and any associated economic activity or impacts.

3) Scenario 3 involves water user groups that rely primarily on aquifers that are being depleted. In this scenario, projected and in some cases existing demands may be unsustainable as groundwater levels decline. Areas that rely on the Ogallala aquifer are a good example. In some communities in the region, irrigated agriculture forms a major base of the regional economy. With less irrigation water from the Ogallala, population and economic activity in the region could decline significantly assuming there are no offsetting developments.

Assessing the social and economic effects of each of the above scenarios requires various levels and methods of analysis and would generate substantially different results for a number of reasons; the most important of which has to do with the time frame of each scenario. Scenario 1 falls into the general category of static analysis. This means that models would measure impacts for a small interval of time such as a drought. Scenarios 2 and 3, on the other hand imply a dynamic analysis meaning that models are concerned with changes over a much longer time period.

Since administrative rules specify that planning analysis be evaluated under drought of record conditions (a static and random event), socioeconomic impact analysis developed by the TWDB for the state water plan is based on assumptions of Scenario 1. Estimated impacts under scenario 1 are point estimates for years in which needs are reported (2010, 2020, 2030, 2040, 2050 and 2060). They are independent and distinct "what if" scenarios for a particular year and shortages are assumed to be temporary events resulting from drought of record conditions. Estimated impacts measure what would happen if water user groups experience water shortages for a period of one year.

The TWDB recognize that dynamic models may be more appropriate for some water user groups; however, combining approaches on a statewide basis poses several problems. For one, it would require a complex array of analyses and models, and might require developing supply and demand forecasts under "normal" climatic conditions as opposed to drought of record conditions. Equally important is the notion that combining the approaches would produce inconsistent results across regions resulting in a so-called "apples to oranges" comparison.

A variety tools are available to estimate economic impacts, but by far, the most widely used today are input-output models (IO models) combined with social accounting matrices (SAMs). Referred to as IO/SAM models, these tools formed the basis for estimating economic impacts for agriculture (irrigation and livestock water uses) and industry (manufacturing, mining, steam-electric and commercial business activity for municipal water uses).

Since the planning horizon extends through 2060, economic variables in the baseline are adjusted in accordance with projected changes in demographic and economic activity. Growth rates for municipal water use sectors (i.e., commercial, residential and institutional) are based on TWDB population forecasts. Future values for manufacturing, agriculture, and mining and steam-electric activity are based on the same underlying economic forecasts used to estimate future water use for each category.

The following steps outline the overall process.

Step 1*: Generate IO/SAM Models and Develop Economic Baseline*

IO/SAM models were estimated using propriety software known as IMPLAN PRO™ (Impact for Planning Analysis). IMPLAN is a modeling system originally developed by the U.S. Forestry Service in the late 1970s. Today, the Minnesota IMPLAN Group (MIG Inc.) owns the copyright and distributes data and software. It is probably the most widely used economic impact model in existence. IMPLAN comes with databases containing the most recently available economic data from a variety of sources.[1] Using IMPLAN software and data, transaction tables conceptually similar to the one discussed previously were estimated for each county in the region and for the region as a whole. Each transaction table contains 528 economic sectors and allows one to estimate a variety of economic statistics including:

- **total sales -** total production measured by sales revenues;
- **intermediate sales -** sales to other businesses and industries within a given region;
- **final sales –** sales to end users in a region and exports out of a region**;**
- **employment -** number of full and part-time jobs (annual average) required by a given industry including self-employment;
- **regional income -** total payroll costs (wages and salaries plus benefits) paid by industries, corporate income, rental income and interest payments; and
- **business taxes -** sales, excise, fees, licenses and other taxes paid during normal operation of an industry (does not include income taxes).

TWDB analysts developed an economic baseline containing each of the above variables using year 2000 data. Since the planning horizon extends through 2060, economic variables in the baseline were allowed to change in accordance with projected changes in demographic and economic activity. Growth rates for municipal water use sectors (i.e., commercial, residential and institutional) are based on TWDB population forecasts. Projections for manufacturing, agriculture, and mining and steam-electric activity are based on the same underlying economic forecasts used to estimate future water use for each category. Monetary impacts in future years are reported in constant year 2006 dollars.

It is important to stress that employment, income and business taxes are the most useful variables when comparing the relative contribution of an economic sector to a regional economy. Total sales as reported in IO/SAM models are less desirable and can be misleading because they include sales to other industries in the region for use in the production of other goods. For example, if a mill buys grain from local farmers and uses it to produce feed, sales of both the processed feed and raw corn are counted as "output" in an IO model. Thus, total sales double-count or overstate the true economic value of goods

[1]The IMPLAN database consists of national level technology matrices based on benchmark input-output accounts generated by the U.S. Bureau of Economic Analysis and estimates of final demand, final payments, industry output and employment for various economic sectors. IMPLAN regional data (i.e. states, a counties or groups of counties within a state) are divided into two basic categories: 1) data on an industry basis including value-added, output and employment, and 2) data on a commodity basis including final demands and institutional sales. State-level data are balanced to national totals using a matrix ratio allocation system and county data are balanced to state totals.

and services produced in an economy. They are not consistent with commonly used measures of output such as Gross National Product (GNP), which counts only final sales.

Another important distinction relates to terminology. Throughout this report, the term *sector* refers to economic subdivisions used in the IMPLAN database and resultant input-output models (528 individual sectors based on Standard Industrial Classification Codes). In contrast, the phrase *water use category* refers to water user groups employed in state and regional water planning including irrigation, livestock, mining, municipal, manufacturing and steam electric. Each IMPLAN sector was assigned to a specific water use category.

Step 2: *Estimate Direct and Indirect Economic Impacts of Water Needs*

Direct impacts are reductions in output by sectors experiencing water shortages. For example, without adequate cooling and process water a refinery would have to curtail or cease operation, car washes may close, or farmers may not be able to irrigate and sales revenues fall. Indirect impacts involve changes in inter-industry transactions as supplying industries respond to decreased demands for their services, and how seemingly non-related businesses are affected by decreased incomes and spending due to direct impacts. For example, if a farmer ceases operations due to a lack of irrigation water, they would likely reduce expenditures on supplies such as fertilizer, labor and equipment, and businesses that provide these goods would suffer as well.

Direct impacts accrue to immediate businesses and industries that rely on water and without water industrial processes could suffer. However, output responses may vary depending upon the severity of shortages. A small shortage relative to total water use would likely have a minimal impact, but large shortages could be critical. For example, farmers facing small shortages might fallow marginally productive acreage to save water for more valuable crops. Livestock producers might employ emergency culling strategies, or they may consider hauling water by truck to fill stock tanks. In the case of manufacturing, a good example occurred in the summer of 1999 when Toyota Motor Manufacturing experienced water shortages at a facility near Georgetown, Kentucky.[2] As water levels in the Kentucky River fell to historic lows due to drought, plant managers sought ways to curtail water use such as reducing rinse operations to a bare minimum and recycling water by funneling it from paint shops to boilers. They even considered trucking in water at a cost of 10 times what they were paying. Fortunately, rains at the end of the summer restored river levels, and Toyota managed to implement cutbacks without affecting production, but it was a close call. If rains had not replenished the river, shortages could have severely reduced output.[3]

To account for uncertainty regarding the relative magnitude of impacts to farm and business operations, the following analysis employs the concept of elasticity. Elasticity is a number that shows how a change in one variable will affect another. In this case, it measures the relationship between a percentage reduction in water availability and a percentage reduction in output. For example, an elasticity of 1.0 indicates that a 1.0 percent reduction in water availability would result in a 1.0 percent reduction in economic output. An elasticity of 0.50 would indicate that for every 1.0 percent of unavailable water, output is reduced by 0.50 percent and so on. Output elasticities used in this study are:[4]

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[2] Royal, W. "*High And Dry - Industrial Centers Face Water Shortages*." in Industry Week, Sept, 2000.

[3] The efforts described above are not planned programmatic or long-term operational changes. They are emergency measures that individuals might pursue to alleviate what they consider a temporary condition. Thus, they are not characteristic of long-term management strategies designed to ensure more dependable water supplies such as capital investments in conservation technology or development of new water supplies.

[4] Elasticities are based on one of the few empirical studies that analyze potential relationships between economic output and water shortages in the United States. The study, conducted in California, showed that a significant number of industries would suffer reduced output during water shortages. Using a survey based approach researchers posed two scenarios to different industries. In

- if water needs are 0 to 5 percent of total water demand, no corresponding reduction in output is assumed;

- if water needs are 5 to 30 percent of total water demand, for each additional one percent of water need that is not met, there is a corresponding 0.50 percent reduction in output;

- if water needs are 30 to 50 percent of total water demand, for each additional one percent of water need that is not met, there is a corresponding 0.75 percent reduction in output; and

- if water needs are greater than 50 percent of total water demand, for each additional one percent of water need that is not met, there is a corresponding 1.0 percent (i.e., a proportional reduction).

In some cases, elasticities are adjusted depending upon conditions specific to a given water user group.

Once output responses to water shortages were estimated, direct impacts to total sales, employment, regional income and business taxes were derived using regional level economic multipliers estimating using IO/SAM models. The formula for a given IMPLAN sector is:

$D_{i,t} = Q_{i,t} *_{,} S_{i,t} * E_Q * RFD_i * DM_{i(Q, L, I, T)}$

where:

$D_{i,t}$ = direct economic impact to sector *i* in period *t*

$Q_{i,t}$ = total sales for sector *i* in period *t* in an affected county

$RFD_{i,}$ = ratio of final demand to total sales for sector *i* for a given region

$S_{i,t}$ = water shortage as percentage of total water use in period *t*

E_Q = elasticity of output and water use

$DM_{i(L, I, T)}$ = direct output multiplier coefficients for labor (L), income (I) and taxes (T) for sector *i*.

Secondary impacts were derived using the same formula used to estimate direct impacts; however, indirect multiplier coefficients are used. Methods and assumptions specific to each water use sector are discussed in Sections 1.1.2 through 1.1.4.

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the first scenario, they asked how a 15 percent cutback in water supply lasting one year would affect operations. In the second scenario, they asked how a 30 percent reduction lasting one year would affect plant operations. In the case of a 15 percent shortage, reported output elasticities ranged from 0.00 to 0.76 with an average value of 0.25. For a 30 percent shortage, elasticities ranged from 0.00 to 1.39 with average of 0.47. For further information, see, California Urban Water Agencies, "*Cost of Industrial Water Shortages,*" Spectrum Economics, Inc. November, 1991.

General Assumptions and Clarification of the Methodology

As with any attempt to measure and quantify human activities at a societal level, assumptions are necessary and every model has limitations. Assumptions are needed to maintain a level of generality and simplicity such that models can be applied on several geographic levels and across different economic sectors. In terms of the general approach used here several clarifications and cautions are warranted:

1. Shortages as reported by regional planning groups are the starting point for socioeconomic analyses.

2. Estimated impacts are point estimates for years in which needs are reported (i.e., 2010, 2020, 2030, 2040, 2050 and 2060).They are independent and distinct "what if" scenarios for each particular year and water shortages are assumed to be temporary events resulting from severe drought conditions combined with infrastructure limitations. In other words, growth occurs and future shocks are imposed on an economy at 10-year intervals and resultant impacts are measured. Given, that reported figures are not cumulative in nature, it is inappropriate to sum impacts over the entire planning horizon. Doing so, would imply that the analysis predicts that drought of record conditions will occur every ten years in the future, which is not the case. Similarly, authors of this report recognize that in many communities needs are driven by population growth, and in the future total population will exceed the amount of water available due to infrastructure limitations, regardless of whether or not there is a drought. This implies that infrastructure limitations would constrain economic growth. However, since needs as defined by planning rules are based upon water supply and demand under the assumption of drought of record conditions, it improper to conduct economic analysis that focuses on growth related impacts over the planning horizon. Figures generated from such an analysis would presume a 50-year drought of record, which is unrealistic. Estimating lost economic activity related to constraints on population and commercial growth due to lack of water would require developing water supply and demand forecasts under "normal" or "most likely" future climatic conditions.

3. While useful for planning purposes, this study is not a benefit-cost analysis. Benefit cost analysis is a tool widely used to evaluate the economic feasibility of specific policies or projects as opposed to estimating economic impacts of unmet water needs. Nevertheless, one could include some impacts measured in this study as part of a benefit cost study if done so properly. Since this is not a benefit cost analysis, future impacts are not weighted differently. In other words, estimates are not discounted. If used as a measure of economic benefits, one should incorporate a measure of uncertainty into the analysis. In this type of analysis, a typical method of discounting future values is to assign probabilities of the drought of record recurring again in a given year, and weight monetary impacts accordingly. This analysis assumes a probability of one.

4. IO multipliers measure the strength of backward linkages to supporting industries (i.e., those who sell inputs to an affected sector). However, multipliers say nothing about forward linkages consisting of businesses that purchase goods from an affected sector for further processing. For example, ranchers in many areas sell most of their animals to local meat packers who process animals into a form that consumers ultimately see in grocery stores and restaurants. Multipliers do not capture forward linkages to meat packers, and since meat packers sell livestock purchased from ranchers as "final sales," multipliers for the ranching sector do fully account for all losses to a region's economy. Thus, as mentioned previously, in some cases closely linked sectors were moved from one water use category to another.

5. Cautions regarding interpretations of direct and secondary impacts are warranted. IO/SAM multipliers are based on "fixed-proportion production functions," which basically means that input use - including labor - moves in lockstep fashion with changes in levels of output. In a

scenario where output (i.e., sales) declines, losses in the immediate sector or supporting sectors could be much less than predicted by an IO/SAM model for several reasons. For one, businesses will likely expect to continue operating so they might maintain spending on inputs for future use; or they may be under contractual obligations to purchase inputs for an extended period regardless of external conditions. Also, employers may not lay-off workers given that experienced labor is sometimes scarce and skilled personnel may not be readily available when water shortages subside. Lastly people who lose jobs might find other employment in the region. As a result, direct losses for employment and secondary losses in sales and employment should be considered an upper bound. Similarly, since projected population losses are based on reduced employment in the region, they should be considered an upper bound as well.

6. IO models are static. Models and resultant multipliers are based upon the structure of the U.S. and regional economies in 2006. In contrast, water shortages are projected to occur well into the future. Thus, the analysis assumes that the general structure of the economy remains the same over the planning horizon, and the farther out into the future we go, this assumption becomes less reliable.

7. Impacts are annual estimates. If one were to assume that conditions persisted for more than one year, figures should be adjusted to reflect the extended duration. The drought of record in most regions of Texas lasted several years.

8. Monetary figures are reported in constant year 2006 dollars.

1.1.2 Impacts to Agriculture

Irrigated Crop Production

The first step in estimating impacts to irrigation required calculating gross sales for IMPLAN crop sectors. Default IMPLAN data do not distinguish irrigated production from dry-land production. Once gross sales were known other statistics such as employment and income were derived using IMPLAN direct multiplier coefficients. Gross sales for a given crop are based on two data sources:

1) county-level statistics collected and maintained by the TWDB and the USDA Farm Services Agency (FSA) including the number of irrigated acres by crop type and water application per acre, and

2) regional-level data published by the Texas Agricultural Statistics Service (TASS) including prices received for crops (marketing year averages), crop yields and crop acreages.

Crop categories used by the TWDB differ from those used in IMPLAN datasets. To maintain consistency, sales and other statistics are reported using IMPLAN crop classifications. Table 1 shows the TWDB crops included in corresponding IMPLAN sectors, and Table 2 summarizes acreage and estimated annual water use for each crop classification (five-year average from 2003-2007). Table 3 displays average (2003-2007) gross revenues per acre for IMPLAN crop categories.

Table 1: Crop Classifications Used in TWDB Water Use Survey and Corresponding IMPLAN Crop Sectors	
IMPLAN Category	**TWDB Category**
Oilseeds	Soybeans and "other oil crops"
Grains	Grain sorghum, corn, wheat and "other grain crops"
Vegetable and melons	"Vegetables" and potatoes
Tree nuts	Pecans
Fruits	Citrus, vineyard and other orchard
Cotton	Cotton
Sugarcane and sugar beets	Sugarcane and sugar beets
All "other" crops	"Forage crops", peanuts, alfalfa, hay and pasture, rice and "all other crops"

Table 2: Summary of Irrigated Crop Acreage and Water Demand for the East Texas Regional Water Planning Area (average 2003-2007)

Sector	Acres (1000s)	Distribution of acres	Water use (1000s of AF)	Distribution of water use
Grains	<1	<1%	<1	<1%
Vegetable and melons	<1	3%	<1	<1%
Fruits	<1	<1%	<1%	<1%
Cotton	<1	2%	0.58	1%
Rice	22	93%	108	99%
Total	23	100%	109	100%

Source: Water demand figures are a 5- year average (2003-2007) of the TWDB's annual Irrigation Water Use Estimates. Statistics for irrigated crop acreage are based upon annual survey data collected by the TWDB and the Farm Service Agency. Values do not include acreage or water use for the TWDB categories classified by the Farm Services Agency as "failed acres," "golf course" or "waste water."

Table 3: Average Gross Sales Revenues per Acre for Irrigated Crops for the East Texas Regional Water Planning Area (2003-2007)		
IMPLAN Sector	**Gross revenues per acre**	**Crops included in estimates**
Grains	$442	Based on five-year (2003-2007) average weighted by acreage for “irrigated grain sorghum,” “irrigated corn”, “irrigated wheat” and “irrigated ‘other’ grain crops.”
Vegetable and melons	$6,184	Based on five-year (2003-2007) average weighted by acreage for “irrigated shallow and deep root vegetables”, “irrigated Irish potatoes” and “irrigated melons.”
Fruits	$3,502	Based on five-year (2003-2007) average weighted by acreage for “irrigated citrus”, “irrigated vineyards” and “irrigated ‘other’ orchard.”
Cotton	$400	Based on five-year (2003-2007) average weighted by acreage for “irrigated cotton.”
All Other Crops	$500	Irrigated figure is based on five-year (2003-2007) average weighted by acreage for “irrigated ‘forage’ crops”, “irrigated peanuts”, “irrigated alfalfa”, “irrigated ‘hay’ and pasture” and “irrigated ‘all other’ crops.”

*Figures are rounded. Source: Based on data from the Texas Agricultural Statistics Service, Texas Water Development Board, and Texas A&M University.

