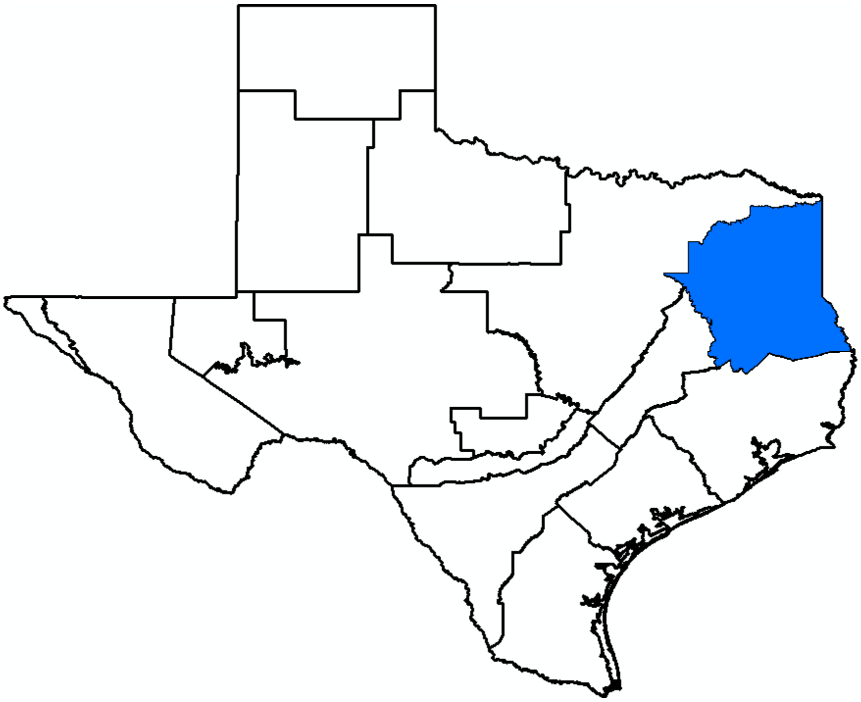
Desired Future Condition Explanatory Report (*Draft 1*)
Carrizo-Wilcox/Queen City/Sparta Aquifers for Groundwater Management Area 11



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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 northeastern part of the state (Figure 1).

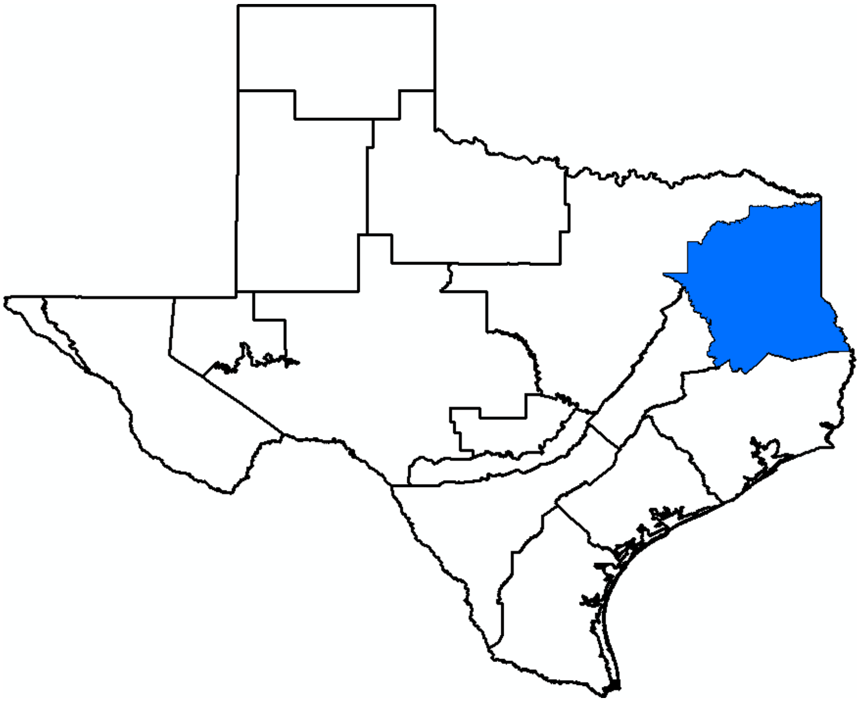


Figure 1. Groundwater Management Area 11

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).

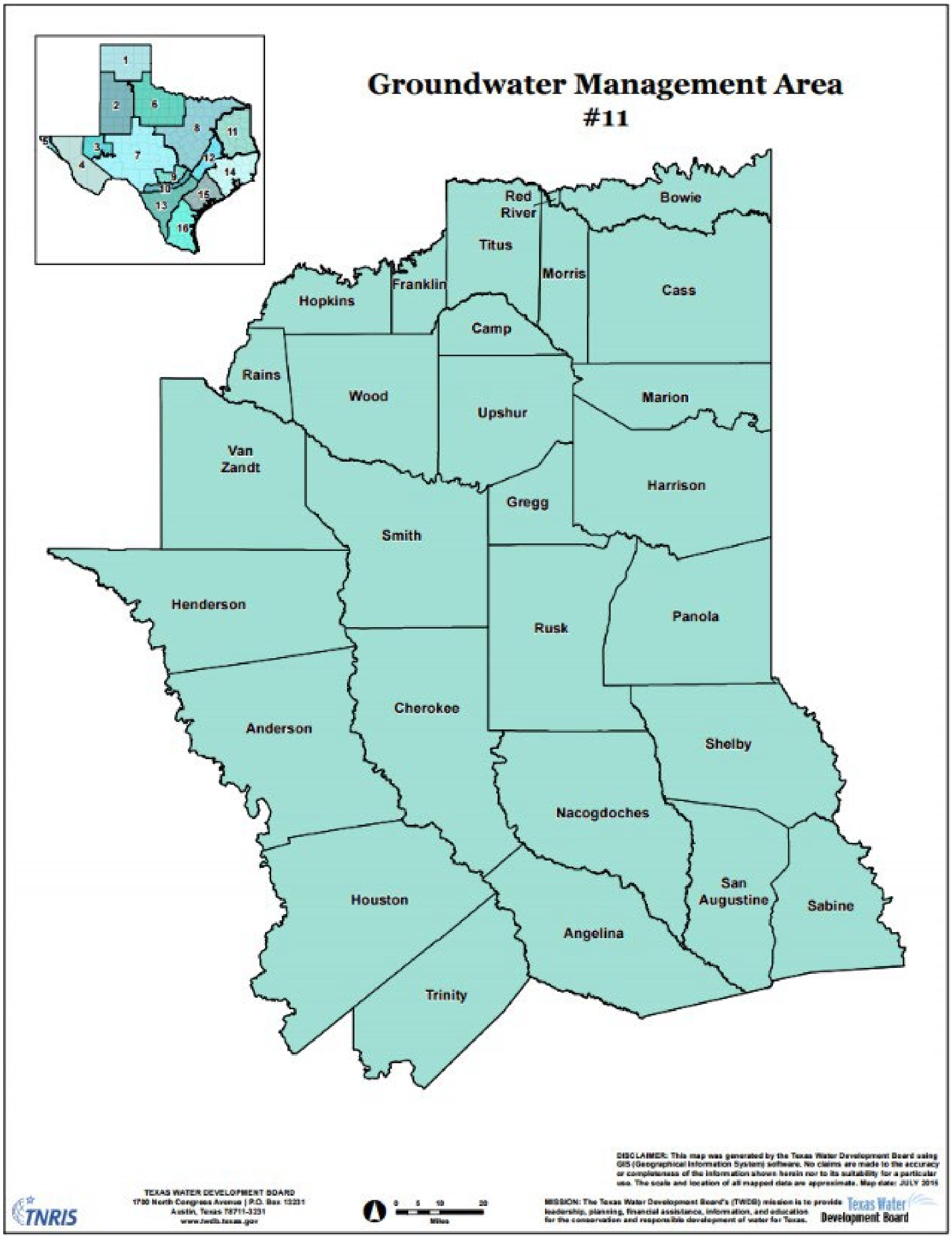


Figure 2. Counties Entirely or Partially in GMA 11 (from TWDB)

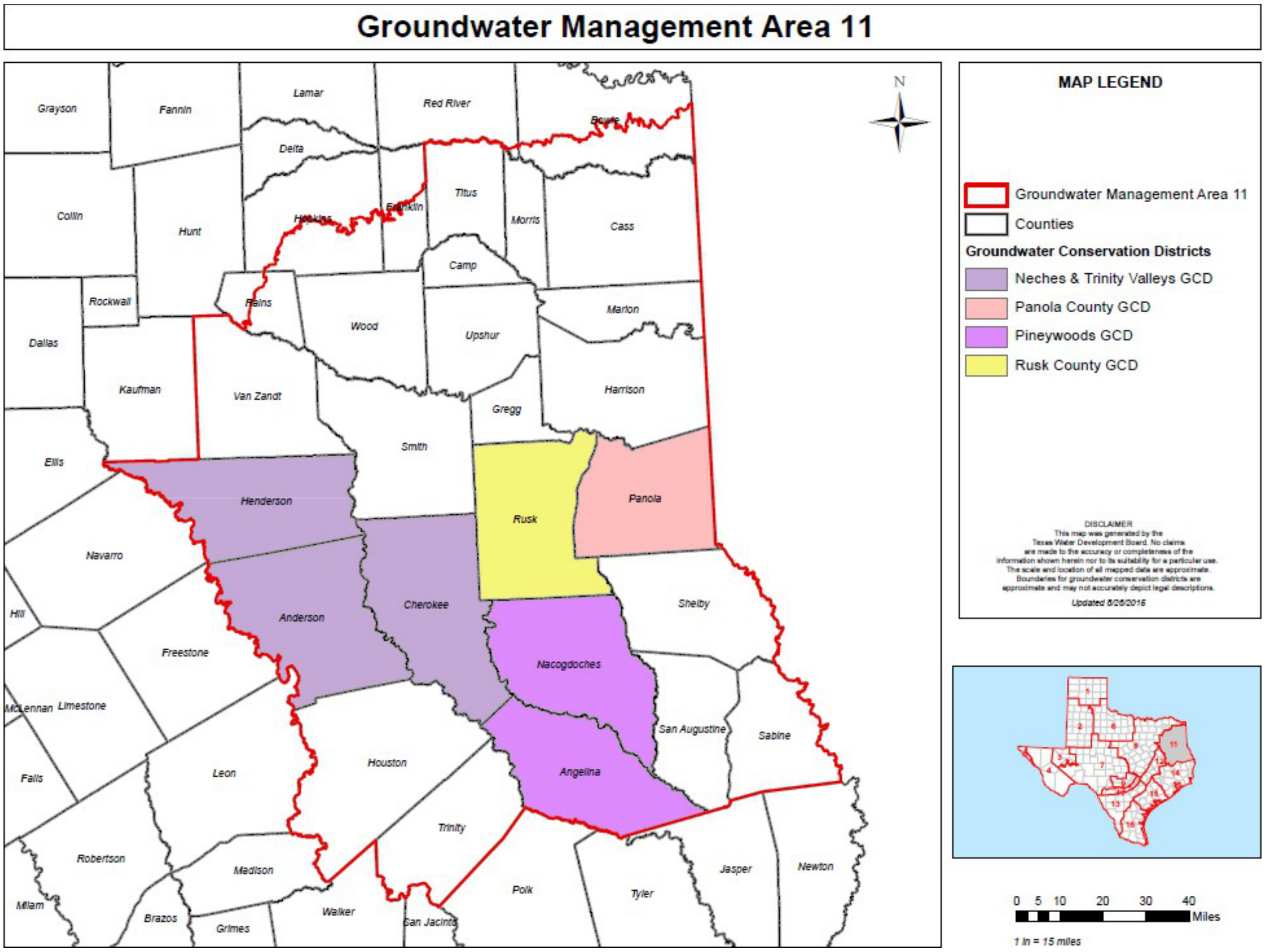


Figure 3. Groundwater Conservation Districts in GMA 11 (from TWDB)

2.0 Desired Future Condition History in GMA 11

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.

2.2 2010 Desired Future Conditions

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 unit. 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 simulated pumping in the Queen City Aquifer is high (as compared to historic pumping) and was guided by evaluating the model output from alternative increases in pumping.

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.

2.3 2016 Desired Future Conditions

In response to specific input from various stakeholders, the 2016 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 to reduce or eliminate planned groundwater level recoveries. However, as developed as described in the associated technical memoranda that were developed as part of this process, there continued to be instances of negative drawdown which are attributable to model limitations. Model limitations included recharge conceptualization problems and model-specific issues related to the movement of groundwater from outcrop areas to downdip areas. These limitations resulted in rising groundwater levels in some of the outcrop areas.

2.4 2021 Desired Future Conditions

After considering the nine statutory factors, the groundwater conservation districts in Groundwater Management Area 11 voted to propose desired future conditions based on the Scenario 33 documented in Technical Memorandum 21-01 on April 28, 2021. The groundwater conservation districts in Groundwater Management Area 11 received no public comments during the public comment period and voted to adopt desired future conditions based on Scenario 33 documented in Technical Memorandum 21-01 on August 11, 2021.

The average drawdowns in the 2021 desired future conditions were greater than the average drawdowns in the 2010 and 2016 desired future conditions future conditions due to the updated GAM that has removed a limitation that caused unrealistic groundwater level increases due to the lack of ability for the model to move water from outcrop areas to downdip areas and issues with recharge conceptualization.

Also as documented in Technical Memoranda 20-05 and 21-01, the future pumping in Scenario 33 was less than the pumping assumed in 2010 and 2016 rounds of joint planning. This is also due to the improved model. As emphasized in Technical Memoranda 20-05 and 21-01, the pumping associated with the previous round of joint planning (2016) and the groundwater availability in the Region D and Region I water plans cannot be sustained with the assumed geographic distribution of pumping used in the predictive scenario. Thus, these lower pumping amounts were less than the previous groundwater availability values in the regional plans. These are not arbitrary reductions, nor are the reductions based on regulation. These pumping amounts reflect the results of an updated and improved groundwater model to make such predictions.

2.5 Institutional Response to 2021 Desired Future Condition

The efforts of GMA 11 to develop a desired future condition that would result in a sustainable amount of pumping through 2080 have not been recognized. In 2023, Rubenstein and Puig-Williams (2023) prepared a report that reviewed the joint planning process and provided recommendations to improve the process. Despite having access to and interviewing the GMA 11 consultant, Rubenstein and Puig-Williams (2023) ignored the accomplishments of GMA 11 and did not recognize the establishment of the sustainable pumping DFC in 2021.

At the January 2024 meeting of Region I, the regional planning group consultants misrepresented the 2021 DFC and MAG. Specifically, the consultants raised concerns that the groundwater availability (MAG) had declined in comparison to 2016. Furthermore, the Region I consultants were incorrect in their assertions that because the groundwater availability model was completed in the middle of the planning cycle GMA 11 "did not have time to make adjustments needed". When GMA 11 GCD members at the Region I meeting explained that the updated model was used and that time was not an issue in calculating water availability, the Region I consultants "explained some of the possible problems with model updates and that the data may need to be adjusted in future planning cycles".

This exchange highlighted the dynamic tension that currently exists between regional planning groups (trying to maximize development to meet projected future demands) and groundwater conservation districts (trying to balance use with conservation). Unfortunately, ignoring or criticizing the results of the joint planning process that are inconsistent with the maximum development paradigm only serve to confuse the real issues facing groundwater management.

Rubenstein and Puig-Williams (2023) represent the opposite of the maximum development paradigm and suggested that the joint planning should focus on finding the amount of groundwater that can be "pumped from an aquifer without causing groundwater declines". This is a poorly posed question because any groundwater pumping will cause some groundwater level declines.

A better concept to apply to the joint planning process is sustainable yield, which is the amount of water that can be pumped from an aquifer over a specified period without causing negative or undesirable effects. The undesirable effects can be hydrogeologic, environmental, or economic.

3.0 2026 Desired Future Conditions

3.1 Application of Sustainable Yield Concepts

It is recognized that the sustainable pumping associated with the 2021 desired future condition and sustainable yield are likely different depending on the definition of undesirable effects. Identifying and characterizing "undesirable effects" is fundamentally improved when there is public participation. GMA 11 has been notable since there has historically (prior to 2024) been no public participation despite outreach efforts. The sustainable pumping approach developed in 2021 was developed by the groundwater conservation districts without the benefit of public participation.

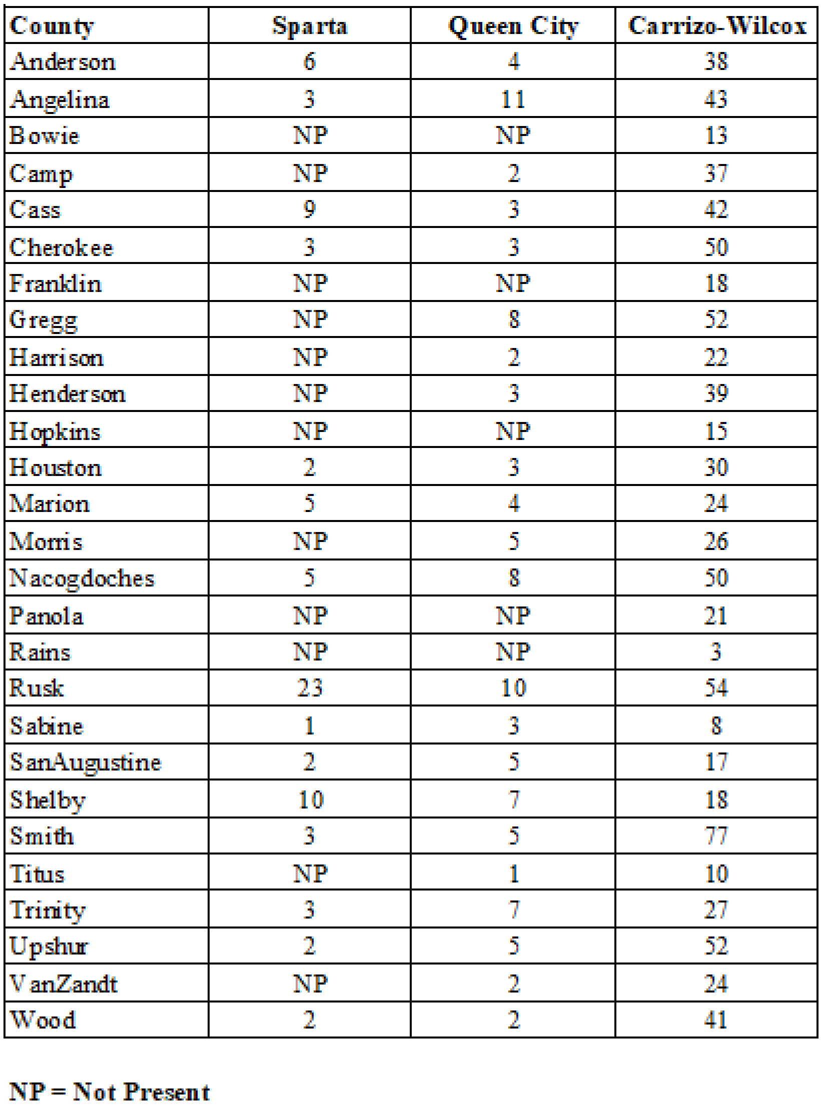
The sustainable pumping associated with the 2021 desired future condition provided a convenient foundation to address issues of sustainable yield. Two specific metrics were used in 2025 and 2026 to advance a more complete implementation of sustainable yield in GMA 11: 1) impact to streamflow and 2) quantifying (and ultimately limiting) the number of dry wells.

Details of the implementation of sustainable yield concepts to the 2026 desired future condition are presented in the discussion of joint planning factors and in Technical Memorandum 26-02 (Appendix A).

3.2 Proposed Desired Future Conditions

After considering the statutory factors and balancing the development of groundwater with the conservation of groundwater, the groundwater conservation district in Groundwater Management Area 11 proposed a desired future conditions on April 28, 2026, based in Scenario 26.1 as detailed in Table 3. As noted, the desired future condition are expressed as average drawdown for each county-aquifer unit from 2013 to 2080. Required decadal values (for monitoring achievement) are included in Technical Memorandum 26-02 (Appendix A).

Table 1. 2026 Desired Future Conditions (Average Drawdown from 2013 to 2080)



County	Sparta	Queen City	Carrizo-Wilcox
Anderson	6	4	38
Angelina	3	11	43
Bowie	NP	NP	13
Camp	NP	2	37
Cass	9	3	42
Cherokee	3	3	50
Franklin	NP	NP	18
Gregg	NP	8	52
Harrison	NP	2	22
Henderson	NP	3	39
Hopkins	NP	NP	15
Houston	2	3	30
Marion	5	4	24
Morris	NP	5	26
Nacogdoches	5	8	50
Panola	NP	NP	21
Rains	NP	NP	3
Rusk	23	10	54
Sabine	1	3	8
SanAugustine	2	5	17
Shelby	10	7	18
Smith	3	5	77
Titus	NP	1	10
Trinity	3	7	27
Upshur	2	5	52
VanZandt	NP	2	24
Wood	2	2	41

NP = Not Present

4.0 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 2021 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 that are 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. This was accomplished in part by considering the results of several simulations with the Northern Carrizo-Wilcox, Sparta, and Queen City Groundwater Availability Model to compare the impacts of varying amounts of groundwater pumping. Specific metrics used to assess impacts included surface water impacts and dry wells.

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.

5.0 Technical Justification

5.1 Groundwater Availability Model

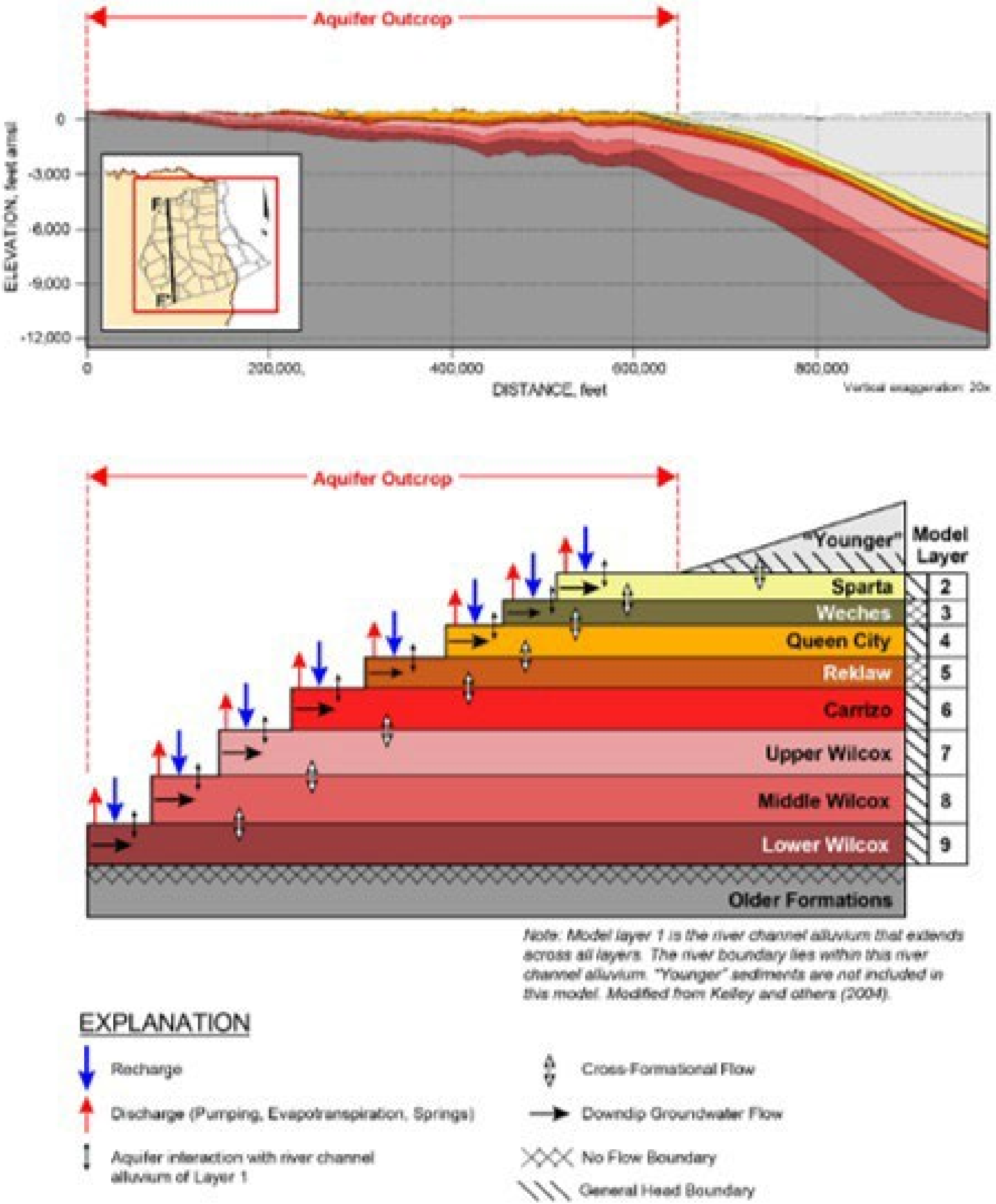
The desired future conditions for the Carrizo-Wilcox/Queen City/Sparta Aquifers were developed based on simulations of alternative scenarios of future pumping using the Groundwater Availability Model (GAM) of the northern Carrizo-Wilcox, Queen City, and Sparta aquifers (Panday and others, 2020) as updated by Hutchison (2026). This updated GAM superseded the previous GAM of the northern Carrizo-Wilcox Aquifer (Kelley and others, 2004) that was used to support the joint planning process in 2010 and 2016. The calibration period for the updated GAM was 1980 to 2013.