An important consideration when estimating impacts to irrigation was determining which crops are affected by water shortages. One approach is the so-called rationing model, which assumes that farmers respond to water supply cutbacks by fallowing the lowest value crops in the region first and the highest valued crops last until the amount of water saved equals the shortage.[5] For example, if farmer A grows vegetables (higher value) and farmer B grows wheat (lower value) and they both face a proportionate cutback in irrigation water, then farmer B will sell water to farmer A. Farmer B will fallow her irrigated acreage before farmer A fallows anything. Of course, this assumes that farmers can and do transfer enough water to allow this to happen. A different approach involves constructing farm-level profit maximization models that conform to widely-accepted economic theory that farmers make decisions based on marginal net returns. Such models have good predictive capability, but data requirements and complexity are high. Given that a detailed analysis for each region would require a substantial amount of farm-level data and analysis, the following investigation assumes that projected shortages are distributed equally across predominant crops in the region. Predominant in this case are crops that comprise at least one percent of total acreage in the region.

The following steps outline the overall process used to estimate direct impacts to irrigated agriculture:

1. *Distribute shortages across predominant crop types in the region*. Again, unmet water needs were distributed equally across crop sectors that constitute one percent or more of irrigated acreage.

2. *Estimate associated reductions in output for affected crop sectors*. Output reductions are based on elasticities discussed previously and on estimated values per acre for different crops. Values per acre stem from the same data used to estimate output for the year 2006 baseline. Using multipliers, we then generate estimates of forgone income, jobs, and tax revenues based on reductions in gross sales and final demand.

Livestock

The approach used for the livestock sector is basically the same as that used for crop production. As is the case with crops, livestock categorizations used by the TWDB differ from those used in IMPLAN datasets, and TWDB groupings were assigned to a given IMPLAN sector (Table 4). Then we:

1) *Distribute projected water needs equally among predominant livestock sectors and estimate lost output*: As is the case with irrigation, shortages are assumed to affect all livestock sectors equally; however, the category of "other" is not included given its small size. If water needs were small relative to total demands, we assume that producers would haul in water by truck to fill stock tanks. The cost per acre-foot ($24,000) is based on 2008 rates charged by various water haulers in Texas, and assumes that the average truck load is 6,500 gallons at a hauling distance of 60 miles.

3) *Estimate reduced output in forward processors for livestock sectors*. Reductions in output for livestock sectors are assumed to have a proportional impact on forward processors in the region such as meat packers. In other words, if the cows were gone, meat-packing plants or fluid milk manufacturers) would likely have little to process. This is not an unreasonable premise. Since the

[5] The rationing model was initially proposed by researchers at the University of California at Berkeley, and was then modified for use in a study conducted by the U.S. Environmental Protection Agency that evaluated how proposed water supply cutbacks recommended to protect water quality in the Bay/Delta complex in California would affect farmers in the Central Valley. See, Zilberman, D., Howitt, R. and Sunding, D. "*Economic Impacts of Water Quality Regulations in the San Francisco Bay and Delt*a." Western Consortium for Public Health. May 1993.

1950s, there has been a major trend towards specialized cattle feedlots, which in turn has decentralized cattle purchasing from livestock terminal markets to direct sales between producers and slaughterhouses. Today, the meat packing industry often operates large processing facilities near high concentrations of feedlots to increase capacity utilization.[6] As a result, packers are heavily dependent upon nearby feedlots. For example, a recent study by the USDA shows that on average meat packers obtain 64 percent of cattle from within 75 miles of their plant, 82 percent from within 150 miles and 92 percent from within 250 miles.[7]

Table 4: Description of Livestock Sectors

IMPLAN Category	**TWDB Category**
Cattle ranching and farming	Cattle, cow calf, feedlots and dairies
Poultry and egg production	Poultry production.
Other livestock	Livestock other than cattle and poultry (i.e., horses, goats, sheep, hogs)
Milk manufacturing	Fluid milk manufacturing, cheese manufacturing, ice cream manufacturing etc.
Meat packing	Meat processing present in the region from slaughter to final processing

1.1.3 Impacts to Municipal Water User Groups

Disaggregation of Municipal Water Demands

Estimating the economic impacts for the municipal water user groups is complicated for a number of reasons. For one, municipal use comprises a range of consumers including commercial businesses, institutions such as schools and government and households. However, reported water needs are not distributed among different municipal water users. In other words, how much of a municipal need is commercial and how much is residential (domestic)?

The amount of commercial water use as a percentage of total municipal demand was estimated based on "GED" coefficients (gallons per employee per day) published in secondary sources.[8] For example, if year 2006 baseline data for a given economic sector (e.g., amusement and recreation services) shows employment at 30 jobs and the GED coefficient is 200, then average daily water use by that sector is (30 x

[6] Ferreira, W.N. "*Analysis of the Meat Processing Industry in the United States*." Clemson University Extension Economics Report ER211, January 2003.

[7] Ward, C.E. "*Summary of Results from USDA's Meatpacking Concentration Study*." Oklahoma Cooperative Extension Service, OSU Extension Facts WF-562.

[8] Sources for GED coefficients include: Gleick, P.H., Haasz, D., Henges-Jeck, C., Srinivasan, V., Wolff, G. Cushing, K.K., and Mann, A. "*Waste Not, Want Not*: *The Potential for Urban Water Conservation in California*." Pacific Institute. November 2003. U.S. Bureau of the Census. 1982 Census of Manufacturers: Water Use in Manufacturing. USGPO, Washington D.C. See also: "*U.S. Army Engineer Institute for Water Resources, IWR Report 88-R-6.*," Fort Belvoir, VA. See also, Joseph, E. S., 1982, "*Municipal and Industrial Water Demands of the Western United States*." Journal of the Water Resources Planning and Management Division, Proceedings of the American Society of Civil Engineers, v. 108, no. WR2, p. 204-216. See also, Baumann, D. D., Boland, J. J., and Sims, J. H., 1981, "*Evaluation of Water Conservation for Municipal and Industrial Water Supply*." U.S. Army Corps of Engineers, Institute for Water Resources, Contract no. 82-C1.

200 = 6,000 gallons) or 6.7 acre-feet per year. Water not attributed to commercial use is considered domestic, which includes single and multi-family residential consumption, institutional uses and all use designated as “county-other.” Based on our analysis, commercial water use is about 5 to 35 percent of municipal demand. Less populated rural counties occupy the lower end of the spectrum, while larger metropolitan counties are at the higher end.

After determining the distribution of domestic versus commercial water use, we developed methods for estimating impacts to the two groups.

Domestic Water Uses

Input output models are not well suited for measuring impacts of shortages for domestic water uses, which make up the majority of the municipal water use category. To estimate impacts associated with domestic water uses, municipal water demand and needs are subdivided into residential, and commercial and institutional use. Shortages associated with residential water uses are valued by estimating proxy demand functions for different water user groups allowing us to estimate the marginal value of water, which would vary depending upon the level of water shortages. The more severe the water shortage, the more costly it becomes. For instance, a 2 acre-foot shortage for a group of households that use 10 acre-feet per year would not be as severe as a shortage that amounted to 8 acre-feet. In the case of a 2 acre-foot shortage, households would probably have to eliminate some or all outdoor water use, which could have implicit and explicit economic costs including losses to the horticultural and landscaping industry. In the case of an 8 acre-foot shortage, people would have to forgo all outdoor water use and most indoor water consumption. Economic impacts would be much higher in the latter case because people, and would be forced to find emergency alternatives assuming alternatives were available.

To estimate the value of domestic water uses, TWDB staff developed marginal loss functions based on constant elasticity demand curves. This is a standard and well-established method used by economists to value resources such as water that have an explicit monetary cost.

A constant price elasticity of demand is estimated using a standard equation:

$$w = kc^{(-\varepsilon)}$$

where:

- w is equal to average monthly residential water use for a given water user group measured in thousands of gallons;
- k is a constant intercept;
- c is the average cost of water per 1,000 gallons; and
- ε is the price elasticity of demand.

Price elasticities (-0.30 for indoor water use and -0.50 for outdoor use) are based on a study by Bell et al.[9] that surveyed 1,400 water utilities in Texas that serve at least 1,000 people to estimate demand elasticity for several variables including price, income, weather etc. Costs of water and average use per month per household are based on data from the Texas Municipal League's annual water and

[9] Bell, D.R. and Griffin, R.C. “*Community Water Demand in Texas as a Century is Turned*.” Research contract report prepared for the Texas Water Development Board. May 2006.

wastewater rate surveys - specifically average monthly household expenditures on water and wastewater in different communities across the state. After examining variance in costs and usage, three different categories of water user groups based on population (population less than 5,000, cities with populations ranging from 5,000 to 99,999 and cities with populations exceeding 100,000) were selected to serve as proxy values for municipal water groups that meet the criteria (Table 5).[10]

Table 5: Water Use and Costs Parameters Used to Estimated Water Demand Functions (average monthly costs per acre-foot for delivered water and average monthly use per household)

Community Population	Water	Wastewater	Total monthly cost	Avg. monthly use (gallons)
Less than or equal to 5,000	$1,335	$1,228	$2,563	6,204
5,000 to 100,000	$1,047	$1,162	$2,209	7,950
Great than or equal to 100,000	$718	$457	$1,190	8,409

Source: Based on annual water and wastewater rate surveys published by the Texas Municipal League.

As an example, Table 6 shows the economic impact per acre-foot of domestic water needs for municipal water user groups with population exceeding 100,000 people. There are several important assumptions incorporated in the calculations:

1) Reported values are net of the variable costs of treatment and distribution such as expenses for chemicals and electricity since using less water involves some savings to consumers and utilities alike; and for outdoor uses we do not include any value for wastewater.

2) Outdoor and "non-essential" water uses would be eliminated before indoor water consumption was affected, which is logical because most water utilities in Texas have drought contingency plans that generally specify curtailment or elimination of outdoor water use during droughts.[11] Determining how much water is used for outdoor purposes is based on several secondary sources. The first is a major study sponsored by the American Water Works Association, which surveyed cities in states including Colorado, Oregon, Washington, California, Florida and Arizona. On average across all cities surveyed 58 percent of single family residential water use was for outdoor activities. In cities with climates comparable to large metropolitan areas of Texas, the average was 40 percent.[12] Earlier findings of the U.S. Water Resources Council showed a national

[10] Ideally, one would want to estimate demand functions for each individual utility in the state. However, this would require an enormous amount of time and resources. For planning purposes, we believe the values generated from aggregate data are more than sufficient.

[11] In Texas, state law requires retail and wholesale water providers to prepare and submit plans to the Texas Commission on Environmental Quality (TCEQ). Plans must specify demand management measures for use during drought including curtailment of "non-essential water uses." Non-essential uses include, but are not limited to, landscape irrigation and water for swimming pools or fountains. For further information see the Texas Environmental Quality Code §288.20.

[12] See, Mayer, P.W., DeOreo, W.B., Opitz, E.M., Kiefer, J.C., Davis, W., Dziegielewski, D., Nelson, J.O. "*Residential End Uses of Water*." Research sponsored by the American Water Works Association and completed by Aquacraft, Inc. and Planning and Management Consultants, Ltd. (PMCL@CDM).

average of 33 percent. Similarly, the United States Environmental Protection Agency (USEPA) estimated that landscape watering accounts for 32 percent of total residential and commercial water use on annual basis.[13] A study conducted for the California Urban Water Agencies (CUWA) calculated average annual values ranging from 25 to 35 percent.[14] Unfortunately, there does not appear to be any comprehensive research that has estimated non-agricultural outdoor water use in Texas. As an approximation, an average annual value of 30 percent based on the above references was selected to serve as a rough estimate in this study.

3) As shortages approach 100 percent values become immense and theoretically infinite at 100 percent because at that point death would result, and willingness to pay for water is immeasurable. Thus, as shortages approach 80 percent of monthly consumption, we assume that households and non-water intensive commercial businesses (those that use water only for drinking and sanitation would have water delivered by tanker truck or commercial water delivery companies. Based on reports from water companies throughout the state, we estimate that the cost of trucking in water is around $21,000 to $27,000 per acre-feet assuming a hauling distance of between 20 to 60 miles. This is not an unreasonable assumption. The practice was widespread during the 1950s drought and recently during droughts in this decade. For example, in 2000 at the heels of three consecutive drought years Electra - a small town in North Texas - was down to its last 45 days worth of reservoir water when rain replenished the lake, and the city was able to refurbish old wells to provide supplemental groundwater. At the time, residents were forced to limit water use to 1,000 gallons per person per month - less than half of what most people use - and many were having water delivered to their homes by private contractors.[15] In 2003 citizens of Ballinger, Texas, were also faced with a dwindling water supply due to prolonged drought. After three years of drought, Lake Ballinger, which supplies water to more than 4,300 residents in Ballinger and to 600 residents in nearby Rowena, was almost dry. Each day, people lined up to get water from a well in nearby City Park. Trucks hauling trailers outfitted with large plastic and metal tanks hauled water to and from City Park to Ballinger.[16]

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[13] U.S. Environmental Protection Agency. *"Cleaner Water through Conservation*." USEPA Report no. 841-B-95-002. April, 1995.

[14] Planning and Management Consultants, Ltd. "*Evaluating Urban Water Conservation Programs: A Procedures Manual*." Prepared for the California Urban Water Agencies. February 1992.

[15] Zewe, C. "*Tap Threatens to Run Dry in Texas Town*." July 11, 2000. CNN Cable News Network.

[16] Associated Press, "*Ballinger Scrambles to Finish Pipeline before Lake Dries Up*." May 19, 2003.

Table 6: Economic Losses Associated with Domestic Water Shortages in Communities with Populations Exceeding 100,000 people				
Water shortages as a percentage of total monthly household demands	**No. of gallons remaining per household per day**	**No of gallons remaining per person per day**	**Economic loss (per acre-foot)**	**Economic loss (per gallon)**
1%	278	93	$748	$0.00005
5%	266	89	$812	$0.0002
10%	252	84	$900	$0.0005
15%	238	79	$999	$0.0008
20%	224	75	$1,110	$0.0012
25%	210	70	$1,235	$0.0015
30%[a]	196	65	$1,699	$0.0020
35%	182	61	$3,825	$0.0085
40%	168	56	$4,181	$0.0096
45%	154	51	$4,603	$0.011
50%	140	47	$5,109	$0.012
55%	126	42	$5,727	$0.014
60%	112	37	$6,500	$0.017
65%	98	33	$7,493	$0.02
70%	84	28	$8,818	$0.02
75%	70	23	$10,672	$0.03
80%	56	19	$13,454	$0.04
85%	42	14	$18,091 ($24,000)[b]	$0.05 ($0.07)[b]
90%	28	9	$27,363 ($24,000)	$0.08 ($0.07)
95%	14	5	$55,182 ($24,000)	$0.17 ($0.07)
99%	3	0.9	$277,728 ($24,000)	$0.85 ($0.07)
99.9%	1	0.5	$2,781,377 ($24,000)	$8.53 ($0.07)
100%	0	0	Infinite ($24,000)	Infinite ($0.07)

[a] The first 30 percent of needs are assumed to be restrictions of outdoor water use; when needs reach 30 percent of total demands all outdoor water uses would be restricted. Needs greater than 30 percent include indoor use

[b] As shortages approach 100 percent the value approaches infinity assuming there are not alternatives available; however, we assume that communities would begin to have water delivered by tanker truck at an estimated cost of $24,000 per acre-foot when shortages breached 85 percent.

Commercial Businesses

Effects of water shortages on commercial sectors were estimated in a fashion similar to other business sectors meaning that water shortages would affect the ability of these businesses to operate. This is particularly true for "water intensive" commercial sectors that are need large amounts of water (in addition to potable and sanitary water) to provide their services. These include:

- car-washes,
- laundry and cleaning facilities,
- sports and recreation clubs and facilities including race tracks,
- amusement and recreation services,
- hospitals and medical facilities,
- hotels and lodging places, and
- eating and drinking establishments.

A key assumption is that commercial operations would not be affected until water shortages were at least 50 percent of total municipal demand. In other words, we assume that residential water consumers would reduce water use including all non-essential uses before businesses were affected.

An example will illustrate the breakdown of municipal water needs and the overall approach to estimating impacts of municipal needs. Assume City A experiences an unexpected shortage of 50 acre-feet per year when their demands are 200 acre-feet per year. Thus, shortages are only 25 percent of total municipal use and residents of City A could eliminate needs by restricting landscape irrigation. City B, on the other hand, has a deficit of 150 acre-feet in 2020 and a projected demand of 200 acre-feet. Thus, total shortages are 75 percent of total demand. Emergency outdoor and some indoor conservation measures could eliminate 50 acre-feet of projected needs, yet 50 acre-feet would still remain. To eliminate" the remaining 50 acre-feet water intensive commercial businesses would have to curtail operations or shut down completely.

Three other areas were considered when analyzing municipal water shortages: 1) lost revenues to water utilities, 2) losses to the horticultural and landscaping industries stemming for reduction in water available for landscape irrigation, and 3) lost revenues and related economic impacts associated with reduced water related recreation.

Water Utility Revenues

Estimating lost water utility revenues was straightforward. We relied on annual data from the "*Water and Wastewater Rate Survey*" published annually by the Texas Municipal League to calculate an average value per acre-foot for water and sewer. For water revenues, average retail water and sewer rates multiplied by total water needs served as a proxy. For lost wastewater, total unmet needs were adjusted for return flow factor of 0.60 and multiplied by average sewer rates for the region. Needs reported as "county-other" were excluded under the presumption that these consist primarily of self-supplied water uses. In addition, 15 percent of water demand and needs are considered non-billed or "unaccountable" water that comprises things such as leakages and water for municipal government functions (e.g., fire departments). Lost tax receipts are based on current rates for the "miscellaneous gross receipts tax, "which the state collects from utilities located in most incorporated cities or towns in Texas. We do not include lost water utility revenues when aggregating impacts of municipal water shortages to regional and state levels to prevent double counting.

Horticultural and Landscaping Industry

The horticultural and landscaping industry, also referred to as the "green Industry," consists of businesses that produce, distribute and provide services associated with ornamental plants, landscape and garden supplies and equipment. Horticultural industries often face big losses during drought. For example, the recent drought in the Southeast affecting the Carolinas and Georgia horticultural and landscaping businesses had a harsh year. Plant sales were down, plant mortality increased, and watering costs increased. Many businesses were forced to close locations, lay off employees, and even file for bankruptcy. University of Georgia economists put statewide losses for the industry at around $3.2 billion during the 3-year drought that ended in 2008.[17] Municipal restrictions on outdoor watering play a significant role. During drought, water restrictions coupled with persistent heat has a psychological effect on homeowners that reduces demands for landscaping products and services. Simply put, people were afraid to spend any money on new plants and landscaping.