The updated GAM was the first one developed with the objective of supporting the joint planning process. Previous GAMs of the area were developed prior to the adoption of HB 1763 in 2005 and were used as a default tool. Part of the development of the updated GAM included running predictive simulations to evaluate its use in the joint planning process. Specifically, the initial predictive simulations included testing various levels of constant pumping from 2014 to 2080 and various levels of constant recharge from 2014 to 2080. These simulations demonstrated that the updated GAM would reach an equilibrium condition and, thus, would not suffer from the problems of rising groundwater levels like the older GAM.

Conceptually, the model simulates groundwater flow in nine 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.

5.2 General Modeling Approach

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 were discussed prior to adopting the 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.



Note: Model layer 1 is the river channel alluvium that extends across all layers. The river boundary lies within this river channel alluvium. "Younger" sediments are not included in this model. Modified from Kelley and others (2004).

Figure 4. Conceptual Model of Flow (from Panday and others, 2020, Figure 2.0-2)

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 *science* 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 numerical "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.

5.3 Specific Application of Model

Model simulations were completed in three steps:

- An initial assessment of the model simulation that was the basis for the 2021 desired future condition in response to early public comments. The objective of this analysis was to more fully evaluate surface water impacts and dry wells associated with the current desired future condition and identify a strategy to develop additional simulations to reduce impacts to "acceptable levels". This effort was summarized during the GMA 14 meeting of October 14, 2025.
- A series of model simulations that sequentially reduced pumping in the Queen City and Carrizo-Wilcox Aquifers and evaluating the impacts on surface water and dry wells. This effort is documented in the first part of Technical Memorandum 26-02 (Appendix A).
- Using the results of the pumping reduction simulations described above, develop a simulation where pumping results in a dry well impact of less than 10 percent in each county-aquifer unit for the Queen City and Carrizo-Wilcox Aquifers. This effort is documented in the second part of Technical Memorandum 26-02 (Appendix A).

6.0 Factor Consideration

6.1 Aquifer Uses and Conditions

For purposes of joint planning, the aquifer uses, and conditions primarily relied on data and estimates from Panday and others (2020) rather than TWDB pumping estimates that had been used in previous rounds of joint planning.

During the development of the updated GAM, Panday and others (2020) identified limitations in the datasets associated with the TWDB pumping estimates. In many instances, using the TWDB pumping estimates were found to be unreliable. Specifically, TWDB pumping data did not show a general trend between 1980 and 2013 while groundwater levels showed declines. Groundwater data were deemed more reliable because they are directly measured values. In contrast, the TWDB groundwater pumping estimates are derived from indirect methods. In addition, the method of estimation appeared to change after 1999. The uncertainty and general inconsistency led Panday and others (2020) to rely on the previous GAM and calibration methods to develop more robust pumping estimates based on historic groundwater level data. This method can be generally summarized to ensure that historic groundwater level declines are associated with increases in pumping. However, the approach was limited in that variations in groundwater elevations and pumping were relatively small during the calibration period.

Figure 5 presents a comparison of 2013 pumping (from the GAM), 2023 pumping (from TWDB), and the current 2080 Modeled Available Groundwater (MAG) that was developed from the desired future condition that was adopted in 2021.

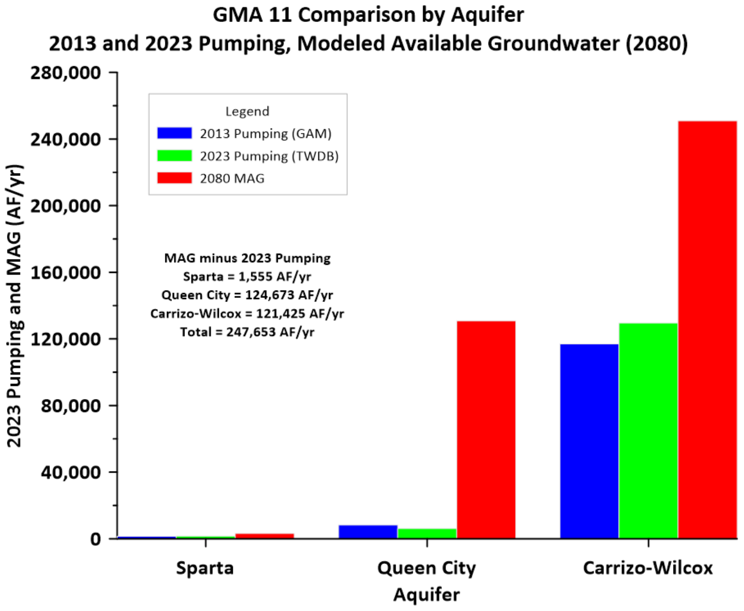


Figure 5. Pumping Comparisons by Aquifer

Please note that the current MAG represents much larger than current or historic pumping. This was a result of attempting to meet state water plan demands as noted above. The amount of increase is greater in the Queen City Aquifer than the increase in the Carrizo-Wilcox Aquifer.

6.2 Water Supply Needs and Water Management Strategies

As noted previously, the 2016 joint planning process used this factor as its primary consideration to ensure that the desired future conditions resulted in modeled available groundwater values that fully supported the regional planning process in Region D and Region I.

The analyses associated with the 2021 joint planning process using the updated GAM showed that these pumping amounts are not sustainable under the assumed geographic distribution of wells in the simulation. As noted earlier, these reductions were not arbitrary, nor were the reductions based on regulation. These pumping amounts reflect the results of an updated and improved groundwater model to make such predictions.

Based on public comments received at the GMA 14 meeting of October 14, 2025, this factor was de-emphasized in this round of joint planning. This round of joint planning focused more on aquifer limitations and reducing impacts of increased pumping. As a result, modeled available groundwater to meet the proposed desired future condition will be reduced in many county-aquifer units as a result of reducing dry wells and mitigating surface water impacts to the point that the impacts are not considered "unacceptable impacts".

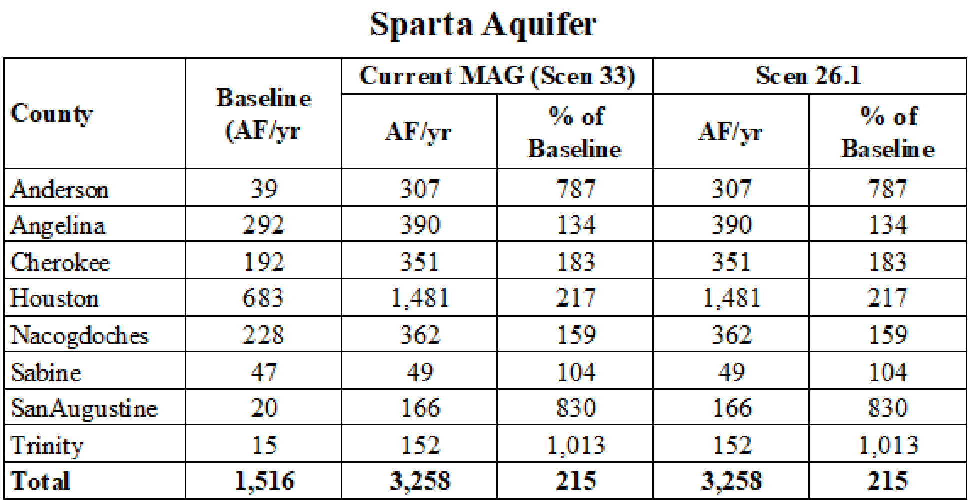
Comparisons of the current MAG and the pumping from Scenario 26.1 (the basis for the desired future condition) for each aquifer are presented as follows:

- Table 2 – Sparta Aquifer
- Table 3 – Queen City Aquifer
- Table 4 – Carrizo-Wilcox Aquifer

In each table, the baseline pumping represents 2013 pumping from the GAM, the current MAG pumping is the modeled available groundwater from the 2021 joint planning process, and Scenario 26.1 pumping is expected to be the modeled available groundwater from this round of joint planning. Please note that the for the current MAG and Scenario 26.1, the percentage increase from the baseline is presented.

Finally, as documented in Technical Memorandum 26-02, the yellow highlights in Table 4 (Carrizo-Wilcox Aquifer) denote pumping reductions that were needed to limit dry wells to less than 10 percent in the specified county.

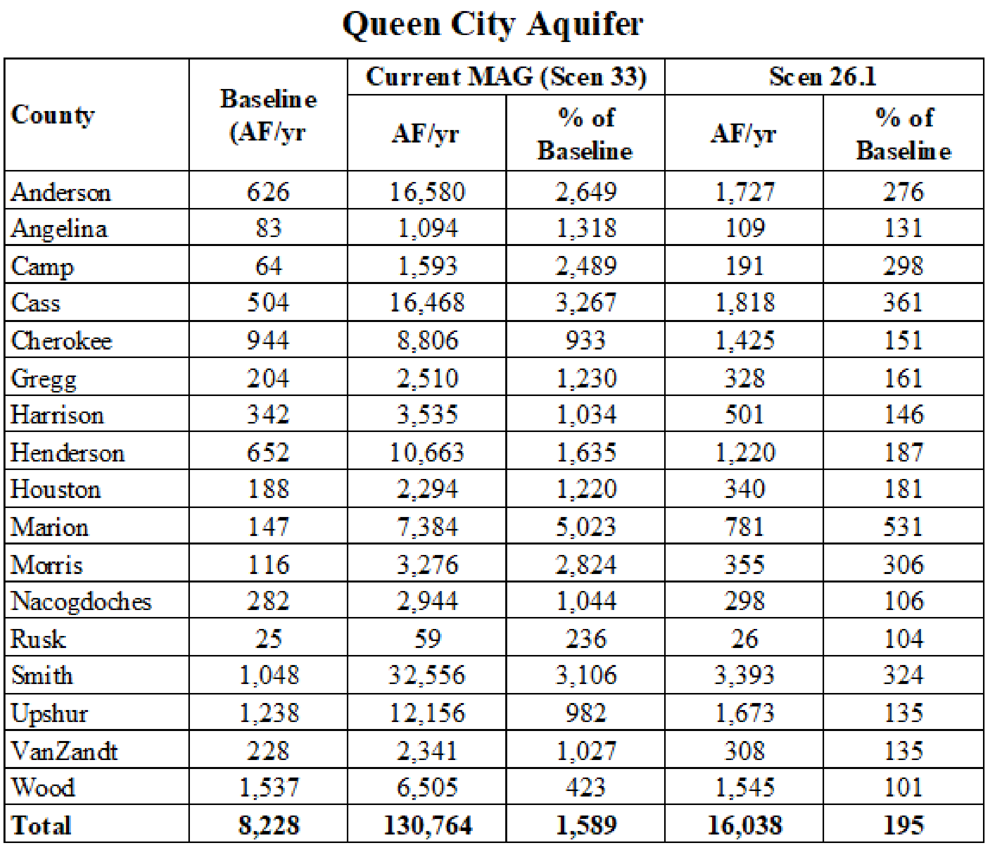
Table 2. Pumping Comparison - Sparta Aquifer



Sparta Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen 26.1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	39	307	787	307	787
Angelina	292	390	134	390	134
Cherokee	192	351	183	351	183
Houston	683	1,481	217	1,481	217
Nacogdoches	228	362	159	362	159
Sabine	47	49	104	49	104
SanAugustine	20	166	830	166	830
Trinity	15	152	1,013	152	1,013
Total	**1,516**	**3,258**	**215**	**3,258**	**215**

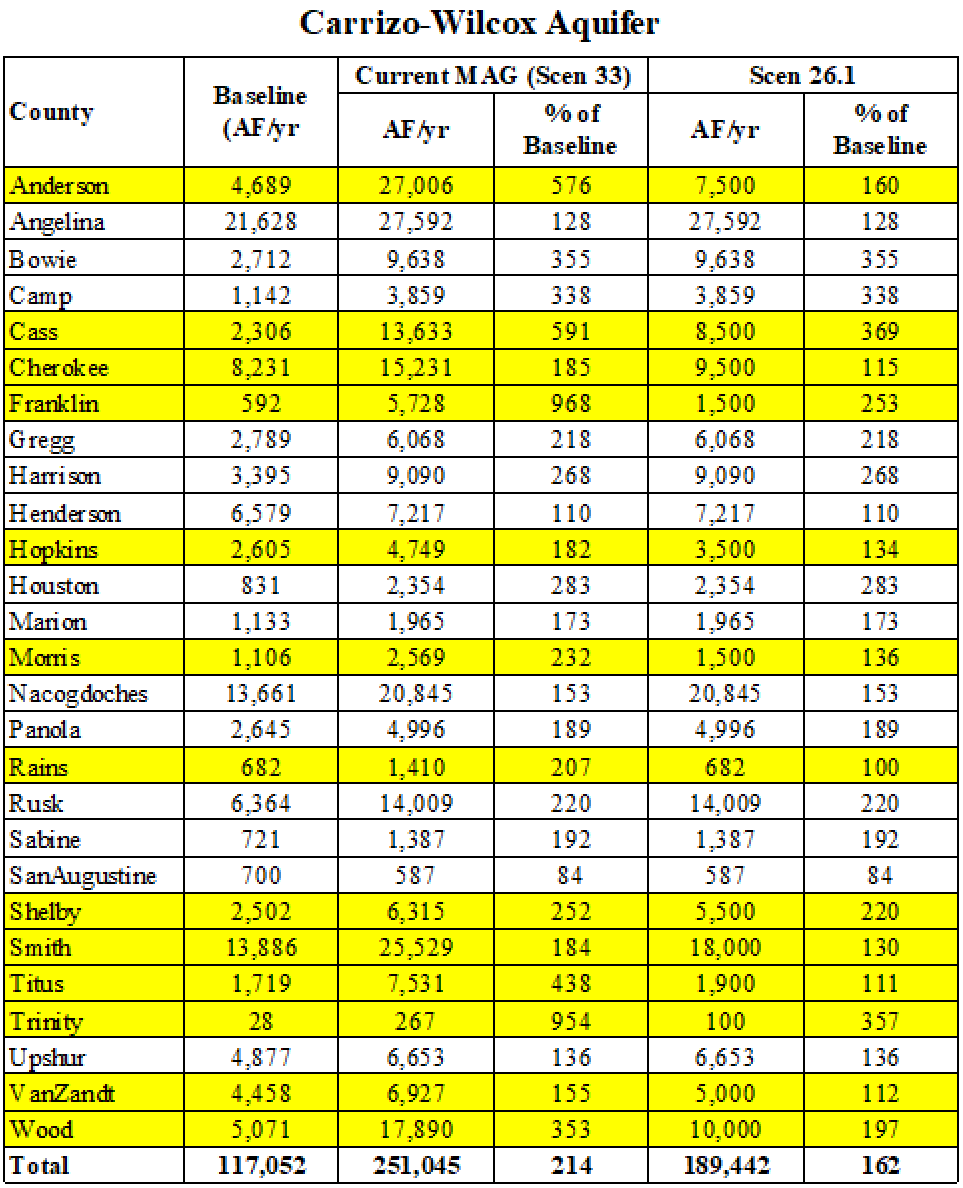
Table 3. Pumping Comparison – Queen City Aquifer



Queen City Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen 26.1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	626	16,580	2,649	1,727	276
Angelina	83	1,094	1,318	109	131
Camp	64	1,593	2,489	191	298
Cass	504	16,468	3,267	1,818	361
Cherokee	944	8,806	933	1,425	151
Gregg	204	2,510	1,230	328	161
Harrison	342	3,535	1,034	501	146
Henderson	652	10,663	1,635	1,220	187
Houston	188	2,294	1,220	340	181
Marion	147	7,384	5,023	781	531
Morris	116	3,276	2,824	355	306
Nacogdoches	282	2,944	1,044	298	106
Rusk	25	59	236	26	104
Smith	1,048	32,556	3,106	3,393	324
Upshur	1,238	12,156	982	1,673	135
VanZandt	228	2,341	1,027	308	135
Wood	1,537	6,505	423	1,545	101
Total	**8,228**	**130,764**	**1,589**	**16,038**	**195**

Table 4. Pumping Comparisons – Carrizo-Wilcox Aquifer



Carrizo-Wilcox Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen 26.1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	4,689	27,006	576	7,500	160
Angelina	21,628	27,592	128	27,592	128
Bowie	2,712	9,638	355	9,638	355
Camp	1,142	3,859	338	3,859	338
Cass	2,306	13,633	591	8,500	369
Cherokee	8,231	15,231	185	9,500	115
Franklin	592	5,728	968	1,500	253
Gregg	2,789	6,068	218	6,068	218
Harrison	3,395	9,090	268	9,090	268
Henderson	6,579	7,217	110	7,217	110
Hopkins	2,605	4,749	182	3,500	134
Houston	831	2,354	283	2,354	283
Marion	1,133	1,965	173	1,965	173
Morris	1,106	2,569	232	1,500	136
Nacogdoches	13,661	20,845	153	20,845	153
Panola	2,645	4,996	189	4,996	189
Rains	682	1,410	207	682	100
Rusk	6,364	14,009	220	14,009	220
Sabine	721	1,387	192	1,387	192
SanAugustine	700	587	84	587	84
Shelby	2,502	6,315	252	5,500	220
Smith	13,886	25,529	184	18,000	130
Titus	1,719	7,531	438	1,900	111
Trinity	28	267	954	100	357
Upshur	4,877	6,653	136	6,653	136
VanZandt	4,458	6,927	155	5,000	112
Wood	5,071	17,890	353	10,000	197
Total	**117,052**	**251,045**	**214**	**189,442**	**162**

6.3 Hydrologic Conditions in GMA 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.

6.3.1 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 B. Please note that these estimates are based on the previous GAM. TWDB has not yet updated these estimates with the updated GAM.

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

As detailed in the 2021 Explanatory Report, these estimates are likely overestimated by about 2 orders of magnitude due to misuse of the specific yield values in the old GAM. At the GMA 11 meeting of October 14, 2025, the presentation included updated estimates using the new GAM and included an analysis of the depth profile of the storage.

Figure 6 presents the depth profile of groundwater storage in the Carrizo-Wilcox Aquifer in GMA 11. Please note that the total storage is estimated to be about 20 million acre-feet. Based on the analysis, about 5 million acre-feet is in the upper 1,000 ft of the aquifer, and about 7 million acre-feet is in the upper 2,000 ft of the aquifer.

Total storage is not a useful metric for groundwater management and should be dropped as a factor in joint planning. Groundwater pumping is from a dynamic system (as noted in the discussion of the groundwater budget analysis), and storage generally plays a minor role in understanding groundwater availability and impacts of increased pumping.

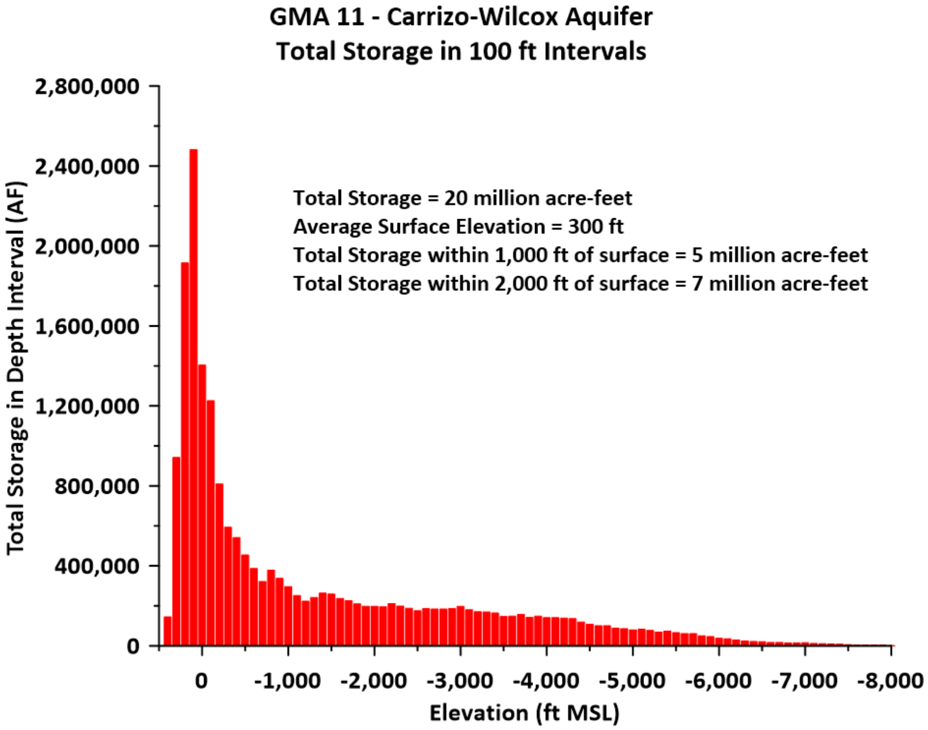


Figure 6. Total Groundwater Storage in GMA 11

6.3.2 Average Annual Recharge, Inflows, and Discharge

The 2021 Explanatory Report presented a groundwater budget analysis that estimated that the pumping increase associated with the desired future condition would be sourced as follows:

- Surface water: 72%
- Reduction in groundwater evapotranspiration: 15%
- Storage reduction: 3%
- GMA 12: 3%
- GMA 14: 3%
- Louisiana: 2%
- Overlying Formations: 1%

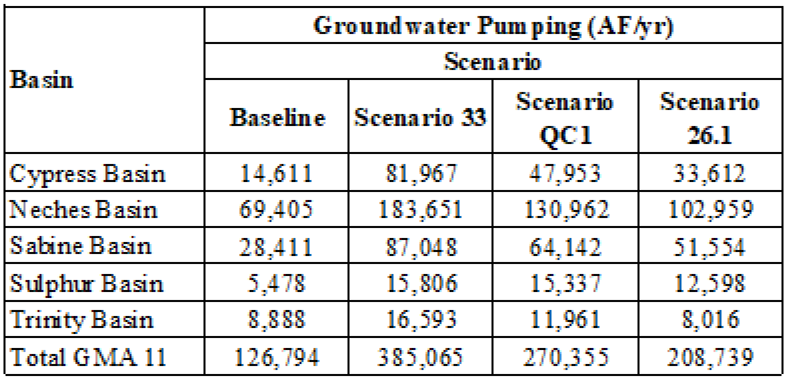
As detailed in Technical Memorandum 26-02 (Appendix A), the groundwater budget analysis for this round of joint planning was enhanced to include groundwater budgets for each major river basin in GMA 11 as defined by TWDB. For comparative purposes, groundwater budgets for four simulations were developed for each major river basin and are included in Technical Memorandum 26-02. Groundwater Pertinent details of that analysis are presented here.

Recharge to each river basin is the same in each scenario:

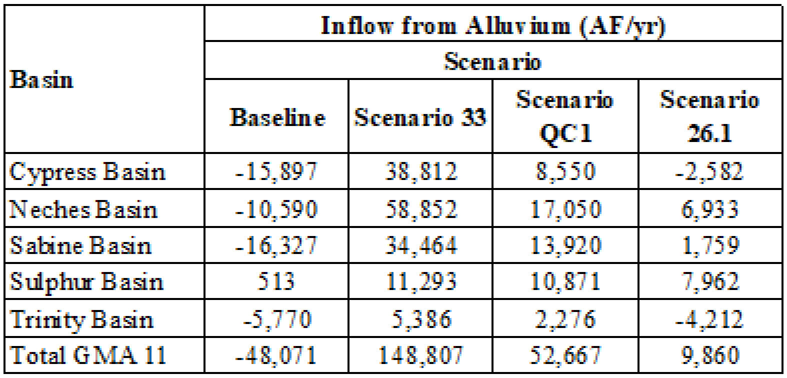
- Cypress: 48,254 AF/yr
- Neches: 89,945 AF/yr
- Sabine: 67,100 AF/yr
- Sulphur: 10,660 AF/yr
- Trinity: 19,373 AF/yr

Groundwater pumping for each scenario is presented in the upper part of Table 6. Inflow from the alluvial layer (taken to be the same as inflow from surface water over a long period) for each scenario is presented in the lower part of Table 6.

Table 6. Summary of Groundwater Pumping and Inflow from Alluvium



Basin	Groundwater Pumping (AF/yr)			
	Scenario			
	Baseline	Scenario 33	Scenario QC1	Scenario 26.1
Cypress Basin	14,611	81,967	47,953	33,612
Neches Basin	69,405	183,651	130,962	102,959
Sabine Basin	28,411	87,048	64,142	51,554
Sulphur Basin	5,478	15,806	15,337	12,598
Trinity Basin	8,888	16,593	11,961	8,016
Total GMA 11	126,794	385,065	270,355	208,739



Basin	Inflow from Alluvium (AF/yr)			
	Scenario			
	Baseline	Scenario 33	Scenario QC1	Scenario 26.1
Cypress Basin	-15,897	38,812	8,550	-2,582
Neches Basin	-10,590	58,852	17,050	6,933
Sabine Basin	-16,327	34,464	13,920	1,759
Sulphur Basin	513	11,293	10,871	7,962
Trinity Basin	-5,770	5,386	2,276	-4,212
Total GMA 11	-48,071	148,807	52,667	9,860

6.4 Other Environmental Impacts

This factor includes spring flow and other interactions between surface water and groundwater. The results from the groundwater budget analysis previously presented in Table 6 demonstrate the link between pumping and inflow from the alluvium. The details of this analysis are included in Technical Memorandum 26-02 (Appendix A) and were discussed at the GMA 11 meeting of March 10, 2026. The impact of increased pumping (as compared to the baseline scenario) on surface water inflow can be summarized as follows:

- Cypress Basin: Under baseline conditions, groundwater supplies a net of about 16,000 AF/yr of baseflow. Under the 2021 DFC, net baseflow is eliminated, and surface water provides about 39,000 AF/yr of recharge. Under Scenario 26.1 (the basis for the 2026 DFC), net baseflow conditions return and groundwater will provide about 2,600 AF/yr of baseflow.
- Neches Basin: Under baseline conditions, groundwater supplies a net of about 11,000 AF/yr of baseflow. Under the 2021 DFC, net baseflow is eliminated, and surface water provides about 59,000 AF/yr of recharge. Under Scenario 26.1 (the basis for the 2026 DFC), net baseflow conditions do not return, but the surface water recharge is reduced to about 7,000 AF/yr.
- Sabine Basin: Under baseline conditions, groundwater supplies a net of about 16,000 AF/yr of baseflow. Under the 2021 DFC, net baseflow is eliminated, and surface water provides about 34,000 AF/yr of recharge. Under Scenario 26.1 (the basis for the 2026 DFC), net baseflow conditions do not return, but the surface water recharge is reduced to about 2,000 AF/yr.
- Sulphur Basin: Under all scenarios, surface water provides recharge to groundwater. Under baseline conditions, recharge is about 500 AF/yr. Under the 2021 DFC, recharge is about 11,000 AF/yr. Under Scenario 26.1 (the basis for the 2026 DFC), the recharge is about 8,000 AF/yr.
- Trinity Basin: Under baseline conditions, groundwater supplies a net of about 6,000 AF/yr of baseflow. Under the 2021 DFC, net baseflow is eliminated, and surface water provides about 5,000 AF/yr of recharge. Under Scenario 26.1 (the basis for the 2026 DFC), net baseflow conditions return and groundwater will provide about 4,200 AF/yr of baseflow.

6.5 Subsidence

Subsidence has not been an issue historically in these aquifers. The Texas Water Development Board Subsidence Prediction Tool was used to assess the risk of subsidence in the future. This tool provides an overall risk score (0 is low risk and 10 is high risk). The application of this tool assumed the highest drawdown listed in Table 1 for each of the aquifers covered in this explanatory report.

For the Sparta Aquifer, it was assumed that the drawdown from 2013 to 2080 was 23 feet from Table 1 (Rusk County). The risk score was 4.22 and the predicted subsidence was 0.03 feet in 2080.

For the Queen City Aquifer, it was assumed that the drawdown from 2013 to 2080 was 10 feet from Table 1 (Rusk County). The risk score was 4.22 and the predicted subsidence in 2080 is 0.00 feet.

For the Carrizo-Wilcox Aquifer, it was assumed that the drawdown from 2013 to 2080 was 77 feet from Table 1 (Smith County). The risk score was 4.69 and the predicted subsidence was 0.24 feet in 2080.

6.6 Socioeconomic Impacts and Private Property Rights

The 2016 and 2021 Explanatory Reports discussed these items separately. The 2016 DFC focused almost entirely on meeting the state water plan needs, and the 2021 DFC met needs to the maximum extent possible under the sustainable pumping approach. Consequently, the Texas Water Development Board prepared reports for each Regional Planning Groups included in the Explanatory Reports. These reports detailed the socioeconomic impact of not meeting the water management strategies in Region D and Region I

The private property sections of the 2016 and 2021 Explanatory Reports stated that the increase in pumping would impact to existing well owners and to surface water resources, but, as part of balancing and given the lack of public participation, GMA 11 concluded that, on balance and with appropriate monitoring and project specific review during the permitting process, the DFC associated with a large pumping increase was approved.

In the current round of joint planning, public comments received at the October 14, 2025 GMA 11 meeting caused GMA 11 to reconsider its previous balancing conclusions. As part of the analysis during this round, additional analyses were completed to evaluate surface water impacts (as discussed above) and analyses were completed to more fully assess dry wells associated with pumping increases.

The analysis included identifying 4,217 wells in GMA 11 from the TWDB Groundwater Database that had good depth data. These wells are presented in Figure 7. Of course, these are not all the wells in GMA 11, but they provide a good framework to understand the potential for wells going dry under scenarios of increased pumping.

Under the current DFC adopted in 2021, about 46 percent of the Queen City wells and about 12 percent of the Carrizo-Wilcox wells would be dry by 2080. For the purposes of this analysis, it was assumed that if a well had less than 20 ft of available drawdown, it would be considered dry.

As presented during the March 10, 2026 GMA 11 meeting, the Scenario 26.1 was developed with the specific objective of reducing the percentage of dry wells in each aquifer and each county to less than 10 percent. Table 7 summarizes the dry well analysis by aquifer for all of GMA 11. Table 8 summarizes the dry well analysis by county for all aquifers and the Carrizo-Wilcox Aquifer. Please note that in each table, the results of the analysis for the previous DFC (Scenario 33) is compared with the results of the analysis for the DFC for this round of joint planning (Scenario 26.1). The yellow cells indicate that the 10 percent threshold is not met and the green cells represent the highest dry well percentage for the aquifer (Table 7) or for the county (Table 8). The two green cells in Table 8 represent one for all aquifers and one for the Carrizo-Wilcox Aquifer (labeled CW in the table).

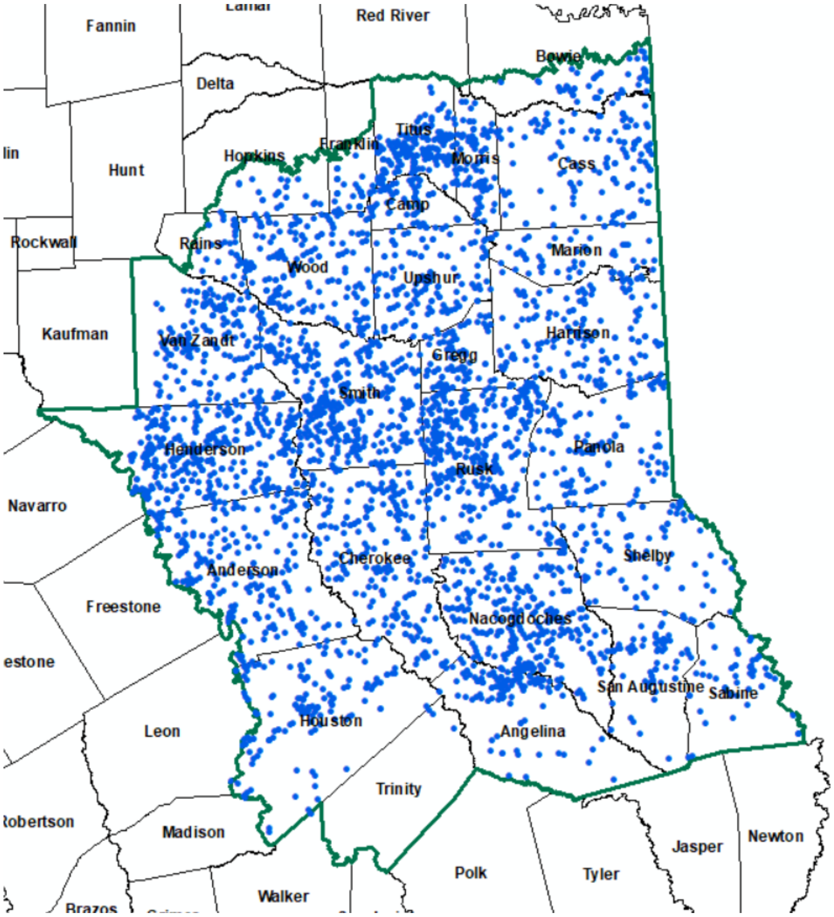


Figure 7. Well Locations in GMA 11

Table 7. Dry Well Analysis by Aquifer for GMA 11

Aquifer	Total Wells	Scen 33 (current DFC)		Scen 26.1	
		Dry Wells	Dry Well %	Dry Wells	Dry Well %
Sparta	155	7	4.5	3	1.9
Queen City	288	133	46.2	15	5.2
Carrizo-Wilcox	3405	297	8.7	56	1.6
All (including other formations)	4217	515	12.2	87	2.1

Table 8. Dry Well Analysis by County for GMA 11

County	Count	Avg Depth (ft)	Scen 33 (Current DFC)					Scen 26.1 (Current DFC)				
			Dry Wells	Dry Well %	CW Count	CW Dry Wells	CW Dry Well %	Dry Wells	Dry Well %	CW Count	CW Dry Wells	CW Dry Well %
Anderson	237	699	22	9.3	184	9	4.9	6	2.5	184	1	0.5
Angelina	118	1243	0	0.0	92	0	0.0	0	0.0	92	0	0.0
Bowie	50	207	3	6.0	46	2	4.3	3	6.0	46	2	4.3
Camp	80	415	4	5.0	72	3	4.2	0	0.0	72	0	0.0
Cass	162	366	28	17.3	115	1	0.9	2	1.2	115	0	0.0
Cherokee	255	408	84	32.9	154	54	35.1	16	6.3	154	11	7.1
Franklin	40	343	10	25.0	40	10	25.0	0	0.0	40	0	0.0
Gregg	107	457	12	11.2	100	5	5.0	2	1.9	100	0	0.0
Harrison	188	255	11	5.9	169	5	3.0	4	2.1	169	4	2.4
Henderson	370	444	44	11.9	314	30	9.6	7	1.9	314	4	1.3
Hopkins	25	357	1	4.0	25	1	4.0	1	4.0	25	1	4.0
Houston	155	756	1	0.6	40	0	0.0	0	0.0	40	0	0.0
Marion	61	334	3	4.9	36	0	0.0	0	0.0	36	0	0.0
Morris	98	292	21	21.4	68	7	10.3	5	5.1	68	2	2.9
Nacogdoches	315	439	25	7.9	229	11	4.8	12	3.8	229	7	3.1
Panola	136	263	2	1.5	133	2	1.5	1	0.7	133	1	0.8
Rains	31	203	3	9.7	30	3	10.0	1	3.2	30	1	3.3
Rusk	428	448	39	9.1	415	38	9.2	13	3.0	415	12	2.9
Sabine	55	831	1	1.8	31	1	3.2	1	1.8	31	1	3.2
SanAugustine	65	543	0	0.0	29	0	0.0	0	0.0	29	0	0.0
Shelby	105	360	3	2.9	103	3	2.9	2	1.9	103	2	1.9
Smith	375	645	105	28.0	282	36	12.8	6	1.6	282	3	1.1
Titus	190	275	41	21.6	187	39	20.9	0	0.0	187	0	0.0
Trinity	3	518	0	0.0	0	0	0.0	0	0.0	0	0	0.0
Upshur	150	473	17	11.3	129	9	7.0	3	2.0	129	2	1.6
VanZandt	218	371	16	7.3	209	11	5.3	2	0.9	209	2	1.0
Wood	200	462	19	9.5	173	17	9.8	0	0.0	173	0	0.0

6.7 Feasibility of Achieving the Desired Future Conditions

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.

At the request of GMA 11, a comparison of measured drawdown and simulated drawdown from the simulation that was the basis for the 2021 DFC was completed. The draft report (Hutchison, 2024, dated May 2, 2024) was discussed at the GMA 11 meeting on May 15, 2024.

Measured drawdown was obtained for 259 wells with groundwater elevation data at the end of 2013 as shown in Figure 8. The baseline year of 2013 corresponds to the starting point for drawdown calculations in the desired future conditions.

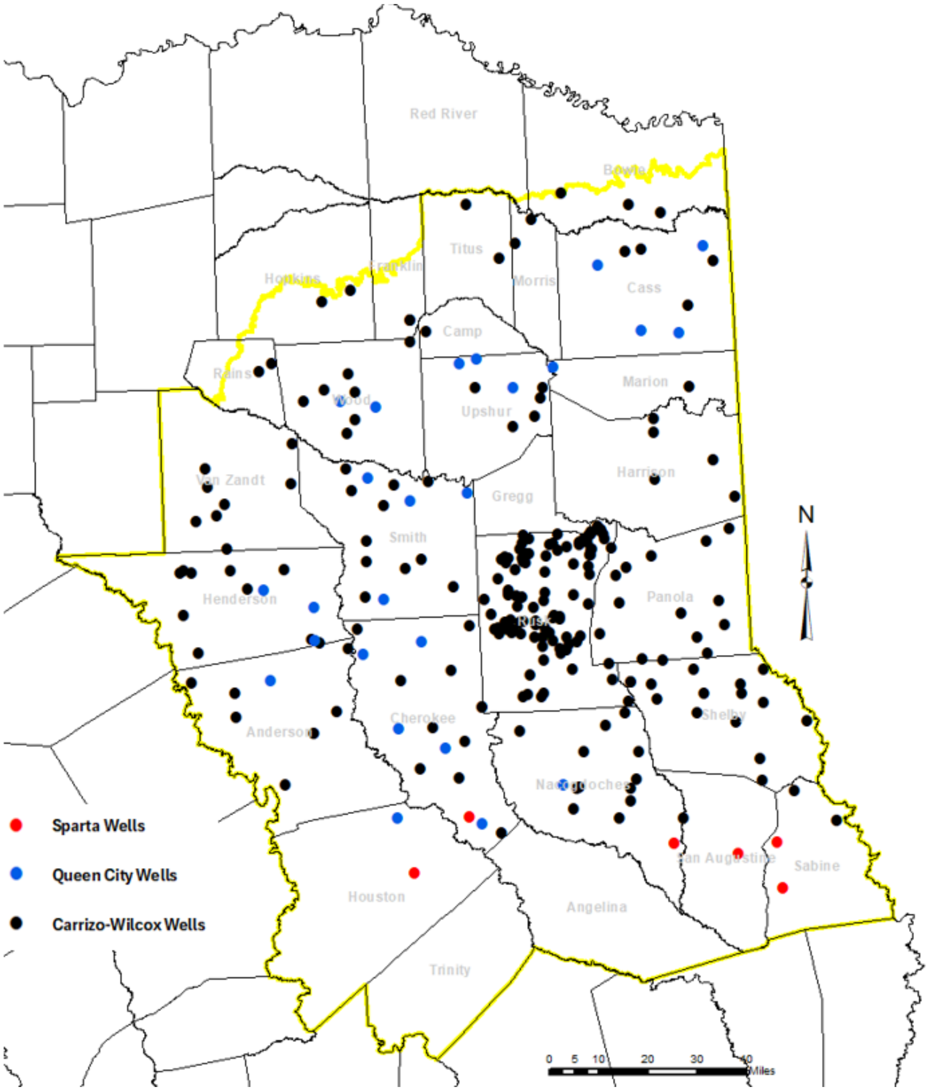


Figure 8. Well Locations for Drawdown Comparison

Figure 9 presents the results of the analysis for all of GMA 11. Please note the diagonal

For this analysis, it is important to note that the DFC simulation is not an actual "prediction" because the simulated drawdown is associated with an assumed level of pumping (the modeled available groundwater). The analysis demonstrated that there are no areas of GMA 11 that are inconsistent with the DFC (99% of measured drawdowns are less than simulated drawdowns).

This method will be the basis for future comparisons with the new DFC to assess achievement.

6.9 Other Information

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 is presented in Appendix C.

7.0 Discussion of Other Desired Future Conditions Considered

7.1 Past Desired Future Conditions

Simulations associated with the joint planning process in 2010 and 2016 provided a basis for comparing various levels of pumping and the associated impacts to the nine statutory factors. Results of these simulations were presented at GMA 11 meetings and in technical memoranda.

The release of the updated GAM in late 2020 prevented the running of large number of simulations during this round of joint planning. However, the predictive simulations developed as part of the development of the updated GAM as documented in Panday and others (2020) provided a solid foundation to understand the impacts of alternative pumping and recharge scenarios.

Limitations associated with the old GAM resulted in an underprediction of average drawdowns due to the issues of recharge and the inability of water to move from the outcrop areas to the downdip areas of the aquifers. The updated GAM has corrected these limitations.

As noted in the 2021 Explanatory Report, based on the simulations with the new GAM, the pumping associated with the previous round of joint planning and the groundwater availability in the Region D and Region I water plans cannot be sustained with the assumed geographic distribution of pumping used in the predictive scenario. GMA 11 considered desired future conditions that would have resulted in decreasing pumping from 2020 to 2080. This option was rejected partly due to a lack of public input and partly because it would complicate the regional planning process as groundwater availability would decrease each decade.

Also as noted in the 2021 Explanatory Report, the modeled available groundwater values associated with these desired future conditions were less than the groundwater availability values associated with the previous round of joint planning and lower than the values in the regional plans. This was not an arbitrary reduction, nor a reduction based on regulation. The reduction reflects the results of an updated and improved groundwater model to make such predictions.

7.2 2026 Desired Future Conditions

As noted above, this round of joint planning included public input that guided the GAM simulations. After evaluating the impacts of the 2021 DFC, twenty simulations were completed to further assess the impacts of increased pumping on groundwater-surface water impacts and analyzed the impact of increased pumping on the number of dry wells that would occur.

Based on the results, a simulation that was designed to reduce surface water and limit the number of dry wells to 10 percent in each county-aquifer unit.

8.0 Discussion of Other Recommendations

To be completed after public comment period.

9.0 References

Hutchison, W.R., 2024. Comparison of Measured Drawdown with Simulated Drawdown from the Desired Future Conditions Adopted in 2021 in Groundwater Management Area 11. Report prepared for GMA 11, May 2, 2024 (draft), 42p.

Hutchison, W.R., 2026. Documentation of Updated Specific Yield Values for the Groundwater Availability Model of the Northern Portion of the Carrizo-Wilcox, Queen City, and Sparta Aquifers. Report prepared for Groundwater Management Area 11. January 28, 2026, 9p.

Kelley, V.A., Deeds, N.E., Fryar, D.G., and Nicot, J.P., 2004. Groundwater Availability Model for the Queen City and Sparta Aquifers. INTERA Incorporated report prepared for the Texas Water Development Board, October 2004, 867p.

Panday, S., Rumbaugh, J., Hutchison, W.R., Schorr, S., 2020. Numerical Model Report: Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers. Final Report prepared for Texas Water Development Board, Contact Number #1648302063. 198p.

Rubenstein, C., and Puig-Williams, V., 2023. Improving Water Planning in Texas, The Critical but Overlooked Link Between Desired Future Conditions and the State Water Plan. Report by Environmental Defense Fund, January 2023, 33p.

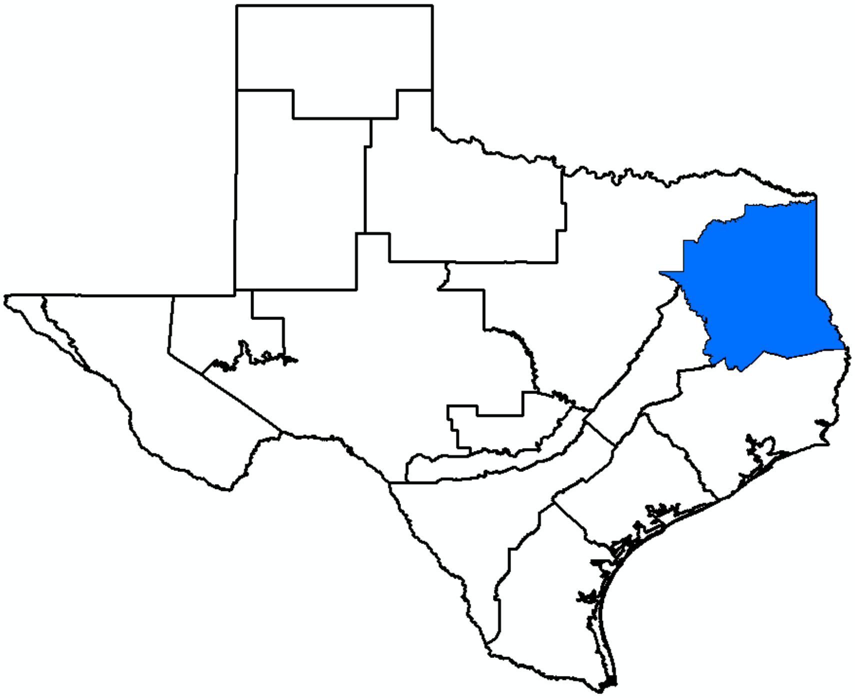
Wade, S., Shi, J., and Seiter-Weatherford, C., 2014. GAM Task 13-034: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 11. Texas Water Development Board, Groundwater Resources Division, April 2, 2014, 30 p.

Appendix A

Technical Memorandum 26-02: Documentation of GMA 11 Pumping Scenarios to Simulate Reduction in Queen City and Carrizo-Wilcox Pumping Relative to Scenario 33 Pumping

GMA 11 Technical Memorandum 26-02 (Draft 1)

Documentation of GMA 11 Pumping Scenarios to Simulate Reduction in Queen City and Carrizo-Wilcox Pumping Relative to Scenario 33 Pumping



Prepared for:
Groundwater Management Area 11

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February 26, 2026

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Draft – To be Signed and Stamped When Final

1.0 Introduction and Background

1.1 GMA 11 Meeting of October 14, 2025

At the GMA 11 meeting of October 14, 2025, the GAM simulation that formed the basis for the current desired future condition (Scenario 33) was reviewed. The review included evaluating simulation output related to estimated dry well impacts and surface water-groundwater impacts. In summary, the significant groundwater pumping increase (as compared with historic groundwater pumping) that is associated with Scenario 33 would result in about 568 dry wells (13 percent of the 4,217 wells available in the database) and about 184,089 AF/yr of the 255,370 AF/yr pumping increase would be sourced from surface water (about 72 percent of the pumping increase).

1.2 Updated Dry Well Analysis for Scenario 33

The TWDB database contains the locations of 5,786 wells in GMA 11. Of these, 4,217 wells had good data on well depth. These 4,217 wells were then located on the model grid, including which layer the bottom of the well is completed. The locations of these 4,217 wells is presented in Figure 1.

These wells, of course, and not all the wells in GMA 11. However, the number of wells and geographic distribution are adequate to assess the impact of increased or decreased pumping on whether the well remains productive or "goes dry". For the purposes of this analysis, if the groundwater level in the wells drops to the point where there is less than 20 feet of water in the well, it is considered "dry".

An update to the Groundwater Availability Model for the northern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Panday and others, 2020) has been completed and is documented in Hutchison (2026). In summary, specific yield values in the alluvial layer (layer 1) were specified as 0.1 in the updated model. This update resulted in slightly different dry well counts for Scenario 33 as compared to those reported at the GMA 11 meeting of October 14, 2025 as presented in Table 1.

Table 2 presents the dry well count by county using the updated GAM. Please note that Scenario 33 suggests that the dry well rate in nine counties would be over 10 percent in 2080.

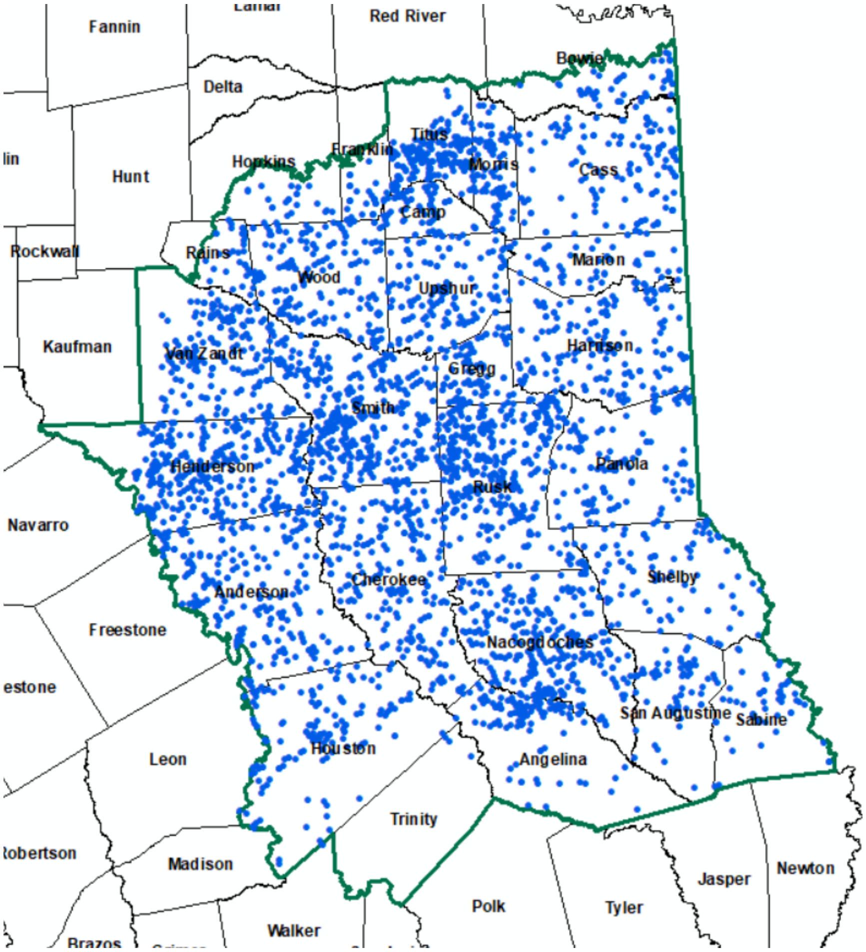


Figure 1. Location of 4,217 Wells in GMA 11 (TWDB Database)

Table 1. Summary of Dry Well Counts for Scenario 33: Original GAM and Updated GAM

Aquifer	Well Count	Original Scenario 33 (Basis for DFC)		Updated Scenario 33 (Adjusted Specific Yield Values)	
		Dry Wells in 2080 (Count)	Dry Wells in 2080 (% of Well Count)	Dry Wells in 2080 (Count)	Dry Wells in 2080 (% of Well Count)
Sparta	155	7	5	7	5
Queen City	288	139	48	133	46
Carrizo-Wilcox	3405	340	10	297	9
All	4217	568	13	515	12

Table 2. Summary of Dry Well Counts by County for Scenario 33 (Updated GAM)

County	Well Count	Average Depth (ft)	Dry Wells in 2080 (Count)	Dry Wells in 2080 (% of Count)
Anderson	237	699	22	9
Angelina	118	1243	0	0
Bowie	50	207	3	6
Camp	80	415	4	5
Cass	162	366	28	17
Cherokee	255	408	84	33
Franklin	40	343	10	25
Gregg	107	457	12	11
Harrison	188	255	11	6
Henderson	370	444	44	12
Hopkins	25	357	1	4
Houston	155	756	1	1
Marion	61	334	3	5
Morris	98	292	21	21
Nacogdoches	315	439	25	8
Panola	136	263	2	1
Rains	31	203	3	10
Rusk	428	448	39	9
Sabine	55	831	1	2
SanAugustine	65	543	0	0
Shelby	105	360	3	3
Smith	375	645	105	28
Titus	190	275	41	22
Trinity	3	518	0	0
Upshur	150	473	17	11
VanZandt	218	371	16	7
Wood	200	462	19	10

1.3 Updated Scenarios

At the October 14, 2025 meeting, GMA 11 approved additional simulations to evaluate the effects of reducing groundwater pumping in the Queen City and Carrizo-Wilcox aquifers as compared with Scenario 33. This technical memorandum documents these simulations. Also, this technical memorandum documents a baseline simulation (pumping from 2013 repeated annually from 2014 to 2080). Finally, after evaluating the results, a final simulation (named Scenario 26.1) that involved targeted reductions in pumping to limit the dry wells in each county to less than 10 percent.