In Texas, there do not appear to be readily available studies that analyze the economic effects of water shortages on the industry. However, authors of this report believe negative impacts do and would result in restricting landscape irrigation to municipal water consumers. The difficulty in measuring them is two-fold. First, as noted above, data and research for these types of impacts that focus on Texas are limited; and second, economic data provided by IMPLAN do not disaggregate different sectors of the green industry to a level that would allow for meaningful and defensible analysis.[18]

Recreational Impacts

Recreational businesses often suffer when water levels and flows in rivers, springs and reservoirs fall significantly during drought. During droughts, many boat docks and lake beaches are forced to close, leading to big losses for lakeside business owners and local communities. Communities adjacent to popular river and stream destinations such as Comal Springs and the Guadalupe River also see their business plummet when springs and rivers dry up. Although there are many examples of businesses that have suffered due to drought, dollar figures for drought-related losses to the recreation and tourism industry are not readily available, and very difficult to measure without extensive local surveys. Thus, while they are important, economic impacts are not measured in this study.

Table 7 summarizes impacts of municipal water shortages at differing levels of magnitude, and shows the ranges of economic costs or losses per acre-foot of shortage for each level.

[17] Williams, D. *"Georgia landscapers eye rebound from Southeast drought."* Atlanta Business Chronicle, Friday, June 19, 2009

[18] Economic impact analyses prepared by the TWDB for 2006 regional water plans did include estimates for the horticultural industry. However, year 2000 and prior IMPLAN data were disaggregated to a finer level. In the current dataset (2006), the sector previously listed as "Landscaping and Horticultural Services" (IMPLAN Sector 27) is aggregated into "Services to Buildings and Dwellings" (IMPLAN Sector 458).

Table 7: Impacts of Municipal Water Shortages at Different Magnitudes of Shortages		
Water shortages as percent of total municipal demands	Impacts	Economic costs per acre-foot*
0-30%	✓ Lost water utility revenues ✓ Restricted landscape irrigation and non-essential water uses	$730 - $2,040
30-50%	✓ Lost water utility revenues ✓ Elimination of landscape irrigation and non-essential water uses ✓ Rationing of indoor use	$2,040 - $10,970
>50%	✓ Lost water utility revenues ✓ Elimination of landscape irrigation and non-essential water uses ✓ Rationing of indoor use ✓ Restriction or elimination of commercial water use ✓ Importing water by tanker truck	$10,970 - varies
*Figures are rounded		

1.1.4 Industrial Water User Groups

Manufacturing

Impacts to manufacturing were estimated by distributing water shortages among industrial sectors at the county level. For example, if a planning group estimates that during a drought of record water supplies in County A would only meet 50 percent of total annual demands for manufactures in the county, we reduced output for each sector by 50 percent. Since projected manufacturing demands are based on TWDB Water Uses Survey data for each county, we only include IMPLAN sectors represented in the TWBD survey database. Some sectors in IMPLAN databases are not part of the TWDB database given that they use relatively small amounts of water - primarily for on-site sanitation and potable purposes. To maintain consistency between IMPLAN and TWDB databases, Standard Industrial Classification (SIC) codes both databases were cross referenced in county with shortages. Non-matches were excluded when calculating direct impacts.

Mining

The process of mining is very similar to that of manufacturing. We assume that within a given county, shortages would apply equally to relevant mining sectors, and IMPLAN sectors are cross referenced with TWDB data to ensure consistency.

In Texas, oil and gas extraction and sand and gravel (aggregates) operations are the primary mining industries that rely on large volumes of water. For sand and gravel, estimated output reductions are straightforward; however, oil and gas is more complicated for a number of reasons. IMPLAN does not necessarily report the physical extraction of minerals by geographic local, but rather the sales revenues reported by a particular corporation.

For example, at the state level revenues for IMPLAN sector 19 (oil and gas extraction) and sector 27 (drilling oil and gas wells) totals $257 billion. Of this, nearly $85 billion is attributed to Harris County. However, only a very small fraction (less than one percent) of actual production takes place in the county. To measure actual potential losses in well head capacity due to water shortages, we relied on county level production data from the Texas Railroad Commission (TRC) and average well-head market prices for crude and gas to estimate lost revenues in a given county. After which, we used to IMPLAN ratios to estimate resultant losses in income and employment.

Other considerations with respect to mining include:

1) Petroleum and gas extraction industry only uses water in significant amounts for secondary recovery. Known in the industry as enhanced or water flood extraction, secondary recovery involves pumping water down injection wells to increase underground pressure thereby pushing oil or gas into other wells. IMPLAN output numbers do not distinguish between secondary and non-secondary recovery. To account for the discrepancy, county-level TRC data that show the proportion of barrels produced using secondary methods were used to adjust IMPLAN data to reflect only the portion of sales attributed to secondary recovery.

2) A substantial portion of output from mining operations goes directly to businesses that are classified as manufacturing in our schema. Thus, multipliers measuring backward linkages for a given manufacturer might include impacts to a supplying mining operation. Care was taken not to double count in such situations if both a mining operation and a manufacturer were reported as having water shortages.

Steam-electric

At minimum without adequate cooling water, power plants cannot safely operate. As water availability falls below projected demands, water levels in lakes and rivers that provide cooling water would also decline. Low water levels could affect raw water intakes and outfalls at electrical generating units in several ways. For one, power plants are regulated by thermal emission guidelines that specify the maximum amount of heat that can go back into a river or lake via discharged cooling water. Low water levels could result in permit compliance issues due to reduced dilution and dispersion of heat and subsequent impacts on aquatic biota near outfalls.[19] However, the primary concern would be a loss of head (i.e., pressure) over intake structures that would decrease flows through intake tunnels. This would affect safety related pumps, increase operating costs and/or result in sustained shut-downs. Assuming plants did shutdown, they would not be able to generate electricity.

[19] Section 316 (b) of the Clean Water Act requires that thermal wastewater discharges do not harm fish and other wildlife.

Among all water use categories steam-electric is unique and cautions are needed when applying methods used in this study. Measured changes to an economy using input-output models stem directly from changes in sales revenues. In the case of water shortages, one assumes that businesses will suffer lost output if process water is in short supply. For power generation facilities this is true as well. However, the electric services sector in IMPLAN represents a corporate entity that may own and operate several electrical generating units in a given region. If one unit became inoperable due to water shortages, plants in other areas or generation facilities that do not rely heavily on water such as gas powered turbines might be able to compensate for lost generating capacity. Utilities could also offset lost production via purchases on the spot market.[20] Thus, depending upon the severity of the shortages and conditions at a given electrical generating unit, energy supplies for local and regional communities could be maintained. But in general, without enough cooling water, utilities would have to throttle back plant operations, forcing them to buy or generate more costly power to meet customer demands.

Measuring impacts end users of electricity is not part of this study as it would require extensive local and regional level analysis of energy production and demand. To maintain consistency with other water user groups, impacts of steam-electric water shortages are measured in terms of lost revenues (and hence income) and jobs associated with shutting down electrical generating units.

1.2 Social Impacts of Water Shortages

As the name implies, the effects of water shortages can be social or economic. Distinctions between the two are both semantic and analytical in nature – more so analytic in the sense that social impacts are harder to quantify. Nevertheless, social effects associated with drought and water shortages are closely tied to economic impacts. For example, they might include:

- demographic effects such as changes in population,
- disruptions in institutional settings including activity in schools and government,
- conflicts between water users such as farmers and urban consumers,
- health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations),
- mental and physical stress (e.g., anxiety, depression, domestic violence),
- public safety issues from forest and range fires and reduced fire fighting capability,
- increased disease caused by wildlife concentrations,
- loss of aesthetic and property values, and
- reduced recreational opportunities.[21]

[20] Today, most utilities participate in large interstate "power pools" and can buy or sell electricity "on the grid" from other utilities or power marketers. Thus, assuming power was available to buy, and assuming that no contractual or physical limitations were in place such as transmission constraints; utilities could offset lost power that resulted from waters shortages with purchases via the power grid.

[21] Based on information from the website of the National Drought Mitigation Center at the University of Nebraska Lincoln. Available online at: http://www.drought.unl.edu/risk/impacts.htm. See also, Vanclay, F. "*Social Impact Assessment*." in Petts, J. (ed) International Handbook of Environmental Impact Assessment. 1999.

Social impacts measured in this study focus strictly on demographic effects including changes in population and school enrollment. Methods are based on demographic projection models developed by the Texas State Data Center and used by the TWDB for state and regional water planning. Basically, the social impact model uses results from the economic component of the study and assesses how changes in labor demand would affect migration patterns in a region. Declines in labor demand as measured using adjusted IMPLAN data are assumed to affect net economic migration in a given regional water planning area. Employment losses are adjusted to reflect the notion that some people would not relocate but would seek employment in the region and/or public assistance and wait for conditions to improve. Changes in school enrollment are simply the proportion of lost population between the ages of 5 and 17.

2. Results

Section 2 presents the results of the analysis at the regional level. Included are baseline economic data for each water use category, and estimated economics impacts of water shortages for water user groups with reported deficits. According to the 2011 *Rio Grande Regional Water Plan*, during severe drought irrigation, livestock, municipal, manufacturing, mining and steam-electric water user groups would experience water shortages in the absence of new water management strategies.

2.1 Overview of Regional Economy

On an annual basis, the East Texas regional economy generates $34 billion in gross state product for Texas ($32 billion in income and $2 billion worth of business taxes) and supports 481,393 jobs (Table 8). Generating about $12 billion worth of income per year, agriculture, manufacturing, and mining are the primary base economic sectors in the region.[22] Municipal sectors also generate substantial amounts of income and are major employers. However, while municipal sectors are the largest employer and source of wealth, many businesses that make up the municipal category such as restaurants and retail stores are non-basic industries meaning they exist to provide services to people who work would in base industries such as manufacturing, agriculture and mining. In other words, without base industries such agriculture, many municipal jobs in the region would not exist.

[22] Base industries are those that supply markets outside of the region. These industries are crucial to the local economy and are called the economic base of a region. Appendix A shows how IMPLAN's 529 sectors were allocated to water use category, and shows economic data for each sector.

Table 8: The East Texas Regional Economy by Water User Group ($millions)*						
Water Use Category	Total sales	Intermediate sales	Final sales	Jobs	Income	Business taxes
Irrigation	$78.03	$8.73	$69.30	618	$20.24	$0.85
Livestock	$2,637.85	$1,339.95	$1,297.90	16,521	$499.23	$21.09
Manufacturing	$62,475.81	$19,826.73	$42,649.08	80,609	$9,096.38	$255.38
Mining	$3,693.95	$1,475.81	$2,218.13	7,862	$1,831.54	$200.96
Steam-electric	$990.40	$278.62	$711.78	1,893	$687.65	$117.45
Municipal	$33,562.37	$9,053.48	$24,508.89	373,890	$19,618.82	$1,723.75
Regional total	$103,438.41	$31,983.32	$71,455.08	481,393	$31,753.86	$2,319.48

[a] Appendix 1 displays data for individual IMPLAN sectors that make up each water use category. Based on data from the Texas Water Development Board, and year 2006 data from the Minnesota IMPLAN Group, Inc.

2.2 Impacts of Agricultural Water Shortages

According to the 2011 *East Texas Regional Water Plan*, during severe drought the counties of Hardin, Houston, San Augustine and Smith would experiences shortages of irrigation water. In 2010, shortages range from about 1 to 48 percent of annual irrigation demands, and farmers would be short nearly 1,675 acre-feet in 2010 and nearly 3,420 acre-feet in 2060. Shortages of these magnitudes would reduce gross state product (income plus state and local business taxes) by less than $1 million per year in each decade.

Table 9: Economic Impacts of Water Shortages for Irrigation Water User Groups ($millions)			
Decade	Lost income from reduced crop production [a]	Lost state and local tax revenues from reduced crop production	Lost jobs from reduced crop production
2010	$0.18	$0.03	2
2020	$0.19	$0.03	2
2030	$0.23	$0.03	2
2040	$0.40	$0.04	2
2050	$0.48	$0.05	2
2060	$0.57	$0.05	3

*Changes to income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

Shortages for livestock producers are reported for Angelina, Henderson, Houston, Nacogdoches, Sabine, San Augustine, and Shelby counties. Shortages of these magnitudes would reduce gross state product (income plus state and local business taxes) by $14 million per year in 2010, and $551 million in 2060 (Table 10).

Table 10: Economic Impacts of Water Shortages for Livestock Water User Groups ($millions)[a]

Decade	Lost income from reduced livestock production[b]	Lost state and local tax revenues from reduced livestock production	Lost jobs from reduced livestock crop production
2010	$13.22	$0.60	124
2020	$53.29	$2.43	500
2030	$92.78	$4.23	873
2040	$266.31	$12.12	2,495
2050	$390.77	$17.79	3,660
2060	$527.74	$24.02	4,942

[a] Includes impacts to forward processors (meat packing and poultry processing).

[b] Changes to income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.3 Impacts of Municipal Water Shortages

Water shortages are projected to occur in a significant number of communities in the region. Deficits range from approximately 1 to roughly 75 percent of total annual water use. At the regional level, the estimated economic value of domestic water shortages totals $19 million in 2010 and $157 million in 2060 (Table 11). Due to curtailment of commercial business activity operation, municipal shortages would reduce gross state product (income plus taxes) by an estimated $34 million in 2020 and $162 million in 2060.

Table 11: Economic Impacts of Water Shortages for Municipal Water User Groups ($millions)					
Decade	Monetary value of domestic water shortages	Lost income from reduced commercial business activity*	Lost state and local taxes from reduced commercial business activity	Lost jobs from reduced commercial business activity	Lost water utility revenues
2010	$19.03	$0.00	$0.00	0	$6.16
2020	$65.60	$33.91	$3.61	754	$10.21
2030	$84.52	$42.30	$4.50	941	$12.92
2040	$102.76	$51.89	$5.53	1,156	$16.54
2050	$193.14	$129.22	$13.84	2,898	$22.23
2060	$162.16	$162.23	$17.55	3,683	$29.75

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.4 Impacts of Manufacturing Water Shortages

Manufacturing water shortages in the region are projected to occur in Angelina, Henderson, Houston, Nacogdoches, Sabine, San Augustine, and Shelby counties. In 2010, the East Texas planning group estimates that these manufacturers would be short about 3,400 acre-feet; and by 2060, this figure increases to nearly 50,000 acre-feet. Shortages of these magnitudes would reduce gross state product (income plus taxes) by an estimated $41 million in 2010 and $1.2 billion in 2060 (Table 12).

Table 12: Economic Impacts of Water Shortages for Manufacturing Water User Groups ($millions)			
Decade	Lost income due to reduced manufacturing output	Lost state and local business tax revenues due to reduced manufacturing output	Lost jobs due to reduced manufacturing output
2010	$40.43	$1.28	79
2020	$292.52	$9.01	651
2030	$397.41	$12.09	1,114
2040	$878.32	$26.94	2,038
2050	$1,026.90	$31.44	2,516
2060	$1,188.24	$36.33	3,046

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.5 Impacts of Mining Water Shortages

Ming water shortages in Region I are projected to occur in San Augustine, Angelina, Jefferson, Nacogdoches, Newton and Rusk counties, and would primarily affect extraction of gas in the Haynesville shale formation. Combined shortages for each county would result in estimated losses in gross state product totaling $1.2 billion dollars in 2010, and about $900 million 2060 (Table 13).

Table 13: Economic Impacts of Water Shortages for Mining Water User Groups ($millions)

Decade	Lost income due to reduced mining output	Lost state and local business tax revenues due to reduced mining output	Lost jobs due to reduced mining output
2010	$1,105.82	$99.40	8,178
2020	$2,226.70	$222.67	16,468
2030	$701.19	$70.12	5,186
2040	$749.60	$74.96	5,544
2050	$797.20	$79.72	5,896
2060	$834.13	$83.41	6,169

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.6 Impacts of Steam-electric Water Shortages

Water shortages for electrical generating units are projected to occur in Anderson, Angelina, Jefferson, Nacogdoches, Newton, and Rusk counties, and would result in estimated losses of gross state product totaling $119 million dollars in 2020, and $3.7 billion 2060 (Table 14).

Table 14: Economic Impacts of Water Shortages for Steam-electric Water User Groups ($millions)			
Decade	**Lost income due to reduced electrical generation**	**Lost state and local business tax revenues due to reduced electrical generation**	**Lost jobs due to reduced electrical generation**
2010	$104.61	$15.01	356
2020	$640.67	$91.96	2,178
2030	$853.57	$122.52	2,902
2040	$1,662.28	$238.59	5,651
2050	$2,682.62	$385.05	9,119
2060	$3,244.45	$465.69	11,029

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.7 Social Impacts of Water Shortages

As discussed previously, estimated social impacts focus on changes in population and school enrollment in the region. In 2010, estimated population losses total 10,511 with corresponding reductions in school enrollment of 2,965 students (Table 15). In 2060, population in the region would decline by 34,773 and school enrollment would fall by 9,865.

Table 15: Social Impacts of Water Shortages (2010-2060)		
Year	**Population Losses**	**Declines in School Enrollment**
2010	10,511	2,965
2020	24,754	7,023
2030	13,269	3,764
2040	20,337	5,770
2050	29,015	8,232
2060	34,773	9,865

2.8 Distribution of Impacts by Major River Basin

Administrative rules require that impacts are presented by both planning region and major river basin. To meet rule requirements, impacts were allocated among basins based on the distribution of water shortages in relevant basins. For example, if 50 percent of water shortages in River Basin A and 50 percent occur in River Basin B, then impacts were split equally among the two basins. Table 16 displays the results.