The results of these simulations focused on reducing the number of dry wells and reducing the surface water impact of increased pumping. Of note is that the groundwater budget analysis has been revised. The groundwater budget analysis presented at the GMA 11 meeting of October 14, 2025 used the entirety of GMA 14 as the area of interest. The groundwater budgets presented in this Technical Memorandum are presented for each river basin in GMA 11 to better characterize areas of concern.

Please note that all files associated with this Technical Memorandum are available for download at:

https://drive.google.com/drive/folders/1OVEA0S6SDPB4NG1XkS4u0AG82QZsTd1w?usp=sharing

2.0 Pumping Reduction Scenarios

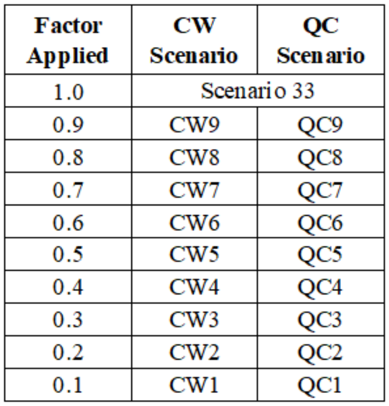
2.1 Baseline Simulation

Prior to developing the pumping reduction scenarios, a baseline scenario was developed that assumed that 2013 pumping (the last year of the model calibration period) was repeated from 2014 to 2080. This baseline simulation provides a more stable set of results to compare and assess changes associated with other predictive simulations.

2.2 Initial Bounding Simulations

The pumping reduction scenarios started with Scenario 33 (the basis for the current DFC). Nine scenarios of pumping reduction in the Carrizo-Wilcox Aquifer (CW) were developed and nine scenarios of pumping reduction in the Queen City Aquifer (QC) were also developed. A pumping reduction factor was applied on a cell-by-cell basis for each scenario with the caveat that pumping could not drop below 2013 pumping (as defined in the calibrated model) for a specific cell. Table 3 summarizes the scenarios.

Table 3. Pumping Reduction Scenarios



Factor Applied	CW Scenario	QC Scenario
1.0	Scenario 33	
0.9	CW9	QC9
0.8	CW8	QC8
0.7	CW7	QC7
0.6	CW6	QC6
0.5	CW5	QC5
0.4	CW4	QC4
0.3	CW3	QC3
0.2	CW2	QC2
0.1	CW1	QC1

2.2.1 Dry Well Analysis Results of Initial Bounding Simulations

Summary results of the pumping reduction scenarios included tracking the number of dry wells in the Queen City and Carrizo-Wilcox Aquifers. Figure 2 presents the summary for Queen City wells. Figure 3 presents the summary for Carrizo-Wilcox wells. Please note that as pumping decreases, the number of dry wells decrease (expressed as a percentage of all wells).

Also, please note that when pumping is reduced in the Queen City Aquifer, not only is there a reduction in dry wells in the Queen City Aquifer, the number of Carrizo-Wilcox dry wells also is decreased. Similarly, when pumping is reduced in the Carrizo-Wilcox Aquifer, not only is there a reduction in dry wells in the Carrizo-Wilcox Aquifer, the number of Queen City dry wells is also reduced. These results highlight the vertical connection between formations in GMA 11.

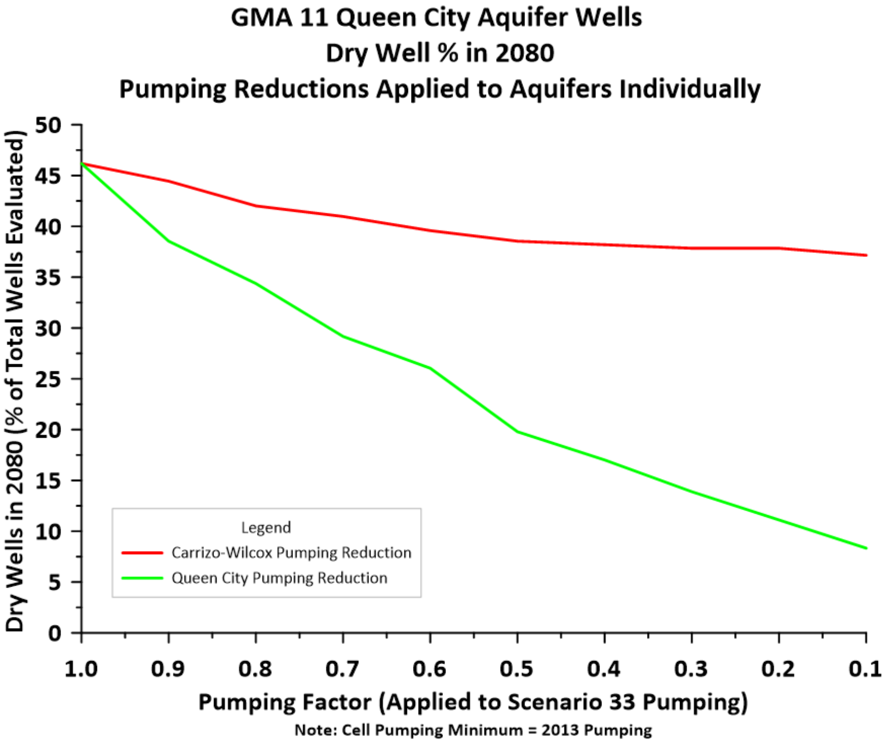


Figure 2. Initial Bounding Simulations Dry Well Analysis: Queen City Wells

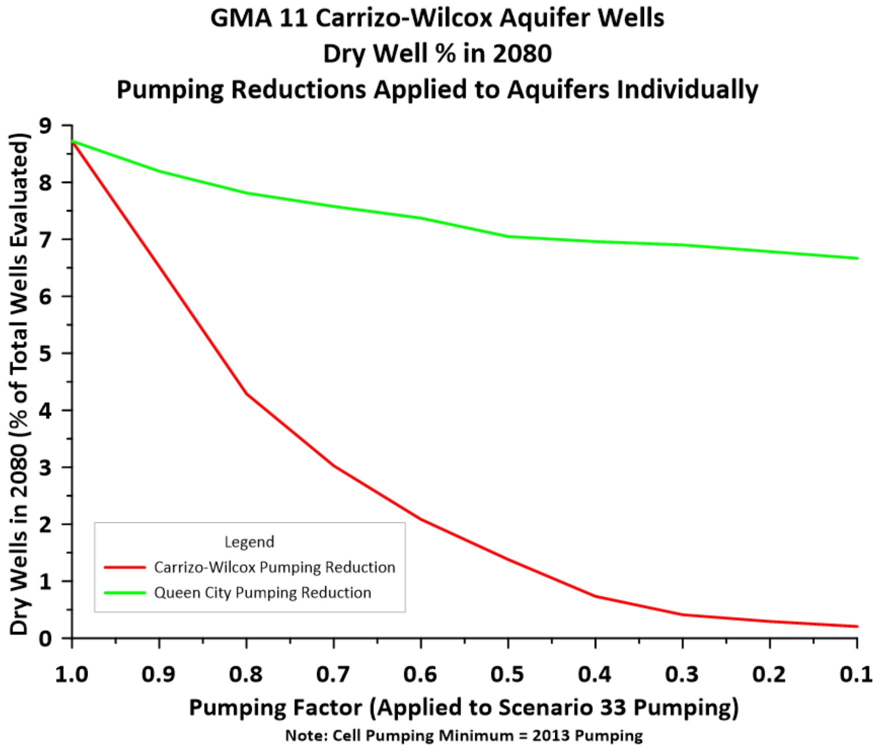


Figure 3. Initial Bounding Simulations Dry Well Analysis: Carrizo-Wilcox Wells

Table 4 presents the county summary of dry wells for Scenario QC1. Please note that the analysis includes all wells and Carrizo-Wilcox wells. Please note that several counties have more than 10 percent of their wells go dry under this scenario.

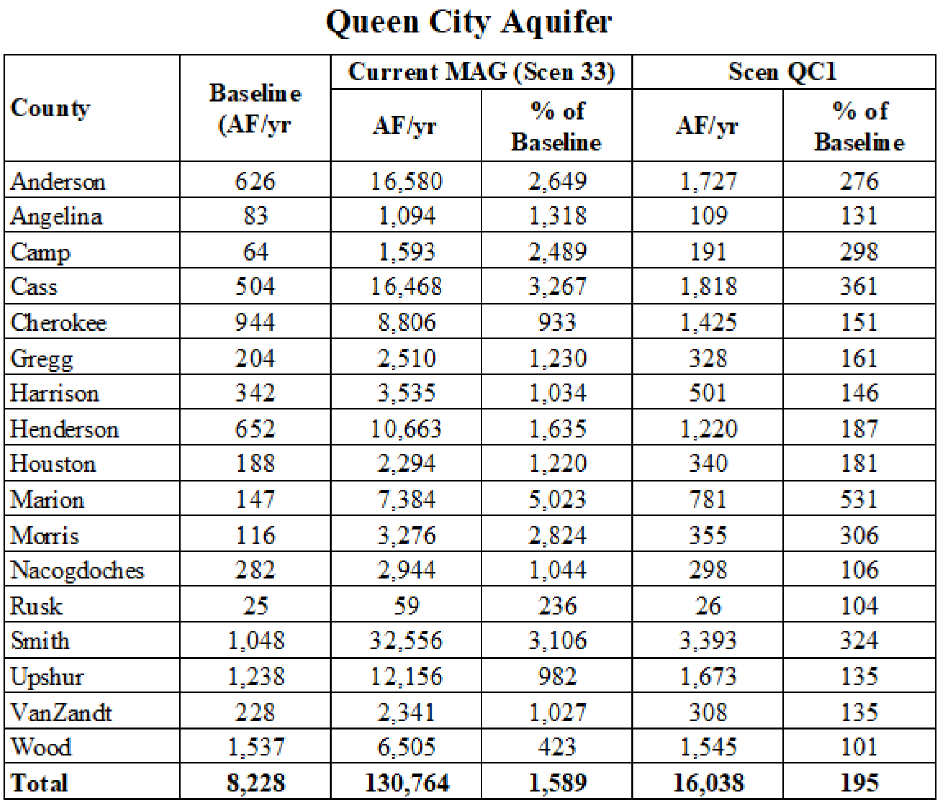
Table 4. Dry Wells Analysis by County - Scenario QC1

County	Count	Avg Depth (ft)	Scenario QC1					
			Dry Wells	Dry Well %	CW Count	CW Dry Wells	CW Dry Well %
Anderson	237	699	12	5	184	7	4
Angelina	118	1243	0	0	92	0	0
Bowie	50	207	3	6	46	2	4
Camp	80	415	3	4	72	3	4
Cass	162	366	5	3	115	1	1
Cherokee	255	408	51	20	154	39	25
Franklin	40	343	10	25	40	10	25
Gregg	107	457	3	3	100	1	1
Harrison	188	255	6	3	169	5	3
Henderson	370	444	24	6	314	16	5
Hopkins	25	357	1	4	25	1	4
Houston	155	756	1	1	40	0	0
Marion	61	334	0	0	36	0	0
Morris	98	292	12	12	68	7	10
Nacogdoches	315	439	16	5	229	11	5
Panola	136	263	2	1	133	2	2
Rains	31	203	3	10	30	3	10
Rusk	428	448	32	7	415	31	7
Sabine	55	831	1	2	31	1	3
SanAugustine	65	543	0	0	29	0	0
Shelby	105	360	3	3	103	3	3
Smith	375	645	33	9	282	22	8
Titus	190	275	39	21	187	37	20
Trinity	3	518	0	0	0	0	0
Upshur	150	473	9	6	129	7	5
VanZandt	218	371	9	4	209	8	4
Wood	200	462	10	5	173	10	6

2.2.2 Pumping in Scenario QC1

While all pumping reductions yield fewer dry wells, the reductions in the Queen City Aquifer pumping have the most benefit, not only to Queen City wells, but also to Carrizo-Wilcox wells. It should be noted that Scenario QC1 (a 90 percent reduction in Queen City pumping from Scenario 33 pumping) still represents a large increase in historic pumping as shown in Table 5.

Table 5. Queen City Pumping Comparison (Baseline, Scenario 33, and Scenario QC1)



Queen City Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen QC1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	626	16,580	2,649	1,727	276
Angelina	83	1,094	1,318	109	131
Camp	64	1,593	2,489	191	298
Cass	504	16,468	3,267	1,818	361
Cherokee	944	8,806	933	1,425	151
Gregg	204	2,510	1,230	328	161
Harrison	342	3,535	1,034	501	146
Henderson	652	10,663	1,635	1,220	187
Houston	188	2,294	1,220	340	181
Marion	147	7,384	5,023	781	531
Morris	116	3,276	2,824	355	306
Nacogdoches	282	2,944	1,044	298	106
Rusk	25	59	236	26	104
Smith	1,048	32,556	3,106	3,393	324
Upshur	1,238	12,156	982	1,673	135
VanZandt	228	2,341	1,027	308	135
Wood	1,537	6,505	423	1,545	101
Total	**8,228**	**130,764**	**1,589**	**16,038**	**195**

2.3 Scenario 26.1

The pumping reduction scenarios described above relied on global pumping reductions applied over an entire aquifer. The analysis showed that Scenario QC1 still represents an increase in pumping compared to historic pumping in the Queen City Aquifer. However, there are still several counties with a relatively high percentage of dry wells.

Scenario 26.1 was developed with the objective of reducing pumping on a county basis such that no county would have more than 10 percent dry wells (all wells and Carrizo-Wilcox Aquifer wells). Limiting the dry wells to 10 percent is an example of avoiding an undesirable effect that is central to the definition of sustainable yield.

The 10 percent standard could be considered arbitrary, but it appears a reasonable point to balance the maximum practicable use of groundwater and conservation of groundwater required in the Texas Water Code for joint planning. Wells represent a significant property right for most rural residents of GMA 11 and the impact of dry wells would certainly fit into the category of socioeconomic impacts. Both property rights and socioeconomic impacts are factors in joint planning.

2.3.1 Sparta Pumping

Scenario 26.1 pumping for the Sparta Aquifer is presented in Table 6 and remains unchanged from Scenario 33 (the basis for the current DFC). Pumping in the Sparta Aquifer is generally low and the dry well rate is below the acceptable threshold used for this analysis.

Table 6. Scenario 26.1 Pumping - Sparta Aquifer

Sparta Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen 26.1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	39	307	787	307	787
Angelina	292	390	134	390	134
Cherokee	192	351	183	351	183
Houston	683	1,481	217	1,481	217
Nacogdoches	228	362	159	362	159
Sabine	47	49	104	49	104
SanAugustine	20	166	830	166	830
Trinity	15	152	1,013	152	1,013
Total	**1,516**	**3,258**	**215**	**3,258**	**215**

2.3.2 Queen City Pumping

Scenario 26.1 pumping for the Queen City Aquifer is presented in Table 7 and is the same as Queen City Aquifer pumping from Scenario QC1 presented and discussed above.

Table 7. Scenario 26.1 Pumping – Queen City Aquifer

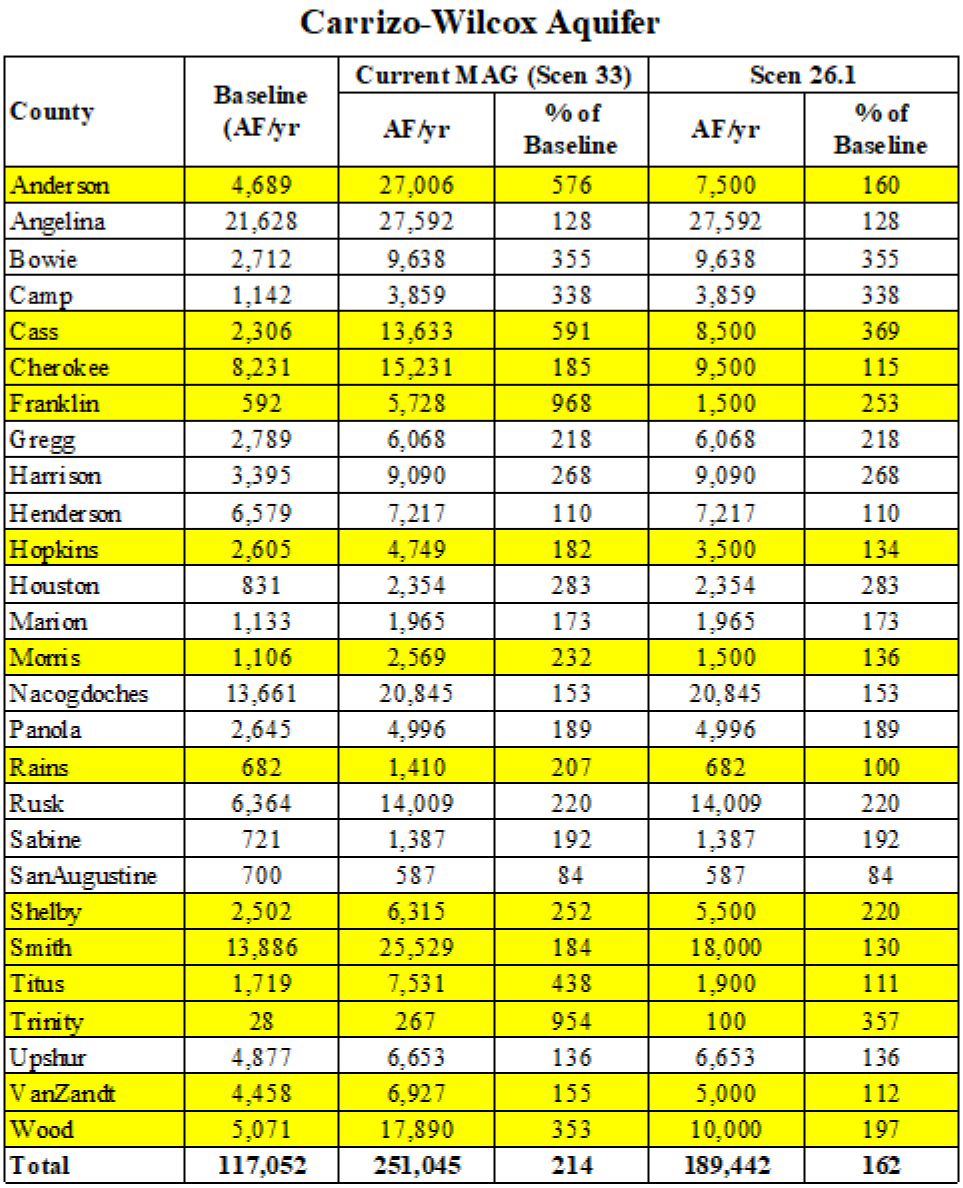
Queen City Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen 26.1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	626	16,580	2,649	1,727	276
Angelina	83	1,094	1,318	109	131
Camp	64	1,593	2,489	191	298
Cass	504	16,468	3,267	1,818	361
Cherokee	944	8,806	933	1,425	151
Gregg	204	2,510	1,230	328	161
Harrison	342	3,535	1,034	501	146
Henderson	652	10,663	1,635	1,220	187
Houston	188	2,294	1,220	340	181
Marion	147	7,384	5,023	781	531
Morris	116	3,276	2,824	355	306
Nacogdoches	282	2,944	1,044	298	106
Rusk	25	59	236	26	104
Smith	1,048	32,556	3,106	3,393	324
Upshur	1,238	12,156	982	1,673	135
VanZandt	228	2,341	1,027	308	135
Wood	1,537	6,505	423	1,545	101
Total	**8,228**	**130,764**	**1,589**	**16,038**	**195**

2.3.3 Carrizo-Wilcox Pumping

Scenario 26.1 pumping in the Carrizo-Wilcox Aquifer is presented in Table 8. Please note that counties with pumping reductions (as compared with the current MAG) are highlighted in yellow.

Table 8. Scenario 26.1 Pumping – Carrizo-Wilcox Aquifer



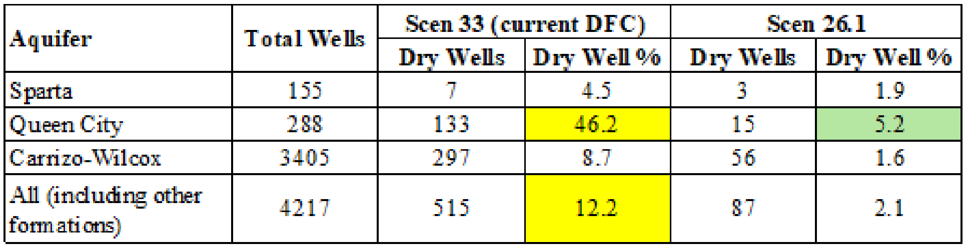
Carrizo-Wilcox Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen 26.1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	4,689	27,006	576	7,500	160
Angelina	21,628	27,592	128	27,592	128
Bowie	2,712	9,638	355	9,638	355
Camp	1,142	3,859	338	3,859	338
Cass	2,306	13,633	591	8,500	369
Cherokee	8,231	15,231	185	9,500	115
Franklin	592	5,728	968	1,500	253
Gregg	2,789	6,068	218	6,068	218
Harrison	3,395	9,090	268	9,090	268
Henderson	6,579	7,217	110	7,217	110
Hopkins	2,605	4,749	182	3,500	134
Houston	831	2,354	283	2,354	283
Marion	1,133	1,965	173	1,965	173
Morris	1,106	2,569	232	1,500	136
Nacogdoches	13,661	20,845	153	20,845	153
Panola	2,645	4,996	189	4,996	189
Rains	682	1,410	207	682	100
Rusk	6,364	14,009	220	14,009	220
Sabine	721	1,387	192	1,387	192
SanAugustine	700	587	84	587	84
Shelby	2,502	6,315	252	5,500	220
Smith	13,886	25,529	184	18,000	130
Titus	1,719	7,531	438	1,900	111
Trinity	28	267	954	100	357
Upshur	4,877	6,653	136	6,653	136
VanZandt	4,458	6,927	155	5,000	112
Wood	5,071	17,890	353	10,000	197
Total	**117,052**	**251,045**	**214**	**189,442**	**162**

3.0 Dry Well Analysis (Scenario 33 and Scenario 26.1)

Table 9 presents the dry well analysis organized by aquifer for Scenario 33 and Scenario 26.1. Please note that in Scenario 33, over 46 percent of the wells go dry in the Queen City Aquifer, and over 12 percent of the wells go dry overall. The yellow shading represents exceedance of the 10 percent threshold discussed above. However, in Scenario 26.1, all aquifers meet the threshold of less than 10 percent dry wells. The Queen City is the highest at about 5 percent, as noted by the green shading.

Table 9. Dry Well Analysis - Scenario 26.1 (Aquifer Based)



Aquifer	Total Wells	Scen 33 (current DFC)		Scen 26.1	
		Dry Wells	Dry Well %	Dry Wells	Dry Well %
Sparta	155	7	4.5	3	1.9
Queen City	288	133	46.2	15	5.2
Carrizo-Wilcox	3405	297	8.7	56	1.6
All (including other formations)	4217	515	12.2	87	2.1

Table 10 presents the dry well analysis organized by county for Scenario 33 and Scenario 26.1. Please note that in Scenario 33, the dry well threshold of 10 percent is exceeded in nine counties for all wells, and in five counties in Carrizo-Wilcox wells, as noted by the yellow shading. However, in Scenario 26.1, all counties have met the 10 percent dry well threshold. The highest dry well percentage for both all wells and Carrizo-Wilcox wells is Cherokee County.