Table 16: Distribution of Impacts by Major River Basin (2010-2060)						
Water Use	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Irrigation						
Neches	100%	100%	90%	82%	76%	70%
Trinity	0%	0%	10%	18%	24%	30%
Livestock						
Neches	48%	36%	38%	38%	39%	38%
Sabine	52%	61%	57%	56%	56%	56%
Trinity	<1%	4%	5%	5%	6%	5%
Manufacturing						
Neches	93%	66%	54%	48%	45%	42%
Sabine	6%	33%	45%	51%	54%	57%
Trinity	<1%	<1%	<1%	<1%	<1%	<1%
Mining						
Neches	>99%	>99%	>99%	>99%	99%	99%
Neches-Trinity	0%	0%	0%	0%	<1%	<1%
Sabine	0%	0%	0%	<1%	1%	1%
Trinity	<1%	<1%	<1%	<1%	<1%	<1%
Municipal						
Neches	96%	96%	96%	96%	97%	97%
Sabine	4%	4%	4%	4%	3%	3%
Trinity	<1%	<1%	<1%	<1%	<1%	<1%
Steam-electric						
Neches	100%	100%	93%	88%	84%	73%
Sabine	0%	0%	7%	12%	16%	27%

Appendix 1: Economic Data for Individual IMPLAN Sectors for the East Texas Regional Water Planning Area

Economic Data for Agricultural Water User Groups ($millions)									
Water Use Category	**IMPLAN Sector**	**IMPLAN Code**	**Total Sales**	**Intermediate Sales**	**Final Sales**	**Jobs**	**Income**	**Business Taxes**
Irrigation	Rice milling	49	$52.89	$0.40	$52.48	88	$6.26	$0.38
Irrigation	Rice	10	$11.49	$7.41	$4.08	164	$5.62	$0.22
Irrigation	Fruit Farming	5	$9.66	$0.81	$8.86	269	$5.53	$0.21
Irrigation	Vegetable and Melon Farming	3	$3.72	$0.10	$3.62	92	$2.73	$0.04
Irrigation	Cotton Farming	8	$0.22	$0	$0.22	3	$0.08	$0.00
Irrigation	Grain Farming	2	$0.05	$0.01	$0.04	2	$0.02	$0.00
	Total irrigation		**$78.03**	**$8.73**	**$69.30**	**618**	**$20.24**	**$0.85**
Livestock	Poultry processing	70	$1,085.13	$345.26	$739.86	4,772	$171.09	$7.77
Livestock	Poultry and egg production	12	$746.27	$584.87	$161.39	2,459	$251.12	$2.53
Livestock	Meat processed from carcasses	68	$380.67	$112.30	$268.36	867	$42.62	$2.18
Livestock	Cattle ranching and farming	11	$378.89	$262.72	$116.17	6,997	$29.93	$7.96
Livestock	Animal production- except cattle and poultry	13	$38.71	$32.82	$5.89	1,412	$3.76	$0.60
Livestock	Fluid milk manufacturing	62	$8.19	$1.97	$6.22	14	$0.71	$0.04
	Total livestock		**$2,637.85**	**$1,339.95**	**$1,297.90**	**16,521**	**$499.23**	**$21.09**
	Total agriculture		**$2,715.88**	**$1,348.69**	**$1,367.20**	**17,139**	**$519.46**	**$21.93**
Based on year 2006 data from the Minnesota IMPLAN Group, Inc.								

Economic Data for Mining and Steam-electric Water User Groups ($millions)								
Water Use Category	**IMPLAN Sector**	**IMPLAN Code**	**Total Sales**	**Intermediate Sales**	**Final Sales**	**Jobs**	**Income**	**Business Taxes**
Mining	Drilling oil and gas wells	27	$1,443.30	$7.20	$1,436.09	2,304	$419.03	$55.25
Mining	Oil and gas extraction	19	$1,377.01	$1,278.81	$98.20	1,902	$791.16	$84.41
Mining	Support activities for oil and gas operations	28	$532.90	$74.02	$458.88	2,706	$482.88	$22.17
Mining	Coal mining	20	$298.50	$111.86	$186.64	734	$115.80	$37.78
Mining	Sand- gravel- clay- and refractory mining	25	$20.75	$2.19	$18.56	138	$12.09	$0.62
Mining	Other nonmetallic mineral mining	26	$11.66	$1.17	$10.50	36	$6.17	$0.44
Mining	Stone mining and quarrying	24	$5.57	$0.57	$5.00	29	$3.07	$0.07
Mining	Iron ore mining	21	$4.26	-$0.01	$4.27	13	$1.34	$0.23
	Total mining		**$3,693.95**	**$1,475.81**	**$2,218.13**	**7,862**	**$1,831.54**	**$200.96**
Steam-electric	**Power generation and supply**	**30**	**$990.40**	**$278.62**	**$711.78**	**1,893**	**$687.65**	**$117.45**
Based on year 2006 data from the Minnesota IMPLAN Group, Inc.								

Economic Data for Manufacturing Water User Groups ($millions)								
Water Use Category	**IMPLAN Sector**	**IMPLAN Code**	**Total Sales**	**Intermediate Sales**	**Final Sales**	**Jobs**	**Income**	**Business Taxes**
Manufacturing	Petroleum refineries	142	$35,420.78	$13,165.92	$22,254.85	4,227	$1,693.35	$71.73
Manufacturing	Petrochemical manufacturing	147	$7,340.32	$3,363.10	$3,977.22	903	$823.05	$46.91
Manufacturing	New residential 1-unit structures- all	33	$1,488.13	$0.00	$1,488.13	9,677	$519.58	$8.18
Manufacturing	Plastics material and resin manufacturing	152	$1,297.60	$51.39	$1,246.21	902	$248.53	$8.15
Manufacturing	Paper and paperboard mills	125	$1,199.74	$0.28	$1,199.46	1,922	$394.51	$10.43
Manufacturing	AC- refrigeration- and forced air heating	278	$947.25	$0.00	$947.24	2,853	$234.89	$5.77
Manufacturing	Synthetic rubber manufacturing	153	$899.08	$22.05	$877.03	1,061	$263.14	$6.33
Manufacturing	Commercial and institutional buildings	38	$855.47	$0.00	$855.47	8,436	$445.87	$5.48
Manufacturing	Pesticide and other agricultural chemical man	159	$724.82	$121.45	$603.37	460	$218.41	$3.81
Manufacturing	Other basic organic chemical manufacturing	151	$706.58	$131.74	$574.84	621	$103.32	$4.05
Manufacturing	Other basic inorganic chemical manufacturing	150	$662.12	$145.88	$516.24	1,201	$213.52	$2.43
Manufacturing	Reconstituted wood product manufacturing	114	$578.60	$242.21	$336.39	1,216	$312.29	$2.90
Manufacturing	Sawmills	112	$524.45	$465.15	$59.30	1,810	$173.11	$3.00
Manufacturing	Industrial gas manufacturing	148	$489.53	$257.41	$232.12	490	$193.08	$2.93
Manufacturing	Sheet metal work manufacturing	236	$460.57	$25.10	$435.47	1,924	$225.10	$2.97
Manufacturing	Logging	14	$448.42	$335.08	$113.34	1,805	$117.91	$3.97
Manufacturing	Iron and steel mills	203	$443.31	$31.93	$411.38	519	$92.33	$3.50
Manufacturing	Ferrous metal foundries	221	$384.48	$0.38	$384.10	1,900	$148.93	$2.96
Manufacturing	Other new construction	41	$374.53	$0.00	$374.53	3,869	$206.68	$1.62
Manufacturing	Fabricated structural metal manufacturing	233	$335.65	$17.38	$318.27	1,183	$132.54	$2.13
Manufacturing	Tire manufacturing	179	$325.28	$0.07	$325.21	1,148	$104.18	$10.68
Manufacturing	Ship building and repairing	357	$320.54	$1.86	$318.69	1,673	$129.83	$1.45
Manufacturing	New residential additions and alterations-all	35	$213.35	$0.00	$213.35	1,151	$82.45	$1.16
Manufacturing	Forest nurseries- forest products- and timber	15	$209.23	$3.23	$206.01	260	$62.29	$9.46
Manufacturing	Metal valve manufacturing	248	$199.73	$21.63	$178.10	698	$91.21	$1.18
Manufacturing	Plastics plumbing fixtures and all other plastics	177	$194.82	$141.13	$53.68	1,068	$66.44	$1.14
Manufacturing	**All other manufacturing**		**$4,280.97**	**$1,186.11**	**$3,094.87**	**22,438**	**$1,451.56**	**$26.15**
Manufacturing	**Total manufacturing**		**$62,475.81**	**$19,826.73**	**$42,649.08**	**80,609**	**$9,096.38**	**$255.38**
Based on year 2006 data from the Minnesota IMPLAN Group, Inc.								

Economic Data for Municipal Water User Groups ($millions)								
Water Use Category	**IMPLAN Sector**	**IMPLAN Code**	**Total Sales**	**Intermediate Sales**	**Final Sales**	**Jobs**	**Income**	**Business Taxes**
Manufacturing	Owner-occupied dwellings	509	$2,769.76	$0.00	$2,769.76	0	$2,145.64	$327.51
Manufacturing	Wholesale trade	390	$1,979.48	$947.70	$1,031.78	12,668	$1,042.46	$292.48
Manufacturing	State & Local Education	503	$1,884.71	$0.00	$1,884.70	46,257	$1,884.71	$0.00
Manufacturing	Hospitals	467	$1,727.97	$0.00	$1,727.96	15,876	$892.06	$11.37
Manufacturing	Offices of physicians- dentists- and other he	465	$1,682.35	$0.00	$1,682.35	12,751	$1,205.26	$10.56
Manufacturing	Food services and drinking places	481	$1,324.54	$169.14	$1,155.40	27,969	$537.72	$62.79
Manufacturing	Monetary authorities and depository credit in	430	$1,099.85	$362.24	$737.61	5,913	$772.33	$14.07
Manufacturing	Architectural and engineering services	439	$1,009.63	$636.44	$373.19	8,507	$531.11	$4.42
Manufacturing	State & Local Non-Education	504	$958.83	$0.00	$958.83	17,038	$958.83	$0.00
Manufacturing	Telecommunications	422	$942.90	$323.87	$619.03	2,611	$390.63	$65.05
Manufacturing	Motor vehicle and parts dealers	401	$866.67	$94.24	$772.43	7,972	$447.32	$126.86
Manufacturing	Legal services	437	$771.37	$489.56	$281.81	5,986	$486.47	$15.24
Manufacturing	Real estate	431	$737.30	$291.86	$445.44	4,444	$426.85	$90.59
Manufacturing	General merchandise stores	410	$729.87	$76.93	$652.94	12,607	$335.61	$106.88
Manufacturing	Lessors of nonfinancial intangible assets	436	$688.93	$375.69	$313.23	39	$323.18	$31.68
Manufacturing	Truck transportation	394	$676.79	$366.46	$310.33	5,415	$299.17	$6.80
Manufacturing	Pipeline transportation	396	$582.34	$254.68	$327.66	925	$168.62	$35.48
Manufacturing	Other State and local government enterprises	499	$490.03	$159.57	$330.46	2,341	$179.70	$0.06
Manufacturing	Food and beverage stores	405	$478.57	$63.98	$414.58	8,897	$240.01	$52.64
Manufacturing	Nursing and residential care facilities	468	$448.72	$0.00	$448.72	10,615	$265.53	$6.25
Manufacturing	Building material and garden supply stores	404	$435.38	$67.52	$367.86	5,102	$205.30	$62.45
Manufacturing	Home health care services	464	$390.02	$0.00	$390.02	11,031	$236.27	$1.39
Manufacturing	Management of companies and enterprises	451	$388.18	$365.05	$23.13	1,671	$243.23	$3.88
Manufacturing	Securities- commodity contracts- investments	426	$373.14	$247.80	$125.34	3,209	$128.28	$3.80
Manufacturing	Automotive repair and maintenance- except car	483	$344.16	$81.75	$262.41	4,607	$127.97	$25.40
Manufacturing	Waste management and remediation services	460	$320.28	$180.02	$140.26	1,915	$152.72	$12.34
Manufacturing	All other municipal		$9,460.62	$3,498.97	$5,961.65	137,524	$4,991.87	$353.80
Manufacturing	**Total**		**$33,562.37**	**$9,053.48**	**$24,508.89**	**373,890**	**$19,618.82**	**$1,723.75**

Based on year 2006 data from the Minnesota IMPLAN Group, Inc.

Appendix 2: Impacts by Water User Group

Irrigation ($millions)						
	2010	2020	2030	2040	2050	2060
Hardin County						
Reduced income from lost crop production	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10
Reduced business taxes from lost crop production	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03
Reduced jobs from lost crop production	2	2	2	2	2	2
Houston County						
Reduced income from lost crop production	$0.058	$0.068	$0.100	$0.271	$0.349	$0.436
Reduced business taxes from lost crop production	$0.004	$0.004	$0.006	$0.017	$0.022	$0.027
Reduced jobs from lost crop production	0	0	0	0	0	0
San Augustine County						
Reduced income from lost crop production	$0.020	$0.020	$0.020	$0.020	$0.020	$0.020
Reduced business taxes from lost crop production	$0.001	$0.001	$0.001	$0.001	$0.001	$0.001
Reduced jobs from lost crop production	0	0	0	0	0	0
Smith						
Reduced income from lost crop production	$0.001	$0.004	$0.007	$0.010	$0.013	$0.017
Reduced business taxes from lost crop production	$0.000	$0.000	$0.000	$0.001	$0.001	$0.001
Reduced jobs from lost crop production	0	0	0	0	0	0

Livestock ($millions)						
	2010	2020	2030	2040	2050	2060
Angelina County						
Reduced income from lost livestock production	$0.00	$0.00	$0.00	$0.08	$0.23	$0.40
Reduced business taxes from lost livestock production	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Reduced jobs from lost crop livestock production	0	0	0	1	3	5
Henderson County						
Reduced income from lost livestock production	$0.00	$0.13	$0.98	$1.75	$2.53	$3.27
Reduced business taxes from lost livestock production	$0.00	$0.01	$0.05	$0.09	$0.13	$0.17
Reduced jobs from lost crop livestock production	0	2	12	22	31	40
Houston County						
Reduced income from lost livestock production	$0.33	$0.95	$1.82	$2.76	$3.77	$4.87
Reduced business taxes from lost livestock production	$0.02	$0.05	$0.09	$0.14	$0.19	$0.25
Reduced jobs from lost crop livestock production	4	12	22	34	46	60
Nacogdoches County						
Reduced income from lost livestock production	$0.00	$0.00	$3.45	$7.97	$26.40	$38.40
Reduced business taxes from lost livestock production	$0.00	$0.00	$0.16	$0.36	$1.20	$1.74
Reduced jobs from lost crop livestock production	0	0	32	74	246	358
Sabine County						
Reduced income from lost livestock production	$0.53	$1.14	$1.84	$2.65	$7.18	$9.24
Reduced business taxes from lost livestock production	$0.02	$0.05	$0.08	$0.12	$0.33	$0.42
Reduced jobs from lost crop livestock production	5	11	17	25	67	86
San Augustine County						
Reduced income from lost livestock production	$1.30	$2.41	$3.71	$10.40	$13.88	$17.70
Reduced business taxes from lost livestock production	$0.06	$0.11	$0.17	$0.47	$0.63	$0.80
Reduced jobs from lost crop livestock production	12	22	35	97	129	165
Shelby County						
Reduced income from lost livestock production	$11.07	$48.66	$80.98	$240.70	$336.76	$453.86
Reduced business taxes from lost livestock production	$0.50	$2.21	$3.68	$10.93	$15.30	$20.62
Reduced jobs from lost crop livestock production	103	453	754	2,243	3,137	4,228

Manufacturing ($millions)	2010	2020	2030	2040	2050	2060
Angelina County						
Reduced income from lost manufacturing	$37.70	$254.28	$314.02	$749.13	$858.12	$975.28
Reduced business taxes from lost manufacturing	$1.18	$7.93	$9.79	$23.36	$26.75	$30.41
Reduced jobs from lost crop livestock manufacturing	45	305	376	898	1,028	1,169
Hardin County						
Reduced income from lost manufacturing	$0.38	$0.65	$1.78	$2.29	$2.74	$3.22
Reduced business taxes from lost manufacturing	$0.02	$0.03	$0.08	$0.10	$0.12	$0.14
Reduced jobs from lost crop livestock manufacturing	4	6	17	22	26	31
Houston County						
Reduced income from lost manufacturing	$0.10	$0.16	$0.23	$0.29	$0.39	$0.49
Reduced business taxes from lost manufacturing	$0.00	$0.01	$0.01	$0.01	$0.02	$0.02
Reduced jobs from lost crop livestock manufacturing	1	2	2	3	4	5
Newton County						
Reduced income from lost manufacturing	$1.16	$2.06	$5.76	$7.43	$8.94	$10.39
Reduced business taxes from lost manufacturing	$0.01	$0.02	$0.06	$0.08	$0.09	$0.11
Reduced jobs from lost crop livestock manufacturing	7	13	36	47	56	65
Orange County						
Reduced income from lost manufacturing	$0.00	$33.43	$72.49	$111.43	$146.00	$184.89
Reduced business taxes from lost manufacturing	$0.00	$0.92	$1.99	$3.06	$4.01	$5.07
Reduced jobs from lost crop livestock manufacturing	0	294	637	979	1,282	1,624
Panola County						
Reduced income from lost manufacturing	$1.10	$1.33	$1.51	$1.68	$1.84	$2.14
Reduced business taxes from lost manufacturing	$0.07	$0.09	$0.10	$0.11	$0.12	$0.14
Reduced jobs from lost crop livestock manufacturing	22	27	30	34	37	43
Polk County						
Reduced income from lost manufacturing	$0.00	$0.61	$1.56	$5.11	$6.93	$8.53
Reduced business taxes from lost manufacturing	$0.00	$0.02	$0.06	$0.19	$0.26	$0.32
Reduced jobs from lost crop livestock manufacturing	0	6	14	47	64	79
San Augustine County						
Reduced income from lost manufacturing	$0.00	$0.00	$0.00	$0.00	$0.01	$0.04
Reduced business taxes from lost manufacturing	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Reduced jobs from lost crop livestock manufacturing	0	0	0	0	0	0

Manufacturing cont. ($millions)						
	2010	2020	2030	2040	2050	2060
Shelby County						
Reduced income from lost manufacturing	$0.00	$0.00	$0.00	$0.00	$0.19	$0.46
Reduced business taxes from lost manufacturing	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Reduced jobs from lost crop livestock manufacturing	0	0	0	0	2	4
Smith County						
Reduced income from lost manufacturing	$0.00	$0.00	$0.06	$0.96	$1.73	$2.80
Reduced business taxes from lost manufacturing	$0.00	$0.00	$0.00	$0.04	$0.06	$0.10
Reduced jobs from lost crop livestock manufacturing	0	0	1	9	16	26

Mining ($millions)	2010	2020	2030	2040	2050	2060
Anderson County						
Reduced income from lost mining output	$0.34	$0.41	$0.84	$1.31	$1.78	$2.23
Reduced business taxes from lost mining output	$0.03	$0.04	$0.08	$0.13	$0.18	$0.22
Reduced jobs from lost mining output	2	3	6	10	13	16
Angelina County						
Reduced income from lost mining output	$149.06	$298.79	$0.00	$0.56	$1.12	$1.65
Reduced business taxes from lost mining output	$3.73	$29.88	$0.00	$0.06	$0.11	$0.16
Reduced jobs from lost mining output	1,102	2,210	0	4	8	12
Cherokee County						
Reduced income from lost mining output	$36.70	$111.91	$0.00	$0.00	$0.00	$0.15
Reduced business taxes from lost mining output	$3.67	$11.19	$0.00	$0.00	$0.00	$0.01
Reduced jobs from lost mining output	271	828	0	0	0	1
Hardin County						
Reduced income from lost mining output	$582.15	$645.67	$688.44	$731.06	$773.98	$806.71
Reduced business taxes from lost mining output	$58.22	$64.57	$68.84	$73.11	$77.40	$80.67
Reduced jobs from lost mining output	4,305	4,775	5,091	5,407	5,724	5,966
Jefferson County						
Reduced income from lost mining output	$0.00	$0.00	$0.00	$0.00	$0.09	$0.17
Reduced business taxes from lost mining output	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Reduced jobs from lost mining output	0	0	0	0	1	1
Nacogdoches County						
Reduced income from lost mining output	$186.88	$523.80	$0.00	$0.00	$0.00	$0.00
Reduced business taxes from lost mining output	$18.69	$52.38	$0.00	$0.00	$0.00	$0.00
Reduced jobs from lost mining output	1,382	3,874	0	0	0	0
Rusk County						
Reduced income from lost mining output	$0.00	$0.00	$0.00	$0.56	$1.12	$1.65
Reduced business taxes from lost mining output	$0.00	$0.00	$0.00	$0.06	$0.11	$0.16
Reduced jobs from lost mining output	0	0	0	4	8	12
Shelby County						
Reduced income from lost mining output	$112.36	$524.33	$0.00	$0.00	$0.00	$0.00
Reduced business taxes from lost mining output	$11.24	$52.43	$0.00	$0.00	$0.00	$0.00
Reduced jobs from lost mining output	831	3,878	0	0	0	0

Mining cont. ($millions)						
	2010	2020	2030	2040	2050	2060
Smith County						
Reduced income from lost manufacturing	$0.88	$9.44	$11.91	$16.10	$19.10	$21.57
Reduced business taxes from lost manufacturing	$0.09	$0.94	$1.19	$1.61	$1.91	$2.16
Reduced jobs from lost crop livestock manufacturing	7	70	88	119	141	160

Steam-electric ($millions)						
	2010	2020	2030	2040	2050	2060
Anderson County						
Reduced income from lost electrical generation	$0.00	$179.52	$209.88	$246.90	$292.01	$347.00
Reduced business taxes from lost electrical generation	$0.00	$25.77	$30.13	$35.44	$41.91	$49.81
Reduced jobs from lost electrical generation	0	610	713	839	993	1,180
Angelina County						
Reduced income from lost electrical generation	$63.51	$31.76	$63.51	$63.51	$63.51	$63.51
Reduced business taxes from lost electrical generation	$9.12	$4.56	$9.12	$9.12	$9.12	$9.12
Reduced jobs from lost electrical generation	216	108	216	216	216	216
Jefferson County						
Reduced income from lost electrical generation	$0.00	$426.37	$498.46	$1,172.73	$1,387.03	$1,648.27
Reduced business taxes from lost electrical generation	$0.00	$61.20	$71.55	$168.33	$199.09	$236.58
Reduced jobs from lost electrical generation	0	1,449	1,694	3,987	4,715	5,603
Nacogdoches County						
Reduced income from lost electrical generation	$41.09	$3.02	$21.56	$44.19	$713.97	$848.43
Reduced business taxes from lost electrical generation	$5.90	$0.43	$3.10	$6.34	$102.48	$121.78
Reduced jobs from lost electrical generation	140	10	73	150	2,427	2,884
Newton County						
Reduced income from lost electrical generation	$0.00	$0.00	$60.14	$134.94	$226.10	$337.25
Reduced business taxes from lost electrical generation	$0.00	$0.00	$8.63	$19.37	$32.45	$48.41
Reduced jobs from lost electrical generation	0	0	204	459	769	1,146

Municipal ($millions)						
	2010	2020	2030	2040	2050	2060
Athens						
Monetary value of domestic water shortages	$0.00	$1.25	$1.68	$1.34	$1.76	$2.32
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.09	$0.13	$0.18
Lost jobs due to reduced commercial business activity	0	0	0	3	5	7
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.01	$0.02	$0.03
Lost utility revenues	$0.00	$0.09	$0.12	$0.15	$0.21	$0.27
Brownsboro						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01
Bullard						
Monetary value of domestic water shortages	$0.00	$0.01	$0.05	$0.11	$0.25	$0.40
Lost utility revenues	$0.00	$0.02	$0.07	$0.13	$0.22	$0.34
Community Water Company						
Monetary value of domestic water shortages	$0.08	$0.97	$1.22	$1.84	$2.74	$4.27
Lost utility revenues	$0.07	$0.15	$0.20	$0.23	$0.30	$0.40
County-other (Anderson)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.07
County-other (Angelina)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.11
County-other (Hardin)						
Monetary value of domestic water shortages	$0.16	$0.30	$0.33	$0.35	$0.41	$0.55
County-other (Henderson)						
Monetary value of domestic water shortages	$0.11	$0.26	$0.44	$0.59	$0.93	$1.62
County-other (Jasper)						
Monetary value of domestic water shortages	$0.10	$0.19	$0.23	$0.15	$0.13	$0.13
County-other (Orange)						
Monetary value of domestic water shortages	$0.12	$0.08	$0.04	$0.01	$0.00	$0.00

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
County-other (Polk)						
Monetary value of domestic water shortages	$0.27	$0.68	$5.21	$3.93	$4.73	$5.83
County-other (Sabine)						
Monetary value of domestic water shortages	$1.26	$1.34	$1.39	$1.44	$1.49	$1.74
County-other (San Augustine)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01
County-other (Shelby)						
Monetary value of domestic water shortages	$0.31	$0.40	$0.53	$0.55	$0.61	$0.69
County-other (Trinity)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.01	$0.03	$0.07
County-other (Tyler)						
Monetary value of domestic water shortages	$0.00	$0.15	$0.27	$0.29	$0.27	$0.27
D&M WSC						
Monetary value of domestic water shortages	$0.00	$0.02	$0.07	$0.14	$0.29	$1.89
Lost utility revenues	$0.00	$0.00	$0.04	$0.12	$0.32	$0.55
Diboll						
Monetary value of domestic water shortages	$0.03	$0.24	$0.61	$3.57	$5.99	$10.75
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$2.28	$4.21
Lost jobs due to reduced commercial business activity	0	0	0	0	72	133
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.33	$0.60
Lost utility revenues	$0.06	$0.33	$0.66	$1.09	$1.70	$2.54
Four Way WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.31
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.40
Frankston						
Monetary value of domestic water shortages	$0.00	$0.00	$0.01	$0.03	$0.05	$0.07
Lost utility revenues	$0.00	$0.00	$0.01	$0.04	$0.07	$0.10

Municipal (cont.)	2010	2020	2030	2040	2050	2060
Hudson						
Monetary value of domestic water shortages	$0.00	$0.00	$0.14	$0.58	$5.00	$9.31
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$3.35
Lost jobs due to reduced commercial business activity	0	0	0	0	0	106
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.48
Lost utility revenues	$0.00	$0.00	$0.22	$0.63	$1.25	$2.07
Hudson WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.11	$0.60	$4.67
Lost utility revenues	$0.00	$0.00	$0.00	$0.18	$0.65	$1.29
Jackson WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.03	$0.09
Lost utility revenues	$0.00	$0.00	$0.07	$0.15	$0.21	$0.28
Lilly Grove SUD						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.24	$0.64
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.39	$0.82
Lindale Rural WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.09
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.13
Lufkin						
Monetary value of domestic water shortages	$16.57	$59.57	$71.97	$86.30	$165.27	$112.62
Lost income from reduced commercial business activity	$0.00	$33.91	$42.30	$51.80	$126.81	$154.49
Lost jobs due to reduced commercial business activity	0	754	941	1,152	2,821	3,437
Lost state and local taxes from reduced commercial business activity	$0.00	$3.61	$4.50	$5.51	$13.49	$16.44
Lost utility revenues	$5.99	$9.45	$11.18	$13.14	$15.54	$18.40
Mauriceville SUD						
Monetary value of domestic water shortages	$0.00	$0.03	$0.08	$0.10	$0.18	$0.26
Lost utility revenues	$0.00	$0.07	$0.14	$0.17	$0.28	$0.36

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
New Summerfield WSC						
Monetary value of domestic water shortages	$0.00	$0.07	$0.18	$1.12	$1.63	$2.34
Lost utility revenues	$0.00	$0.00	$0.07	$0.13	$0.21	$0.29
Rusk WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.04	$0.12	$0.24
Lost utility revenues	$0.00	$0.00	$0.00	$0.07	$0.20	$0.37
Swift WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.06	$0.24	$0.49
Lost utility revenues	$0.00	$0.00	$0.00	$0.11	$0.42	$0.75
Whitehorse						
Monetary value of domestic water shortages	$0.02	$0.05	$0.07	$0.11	$0.16	$0.26
Lost utility revenues	$0.05	$0.10	$0.14	$0.18	$0.27	$0.39

Appendix F

Letter Template and List of Stakeholders Receiving Letter Soliciting Input and Participation

September 8, 2015

Groundwater Management Area 11

«First_Name» «Last_Name»
«Org_Name»
«Address»
«City», «State» «Zip»

Dear «First_Name» «Last_Name»:

The Groundwater Management Area 11 (GMA 11) is reaching out to request your participation and feedback in the GMA 11's joint planning efforts in adopting the Desired Future Conditions (DFCs) for relevant aquifers of our groundwater management area that your organization is located within. As required in section 36.108 of the Texas Water Code requires the GMA 11 to review and consider specific factors before voting on the proposed DFCs by May 1, 2016 and in doing so the GMA 11 would also like to consider any of your concerns. Once adopted, the DFCs will be considered as groundwater planning numbers in the State Water Plan.

A DFC is defined in Title 31, Part 10, §356.10 (6) of the Texas Administrative Code as "the desired, quantified condition of groundwater resources (such as water levels, spring flows, or volumes) within a management area at one or more specified future times as defined by participating groundwater conservation districts within a groundwater management area as part of the joint planning process."

The GMA 11 members are in the process of developing the desired future conditions (DFCs) and would like your participation and input on setting the DFC in your area. As the attached map shows, GMA 11 covers the northern part of the Carrizo-Wilcox aquifer and includes all and/or part of 27 counties from Bowie County to Angelina County in the north and south and Henderson County to Panola County from west to east.

As part of this process, GMA 11 has identified through review of estimates of future pumping from each regional water plan and state historic pumping data initial simulations for projected groundwater use. Available for you to review are the initial simulations for groundwater usage located at http://pcgcd.org/gma-11/ or http://www.rcgcd.org/GMA11.htm. You may also view a map of the GMA 11 Administrative Boundary at this website or at:

http://www.twdb.texas.gov/groundwater/management_areas/gma11.asp.

We welcome any corrections and/or updates for inclusion in future DFC predictions. Please provide comments by October 9, 2015 through mail, email, or fax to:

Leah Adams
Panola County GCD
419 West Sabine Street
Carthage, TX 75633
ladams@pcgcd.org
Phone: 903-690-0143
Fax: 903-690-0135

The next GMA 11 meeting will be on November 4, 2015 at 10:30AM at the Nacogdoches City Council Chambers, room 119 in the Nacogdoches City Hall to discuss the proposed DFCs for GMA 11 and would appreciate your participation. If you would like receive notices for all GMA 11 meetings, please contact the GMA 11 administrative contact at the contact information provided above. We thank you in advance for your participation.

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Anderson	Anderson County
Anderson	Anderson County Cedar Creek WSC
Anderson	Anderson County FWSD 1
Anderson	Azleway Pine Mountain
Anderson	Bassett Road Moble Home Park
Anderson	BBS WSC
Anderson	BCY WSC
Anderson	BRUSHY CREEK WSC
Anderson	Camp Betty Perot
Anderson	Cayuga WSC
Anderson	City of Elkhart
Anderson	City of Frankston
Anderson	City of Palestine
Anderson	Dogwood Hills
Anderson	Dogwood Springs WSC
Anderson	Dogwood Springs WSC Plant 1
Anderson	Edgewood Shores Water Supply
Anderson	Four Pines WSC
Anderson	Frankston Rural WSC
Anderson	Kickory Ridge MHP
Anderson	Lake Ioni Water Supply
Anderson	Lakeview Methodist Conference Center
Anderson	Lone Pine WSC
Anderson	Montalba WSC
Anderson	Mountain Pure TX
Anderson	Neches WSC
Anderson	Norwood WSC
Anderson	Pleasant Springs WSC
Anderson	Sanderson Farms Palestine Facility
Anderson	Sandy Hills Moble Home Park
Anderson	Slocum WSC
Anderson	TJCD Coffield Michael
Anderson	Upper Neches River Municipal Water Authority
Anderson	Walmart Distribution Center
Anderson	Walston Springs WSC
Angelina	ABITIBI CONSOLIDATED

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Angelina	Angelina County
Angelina	ANGELINA COUNTY FWSD 1
Angelina	ANGELINA WSC
Angelina	BEULAH WSC
Angelina	BILL WILLIAMS WATER SYSTEM
Angelina	CASSELS BOYKIN COUNTY PARK
Angelina	CENTRAL WCID OF ANGELINA COUNTY
Angelina	City of Burke
Angelina	City of Diboll
Angelina	City of Hudson
Angelina	City of Huntington
Angelina	City of Lufkin
Angelina	City of Zavalla
Angelina	DADS LUFKIN STATE SUPPORTED LIVING CENTE
ANGELINA	FOUR WAY SUD
Angelina	HOLLYWOOD MOTEL
Angelina	HUDSON WSC
Angelina	JANES SHADY ACRES R V PARK
Angelina	KERVINS RV PARK
Angelina	KNUPPS KORNER STORE
Angelina	LAKESIDE WATER COMPANY
Angelina	LAKEVIEW
Angelina	LUFKIN CREOSOTING
Angelina	M & M WSC
Angelina	PINE OAKS OASIS
Angelina	PLEASURE POINT
Angelina	POLLOK-REDTOWN WSC
Angelina	PRAIRIE GROVE WSC
Angelina	RAYBURN LODGE & WHITE CAPP CAFE
Angelina	RAYLAKE WSC
Angelina	REDLAND WSC
Angelina	ROCKY CREEK ESTATES WS
Angelina	SUN N FUN ASSOCIATION
Angelina	TX AIRSTREAM HARBOR WATER
Angelina	USCOE HANKS CREEK PARK
Angelina	USFS ANGELINA DISTRICT

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Angelina	USFS CANEY CREEK RECREATION AREA
Angelina	USFS ZAVALLA WORK CENTER
Angelina	WALNUT BEND WATER SYSTEM
Angelina	WALNUT RIDGE ESTATES WATER SYSTEM
Angelina	WOODLAWN WSC
Bowie	Big Creek Landing
Bowie	Bowie County
Bowie	Bowie County Rest Area
Bowie	Burns Redbank WSC
Bowie	Central Bowie County WSC
Bowie	Cinema City 6
Bowie	City of Dekalb
Bowie	City of Hooks
Bowie	City of Leary
Bowie	City of Maud
Bowie	City of Nash
Bowie	City of New Boston
Bowie	City of Redwater
Bowie	City of Texarkana
Bowie	City of Wake Village
Bowie	City Redwater
Bowie	Codys Mobile Home Park
Bowie	Crystal Springs Beach
Bowie	Eats Café Water System
Bowie	El Chaparral Mobile Home Park
Bowie	EZ Mart Store 3
Bowie	Federal Correctional Institute Texarkana
Bowie	Harrison Mobile Home Park
Bowie	International Paper County Water District
Bowie	Kelly Creek Landing
Bowie	LE Kwick Stop
Bowie	Leroys Mobile Home Park
Bowie	Lindblad Water System
Bowie	Lone Star Army Ammunition Plant
Bowie	Macedonia EYLUA MUD 1
Bowie	Nash

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Bowie	Northeast TX Restitution Center
Bowie	Oak Grove WSC
Bowie	Red Lick Preschool
Bowie	Sherwood Forest Subdivision
Bowie	Texamericas Center
Bowie	Texarkana
Bowie	Texarkana Mobile Home Park
Bowie	Trails West Mobile Home Park
Bowie	Triple C Truck Terminal
Bowie	Wake Village
Bowie	Woodlands Estates
Camp	Barefoot Bay Marina
Camp	BI County WSC 1
CAMP	BI-COUNTY WSC
Camp	Camp Branch Estates
Camp	Camp County
Camp	Camp Shiloh Lutheran Retreat Center
Camp	Cherokee Point Water CO
Camp	City of Pittsburg
CAMP	CYPRESS SPRINGS SUD
Camp	HAB WSC
Camp	Havenport Water System
Camp	Hidden Village RV Park
Camp	Newsome WSC
Camp	Northeast Texas MWD Pittsburg Plant
Camp	Thunderbird Point Water System
Camp	Woodland Harbor
Cass	Antioch General Store
Cass	Atlanta
Cass	Bloomburg WSC
Cass	Braddocks Bar B Q
Cass	Cass County
Cass	City of Atlanta
Cass	City of Avinger
Cass	City of Domino
Cass	City of Douglassville

Appendix F

List of Stakeholders Receiving Letter

County	Organization Name
Cass	City of Hughes Springs
Cass	City of Linden
Cass	City of Marietta
Cass	City of Queen City
Cass	Eastern Cass WSC
Cass	Fats 7 Burger King
Cass	Gibson Recycling Water System
Cass	Green Hills Subdivision
Cass	Holly Springs WSC
Cass	Holly Springs WSC East Meter
Cass	International Paper Texarkana Mill
Cass	Kildare Kosy Kitchen Club
Cass	Sleepy Hollow Catfish House
Cass	South Lakewood Grocery
Cass	Spring Valley Subdivision
Cass	Springdale Baptist Church
Cass	Sulphur River Gathering LP
Cass	Vaughans Catfish Restaurant
Cass	Vickys Playcare
Cass	Western Cass WSC
Cass	Whispering Pines Subdivision
Cass	Wooden Indian
Cherokee	Afton Grove WSC
Cherokee	Alto Rural WSC
Cherokee	Blackjack WSC
Cherokee	Cherokee County
Cherokee	City of Alto
Cherokee	City of Cuney
Cherokee	City of Gallatin
Cherokee	City of Jacksonville
Cherokee	City of New Summerfield
Cherokee	City of Reklaw
Cherokee	City of Rusk
Cherokee	City of Wells
Cherokee	CRAFT TURNEY WSC MAIN
Cherokee	Dialville Oakland WSC