Table 10. Dry Well Analysis - Scenario 26.1 (County Based)

County	Count	Avg Depth (ft)	Scen 33 (Current DFC)					Scen 26.1 (Current DFC)				
			Dry Wells	Dry Well %	CW Count	CW Dry Wells	CW Dry Well %	Dry Wells	Dry Well %	CW Count	CW Dry Wells	CW Dry Well %
Anderson	237	699	22	9.3	184	9	4.9	6	2.5	184	1	0.5
Angelina	118	1243	0	0.0	92	0	0.0	0	0.0	92	0	0.0
Bowie	50	207	3	6.0	46	2	4.3	3	6.0	46	2	4.3
Camp	80	415	4	5.0	72	3	4.2	0	0.0	72	0	0.0
Cass	162	366	28	17.3	115	1	0.9	2	1.2	115	0	0.0
Cherokee	255	408	84	32.9	154	54	35.1	16	6.3	154	11	7.1
Franklin	40	343	10	25.0	40	10	25.0	0	0.0	40	0	0.0
Gregg	107	457	12	11.2	100	5	5.0	2	1.9	100	0	0.0
Harrison	188	255	11	5.9	169	5	3.0	4	2.1	169	4	2.4
Henderson	370	444	44	11.9	314	30	9.6	7	1.9	314	4	1.3
Hopkins	25	357	1	4.0	25	1	4.0	1	4.0	25	1	4.0
Houston	155	756	1	0.6	40	0	0.0	0	0.0	40	0	0.0
Marion	61	334	3	4.9	36	0	0.0	0	0.0	36	0	0.0
Morris	98	292	21	21.4	68	7	10.3	5	5.1	68	2	2.9
Nacogdoches	315	439	25	7.9	229	11	4.8	12	3.8	229	7	3.1
Panola	136	263	2	1.5	133	2	1.5	1	0.7	133	1	0.8
Rains	31	203	3	9.7	30	3	10.0	1	3.2	30	1	3.3
Rusk	428	448	39	9.1	415	38	9.2	13	3.0	415	12	2.9
Sabine	55	831	1	1.8	31	1	3.2	1	1.8	31	1	3.2
SanAugustine	65	543	0	0.0	29	0	0.0	0	0.0	29	0	0.0
Shelby	105	360	3	2.9	103	3	2.9	2	1.9	103	2	1.9
Smith	375	645	105	28.0	282	36	12.8	6	1.6	282	3	1.1
Titus	190	275	41	21.6	187	39	20.9	0	0.0	187	0	0.0
Trinity	3	518	0	0.0	0	0	0.0	0	0.0	0	0	0.0
Upshur	150	473	17	11.3	129	9	7.0	3	2.0	129	2	1.6
VanZandt	218	371	16	7.3	209	11	5.3	2	0.9	209	2	1.0
Wood	200	462	19	9.5	173	17	9.8	0	0.0	173	0	0.0

4.0 Groundwater Budget Analyses

Groundwater budgets quantify the inflows to, outflows from, and storage change within an specified geographic area. During the GMA 11 meeting of October 14, 2025, the groundwater budgets that had been presented in the 2021 GMA 11 Explanatory Report were discussed. These groundwater budgets defined the geographic area as GMA 11 (with the alluvial layer as separate zone). In order to provide a more granular analysis for this effort, the zones were redefined by river basin and GMA.

4.1 Zone Definition

Each cell in the model was given a three-digit code. The first digit is based on the basin, or state (for cells outside Texas):

- 1 = Arkansas
- 2 = Brazos Basin
- 3 = Cypress Basin
- 4 = Louisiana
- 5 = Neches Basin
- 6 = Sabine Basin
- 7 = San Jacinto Basin
- 8 = Sulphur Basin
- 9 = Trinity Basin

The second and third digits were the GMA (for Texas cells) or a two-digit code for Arkansas and Louisiana:

- 08 = GMA 8
- 11 = GMA 11
- 12 = GMA 12
- 14 = GMA 14
- 98 = Arkansas
- 99 = Louisiana

The Fortran program named *GMA11Zone.exe* was written to assign zone numbers. The USGS program ZoneBudget was used to develop groundwater budgets for each zone.

Appendix A contains the groundwater budgets for each basin in GMA 11 and includes maps that shows the geographic extent of each basin.

Among the analyses presented in this Technical Memorandum are the general character of the alluvium (layer 1 of the model) interactions with the bedrock aquifers (layers 2 to 9) and the interbasin movement of groundwater.

4.2 Groundwater Pumping and Inflow from Alluvium Results

The upper part of Table 11 summarizes the groundwater pumping by basin for four scenarios. The lower part of Table 11 summarizes the inflow from the alluvium by basin for the same four scenarios.

Table 11. Summary of Groundwater Pumping and Inflow from Alluvium

Basin	Groundwater Pumping (AF/yr)			
	Scenario			
	Baseline	Scenario 33	Scenario QC1	Scenario 26.1
Cypress Basin	14,611	81,967	47,953	33,612
Neches Basin	69,405	183,651	130,962	102,959
Sabine Basin	28,411	87,048	64,142	51,554
Sulphur Basin	5,478	15,806	15,337	12,598
Trinity Basin	8,888	16,593	11,961	8,016
Total GMA 11	126,794	385,065	270,355	208,739

Basin	Inflow from Alluvium (AF/yr)			
	Scenario			
	Baseline	Scenario 33	Scenario QC1	Scenario 26.1
Cypress Basin	-15,897	38,812	8,550	-2,582
Neches Basin	-10,590	58,852	17,050	6,933
Sabine Basin	-16,327	34,464	13,920	1,759
Sulphur Basin	513	11,293	10,871	7,962
Trinity Basin	-5,770	5,386	2,276	-4,212
Total GMA 11	-48,071	148,807	52,667	9,860

Based on these data, the groundwater pumping for each basin can be summarized as follows, depending on scenario:

- Cypress Basin: 12 to 21 percent of GMA 11 pumping
- Neches Basin: 48 to 55 percent of GMA 11 pumping
- Sabine Basin: 22 to 25 percent of GMA 11 pumping
- Sulphur Basin: 4 to 6 percent of GMA 11 pumping
- Trinity Basin: 4 to 7 percent of GMA 11 pumping

Please note that the inflow from the alluvium in the baseline is negative in all basins (except the Sulphur Basin). The negative number represents an outflow from the bedrock aquifers to the alluvium and suggests net gaining stream conditions. In contrast, all basins have positive numbers for Scenario 33 (the basis for the current DFC) and Scenario QC1. Finally, Scenario 26.1 shows net gaining stream conditions in the Cypress and Trinity basins. The net losing stream conditions for the other basins in Scenario 26.1 are mitigated by the reduced pumping. For example, the increased pumping Neches Basin (the majority of the pumping in GMA 11) induces about 69,000

AF/yr from the alluvium into the bedrock aquifers, but only about 18,000 AF/yr is induced in Scenario 26.1.

In the 2021 GMA 11 Explanatory Report, it was noted that about 72 percent of the pumping increase was sourced from surface water. These groundwater budgets do not lend themselves to a clean analysis of the source of the increased pumping due to changes in interbasin movement of water, which is a significant component of the groundwater water budgets. However, it is reasonable to conclude that these groundwater budgets demonstrate that most of the groundwater pumping is sourced from surface water rather than from groundwater storage.

4.3 Interbasin Flow

Interbasin flows from the groundwater budgets presented in Appendix A are discussed below by river basin (in alphabetical order).

4.3.1 Cypress Basin

Table 12 presents a summary of pumping and interbasin flow for the Cypress Basin.

Table 12. Groundwater Pumping and Interbasin Flow - Cypress Basin

Scenario	Cypress Basin		
	Pumping (AF/yr)	Inflow from Sabine (AF/yr)	Inflow from Sulphur (AF/yr)
Baseline	14,611	258	1,518
Scenario 33	81,967	-1,373	6,022
Scenario QC1	47,953	-1,729	5,590
Scenario 26.1	33,612	-780	3,957

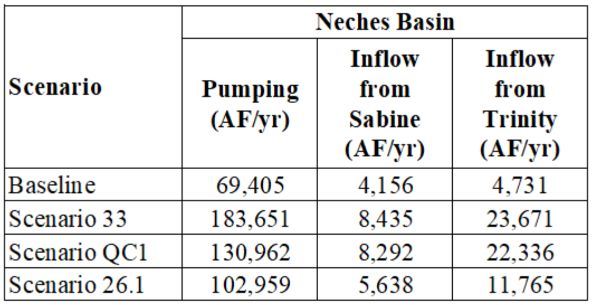
During the baseline simulation, there is a net inflow from the Sabine Basin to the Cypress Basin. In all the other scenarios, groundwater flow is from the Cypress Basin to the Sabine Basin.

The changes in inflow from the Sulphur Basin correlate to changes in pumping in the Cypress Basin (more inflow with more pumping). This suggests that some of the increased pumping in the Cypress Basin is sourced from the Sulphur Basin.

4.3.2 Neches Basin

Table 13 presents a summary of pumping and interbasin flow for the Neches Basin.

Table 13. Groundwater Pumping and Interbasin Flow - Neches Basin



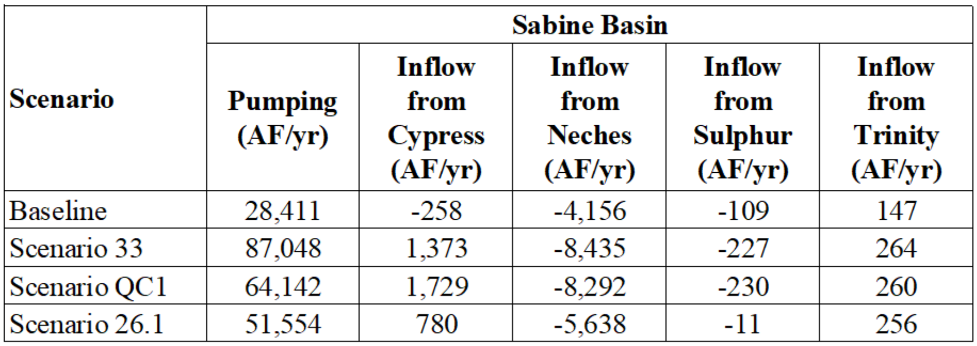
Scenario	Neches Basin		
	Pumping (AF/yr)	Inflow from Sabine (AF/yr)	Inflow from Trinity (AF/yr)
Baseline	69,405	4,156	4,731
Scenario 33	183,651	8,435	23,671
Scenario QC1	130,962	8,292	22,336
Scenario 26.1	102,959	5,638	11,765

Please recall that the majority of GMA 11 pumping is in the Neches Basin. Under all scenarios, there is inflow from the Sabine and Trinity basins. The changes in pumping correlate with the changes in inflow, which suggests that a relatively large amount of pumping in the Neches Basin is sourced from the Sabine and Trinity basins.

4.3.3 Sabine Basin

Table 14 presents a summary of pumping and interbasin flow for the Sabine Basin.

Table 14. Groundwater Pumping and Interbasin Flow - Sabine Basin



Scenario	Sabine Basin				
	Pumping (AF/yr)	Inflow from Cypress (AF/yr)	Inflow from Neches (AF/yr)	Inflow from Sulphur (AF/yr)	Inflow from Trinity (AF/yr)
Baseline	28,411	-258	-4,156	-109	147
Scenario 33	87,048	1,373	-8,435	-227	264
Scenario QC1	64,142	1,729	-8,292	-230	260
Scenario 26.1	51,554	780	-5,638	-11	256

The Sabine Basin border all of the other four basins in GMA 11. In general, flow to and from the Sulphur and Trinity are minor.

Under baseline conditions, there is outflow from the Sabine to the Cypress, but changes to inflow in the other three scenarios. Correlation between pumping and inflow from Cypress is moderate.

Outflow from the Sabine to the Neches occurs in all scenarios, and as noted above, Sabine Basin groundwater is a source of the increased pumping in the Neches Basin.

4.3.4 Sulphur Basin

Table 15 presents a summary pumping and interbasin flow for the Sulphur Basin.

Table 15. Groundwater Pumping and Interbasin Flow - Sulphur Basin

Scenario	Sulphur Basin		
	Pumping (AF/yr)	Inflow from Cypress (AF/yr)	Inflow from Sabine (AF/yr)
Baseline	5,478	-1,518	109
Scenario 33	15,806	-6,022	227
Scenario QC1	15,337	-5,590	230
Scenario 26.1	12,598	-3,957	11

The inflow from the Sabine to the Sulphur Basin is relatively low. As noted above, the outflow from the Sulphur Basin to the Cypress Basin is due to the increased pumping in the Cypress Basin.

4.3.5 Trinity Basin

Table 16 presents a summary of pumping and interbasin flow for the Trinity Basin.

Table 16. Groundwater Pumping and Interbasin Flow - Trinity Basin

Scenario	Trinity Basin		
	Pumping (AF/yr)	Inflow from Neches (AF/yr)	Inflow from Sabine (AF/yr)
Baseline	8,888	-4,731	-147
Scenario 33	16,593	-23,671	-264
Scenario QC1	11,961	-22,336	-260
Scenario 26.1	8,016	-11,765	-256

The Trinity Basin covers a relatively small part of GMA 11 on its western boundary, and pumping is relatively small. As noted above, some of the increased pumping in the Neches Basin is sourced from outflow from the Trinity into the Neches Basin.

5.0 Average Drawdown Calculations

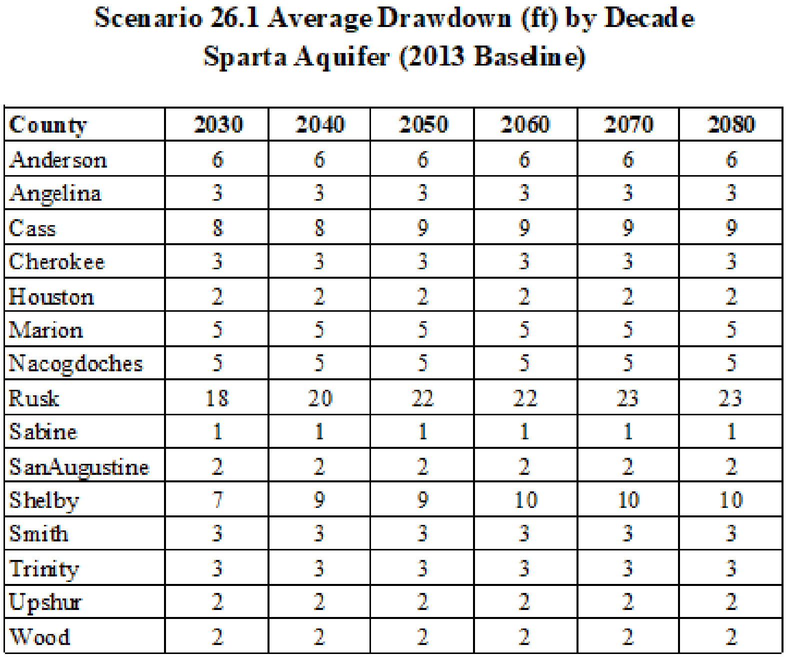
GMA 11 has historically expressed desired future conditions (DFCs) as average drawdown by county and aquifer at the end of the planning period. In 2021, the DFCs used 2080 as the end of the planning period. TWDB has provided guidance that DFCs for the current round of joint planning should again use 2080 as the end of the planning period. New requirement from HB 2078 also require “intermediate” (decadal) DFCs.

Average drawdown values were calculated from the output of Scenario 26.1 using the Fortran program *getdd.exe*, which calculated area-weighted average for each county for the Sparta, Queen City, and Carrizo-Wilcox aquifers.

The decadal average drawdown results are presented as follows:

- Table 17: Sparta Aquifer
- Table 18: Queen City Aquifer
- Table 19: Carrizo-Wilcox Aquifer

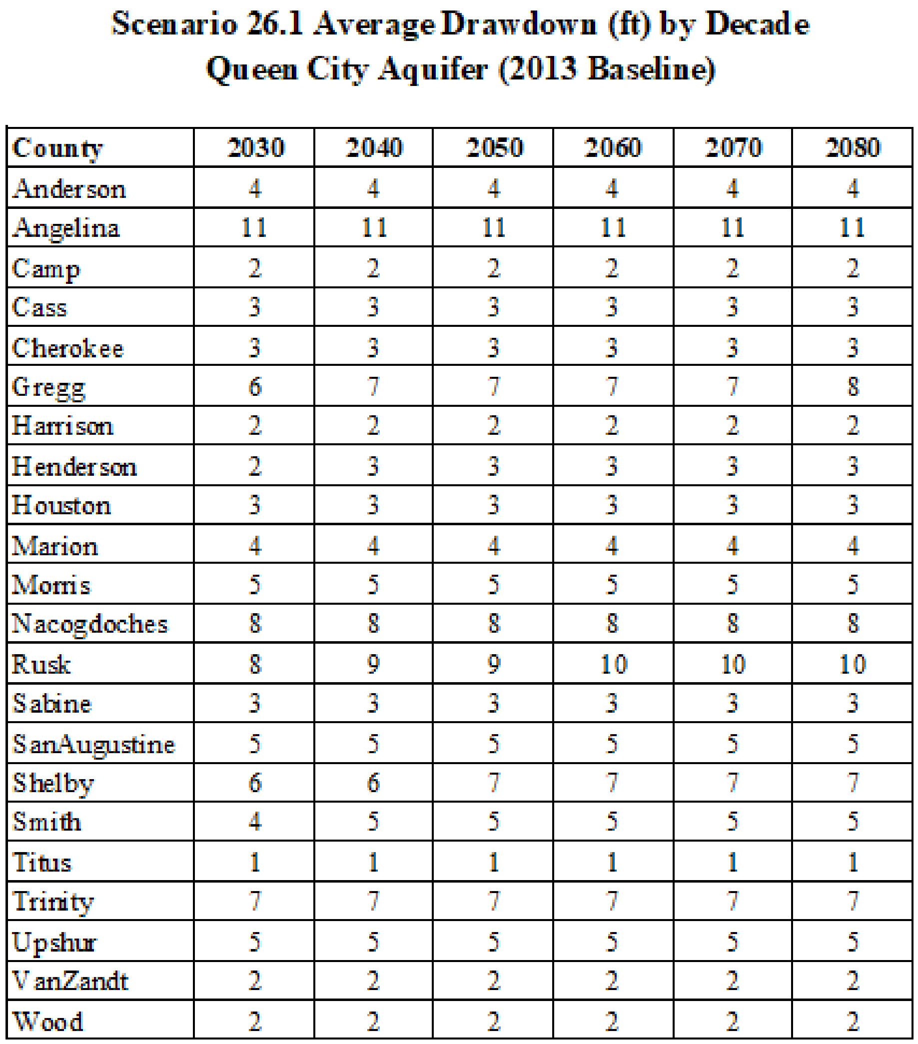
Table 17. Average Drawdown by County - Sparta Aquifer, Scenario 26.1



Scenario 26.1 Average Drawdown (ft) by Decade
Sparta Aquifer (2013 Baseline)

County	2030	2040	2050	2060	2070	2080
Anderson	6	6	6	6	6	6
Angelina	3	3	3	3	3	3
Cass	8	8	9	9	9	9
Cherokee	3	3	3	3	3	3
Houston	2	2	2	2	2	2
Marion	5	5	5	5	5	5
Nacogdoches	5	5	5	5	5	5
Rusk	18	20	22	22	23	23
Sabine	1	1	1	1	1	1
SanAugustine	2	2	2	2	2	2
Shelby	7	9	9	10	10	10
Smith	3	3	3	3	3	3
Trinity	3	3	3	3	3	3
Upshur	2	2	2	2	2	2
Wood	2	2	2	2	2	2

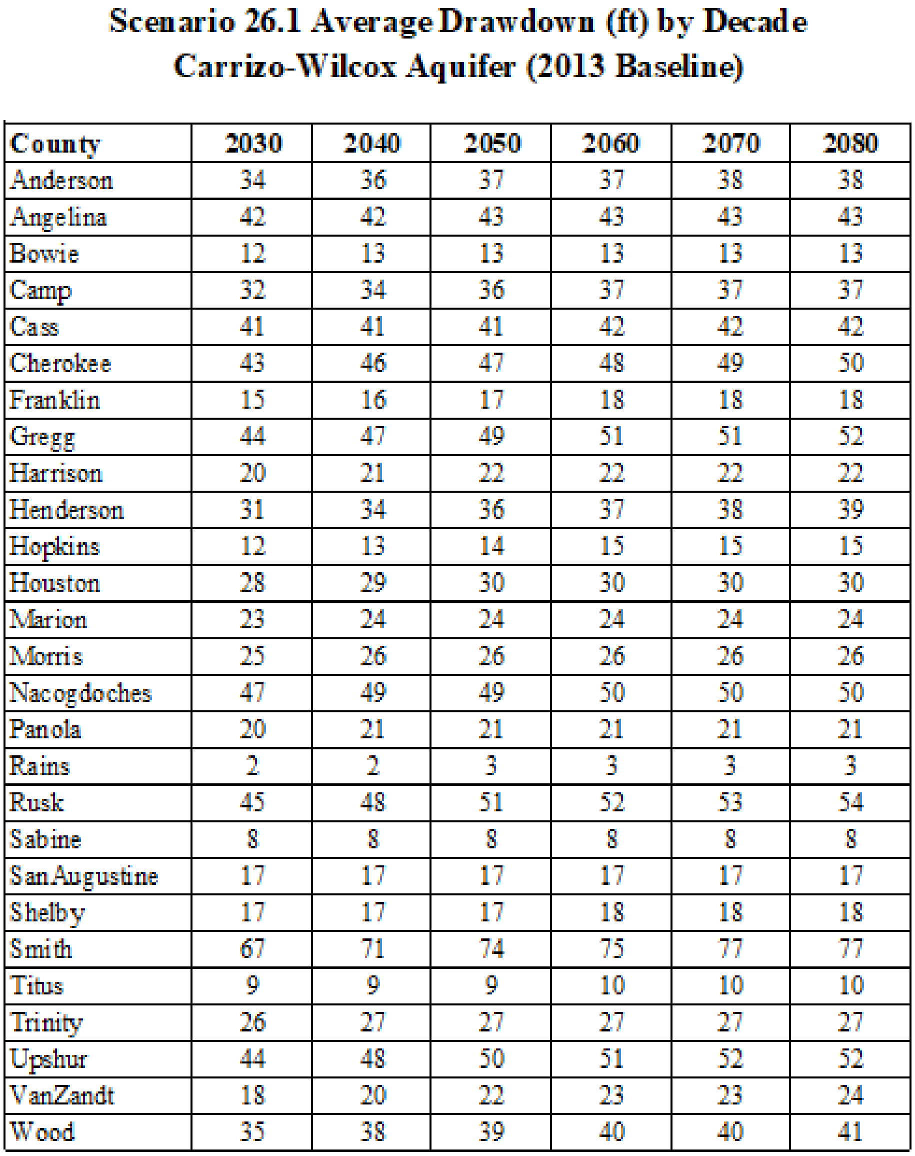
Table 18. Average Drawdown by County – Queen City Aquifer, Scenario 26.1



Scenario 26.1 Average Drawdown (ft) by Decade
Queen City Aquifer (2013 Baseline)

County	2030	2040	2050	2060	2070	2080
Anderson	4	4	4	4	4	4
Angelina	11	11	11	11	11	11
Camp	2	2	2	2	2	2
Cass	3	3	3	3	3	3
Cherokee	3	3	3	3	3	3
Gregg	6	7	7	7	7	8
Harrison	2	2	2	2	2	2
Henderson	2	3	3	3	3	3
Houston	3	3	3	3	3	3
Marion	4	4	4	4	4	4
Morris	5	5	5	5	5	5
Nacogdoches	8	8	8	8	8	8
Rusk	8	9	9	10	10	10
Sabine	3	3	3	3	3	3
SanAugustine	5	5	5	5	5	5
Shelby	6	6	7	7	7	7
Smith	4	5	5	5	5	5
Titus	1	1	1	1	1	1
Trinity	7	7	7	7	7	7
Upshur	5	5	5	5	5	5
VanZandt	2	2	2	2	2	2
Wood	2	2	2	2	2	2

Table 19. Average Drawdown by County – Carrizo-Wilcox Aquifer, Scenario 26.1



Scenario 26.1 Average Drawdown (ft) by Decade
Carrizo-Wilcox Aquifer (2013 Baseline)

County	2030	2040	2050	2060	2070	2080
Anderson	34	36	37	37	38	38
Angelina	42	42	43	43	43	43
Bowie	12	13	13	13	13	13
Camp	32	34	36	37	37	37
Cass	41	41	41	42	42	42
Cherokee	43	46	47	48	49	50
Franklin	15	16	17	18	18	18
Gregg	44	47	49	51	51	52
Harrison	20	21	22	22	22	22
Henderson	31	34	36	37	38	39
Hopkins	12	13	14	15	15	15
Houston	28	29	30	30	30	30
Marion	23	24	24	24	24	24
Morris	25	26	26	26	26	26
Nacogdoches	47	49	49	50	50	50
Panola	20	21	21	21	21	21
Rains	2	2	3	3	3	3
Rusk	45	48	51	52	53	54
Sabine	8	8	8	8	8	8
SanAugustine	17	17	17	17	17	17
Shelby	17	17	17	18	18	18
Smith	67	71	74	75	77	77
Titus	9	9	9	10	10	10
Trinity	26	27	27	27	27	27
Upshur	44	48	50	51	52	52
VanZandt	18	20	22	23	23	24
Wood	35	38	39	40	40	41

Please note that in many instances, drawdowns reach an equilibrium level and do not change in the last few decades. However, in many instances, drawdowns continue to increase throughout all decades, which means that equilibrium levels have not yet been achieved by 2080. As an example of this phenomenon, Figure 4 presents the annual average drawdown in the Carrio-Wilcox Aquifer for Anderson, Cherokee, and Houston counties.

Please note that an equilibrium level would be reached in Houston County by 2050 under the pumping conditions of Scenario 26.1. However, the Anderson County equilibrium level is not reached until 2070. Finally, an equilibrium level has not been reached by 2080 in Cherokee County. However, from 2040 to 2080, the average drawdown dropped by about one foot per decade.

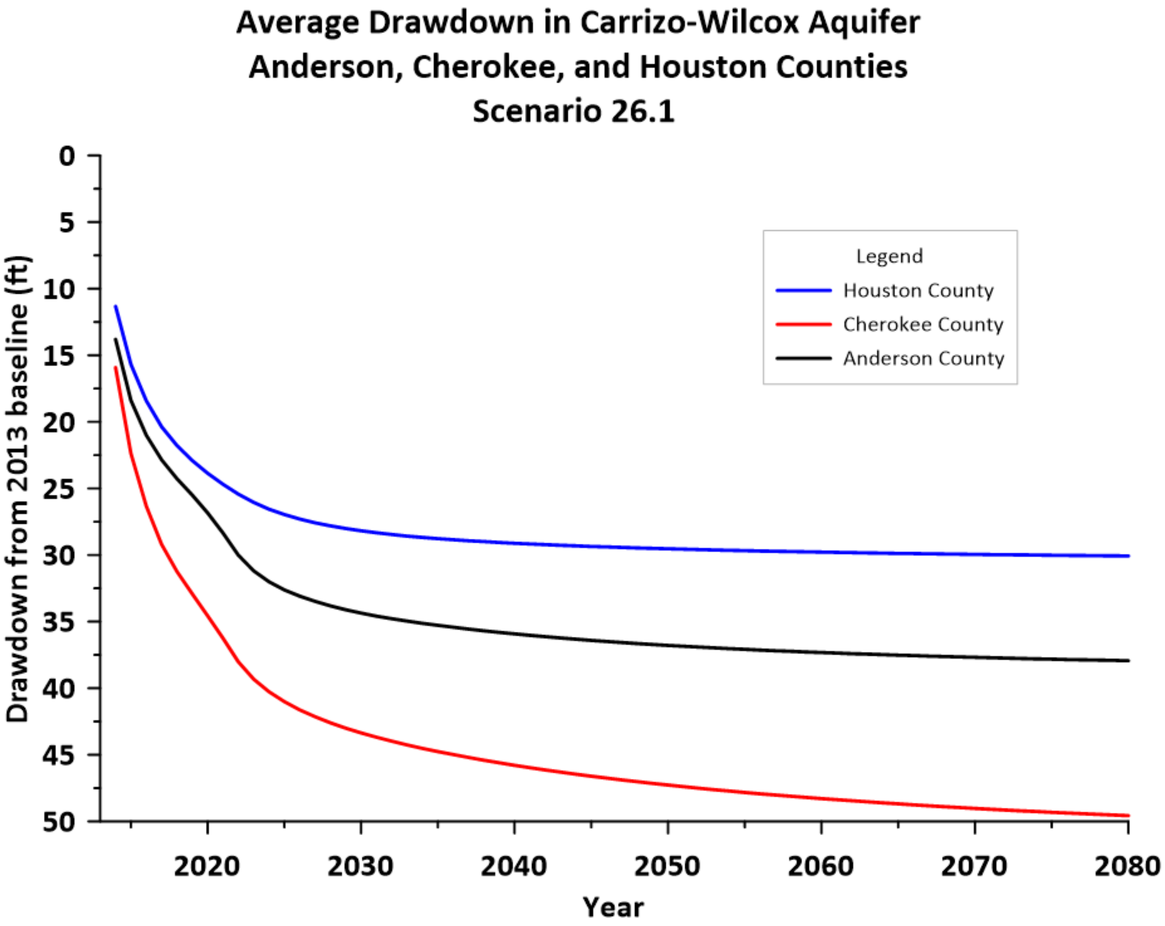
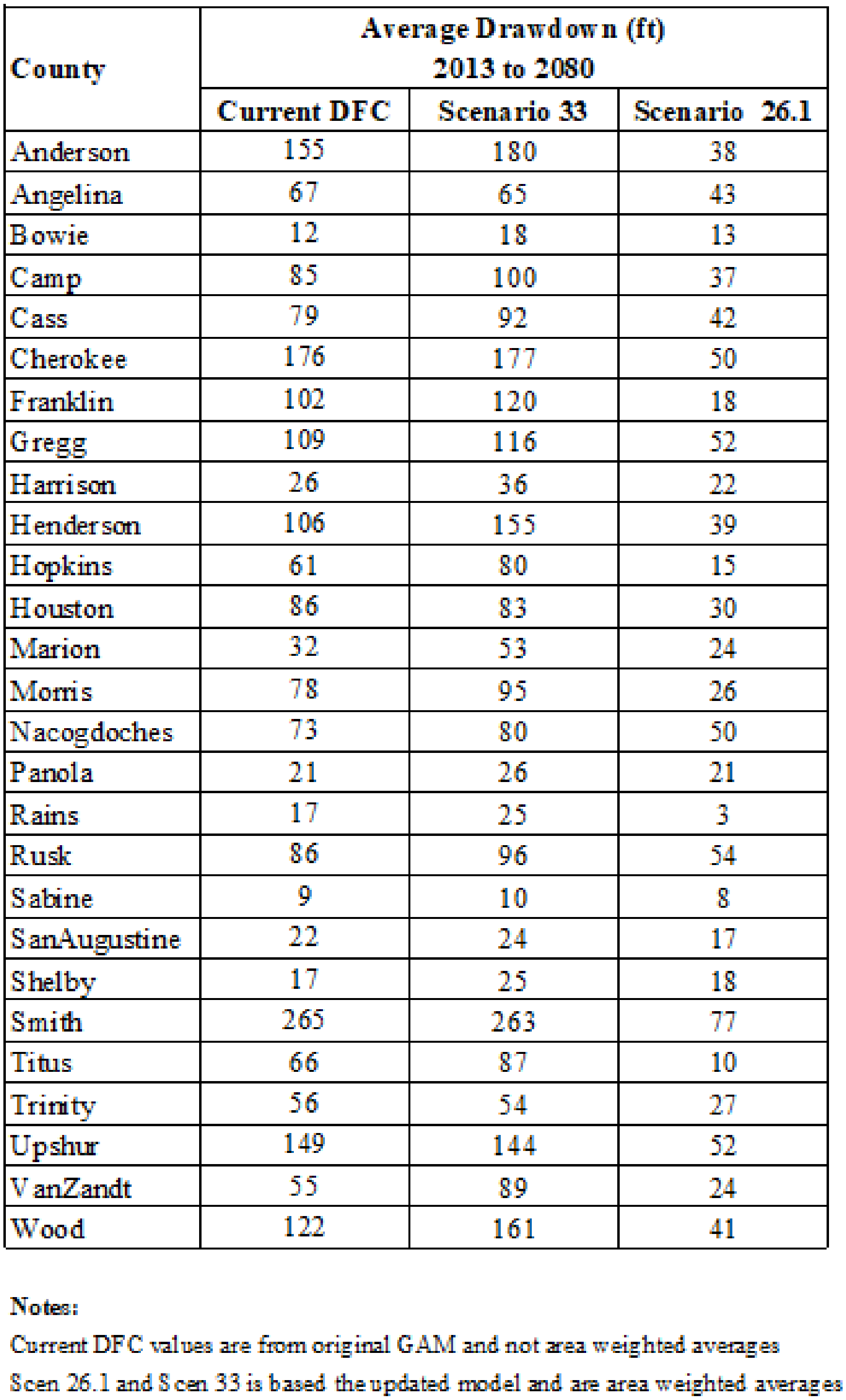


Figure 4 Hydrograph of Carrizo-Wilcox Average Drawdown for Selected Counties, Scenario 26.1

Table 20 presents a comparison of the 2080 county average drawdowns from Scenario 26.1 for the Carrizo-Wilcox Aquifer with the current DFCs and the average drawdowns from Scenario 33. As noted on the table, the current DFC and the average drawdown for Scenario 33 are slightly different. A minor difference is because the average drawdowns in Scenario 33 are from the updated GAM. A more significant difference is due to the fact that the current DFCs are not area-weighted averages and Scenario 33 (and Scenario 26.1) average drawdowns are area-weighted averages.

The current GAM has a variable sized grid. Thus, a non-weighted average would be an over representation of small cells and an under representation of large cells. The average drawdowns for Scenario 33 and 26.1 correct that limitation.

Table 20. Comparison of Current Carrizo-Wilcox DFC and 2080 Drawdown for Scenarios 33 and 26.1



County	Average Drawdown (ft) 2013 to 2080		
	Current DFC	Scenario 33	Scenario 26.1
Anderson	155	180	38
Angelina	67	65	43
Bowie	12	18	13
Camp	85	100	37
Cass	79	92	42
Cherokee	176	177	50
Franklin	102	120	18
Gregg	109	116	52
Harrison	26	36	22
Henderson	106	155	39
Hopkins	61	80	15
Houston	86	83	30
Marion	32	53	24
Morris	78	95	26
Nacogdoches	73	80	50
Panola	21	26	21
Rains	17	25	3
Rusk	86	96	54
Sabine	9	10	8
SanAugustine	22	24	17
Shelby	17	25	18
Smith	265	263	77
Titus	66	87	10
Trinity	56	54	27
Upshur	149	144	52
VanZandt	55	89	24
Wood	122	161	41

Notes:

Current DFC values are from original GAM and not area weighted averages

Scen 26.1 and Scen 33 is based the updated model and are area weighted averages

6.0 References

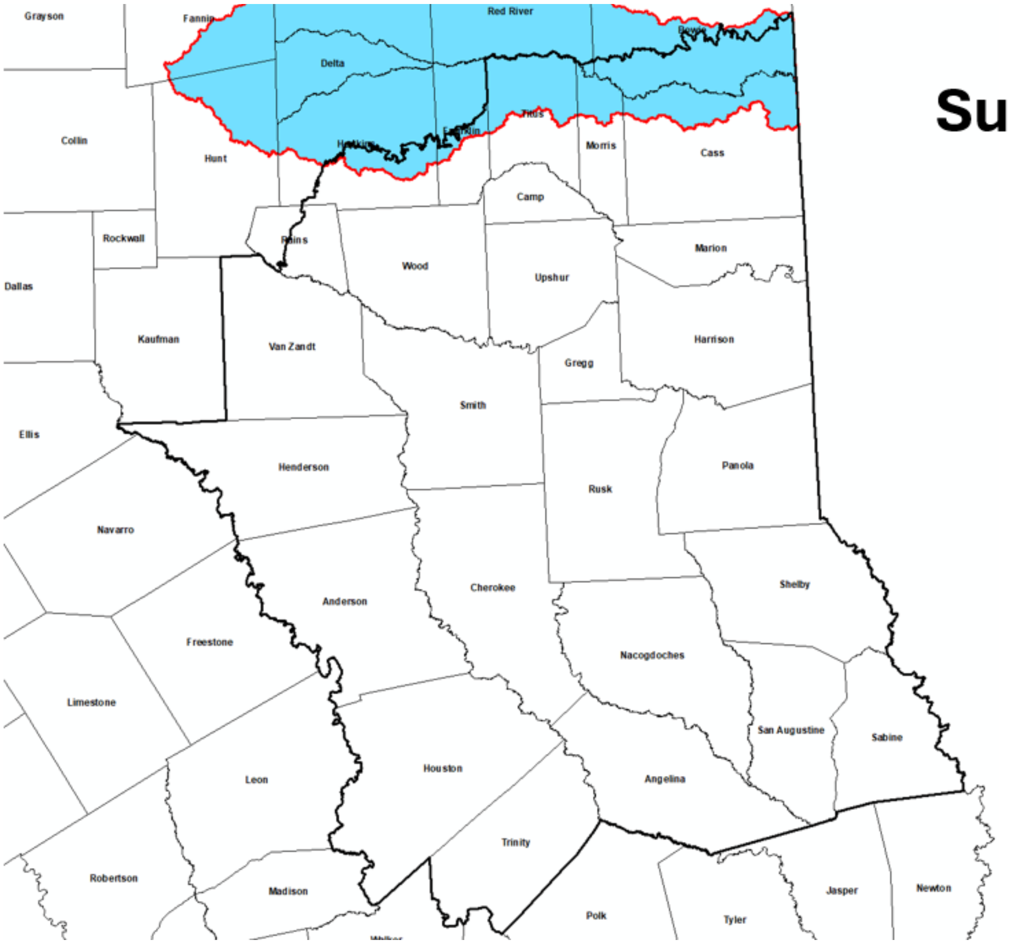
Hutchison, W.R, 2026. Documentation of Updated Specific Yield Values for the Groundwater Availability of Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers. GMA 11 Technical Memorandum 26-01, January 28, 2026, 9p.

Panday, S., Rumbaugh, J., Hutchison, W.R., Schorr, S., 2020. Numerical Model Report: Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers. Final Report prepared for Texas Water Development Board, Contact Number #1648302063. 198p.

Appendix A

Groundwater Budgets for Five River Basins within GMA 11

Sulphur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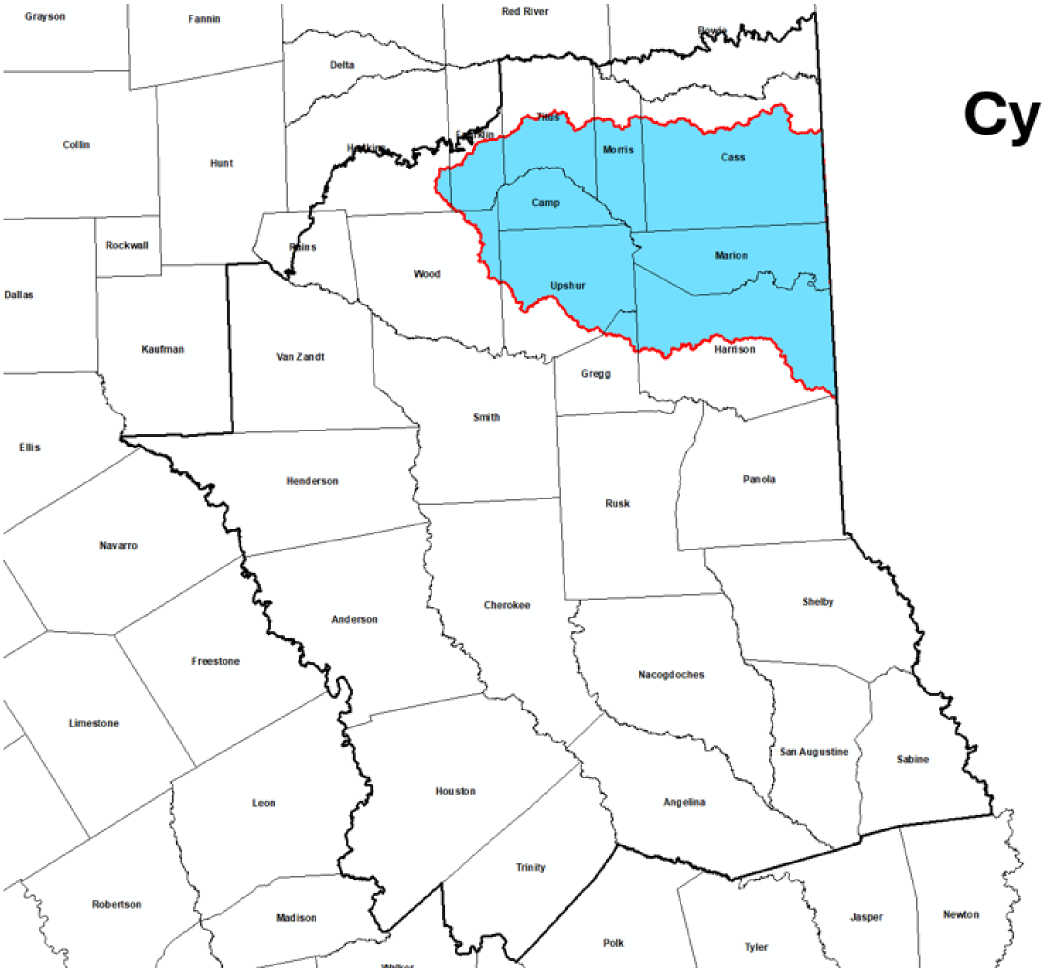
Polk
Tyler

Sulphur Basin Groundwater Budgets
All Values in AF/yr

		Baseline	Scenario 33 (Current DFC)	Scen QC1	Scenario 26.1
Inflow					
	Recharge	10,660	10,660	10,660	10,660
	Alluvium (Zone 1)	513	11,293	10,871	7,962
	Arkansas (Zone 198)	0	548	473	239
	Sabine (Zone 611)	109	227	230	11
	GMA 8 Sulphur (Zone 808	7	6	6	7
Total Inflow		11,289	22,735	22,240	18,879
Outflow					
	Pumping	5,478	15,806	15,337	12,598
	Evapotranspiration	3,821	1,111	1,496	2,359
	Arkansas (Zone 198)	471	0	0	0
	Cypress (Zone 311)	1,518	6,022	5,590	3,957
Total Outflow		11,288	22,939	22,423	18,914
Storage Change					
	Confined	0	-8	-7	-2
	Unconfined	1	-197	-175	-33
Total Storage Change		1	-205	-183	-35
Inflow - Outflow		1	-205	-183	-35
Model Error		0	0	0	0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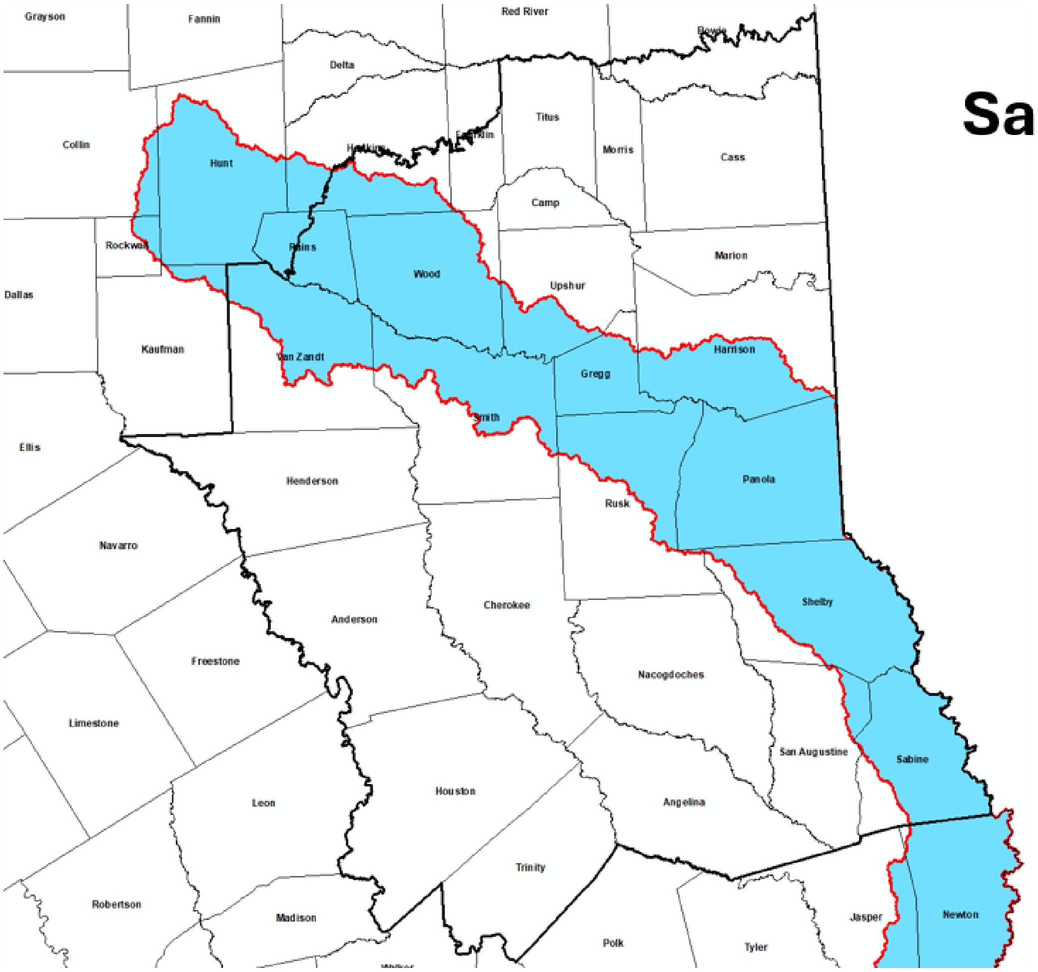
Cypress

Cypress Basin Groundwater Budgets
All Values in AF/yr

	Baseline	Scenario 33 (Current DFC)	Scenario QC1	Scenario 26.1
Inflow				
Recharge	48,254	48,254	48,254	48,254
Alluvium (Zone 1)	0	32,812	8,550	0
Arkansas (Zone 198)	0	1,135	704	197
Louisiana (Zone 499)	0	240	0	0
Sabine (Zone 611)	258	0	0	0
Sulphur (Zone 811)	1,518	6,022	5,590	3,957
Total Inflow	50,030	88,463	63,097	52,408
Outflow				
Pumping	14,611	81,967	47,953	33,612
Evapotranspiration	18,343	6,486	13,959	15,232
Alluvium (Zone 1)	15,897	0	0	2,582
Arkansas (Zone 198)	392	0	0	0
Louisiana (Zone 499)	789	0	40	368
Sabine (Zone 611)	0	1,373	1,729	780
Total Outflow	50,033	89,826	63,681	52,574
Storage Change				
Confined	0	-89	-64	-28
Unconfined	-4	-1,274	-520	-138
Total Storage Change	-4	-1,363	-584	-165
Inflow - Outflow	-3	-1,363	-584	-166
Model Error	-1	0	0	0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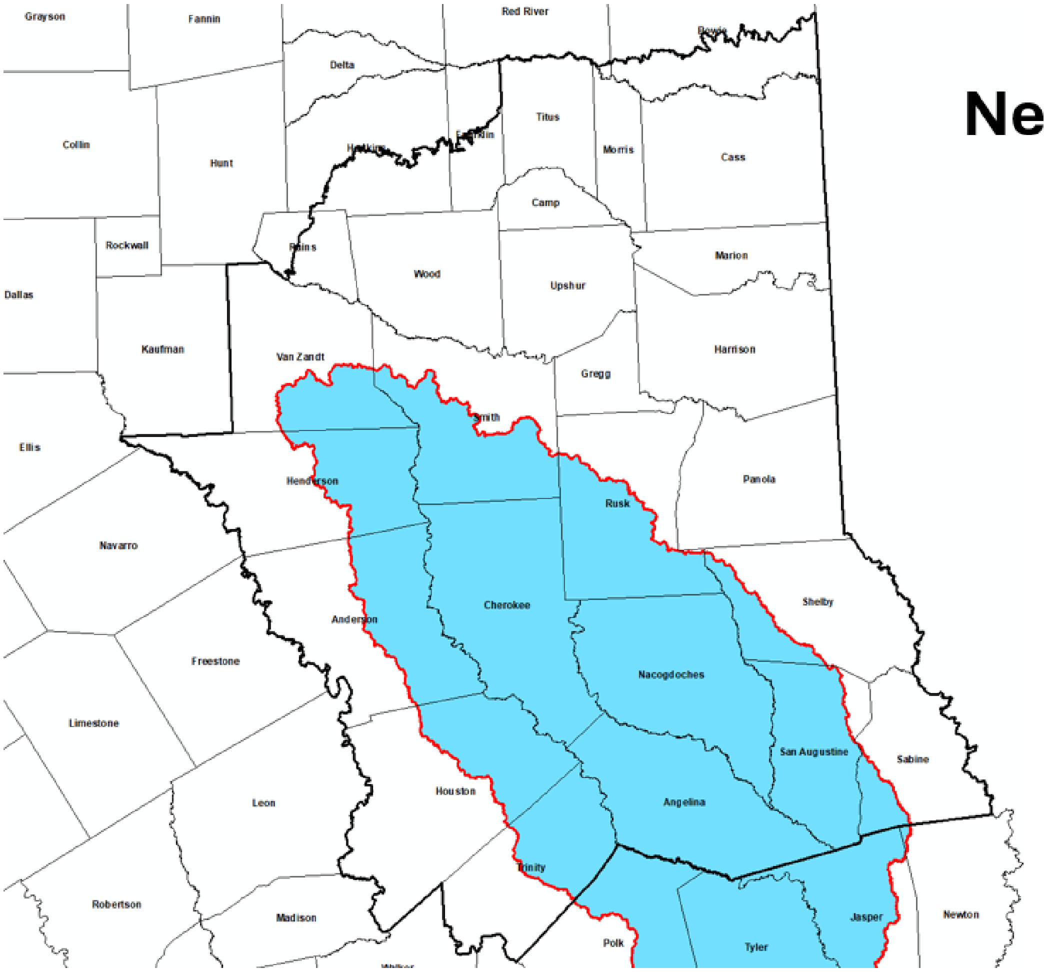
Sabine