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Cherokee	Forest WSC
Cherokee	Gallatin WSC
Cherokee	Gum Creek WSC
Cherokee	Iron Hill WSC
Cherokee	Luminant
Cherokee	Maydelle WSC
Cherokee	Mountain View Camp
Cherokee	New Concord WSC
Cherokee	North Cherokee WSC
Cherokee	Rusk Rural WSC
Cherokee	Rusk State Hospital
Cherokee	Stryker Lake WSC
Cherokee	Texas State Railroad Rusk
Cherokee	West Jacksonville Water Supply
Franklin	City of Mount Vernon
Franklin	Cypress Spings SUD
Franklin	Cypress Spings SUD NE
Franklin	Deer Cove POA WS
Franklin	Franklin County
Franklin	Indian Springs Water Company
Franklin	Kings Country 1 and 2
Franklin	Winnsboro
Gregg	C & C Mobile Home Park
Gregg	Christian Heritage School
Gregg	City of Clarksville City
Gregg	City of Easton
Gregg	City of Gladewater
Gregg	City of Kilgore
Gregg	City of Longview
Gregg	City of Warren City
Gregg	City of White Oak
GREGG	CROSS ROADS SUD
Gregg	Danville Mobile Home Village
Gregg	EJ Water Company
Gregg	Elderville WSC
Gregg	Forest Lake Subdivion

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Gregg	Garden Acres Subdivision
Gregg	Gladewater
Gregg	Gregg County
Gregg	Jones Mobile Home Park
Gregg	Liberty City WSC
Gregg	Liberty Danville FWSD 2
Gregg	Lone Star Speedway Water System
Gregg	Richards MHP
Gregg	Sun Acres Mobile Home Park
Gregg	Tryon Road SUD
Gregg	West Gregg SUD
HARDIN	CITY OF KOUNTZE
HARDIN	CITY OF SILSBEE
HARDIN	CITY OF SOUR LAKE
HARDIN	LAKE LIVINGSTON BIG THICKET RETREAT
HARDIN	LUMBERTON MUD
HARDIN	NORTH HARDIN WSC
HARDIN	WEST HARDIN WSC
Harrison	Bass Fishing and Rentals
Harrison	Big Oak MHP
Harrison	Blocker Crossroads Water Supply Corporate
Harrison	C & C Service and Supply
Harrison	Caddo Lake WSC
Harrison	Caddo Lake WSC Mossy Acres
Harrison	Camp Fern
Harrison	Circle H Mobile Home Park
Harrison	City of Hallsville
Harrison	City of Marshall
Harrison	City of Scottsville
Harrison	City of Waskom
Harrison	Clearwater Distribution
Harrison	Country Pines RV Park
Harrison	Country Villa Mobile Home Park
Harrison	Cypress Hills Golf
Harrison	Cypress Valley WSC
Harrison	Cypress Valley WSC Plant

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Harrison	Cypress Village Water System
HARRISON	DIANA SUD
Harrison	Eastman Chemical Company Texas Operation
Harrison	Elysian Fields WSC
Harrison	Galindos Restaurant
Harrison	Gill WSC
Harrison	Gum Springs RV Park
Harrison	Gum Springs WSC
HARRISON	GUM SPRINGS WSC
Harrison	Gum Springs WSC 1
Harrison	Hallelujah Hill MHP
Harrison	Harleton WSC
Harrison	Harrison County
Harrison	Harrison County Power Project
Harrison	Hillcrest Mobile Home Park
Harrison	Hitchin Post RV Park
Harrison	Holiday Springs Mobile Home Park
Harrison	Johnson Mobile Home Park
Harrison	Karnack WSC
Harrison	Leigh WSC
Harrison	Leigh WSC Port Caddo
Harrison	Longhorn Army Ammunition Plant
Harrison	Millennium Rail
Harrison	North Harrison WSC
Harrison	Old Town WSC
Harrison	Pergan Marshall
Harrison	Pine Hill Mobile Home Park
Harrison	Pirkey Power Plant SWEPCO
Harrison	Sabine Mining CO Lignite Mine
Harrison	Sabine Valley Rehabilitation Center
Harrison	Saddlewood Estates
Harrison	Shadowood Water CO
Harrison	Southford Mobile Home Park
Harrison	Talley WSC
Harrison	Timberbrook Mobile Home Park
Harrison	TPWD Caddo Lake State Park

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Harrison	TXDOT Comfort Station H
Harrison	Waskcom Rural WSC
Harrison	West Harrison WSC
Harrison	Whispering Pines Mobile Home Park
Henderson	4D Mobile Home Park
Henderson	Andrews Center
Henderson	Athens Municipal Water Authority
Henderson	Athens Water System Coop
Henderson	Bethel Ash WSC
Henderson	Blue Water Key Water System
Henderson	Camp Lone Star
Henderson	Camp Meisenbach Circle Ten Council
Henderson	Caney Cove Water System
Henderson	Cape Tranquility System
Henderson	Carrizo Water Copr Forest Grove
Henderson	Chandler Water Co
Henderson	Christian Youth Foundation
Henderson	City of Athens
Henderson	City of Berryville
Henderson	City of Brownsboro
Henderson	City of Chandler
Henderson	City of Coffee City
Henderson	City of Cross Roads
Henderson	City of Enchanted Oaks
Henderson	City of Eustace
Henderson	City of Gun Barrel City
Henderson	City of Log Cabin
Henderson	City of Malakof
Henderson	City of Murchison
HENDERSON	CITY OF MURCHISON
Henderson	City of Payne Springs
Henderson	City of Seven Points
Henderson	City of Star Harbor
Henderson	City of Trinidad
Henderson	Clear Creek Resort Water System
Henderson	Coon Creek Club

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Henderson	County Line Express Hauling
Henderson	CRC WSC
Henderson	Cresent Heights WSC
Henderson	Cross Roads ISD Water System
Henderson	Dal High Water System
Henderson	Debs Deli & Grocery
Henderson	Dogwood Estates Water Company
Henderson	East Cedar Creek
Henderson	East Cedar Creek FWSD
Henderson	Echo Hills POA Water System
Henderson	Echo Lake Water System
Henderson	Flat Creek Cove Property Owners Association
Henderson	Henderson County
Henderson	La Poynor ISD
Henderson	Lake Palestine Resort
Henderson	Lake Utility Company
Henderson	Lake View Mgmt & Development
Henderson	Lakeview Beverage
Henderson	Lakewood Water East
Henderson	Lakewood Water West
Henderson	Leagueville WSC
Henderson	Lollipop Water Works Inc
Henderson	Moore Station WSC
Henderson	North Loop Apartments
Henderson	Oakwood Subdivision Water System
Henderson	Payne Springs WSC
Henderson	Point Royal Water System
Henderson	Poynor Community WSC
Henderson	Roher Springs
Henderson	Ruth Springs Water Coop
Henderson	Staway Ranch & RV Park
Henderson	Sunny Glen Resort
Henderson	The Feed Box
Henderson	Three Community WSC
Henderson	TPWD Purtis Crrek State
Henderson	Trevor Rees-Jones Scout Camp

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Henderson	Tristream East Texas Eustace System
Henderson	Twin Oaks MHP Henderson
Henderson	Union Hill WSC
Henderson	Virgina Hill WSC
Henderson	West Cedar Creek MUD
Henderson	Woodmere Park
Hopkins	Brashear WSC
Hopkins	Brinker WSC
Hopkins	City of Como
Hopkins	City of Cumby
Hopkins	City of Seymour
Hopkins	City of Sulpher Springs
Hopkins	Cornersville WSC
Hopkins	Gafford Chapel WSC
Hopkins	Hopkins County
HOPKINS	JONES WSC
Hopkins	Martin Springs WSC
Hopkins	Miller Grove WSC
Hopkins	North Hopkins Industrial Park
Hopkins	North Hopkins WSC
Hopkins	Pickton WSC
Hopkins	Pleasant Hill WSC 2
Hopkins	Shady Grove NO 2 WSC
Hopkins	Shirley WSC
Houston	City of Crockett
Houston	CITY OF GRAPELAND
Houston	City of Kennard
Houston	City of Latexo
Houston	City of Lovelady
Houston	CONSOLIDATED WSC
Houston	Houston County
Houston	HOUSTON COUNTY WCID 1
Houston	LATEXO FACILITY
Houston	PREMIUM WATERS
Houston	RATCLIFF WORK CENTER
Houston	RATCLIFF WSC

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Houston	TDCJ EASTHAM UNIT
HUNT	ABLES SPRINGS WSC
HUNT	COMBINED CONSUMERS SUD
HUNT	MACBEE SUD
JASPER	CITY OF JASPER
JASPER	CITY OF KIRBYVILLE
JASPER	JASPER COUNTY WCID 1
JEFFERSON	BEVIL OAKS MUD
JEFFERSON	CITY OF BEAUMONT WATER UTILITY DEPT
JEFFERSON	CITY OF CHINA
JEFFERSON	CITY OF GROVES
JEFFERSON	CITY OF NEDERLAND
JEFFERSON	CITY OF NOME
JEFFERSON	CITY OF PORT ARTHUR
JEFFERSON	CITY OF PORT NECHES
JEFFERSON	JEFFERSON COUNTY WCID 10
JEFFERSON	MEEKER MWD
JEFFERSON	WEST JEFFERSON COUNTY MWD
Marion	Big Cypress Marina
Marion	Budget Inn Motel
Marion	City of Jefferson
Marion	Creek Water Utility
Marion	Crestwood Water CO
Marion	East Marion County Water Supply
Marion	Genes Truck Stop WS
Marion	Holiday Harbor
Marion	Indian Hills Harbor
Marion	Island View Landing
Marion	Jefferson
Marion	Kellyville Berea WSC
Marion	Marion County
Marion	Mims WSC
Marion	Northeast Texas Municipal Water District
Marion	Pine Harbor Subdivision
Marion	Shady Shores Water System
Marion	Tejas Village

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Marion	USCOE Alley Creek Park
Marion	Wilkes Lodge Water System
Marion	Wilkes Power Plant SEWPCO
Morris	BI County WSC 3
Morris	City of Daingerfield
Morris	City of Lone Star
Morris	City of Naples
Morris	City of Omaha
Morris	Daingerfield
Morris	Lone Star Tubular Operations
Morris	Morris County
Morris	Omaha
Morris	Texas Operations Diviion Highway 259
MORRIS	TRI SUD
Nacogdoches	APPLEBY WSC
Nacogdoches	CARO WSC
Nacogdoches	CENTRAL HEIGHTS WSC
Nacogdoches	City of Chireno
Nacogdoches	City of Cushing
Nacogdoches	CITY OF CUSHING
Nacogdoches	City of Garrison
Nacogdoches	City of Nacogdoches
NACOGDOCHES	D & M WSC
Nacogdoches	ETOILE WSC
Nacogdoches	LIBBY WSC
Nacogdoches	LILBERT LOONEYVILLE WSC
NACOGDOCHES	LILLY GROVE SUD
Nacogdoches	MELROSE WSC
Nacogdoches	NACOGDOCHES BOYS RANCH
Nacogdoches	Nacogdoches County
Nacogdoches	NACOGDOCHES COUNTY MUD 1
Nacogdoches	RAYBURN HIDEAWAY
Nacogdoches	SACUL WSC
Nacogdoches	SHIRLEY CREEK MARINA
NACOGDOCHES	SWIFT WSC
Nacogdoches	THE GERMAN HAUS RESTAURANT AND PUB

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Nacogdoches	TONKAWA SPRING
Nacogdoches	UNION SPRINGS WATER
Nacogdoches	WODEN WSC
NEWTON	CITY OF NEWTON
NEWTON	SOUTH NEWTON WSC
ORANGE	CITY OF BRIDGE CITY
ORANGE	CITY OF ORANGE
ORANGE	CITY OF PINEHURST
ORANGE	CITY OF ROSE CITY
ORANGE	MAURICEVILLE MUD
ORANGE	ORANGEFIELD WSC
Panola	A & P WSC
Panola	City of Beckville
Panola	City of Carthage
Panola	City of Gary
Panola	Clayton WSC Plant 1
Panola	Country Lakes Water Supply
Panola	Daniel Springs Baptist Camp
Panola	Deadwood WSC
Panola	Deberry WSC
Panola	East Texas Gas Plant
Panola	Fairplay WSC
Panola	Gary WSC
Panola	Hollands Quarter WSC
Panola	Luminant
Panola	Murvaul WSC
Panola	Panola County
Panola	Panola-Bethany WSC
Panola	Pirtle Scout Reservation Water System
Panola	Rehobeth WSC
Panola	Riderville WSC
Panola	Rock Hill WSC
Panola	South Murvaul WSC
POLK	CITY OF CORRIGAN
Rains	Alba
Rains	American Aero Crane

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Rains	Bright Star Salem SUD
Rains	Bright Star Salem SUD 2
Rains	City of East Tawakoni
Rains	City of Emory
Rains	City of Point
RAINS	GOLDEN WSC
Rains	MHC Lake Tawakoni Campgrounds
Rains	Rains County
Rains	South Rains SUD
Red River	410 WSC
Red River	City of Annona
Red River	City of Avery
Red River	City of Bogata
Red River	City of Clarksville
Red River	City of Detroit
Red River	Lorettas
Red River	Red River County
Red River	Red River County WSC
Red River	Rose Acre Farms
Red River	The Bakers Dozen
Rusk	A & P Water Company
Rusk	Arlam Concord WSC
Rusk	Bryce Springs Inc
Rusk	CHALK HILL SUD
Rusk	Church Hill WSC
Rusk	City of Henderson
Rusk	City of Mount Enterprise
Rusk	City of New London
Rusk	City of Overton
Rusk	City of Tatum
Rusk	Crims Chapel WSC
Rusk	CROSS ROADS SUD
Rusk	Crystal Farms WSC
Rusk	Dirgin WSC
Rusk	Ebenezer WSC
Rusk	Gaston WSC

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Rusk	Goodsprings WSC
Rusk	Herrings Café
Rusk	Holmes Mobile Home Park
Rusk	Jacobs WSC
Rusk	Kennedy Road WSC
Rusk	Laneville WSC
Rusk	Leveretts Chapel WSC
Rusk	Luminant
Rusk	Martin Creek Lake State Park
Rusk	Martin Lake Steam Electric Station
Rusk	Minden Brachfield WSC
Rusk	Mt Enterprise WSC
Rusk	New Prospect WSC
Rusk	Oakland WSC
Rusk	Pine Hill Chapman WSC
Rusk	Pine Springs Baptist Camp
Rusk	Pleasant Hill WSC
Rusk	Price WSC
Rusk	Rusk County
Rusk	Shan D Water Supply
Rusk	South Rusk County WSC
Rusk	Southern Utilities
Rusk	Stafford Country Estates
Rusk	Tenaska Gateway Generating Station
Sabine	BEECHWOOD WSC
Sabine	BROOKELAND FWSD
Sabine	City of Hemphill
Sabine	City of Pineland
Sabine	EL CAMINO BAY WATER SYSTEM
Sabine	FRONTIER PARK MARINA
Sabine	G-M WSC
Sabine	LAKESHORES INC
Sabine	LOWES CREEK MARINA
Sabine	MID LAKE KAMP GROUND
Sabine	PARADISE POINT MARINA
Sabine	PENDLETON HARBOR

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Sabine	RUSTY ANCHOR CAFEQ
Sabine	Sabine County
Sabine	SOUTH SABINE WSC
Sabine	SUPER 8 MOTEL
Sabine	TEMPLE INLAND PINELAND
Sabine	TIMBERLANE ESTATES PROPERTY OWNERS ASSOC
Sabine	TIMBERLANE WATER SYSTEM
Sabine	USCOE MILL CREEK PARK
Sabine	USFS LAKEVIEW RECREATION AREA
San Augustine	ANTHONY HARBOR SUBDIVISION
San Augustine	BLAND LAKE RURAL WSC
San Augustine	City of Broaddus
San Augustine	CITY OF SAN AUGUSTINE
San Augustine	City of San Augustine
San Augustine	DENNING WSC
San Augustine	HICKORY HOLLOW WATER SYSTEM
San Augustine	JACKSON HILL PARK & MARINA
San Augustine	NEW WSC
San Augustine	PINEYWOODS CONSERVATION CENTER SFA
San Augustine	San Augustine County
San Augustine	SAN AUGUSTINE RURAL WSC
San Augustine	SUTTON HILLS ESTATES
San Augustine	USCOE JACKSON HILL PARK
San Augustine	USFS HARVEY CREEK RECREATION AREA
San Augustine	USFS TOWNSEND RECREATION AREA
Shelby	Buena Vista WSC
Shelby	Camp Huawni Water System
Shelby	Choice WSC
Shelby	City of Center
Shelby	City of Huxley
Shelby	City of Joaquin
Shelby	City of Tenaha
Shelby	City of Timpson
Shelby	East Lamar WSC
Shelby	Five Way WSC
Shelby	Flat Fork WSC

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Shelby	Haslam Community
Shelby	Huber WSC
Shelby	McClelland WSC
Shelby	Parmer RV Park
Shelby	Paxton WSC
Shelby	Rolling Hills Subdivision
Shelby	Sandy Hills WSC
Shelby	Shelby County
Shelby	Shelbyville WSC
Shelby	Tennessee WSC
Shelby	Timpson Rural WSC
Shelby	Woodland Shores Subdivision
Smith	American Ecology & Enviromental Service
Smith	Big T Industrial Park
Smith	Carroll WSC Well
Smith	Carroll WSC Well 4
Smith	City oF Arp
Smith	City of Bullard
Smith	City of Lindale
Smith	City of Noonday
Smith	City of Troup
Smith	City of Tyler
Smith	City of Whitehouse
Smith	City of Winona
Smith	Community Water Company Montogomery Garden
Smith	Crystal Systems
SMITH	CRYSTAL SYSTEMS TEXAS, INC
Smith	Dean WSC
Smith	East Lake Woods
Smith	East Texas MUD of Smith County
Smith	Emerald Bay MUD
Smith	Enchanted Lakes Water System
Smith	Garden Valley Water CO
Smith	Heights Water
Smith	Hideaway
Smith	Jackson Texaco Station

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Smith	Jackson WSC
Smith	John Soules Foods
Smith	Lamplighter Mobile Home Park
Smith	Lindale
Smith	Lindale Rural WSC
Smith	Mercy Ships Training Center
Smith	Morriss Country Meat Market
Smith	Mount Sylvan Water System
Smith	Overton
Smith	Pine Cove Conference Center
Smith	Pine Cove Ranch Camp
Smith	Pine Cove Towers Camp
Smith	Pine Ridge WSC
Smith	Pine Ridge WSC South
Smith	Pine Trail Shores
Smith	Rockin C Ranch
Smith	Sand Flat WSC
Smith	Sierra Club
Smith	Sky Ranch Retreat Center
Smith	Smith County
SMITH	SMITH COUNTY MUD #1
Smith	Southern Utilities
SMITH	SOUTHERN UTILITIES COMPANY
Smith	Southpark Mobile Home Estates
Smith	Spring Lake Mobile Home Park
Smith	Star Mountain WSC
Smith	Starrville WSC
Smith	Starrville-Friendship WSC
Smith	Teen Mania Ministries
Smith	The Villages Resort
Smith	TPWD Tyler State Park
Smith	Twin Oaks Ranch
Smith	Tyler
Smith	Tyler Pipe Company
Smith	Walnut Grove WSC
Smith	Whispering Pines RV & Cabin Resort

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Smith	Willow Branch RV Park
Smith	Winona
Smith	Wright City WSC
Smith	Yellow Rose RV Park
Titus	City of Mount Pleasant
Titus	City of Talco
Titus	City of Winfield
Titus	Monticello Train Maintenance Facility
Titus	Northeast Texas Community College
Titus	Ranch Village Mobile Home Park
Titus	Titus County
Titus	Town of Millers Cove
Titus	TPWD Lake Bob Sandlin State Park
Titus	Tri SUD
Trinity	APPLE SPRINGS WSC
Trinity	BELL WATER SUBDIVISION
TRINITY	BETHEL-ASH WSC
Trinity	CAMP MANAGEMENT INC
Trinity	CENTERVILLE WSC
Trinity	City of Groveton
Trinity	City of Trinity
Trinity	DEER RUN AND WHITE ROCK CITY MARINA
Trinity	EAGLE FALLS SUBDIVISION
Trinity	GLENDALE WSC
Trinity	HOPE CENTER FOR YOUTH GIRLS
Trinity	LAKE LIVINGSTON OAKRIDGE WATER
Trinity	LONE STAR EXPEDITIONS
Trinity	NIGTON WAKEFIELD WSC
Trinity	NOGALUS CENTRALIA WSC
Trinity	PENNINGTON WSC
Trinity	TRA TRINITY COUNTY REGIONAL
Trinity	Trinity County
Trinity	TRINITY PINES CONFERENCE CENTER
Trinity	TRINITY RURAL WSC
Trinity	TRINITY RURAL WSC 3
Trinity	WESTWOOD SHORES MUD

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Trinity	WHISPERING PINES GOLF CLUB
Trinity	WOODLAKE JOSSERAND WSC
Trinity	YMCA CAMP CULLEN
TYLER	CITY OF COLMESNEIL
TYLER	CITY OF WOODVILLE
TYLER	IVANHOE LAND OF LAKES
TYLER	LAKE LIVINGSTON WAYWARD WINDS OASIS
TYLER	TYLER COUNTY WSC
Upshur	Big Sandy
Upshur	Brookshires Camp Joy Water System
Upshur	Camp Glimont
Upshur	City of Big Sandy
Upshur	City of East Mountain
Upshur	City of Gilmer
Upshur	City of Ore City
Upshur	Diana SUD
Upshur	East Mountain
UPSHUR	FOUKE WSC
Upshur	Friendship Water System
Upshur	Glenwood WSC
Upshur	Harmony ISD
Upshur	International Alert Academy
Upshur	Lakeview Camping Resort
Upshur	Latch Grocery
Upshur	Pritchett WSC
UPSHUR	SHARON WSC
Upshur	Tuels M&E T Restaurant
Upshur	Union Grove WSC
Upshur	Upshur County
Upshur	Verns Truck Plaza
Van Zandt	Ben Wheeler WSC
Van Zandt	Big Willies BBQ
Van Zandt	Canton
Van Zandt	Canton Travel Plaza
Van Zandt	City of Canton
Van Zandt	City of Edgewood

Appendix F
List of Stakeholders Receiving Letter

County	Organization Name
Van Zandt	City of Edom
Van Zandt	City of Grand Saline
Van Zandt	City of Van
Van Zandt	City of Wills Point
Van Zandt	Corinth WSC
Van Zandt	Crooked Creek WSC
Van Zandt	Dynegy Midstream Services
Van Zandt	Edom WSC
Van Zandt	Fruitvale WSC
Van Zandt	Gator Creek Enterprises
Van Zandt	Golden WSC
Van Zandt	Henry Lewis RV Park
Van Zandt	Hydration Source
Van Zandt	JCs Buffet
Van Zandt	Lakewood Trails Water System
Van Zandt	Little Hope-Moore Water Supply
Van Zandt	MacBee SUD
Van Zandt	Martins Mill WSC
Van Zandt	Mytle Springs WSC
Van Zandt	Pruitt Sandflat WSC
VAN ZANDT	R P M WSC
Van Zandt	Rons Trading Post
Van Zandt	RPM WSC
Van Zandt	Shady Acres
Van Zandt	South Tawakoni WSC
Van Zandt	Tall Oaks Estates Water System
Van Zandt	Twin Lakes Golf Course INC
Van Zandt	Van Zandt at Fossil Creek
Van Zandt	Van Zandt County
Van Zandt	Wagon Train RV Park
Van Zandt	Wills Point
Wood	B & D Water CO
Wood	Big Wood Springs Water System
Wood	Bright Star Salem SUD
Wood	Brookhaven Retreat
Wood	C&C Corner Store

Appendix F

List of Stakeholders Receiving Letter

County	Organization Name
Wood	Chaney Point RV Park
Wood	City of Alba
Wood	City of Hawkins
Wood	City of Mineola
Wood	City of Quitman
Wood	City of Winnsboro
Wood	City of Yantis
Wood	Clear Lakes
Wood	Dees Mexican Restaurant
Wood	Eagle Point Estates WS
Wood	Fouke WSC
Wood	Harmony Springs
Wood	Hawkins
Wood	Hideaway Harbor
Wood	Highland Shores RV Park
Wood	Holly Lake Ranch
WOOD	HOLLY RANCH WATER COMPANY
Wood	Hurleys RV Park
Wood	Indian Creek RV Park
Wood	Jarvis Christian College
Wood	Jones WSC
Wood	Lake Fork WSC
Wood	Mineola
Wood	New Hope SUD
Wood	Piney Wood Springs
Wood	Quail Hollow RV Park
Wood	Quitman
Wood	Ramey WSC
Wood	Sharon WSC
Wood	Tamerarias Restaurant
Wood	Whites Landing
Wood	Wood County
Wood	Wood County Bottling Plant
Wood	Wooded Shores RV Park

Appendix G

Documentation for Aquifers Classified as Not Relevant for Purposes of Joint Planning

Tech Memo 16-03: Gulf Coast Aquifer
Tech Memo 16-04: Nacatoch Aquifer
Tech Memo 16-05: Trinity Aquifer
Tech Memo 16-06: Yegua-Jackson Aquifer

Gulf Coast Aquifer: Not Relevant for Purposes of Joint Planning
GMA 11 Technical Memorandum 16-03

Nacatoch Aquifer: Not Relevant for Purposes of Joint Planning
GMA 11 Technical Memorandum 16-04

Trinity Aquifer: Not Relevant for Purposes of Joint Planning
GMA 11 Technical Memorandum 16-05

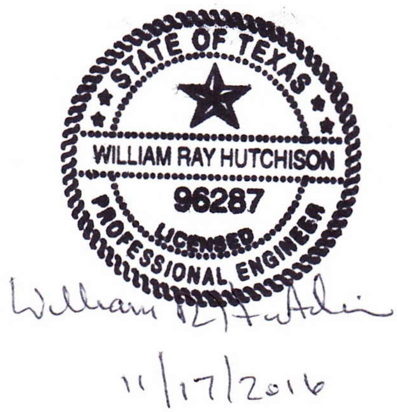
Yegua-Jackson Aquifer: Not Relevant for Purposes of Joint Planning
GMA 11 Technical Memorandum 16-06

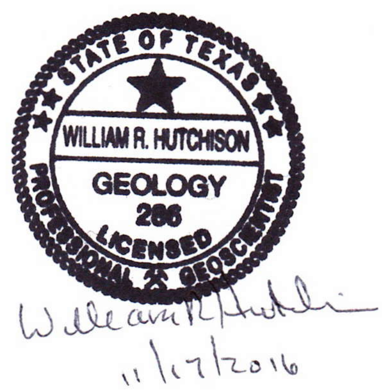
Geoscientist and Engineering Seal

This report documents the work and supervision of work of the following licensed Texas Professional Geoscientist and licensed Texas Professional Engineers:

William R. Hutchison, Ph.D., P.E. (96287), P.G. (286)

Dr. Hutchison completed the analyses and model simulations described in this report, and was the principal author of the final report.





Gulf Coast Aquifer: Not Relevant for Purposes of Joint Planning

GMA 11 Technical Memorandum 16-03, Final

William R. Hutchison, Ph.D., P.E., P.G.
November 17, 2016

Introduction

The Texas Water Development Board, in its July 2013 document, Explanatory Report for Submittal of Desired Future Conditions to the Texas Water Development Board, offers the following guidance regarding documentation for aquifers that are to be classified not relevant for purposes of joint planning:

> *Districts in a groundwater management area may, as part of the process for adopting and submitting desired future conditions, propose classification of a portion or portions of a relevant aquifer as non-relevant (31 Texas Administrative Code 356.31 (b)). This proposed classification of an aquifer may be made if the districts determine that aquifer characteristics, groundwater demands, and current groundwater uses do not warrant adoption of a desired future condition.*
>
> *The districts must submit to the TWDB the following documentation for the portion of the aquifer proposed to be classified as non-relevant:*
>
> 1. *A description, location, and/or map of the aquifer or portion of the aquifer;*
> 2. *A summary of aquifer characteristics, groundwater demands, and current groundwater uses, including the total estimated recoverable storage as provided by the TWDB, that support the conclusion that desired future conditions in adjacent or hydraulically connected relevant aquifer(s) will not be affected; and*
> 3. *An explanation of why the aquifer or portion of the aquifer is non-relevant for joint planning purposes.*

This technical memorandum provides the required documentation to classify the Gulf Coast Aquifer as not relevant for purposes of joint planning.

Aquifer Description and Location

As described in George and others (2011):

> ***The Gulf Coast Aquifer*** *is a major aquifer paralleling the Gulf of Mexico coastline from the Louisiana border to the border of Mexico. It consists of several aquifers, including the Jasper, Evangeline, and Chicot aquifers, which are composed of discontinuous sand, silt, clay, and gravel beds. The maximum total sand thickness of the Gulf Coast Aquifer ranges from 700 feet in the south to 1,300 feet in the north. Freshwater saturated thickness averages about 1,000 feet. Water quality varies with depth and locality: it is generally good in the*

> *central and northeastern parts of the aquifer, where the water contains less than 500 milligrams per liter of total dissolved solids, but declines to the south, where it typically contains 1,000 to more than 10,000 milligrams per liter of total dissolved solids and where the productivity of the aquifer decreases. High levels of radionuclides, thought mainly to be naturally occurring, are found in some wells in Harris County in the outcrop and in South Texas. The aquifer is used for municipal, industrial, and irrigation purposes. In Harris, Galveston, Fort Bend, Jasper, and Wharton counties, water level declines of as much as 350 feet have led to land subsidence. The regional water planning groups, in their 2006 Regional Water Plans, recommended several water management strategies that use the Gulf Coast Aquifer, including drilling more wells, pumping more water from existing wells, temporary overdrafting, constructing new or expanded treatment plants, desalinating brackish groundwater, developing conjunctive use projects, and reallocating supplies.*

Figure 1 (taken from Wade and others, 2014) shows the limited extent of the Gulf Coast Aquifer in GMA 11. Note that it occurs only in a small portion of Angelina, Sabine, and Trinity counties.

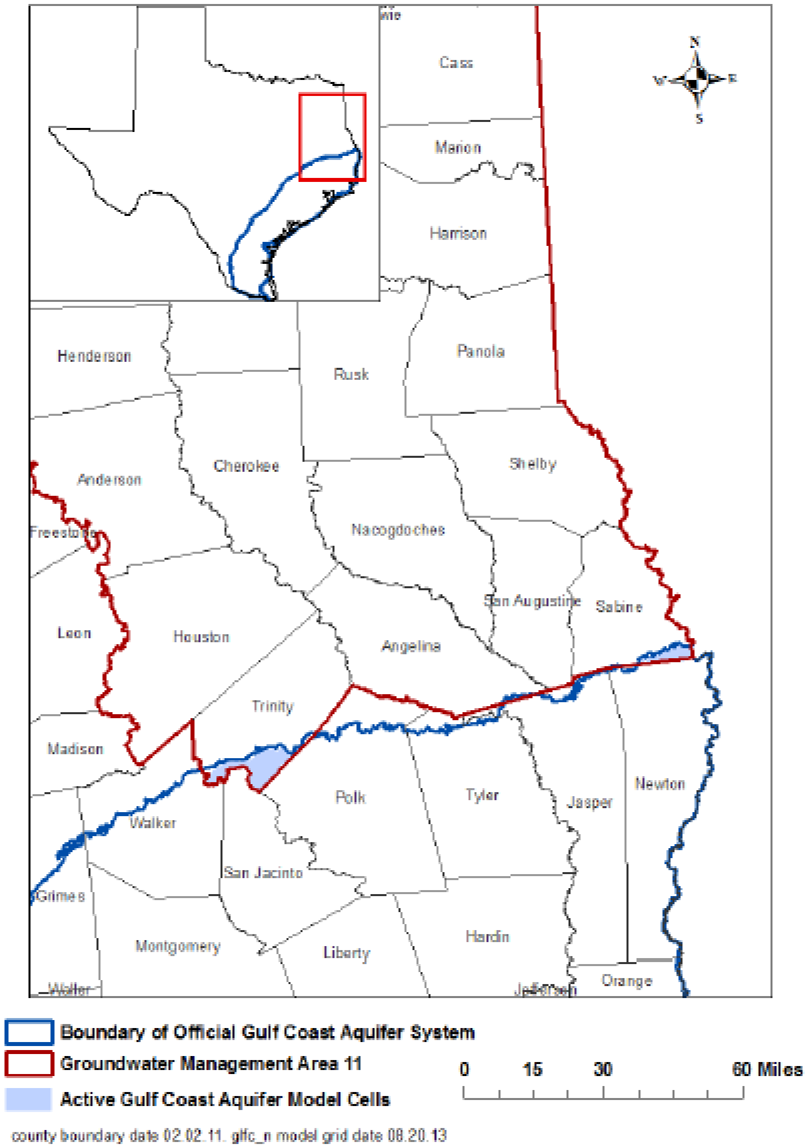


Figure 1. Location of Gulf Coast Aquifer in GMA 11

Aquifer Characteristics

The Jasper Aquifer is the relevant formation within the Gulf Coast Aquifer system in GMA 11. Previous studies (i.e. Chowdhury and others, 2004, pg. 36) noted that hydraulic conductivity in the Jasper is about 1 ft/day.

Gulf Coast Aquifer: Not Relevant for Purposes of Joint Planning

GMA 11 Technical Memorandum 16-03, Final

William R. Hutchison, Ph.D., P.E., P.G.
November 17, 2016

Groundwater Demands and Current Groundwater Uses

The Texas Water Development Board pumping database shows 2012 groundwater pumping for the Gulf Coast Aquifer as follows:

- Sabine: 18 AF/yr
- Trinity: 333 AF/yr

No pumping was listed for Angelina County.

Total Estimated Recoverable Storage

Wade and others (2013) documented the total estimated recoverable storage for the Gulf Coast Aquifer in GMA 11 as follows:

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Angelina	27,000	6,750	20,250
Sabine	120,000	30,000	90,000
Trinity	1,300,000	325,000	975,000
Total	1,447,000	361,750	1,085,250

Total storage is given in the first column. The recoverable storage is assumed to be between 25 and 75 percent of the total storage.

Explanation of Non-Relevance

Due to its limited areal extent and generally low use, the Gulf Coast Aquifer is classified as not relevant for purposes of joint planning in Groundwater Management Area 11.

References

Chowdhury, A.H., Wade, S., Mace, R.E., Ridgeway, C., 2004. Groundwater Availability Model of the Central Gulf Coast Aquifer System: Numerical Simulations through 1999. Texas Water Development Board, Groundwater Availability Modeling Section, September 27, 2004, 114p.

George, P.G., Mace, R.E., and Petrossian, R., 2011. Aquifers of Texas. Texas Water Development Board Report 380, July 2011, 182p.

Wade, S., Shi, J., and Seiter-Weatherford, C. 2014. GAM Task 13-034: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 11. Texas Water Development Board, Groundwater Resources Division, April 2, 2014, 30p.

Nacatoch Aquifer: Not Relevant for Purposes of Joint Planning

GMA 11 Technical Memorandum 16-04, Final

William R. Hutchison, Ph.D., P.E., P.G.
November 17, 2016

Introduction

The Texas Water Development Board, in its July 2013 document, Explanatory Report for Submittal of Desired Future Conditions to the Texas Water Development Board, offers the following guidance regarding documentation for aquifers that are to be classified not relevant for purposes of joint planning:

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> 1. *A description, location, and/or map of the aquifer or portion of the aquifer;*
> 2. *A summary of aquifer characteristics, groundwater demands, and current groundwater uses, including the total estimated recoverable storage as provided by the TWDB, that support the conclusion that desired future conditions in adjacent or hydraulically connected relevant aquifer(s) will not be affected; and*
> 3. *An explanation of why the aquifer or portion of the aquifer is non-relevant for joint planning purposes.*

This technical memorandum provides the required documentation to classify the Nacatoch Aquifer as not relevant for purposes of joint planning.