Sabine Basin Groundwater Budgets
All Values in AF/yr

		Baseline	Scenario 33 (Current DFC)	Scenario QC1	Scenario 26.1
Inflow					
	Overlying Formations (GHB)	117	146	145	141
	Recharge	67,100	67,100	67,100	67,100
	Alluvium (Zone 1)	0	34,464	13,920	1,759
	Cypress (Zone 311)	0	1,373	1,729	780
	Louisiana (Zone 499)	588	1,159	1,148	1,057
	GMA 8 Sabine (Zone 608)	0	1	1	0
	Sabine (Zone 614)	216	292	292	290
	Trinity (Zone 911)	147	264	260	256
Total Inflow		68,168	104,799	84,595	71,382
Outflow					
	Pumping	28,411	87,048	64,142	51,554
	Evapotranspiration	18,873	10,814	12,906	14,543
	Alluvium (Zone 1)	16,327	0	0	0
	Cypress (Zone 311)	258	0	0	0
	Neches (Zone 511)	4,156	8,435	8,292	5,638
	GMA 14 Neches (Zone 511)	26	46	45	41
	Sulphur (Zone 811)	109	227	230	11
Total Outflow		68,160	106,570	85,615	71,787
Storage Change					
	Confined	2	-152	-122	-56
	Unconfined	6	-1,618	-897	-348
Total Storage Change		8	-1,771	-1,020	-405
Inflow - Outflow		8	-1,771	-1,020	-405
Model Error		0	0	0	0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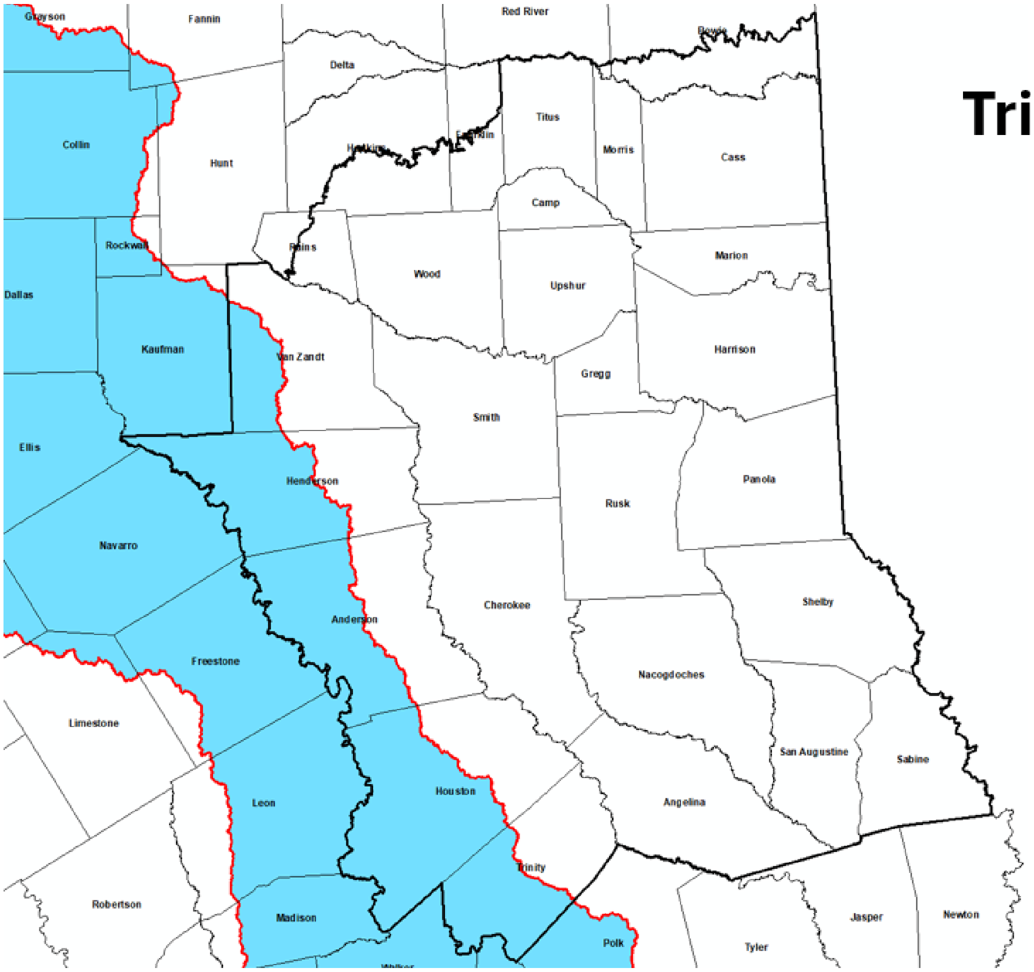
Madison
Jasper
Newton
Polk
Tyler

Neches

Neches Basin Groundwater Budgets
All Values in AF/yr

	Baseline	Scenario 33 (Current DFC)	Scenario QC1	Scenario 26.1
Inflow				
Overlying Fomations (GHB)	1,811	3,732	3,091	2,877
Recharge	89,945	89,945	89,945	89,945
Alluvium (Zone 1)	0	58,852	17,050	6,933
GMA 14 - Neches (Zone 514)	4,554	9,266	9,071	8,061
Sabine (Zone 611)	4,156	8,435	8,292	5,638
GMA 14 - Sabine (Zone 614)	2	2	2	2
Trinity (Zone 911)	4,731	23,671	22,336	11,765
Total Inflow	105,199	193,903	149,786	125,221
Outflow				
Pumping	69,405	183,651	130,962	102,959
Evapotranspiration	25,191	14,209	21,122	22,950
Alluvium (Zone 1)	10,590	0	0	0
Total Outflow	105,186	197,859	152,083	125,908
Storage Change				
Confined	11	-638	-547	-246
Unconfined	1	-3,318	-1,751	-441
Total Storage Change	12	-3,957	-2,298	-687
Inflow - Outflow	13	-3,957	-2,298	-687
Model Error	0	0	0	0

Trinity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Walker

Trinity Basin Groundwater Budgets
All Values in AF/yr

	Baseline	Scenario 33 (Current DFC)	Scenario QC1	Scenario 26.1
Inflow				
Overlying Formations (GHB)	1,419	2,279	2,140	1,976
Recharge	19,373	19,373	19,373	19,373
Alluvium (Zone 1)	0	5,386	2,276	0
GMA 12 Trinity (Zone 912)	5,480	12,935	12,478	7,330
GMA 14 Trinity (Zone 914)	638	3,557	3,383	2,050
Total Inflow	26,910	43,531	39,650	30,729
Outflow				
Pumping	8,888	16,593	11,961	8,016
Evapotranspiration	7,373	3,618	5,536	6,577
Alluvium (Zone 1)	5,770	0	0	4,212
Neches (Zone 511)	4,731	23,671	22,336	11,765
Sabine (Zone 611)	147	264	260	256
Total Outflow	26,908	44,146	40,093	30,827
Storage Change				
Confined	2	-156	-141	-48
Unconfined	-1	-459	-302	-50
Total Storage Change	1	-615	-442	-98
Inflow - Outflow	2	-615	-442	-98
Model Error	0	0	0	0

Appendix B

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
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April 2, 2014

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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).

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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)

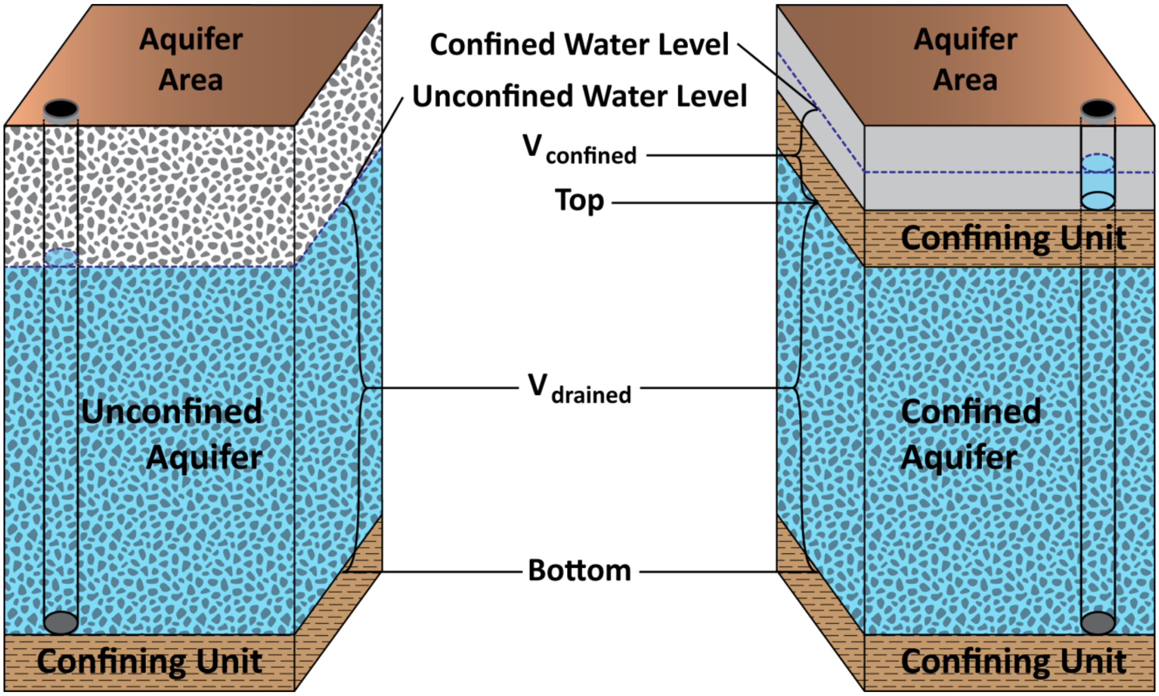


FIGURE 1. SCHEMATIC GRAPH SHOWING THE DIFFERENCE BETWEEN UNCONFINED AND CONFINED AQUIFERS.

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:

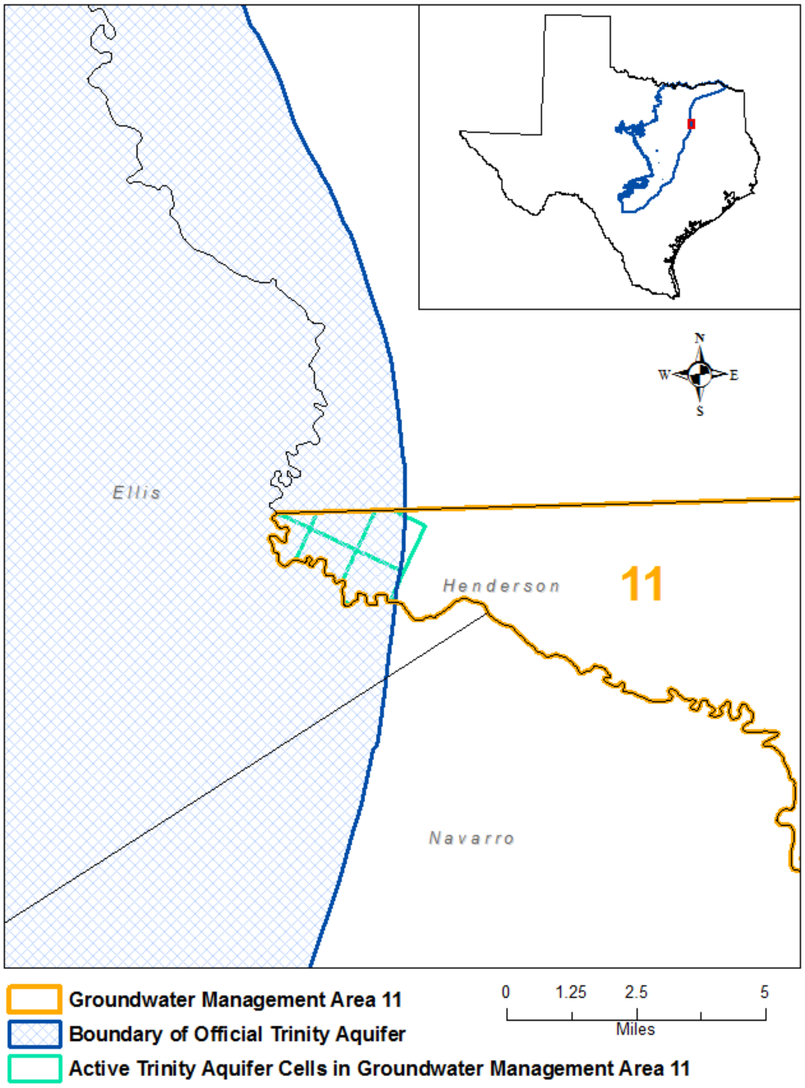
Tables 1 through 14 summarize the total estimated recoverable storage required by statute. The county and groundwater conservation district total storage estimates are rounded to two significant digits. Figures 2 through 8 indicate the extent of the groundwater availability models in Groundwater Management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



county boundary date 02.02.11. trnt_n model grid date 01.14.13

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**

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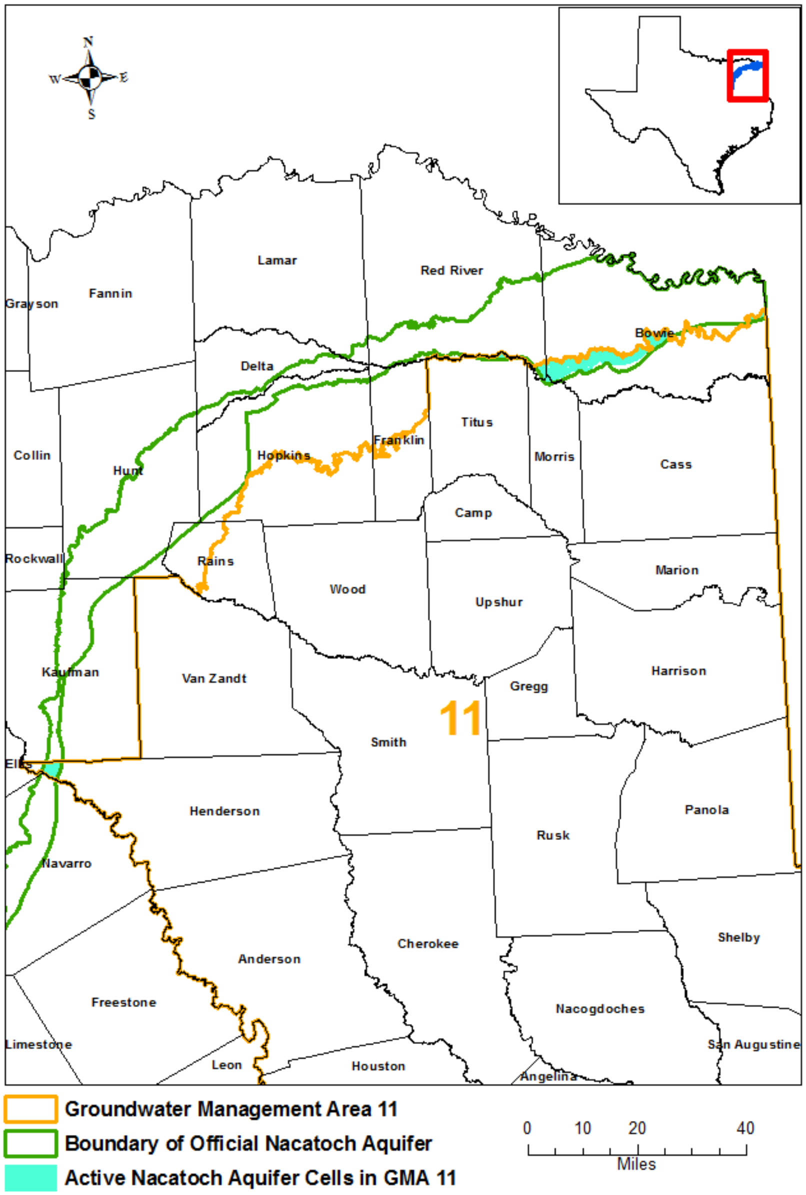
[1] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant digits.



county boundary date 02.02.11. nctc model grid date 10.13.11

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**

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[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.

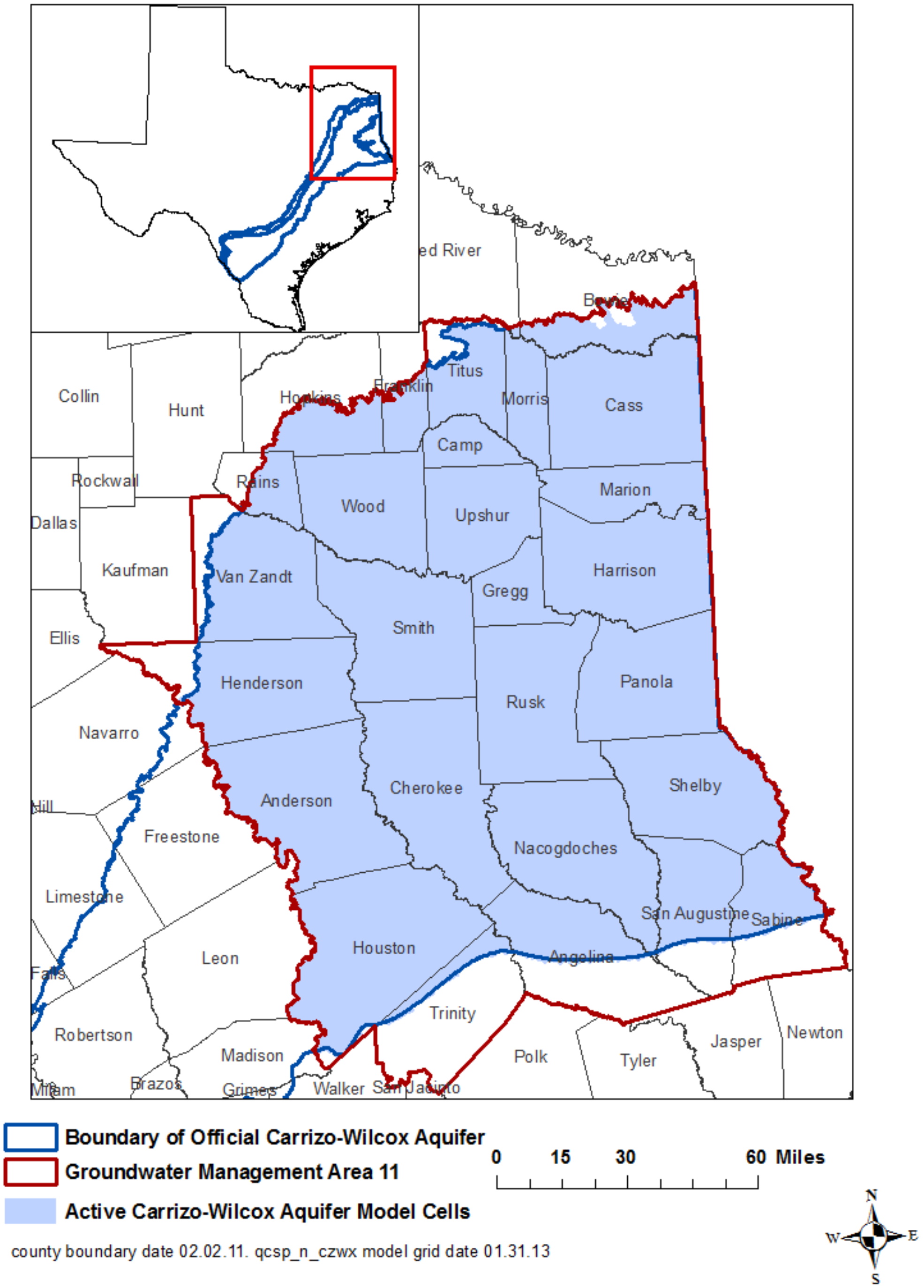

FIGURE 4. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PART OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE CARRIZO-WILCOX AQUIFER (TABLES 5 AND 6) WITHIN GROUNDWATER MANAGEMENT AREA 11.

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**

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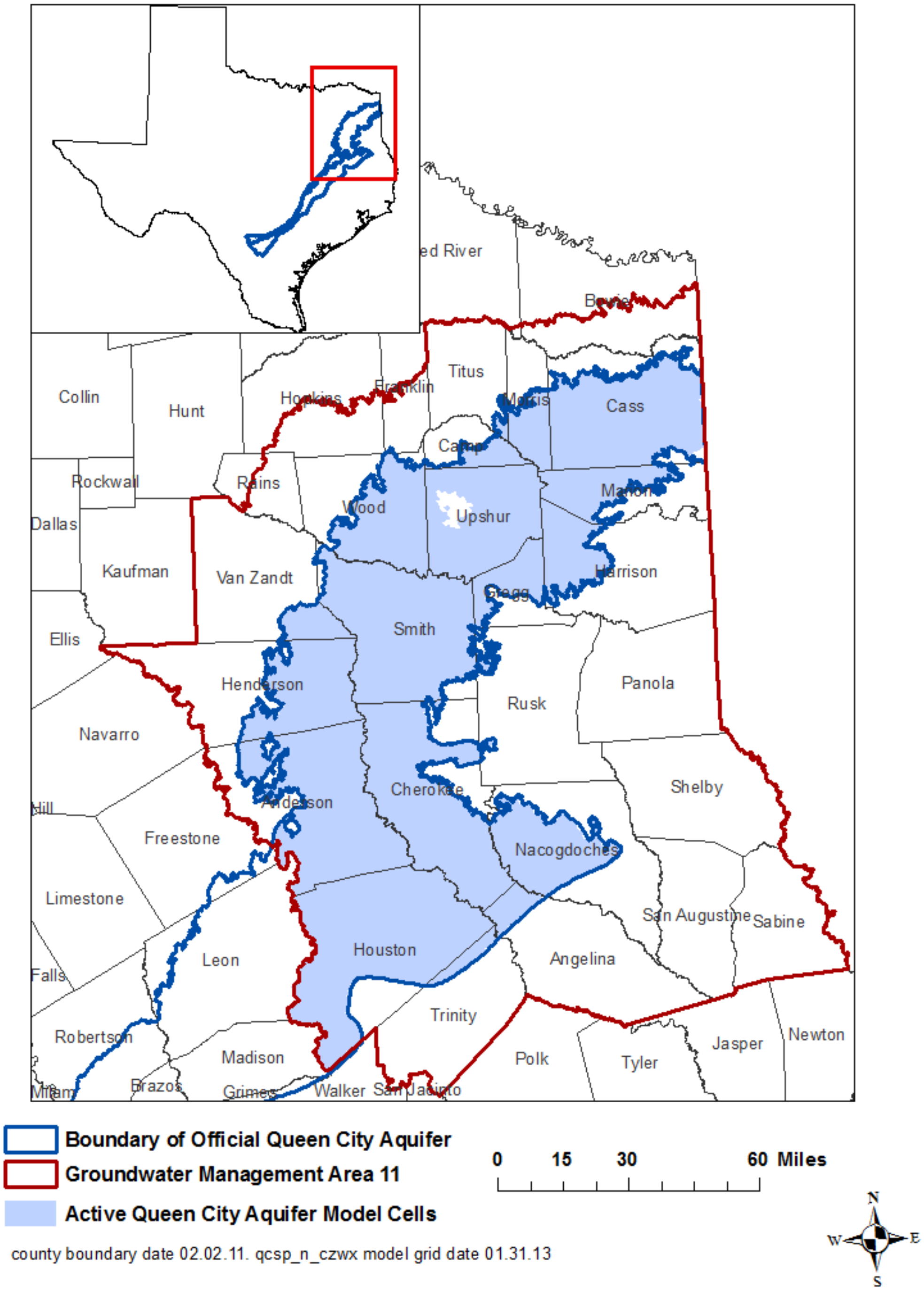
[5] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant digits.

[6] UWCD stands for Underground Water Conservation District



county boundary date 02.02.11. qcsp_n_czwx model grid date 01.31.13

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**

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[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.

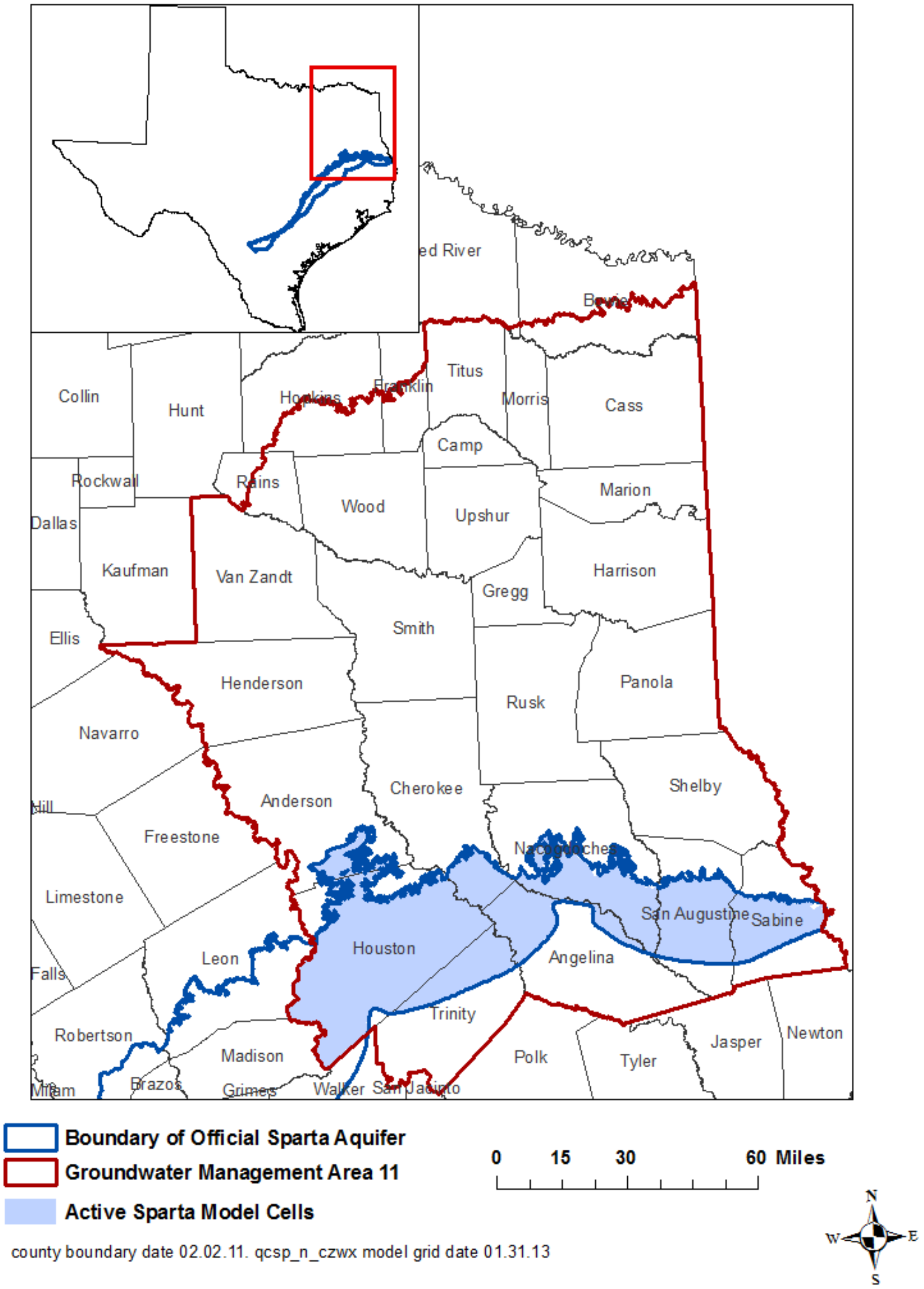

FIGURE 6. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CENTRAL PART OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE SPARTA AQUIFER (TABLES 9 AND 10) WITHIN GROUNDWATER MANAGEMENT AREA 11.

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**

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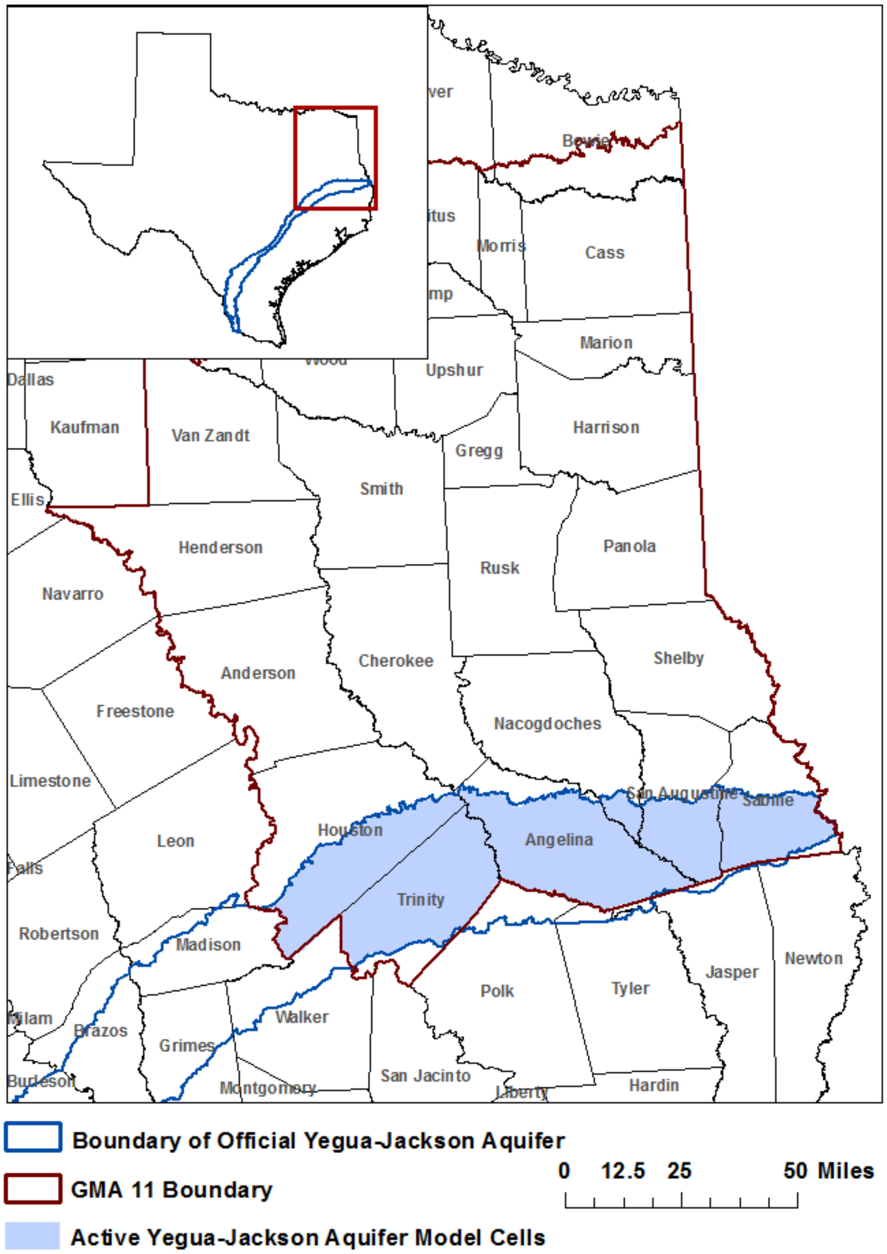
[9] The total estimated recoverable storages values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant digits.

[10] Deep East Texas Groundwater Conservation District is pending confirmation.



county boundary date 02.02.11. ygjk model grid date 10.14.11

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**

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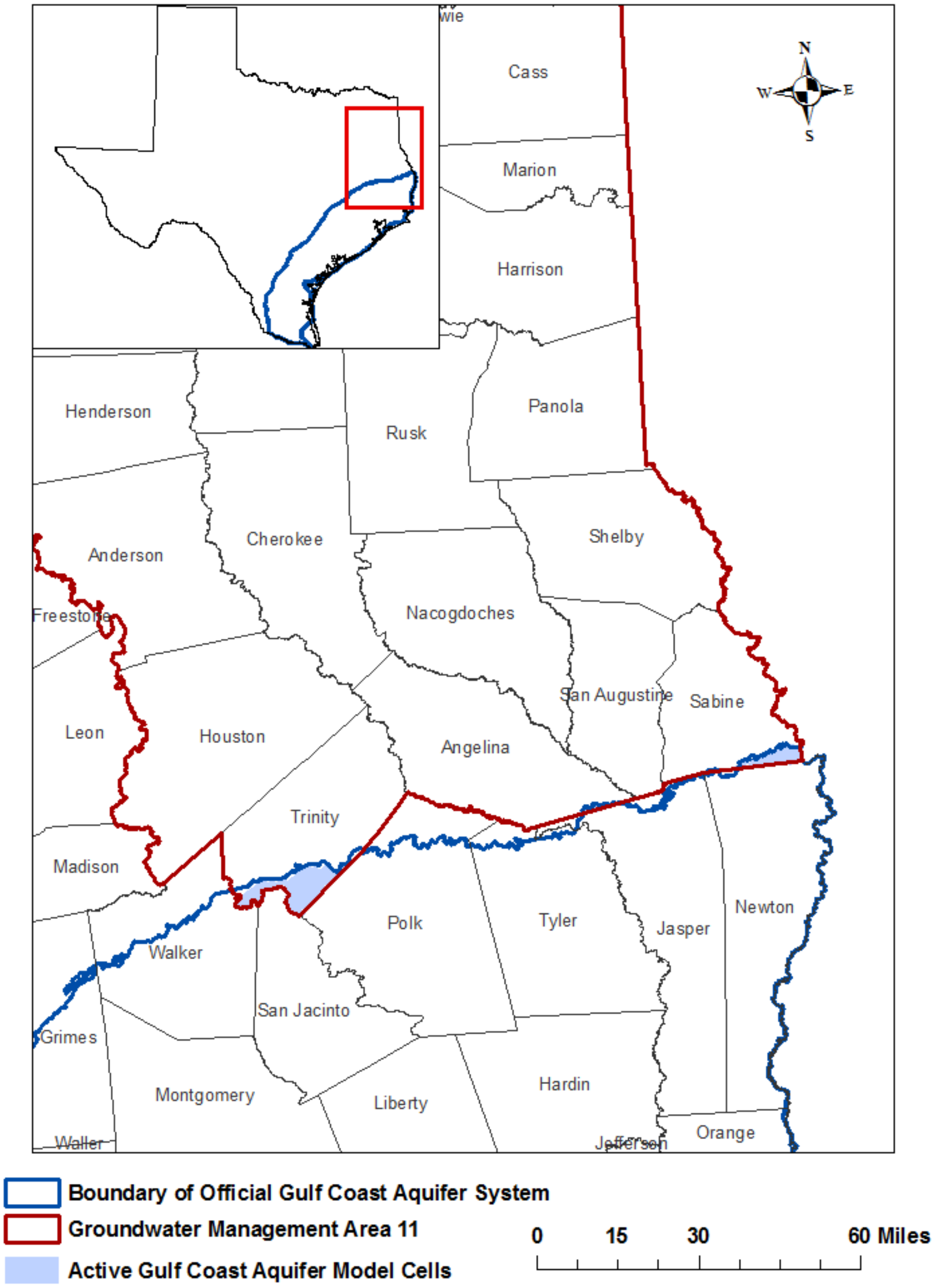
[11] The total estimated recoverable storages values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant digits.



county boundary date 02.02.11. glfc_n model grid date 08.20.13

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.

REFERENCES:

Beach, J.A., Huang, Y., Symank, L., Ashworth, J.B., Davidson, T., Vreugdenhil, A.M., and Deeds, N.E., 2009, Nacatoch Aquifer Groundwater Availability Model: contract report to the Texas Water Development Board, 304 p., http://www.twdb.texas.gov/groundwater/models/gam/nctc/NCTC_Model_Report.pdf

Bené, J., Harden, B., O'Rourke, D., Donnelly, A., and Yelderman, J., 2004, Northern Trinity/Woodbine Groundwater Availability Model: contract report to the Texas Water Development Board by R.W. Harden and Associates, 391 p., http://www.twdb.texas.gov/groundwater/models/gam/trnt_n/TRNT_N_Model_Report.pdf

Deeds, N.E., Yan, T., Singh, A., Jones, T.L., Kelley, V.A., Knox, P.R., Young, S.C., 2010, Groundwater availability model for the Yegua-Jackson Aquifer: Final report prepared for the Texas Water Development Board by INTERA, Inc., 582 p., http://www.twdb.texas.gov/groundwater/models/gam/ygjk/YGJK_Model_Report.pdf.

Fryar, D., Senger, R., Deeds, N., Pickens, J., Jones, T., Whallon, A.J., Dean, K.E., 2003, Groundwater availability model for the northern Carrizo-Wilcox aquifer: Contract report to the Texas Water Development Board, 529 p., http://www.twdb.texas.gov/groundwater/models/gam/czwx_n/czwx_n.asp

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

Kasmarek, M.C., 2013, Hydrogeology and Simulation of Groundwater Flow and Land-Surface Subsidence in the Northern Part of the Gulf Coast Aquifer System, Texas, 1891-2009: United States Geological Survey Scientific investigations Report 2012-5154 Version 1.1, 55 p., http://www.twdb.texas.gov/groundwater/models/gam/glfc_n/HAGM.SIR.Version1.1.November2013.pdf

Kelley, V.A., Deeds, N.E., Fryar, D.G., and Nicot, J.P., 2004, Groundwater availability models for the Queen City and Sparta aquifers: Contract report to the Texas Water Development Board, 867 p., http://www.twdb.texas.gov/groundwater/models/gam/qcsp/QCSP_Model_Report.pdf.

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

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

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

Appendix C

Documentation for Aquifers Classified as Not Relevant for Purposes of Joint Planning
Tech Memo 16-03: Gulf Cost 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.

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11/17/2016

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.

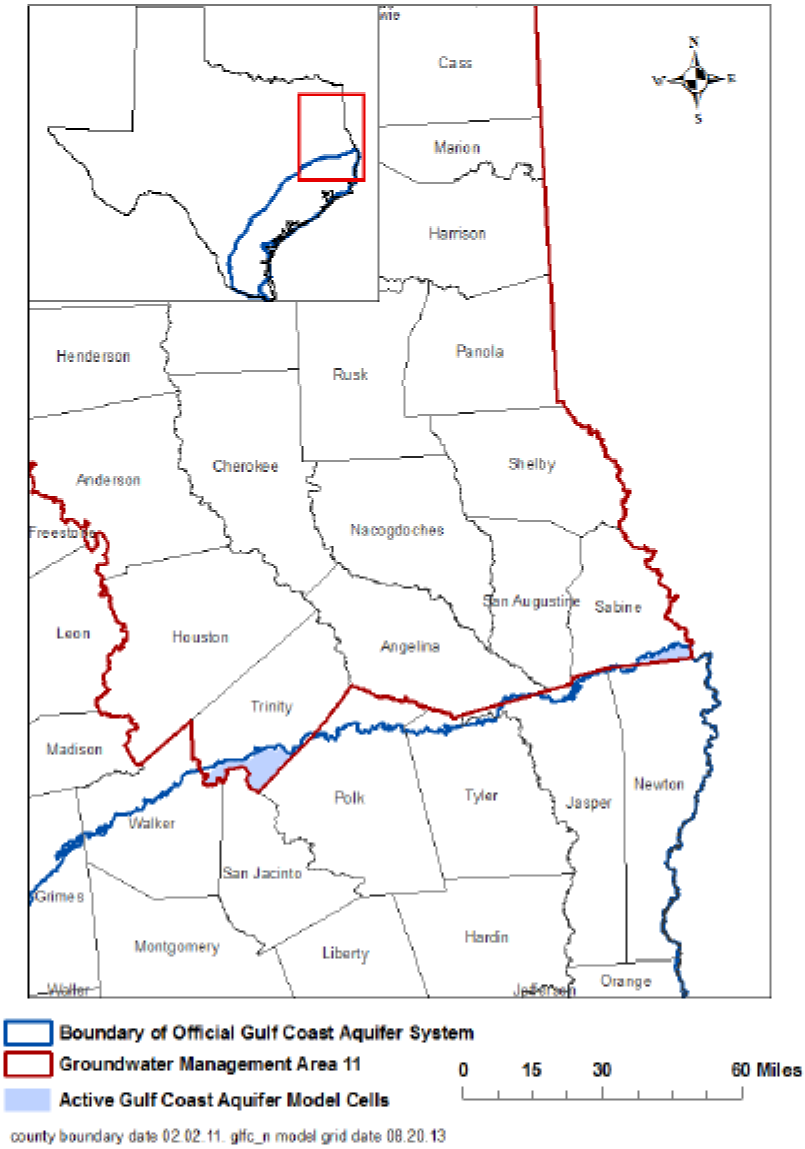

Figure 1. Location of Gulf Coast Aquifer in GMA 11

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

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Groundwater Demands and Current Groundwater Uses

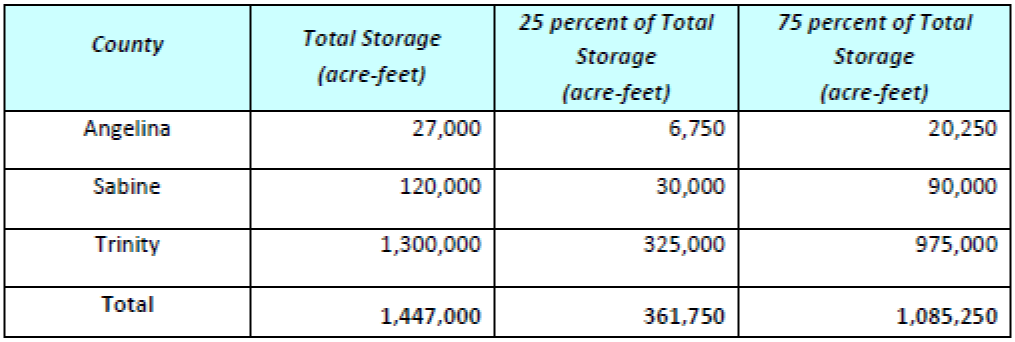
The Texas Water Development Board pumping database shows 2012 groundwater pumping for the Gulf Coast Aquifer as follows:

- 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:

> *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.*
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> *The districts must submit to the TWDB the following documentation for the portion of the aquifer proposed to be classified as non-relevant:*
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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.

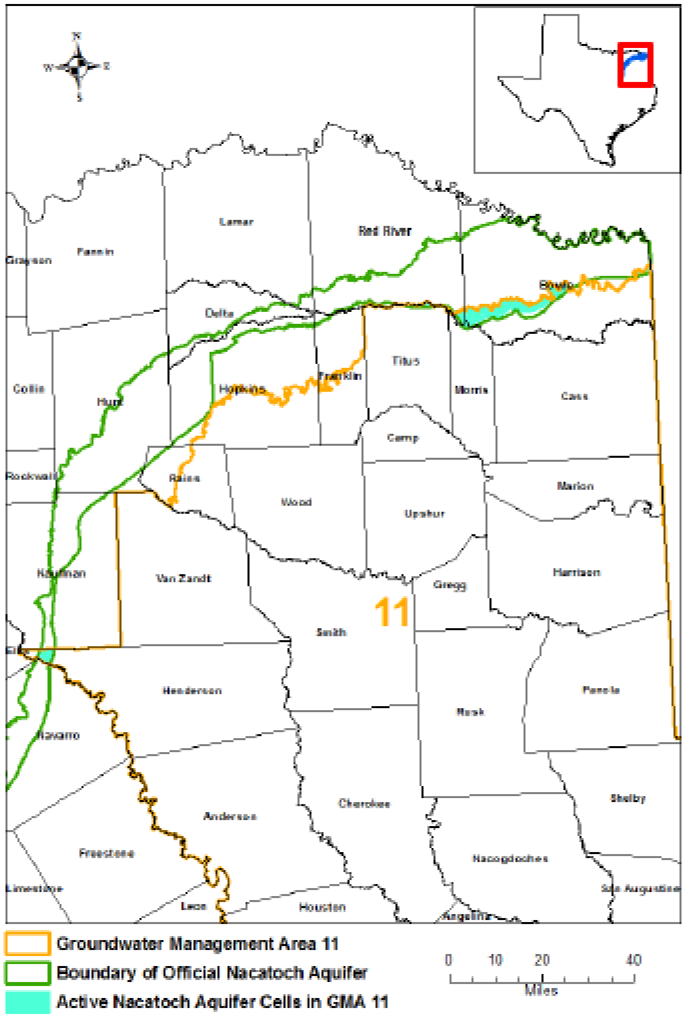
Aquifer Description and Location

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.



county boundary date 02.02.11. ndc model grid date 10.13.11

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.
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Groundwater Demands and Current Groundwater Uses

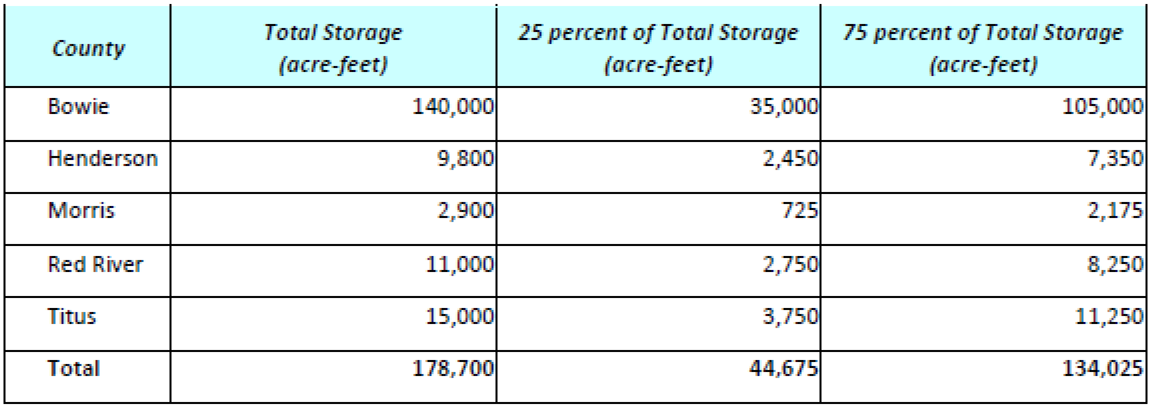
The Texas Water Development Board pumping database shows 2012 groundwater pumping for the Nacatoch Aquifer as follows:

- 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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> 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*

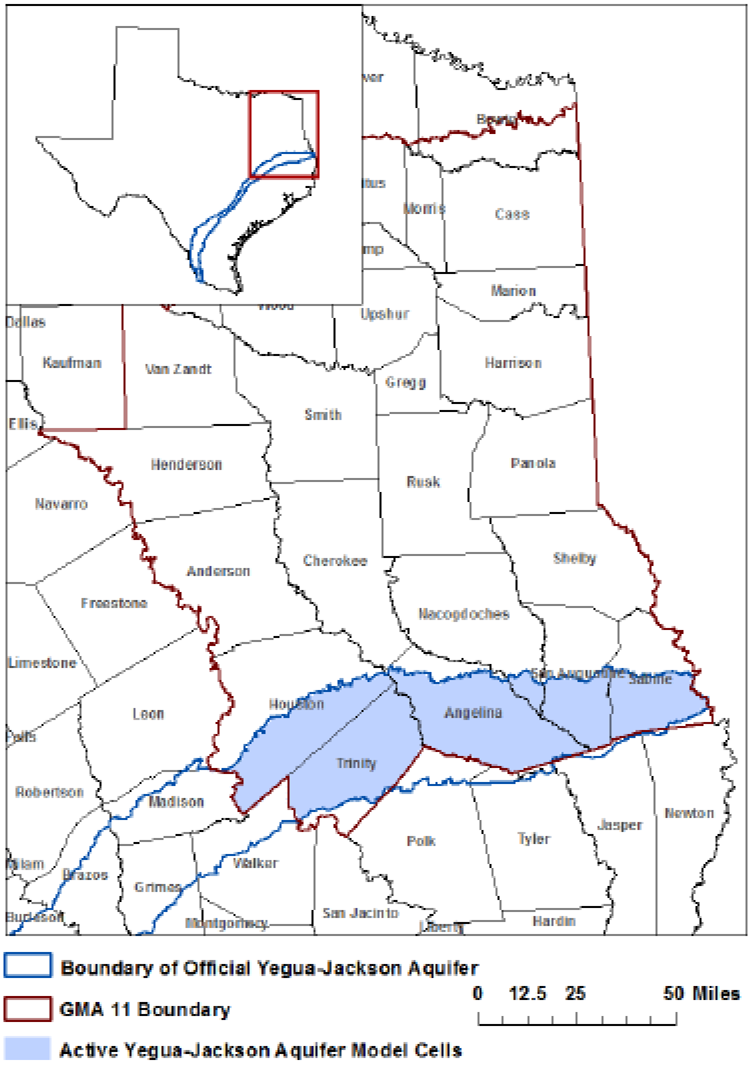
> *varies greatly owing to sediment composition in the aquifer formations, and in all areas the aquifer becomes highly mineralized with depth. Most groundwater is produced from the sand units of the aquifer, where the water is fresh and ranges from less than 50 to 1,000 milligrams per liter of total 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



county boundary date 02.02.11. ygjk model grid date 10.14.11

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

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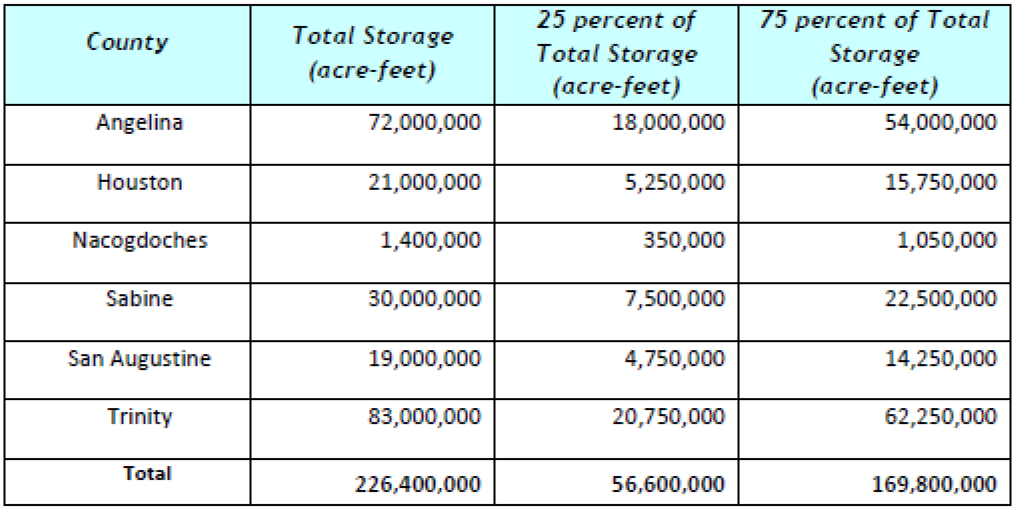
Groundwater Demands and Current Groundwater Uses

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.