Aquifer Description and Location

As described in George and others (2011):

> ***The Nacatoch Aquifer*** *is a minor aquifer occurring in a narrow band across northeast Texas. The aquifer consists of the Nacatoch Sand, composed of sequences of sandstone separated by impermeable layers of mudstone or clay. These sandstones are marine in origin, coarsen upward, and are laterally discontinuous. The number of sand layers varies throughout the Nacatoch's extent, and the thickness of individual sand units ranges from more than 100 feet in the north to less than 20 feet to the south. Thickness of intervening mudstone*

> *units similarly ranges from more than 100 feet to only a few feet. Freshwater saturated thickness averages about 50 feet. The aquifer also includes a hydraulically connected cover of alluvium that is as much as 80 feet thick along major drainages. Groundwater in this aquifer is usually under artesian conditions except in shallow wells where the Nacatoch Formation crops out and water table conditions exist. The Mexia-Talco Fault Zone generally delineates the subsurface limit of the aquifer. The groundwater in the aquifer is typically alkaline, high in sodium bicarbonate, and soft. Total dissolved solids in the subsurface increase and are significantly higher south of the Mexia-Talco Fault Zone, where the water contains between 1,000 and 3,000 milligrams per liter of total dissolved solids. Water from the aquifer is extensively used for domestic and livestock purposes. The city of Commerce historically pumped the greatest amount from the Nacatoch Aquifer but has recently attempted to convert to surface water; however, because of recent droughts, the city has pumped 30 to 50 percent of its water from the aquifer. As a result of Commerce's reduced pumping, the declining water levels that had developed around Commerce in Delta and Hunt counties are stabilizing. The North East Texas Regional Water Planning Group, in its 2006 Regional Water Plan, recommended new and supplemental groundwater wells in the Nacatoch Aquifer as a water management strategy.*

Figure 1 (taken from Wade and others, 2014) shows the limited extent of the Nacatoch Aquifer in GMA 11. Note that it occurs only in a small portion of Bowie, Henderson, Morris, Red River, and Titus counties.

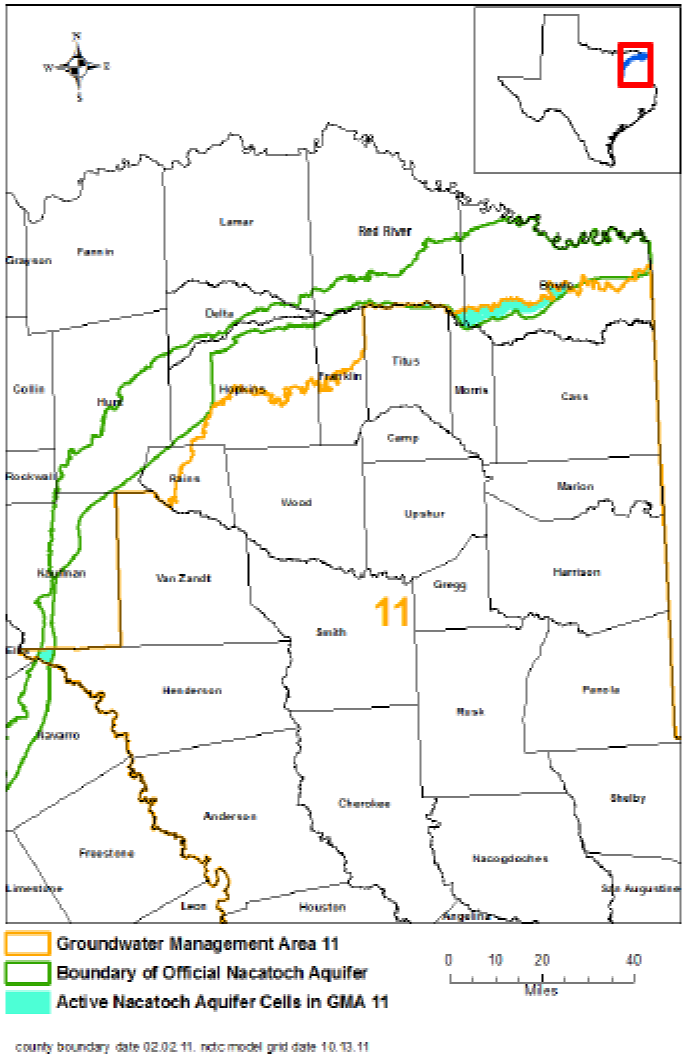

Figure 1. Location of Nacatoch Aquifer in GMA 11

Aquifer Characteristics

Beach and others (2009) developed a groundwater availability model for the Nacatoch Aquifer for the Texas Water Development Board. This study appears to document only two estimates of hydraulic conductivity in GMA 11 (Beach and others, 2009, pg. 4-57) in Bowie County (1 to 3 ft/day). The groundwater modeling effort included developing estimates of hydraulic conductivity throughout the area (Beach and others, 2009, pp 8-4 and 8-5).

Nacatoch Aquifer: Not Relevant for Purposes of Joint Planning

GMA 11 Technical Memorandum 16-04, Final

William R. Hutchison, Ph.D., P.E., P.G.
November 17, 2016

Groundwater Demands and Current Groundwater Uses

The Texas Water Development Board pumping database shows 2012 groundwater pumping for the Nacatoch Aquifer as follows:

- Bowie: 1,466 AF/yr
- Henderson: 12 AF/yr
- Hopkins: 1,113 AF/yr
- Titus: 100 AF/yr

No pumping estimates are listed for Morris or Red River counties.

Total Estimated Recoverable Storage

Wade and others (2013) documented the total estimated recoverable storage for the Nacatoch Aquifer in GMA 11 as follows:

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Bowie	140,000	35,000	105,000
Henderson	9,800	2,450	7,350
Morris	2,900	725	2,175
Red River	11,000	2,750	8,250
Titus	15,000	3,750	11,250
Total	178,700	44,675	134,025

Total storage is given in the first column. The recoverable storage is assumed to be between 25 and 75 percent of the total storage.

Explanation of Non-Relevance

Due to its limited areal extent and generally low use, the Nacatoch Aquifer is classified as not relevant for purposes of joint planning in Groundwater Management Area 11.

References

Beach, J.A., Huang, Y., Symank, L., Ashworth, J.B., Davidson, T., Vreugdenhil, A.M., and Deeds, N.E., 2009. Final Report: Nacatoch Aquifer Groundwater Availability Model. Prepared for the Texas Water Development Board, January 2009, 304p.

George, P.G., Mace, R.E., and Petrossian, R., 2011. Aquifers of Texas. Texas Water Development Board Report 380, July 2011, 182p.

Wade, S., Shi, J., and Seiter-Weatherford, C. 2014. GAM Task 13-034: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 11. Texas Water Development Board, Groundwater Resources Division, April 2, 2014, 30p.

Trinity Aquifer: Not Relevant for Purposes of Joint Planning

GMA 11 Technical Memorandum 16-05, Final

William R. Hutchison, Ph.D., P.E., P.G.
November 17, 2016

Introduction

The Texas Water Development Board, in its July 2013 document, Explanatory Report for Submittal of Desired Future Conditions to the Texas Water Development Board, offers the following guidance regarding documentation for aquifers that are to be classified not relevant for purposes of joint planning:

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> 1. *A description, location, and/or map of the aquifer or portion of the aquifer;*
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> 3. *An explanation of why the aquifer or portion of the aquifer is non-relevant for joint planning purposes.*

This technical memorandum provides the required documentation to classify the Trinity Aquifer as not relevant for purposes of joint planning.

Aquifer Description and Location

As described in George and others (2011):

> ***The Trinity Aquifer,*** *a major aquifer, extends across much of the central and northeastern part of the state. It is composed of several smaller aquifers contained within the Trinity Group. Although referred to differently in different parts of the state, they include the Antlers, Glen Rose, Paluxy, Twin Mountains, Travis Peak, Hensell, and Hosston aquifers. These aquifers consist of limestones, sands, clays, gravels, and conglomerates. Their combined freshwater saturated thickness averages about 600 feet in North Texas and about 1,900 feet in Central Texas. In*

general, groundwater is fresh but very hard in the outcrop of the aquifer. Total dissolved solids increase from less than 1,000 milligrams per liter in the east and southeast to between 1,000 and 5,000 milligrams per liter, or slightly to moderately saline, as the depth to the aquifer increases. Sulfate and chloride concentrations also tend to increase with depth. The Trinity Aquifer discharges to a large number of springs, with most discharging less than 10 cubic feet per second. The aquifer is one of the most extensive and highly used groundwater resources in Texas. Although its primary use is for municipalities, it is also used for irrigation, livestock, and other domestic purposes. Some of the state's largest water level declines, ranging from 350 to more than 1,000 feet, have occurred in counties along the IH-35 corridor from McLennan County to Grayson County. These declines are primarily attributed to municipal pumping, but they have slowed over the past decade as a result of increasing reliance on surface water. The regional water planning groups, in their 2006 Regional Water Plans, recommended numerous water management strategies for the Trinity Aquifer, including developing new wells and well fields, pumping more water from existing wells, overdrafting, reallocating supplies, and using surface water and groundwater conjunctively.

Figure 1 (taken from Wade and others, 2014) shows the limited extent of the Trinity Aquifer in GMA 11. Note that it occurs only in a small portion of Henderson County.

Figure 1. Location of Trinity Aquifer in GMA 11

Aquifer Characteristics

Kelley and others (2014) developed an updated groundwater availability model of the Northern Trinity and Woodbine aquifers for four groundwater conservation districts in north Texas. This model covered the entire Northern Trinity Aquifer, including the small portion in Henderson County. Maps of calibrated horizontal hydraulic conductivity are provided in Kelley and others (2014, pg. 8:1-6, 8:1-7, 8:1-8, 8:1-9, 8:1-10, 8:1-11, 8:1-12). Estimated values are typically 0.1 ft/day or less, except for the Hosston Aquifer, which was shown as between 3 and 10 ft/day.

Trinity Aquifer: Not Relevant for Purposes of Joint Planning

GMA 11 Technical Memorandum 16-05, Final

William R. Hutchison, Ph.D., P.E., P.G.
November 17, 2016

Groundwater Demands and Current Groundwater Uses

The Texas Water Development Board pumping database does not list any pumping from the Trinity Aquifer in Henderson County. However, the database shows 42 AF/yr was pumping from the Trinity Aquifer in Trinity County in 2012.

Total Estimated Recoverable Storage

Wade and others (2013) documented the total estimated recoverable storage for the Trinity Aquifer in GMA 11 as follows:

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Henderson	500,000	125,000	375,000
Total	500,000	125,000	375,000

Total storage is given in the first column. The recoverable storage is assumed to be between 25 and 75 percent of the total storage.

Explanation of Non-Relevance

Due to its limited areal extent and generally low use, the Trinity Aquifer is classified as not relevant for purposes of joint planning in Groundwater Management Area 11.

References

Kelley, V.A., Ewing, J., Jones, T.L., Young, S.C., Deeds, N., Hamlin, S., Jigmond, M., Harding, J., Pinkard, J., Yan, T.T., Scanlon, B., Beach, J., Davidson, T., Laughlin, K., 2014, Final Report: Updated Groundwater Availability Model of the Northern Trinity and Woodbine Aquifers. Report prepared for North Texas GCD, Northern Trinity GCD, Prairielands GCD, and Upper Trinity GCD. August 2014, Volume 1, 990p.

George, P.G., Mace, R.E., and Petrossian, R., 2011. Aquifers of Texas. Texas Water Development Board Report 380, July 2011, 182p.

Wade, S., Shi, J., and Seiter-Weatherford, C. 2014. GAM Task 13-034: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 11. Texas Water Development Board, Groundwater Resources Division, April 2, 2014, 30p.

Yegua-Jackson Aquifer: Not Relevant for Purposes of Joint Planning

GMA 11 Technical Memorandum 16-06, Final

William R. Hutchison, Ph.D., P.E., P.G.
November 17, 2016

Introduction

The Texas Water Development Board, in its July 2013 document, Explanatory Report for Submittal of Desired Future Conditions to the Texas Water Development Board, offers the following guidance regarding documentation for aquifers that are to be classified not relevant for purposes of joint planning:

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> 3. *An explanation of why the aquifer or portion of the aquifer is non-relevant for joint planning purposes.*

This technical memorandum provides the required documentation to classify the Yegua-Jackson Aquifer as not relevant for purposes of joint planning.

Aquifer Description and Location

As described in George and others (2011):

> ***The Yegua-Jackson Aquifer** is a minor aquifer stretching across the southeast part of the state. It includes water-bearing parts of the Yegua Formation (part of the upper Claiborne Group) and the Jackson Group (comprising the Whitsett, Manning, Wellborn, and Caddell formations). These geologic units consist of interbedded sand, silt, and clay layers originally deposited as fluvial and deltaic sediments. Freshwater saturated thickness averages about 170 feet. Water quality*

> *varies greatly owing to sediment composition in the aquifer formations, and in all areas the aquifer becomes highly mineralized with depth. Most groundwater is produced from the sand units of the aquifer, where the water is fresh and ranges from less than 50 to 1,000 milligrams per liter of total dissolved solids. Some slightly to moderately saline water, with concentrations of total dissolved solids ranging from 1,000 to 10,000 milligrams per liter, also occurs in the aquifer. No significant water level declines have occurred in wells measured by the TWDB. Groundwater for domestic and livestock purposes is available from shallow wells over most of the aquifer's extent. Water is also used for some municipal, industrial, and irrigation purposes. The regional water planning groups, in their 2006 Regional Water Plans, recommended several water management strategies that use the Yegua-Jackson Aquifer, including drilling more wells and desalinating the water.*

Figure 1 (taken from Wade and others, 2014) shows the limited extent of the Yegua-Jackson Aquifer in GMA 11.

Yegua-Jackson Aquifer: Not Relevant for Purposes of Joint Planning

GMA 11 Technical Memorandum 16-06, Final

William R. Hutchison, Ph.D., P.E., P.G.
November 17, 2016

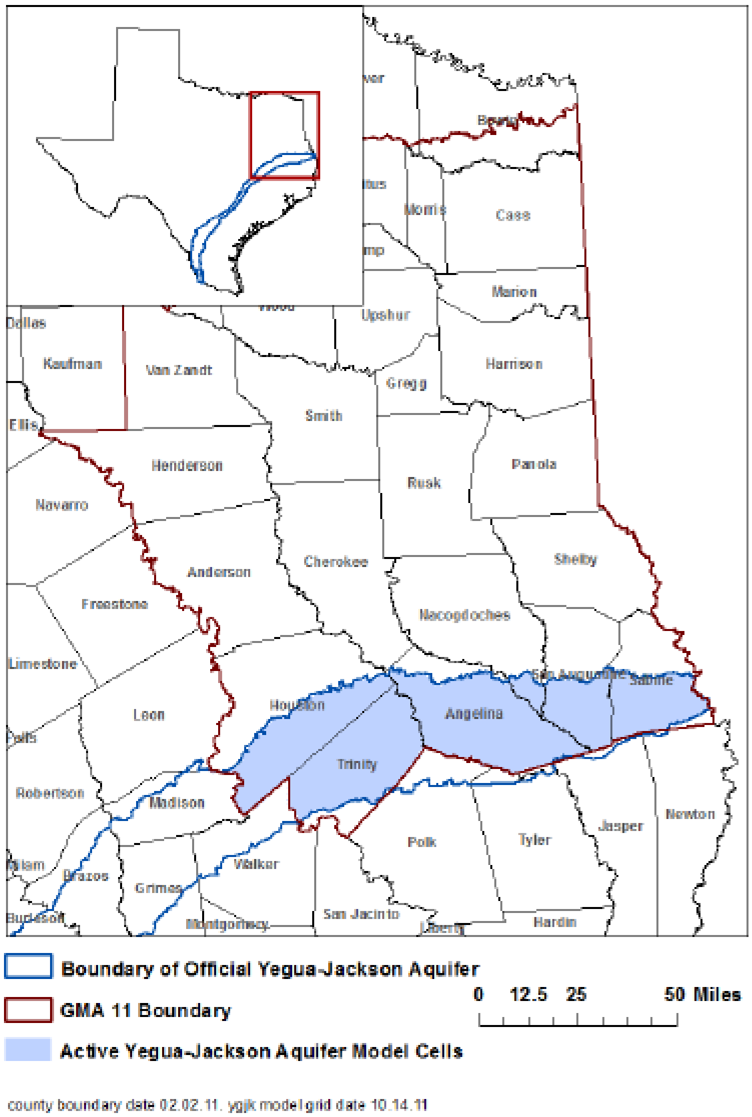

Figure 1. Location of Yegua-Jackson Aquifer in GMA 11

Aquifer Characteristics

Deeds and others (2010) developed a groundwater availability model of the Yegua-Jackson Aquifer for the Texas Water Development Board. Maps of calibrated horizontal hydraulic conductivity are provided on pages 8-7, to 8-11. Estimated values in the GMA 11 area vary considerably from less than 1ft/day to over 30 ft/day, depending on the unit and location.

Yegua-Jackson Aquifer: Not Relevant for Purposes of Joint Planning

GMA 11 Technical Memorandum 16-06, Final

William R. Hutchison, Ph.D., P.E., P.G.
November 17, 2016

Groundwater Demands and Current Groundwater Uses

The Texas Water Development Board pumping database does not list any pumping from the Trinity Aquifer in Henderson County. However, the database shows 42 AF/yr was pumping from the Trinity Aquifer in Trinity County in 2012.

Total Estimated Recoverable Storage

Wade and others (2013) documented the total estimated recoverable storage for the Yegua-Jackson Aquifer in GMA 11 as follows:

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Angelina	72,000,000	18,000,000	54,000,000
Houston	21,000,000	5,250,000	15,750,000
Nacogdoches	1,400,000	350,000	1,050,000
Sabine	30,000,000	7,500,000	22,500,000
San Augustine	19,000,000	4,750,000	14,250,000
Trinity	83,000,000	20,750,000	62,250,000
Total	**226,400,000**	**56,600,000**	**169,800,000**

Total storage is given in the first column. The recoverable storage is assumed to be between 25 and 75 percent of the total storage.

Explanation of Non-Relevance

Due to its limited areal extent and generally low use, the Yegua-Jackson Aquifer is classified as not relevant for purposes of joint planning in Groundwater Management Area 11.

References

Deeds, N.E., Yan, T., Singh, A., Jones, T.L., Kelley, V.A., Knox, P.R., and Young, S.C., 2010. Final Report: Groundwater Availability Model for the Yegua-Jackson Aquifer. Prepared for the Texas Water Development Board, March 2010, 582p.

George, P.G., Mace, R.E., and Petrossian, R., 2011. Aquifers of Texas. Texas Water Development Board Report 380, July 2011, 182p.

Wade, S., Shi, J., and Seiter-Weatherford, C. 2014. GAM Task 13-034: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 11. Texas Water Development Board, Groundwater Resources Division, April 2, 2014, 30p.