Final Summary Report on science utilized in the Groundwater Management Area (GMA) joint planning process utilized by Carrizo-Wilcox Groundwater Conservation District (GCD), the appropriateness of current GCD rules to achieve Desired Future Conditions (DFCs) and other long-term impacts

1.0 Introduction and Background

Task 5 of the Carrizo-Wilcox Aquifer Study (the Study) directs the Bureau of Economic Geology (BEG) to "*Review available records from GMAS 11, 12, and 13 and evaluate science behind ultimate Desired Future Conditions (DFCs) recommendations*. " The Study was designed to collect this information regarding science considered during the joint-planning process by utilizing the online survey developed specifically for the Study.

The BEG was also tasked to "*Evaluate whether the rules adopted by the appropriate GCDs are designed to achieve the probable DFC for each GMA."* In a separate report produced for the Study, (*Summary Report for Task 3*) the challenges presented by the various timelines for joint-planning by GCDs in GMAs, and the development and adoption of Regional and State Water Plans were discussed. As was the case with Task 3, ideally, this evaluation for the Study would occur after the 2011 Regional Water Plans were adopted ***and*** all Carrizo-Wilcox GCDs had amended their respective management plans to reflect adopted DFCs and estimates of Managed Available Groundwater (MAG). At the time of this writing however, all estimates of MAG are still in draft form and the Carrizo-Wilcox GCDs have not had sufficient time to amend their management plans to integrate their adopted DFCs and the resulting estimates of MAG. As such, it is not possible for the purposes of the Study to determine whether the Carrizo-Wilcox GCDs have adopted rules (or management plans) designed to achieve their adopted DFCs. A realistic review of time requirements for this task by the Carrizo-Wilcox GCDs (revise and adoption of rules) suggests that initial efforts to first review and amend the respective management plans and ***then*** adopt revised rules to achieve the applicable DFCs will not be initiated until late 2010 – early 2011. Based on similar previous efforts, this task by the Carrizo-Wilcox GCDs could take as long as one to two years to complete, once initiated.

Finally, the BEG was to "*Determine other long-term impacts of the GCD rules and plans on the entire Carrizo-Wilcox Aquifer, considering projected agricultural, industrial and municipal demands for water from the aquifer.*" In order to evaluate long-term impacts on the Carrizo-Wilcox Aquifer, the primary focus for this evaluation was to review the potential socio-economic impacts of not meeting future water supply needs that are the result of policy decisions made in the joint planning process resulting in the adopted DFCs for the Carrizo-Wilcox Aquifer.

As was the case with the *Summary Report for Task 3*, the following statements are reiterated so as to allow the reader an understanding of the provisional nature of much of the data presented in this report:

- It is understood that regional water planning data provided by the Texas Water Development Board (TWDB) are provisional in nature, in that TWDB staff are currently (at the time of this writing) engaged in the final review and approval of Regional Water Plans, and as such, certain water management strategies may need to be revised prior to final approval of the Regional Water Plans by the TWDB. However, it is not anticipated that revision necessary to water management strategies that are based on groundwater sources will need to be substantively revised. (Note – all regional water plans have now been adopted as of December 16, 2010. However, public access to the regional water planning database to confirm provisional data utilized in the Study will not be available according to TWDB staff until early 2011).
- It is also understood that the MAGs provided by the TWDB to the BEG for the Study are currently in draft form, pending review and comment from the Carrizo-Wilcox GCDs regarding quantification of exempt use. After exempt use has been established for each county and aquifer, that amount will be deducted from the draft MAGs utilized in this report. The sum of exempt use and MAG estimates will then represent the total amount of pumping consistent with the adopted DFC. While the MAG estimates may change due to comments from the GCDs, the estimates of total amount of pumping consistent with the DFCs (referred to as MAGs in this report) are not expected to change. This total amount of pumping is what is directly analogous to groundwater availability in the Regional Water Plans. It is expected that the 2016 Regional Water Plans will include this total amount of pumping (which includes exempt use + the MAG). Until exempt use has been quantified, ***for the purposes of this report only***, MAG equals the total amount of pumping consistent with the DFC.
- With respect to a review of the Regional and State Water Plans, it is recognized that we are currently in the interval between adoption of Regional Water Plans and adoption of a State Water Plan. As such, the current State Water Plan is now four years old, and in many cases, inconsistent with recently adopted Regional Water Plans. For the purposes of this report, in order to utilize the most current information and to avoid unnecessary confusion, information regarding currently available supplies and water management strategies from the recently adopted 2011 Regional Water Plans was utilized for this analysis. Information from the 2007 State Water Plan was reviewed, but will not be presented in this report.
- In the 2016 Regional Water Plans and the 2017 State Water Plan, the total amount of groundwater available to meet current and future needs can be no more than the MAG for the most recently adopted DFC. This task (Task 5) asks the BEG ***to "Determine other long-term impacts*** *of the GCD rules and plans on the entire Carrizo-Wilcox Aquifer, considering projected agricultural, industrial and municipal demands for water from the aquifer".* In order to conduct this evaluation of long-term impacts, information developed in the *Summary Report for Task 3* was utilized. *Summary Report for Task 3* was primarily focused on the identification and quantification of *conflicts* between DFCs adopted in the joint-planning process *and* the sum of currently available supplies and water management strategies from the recently adopted 2011 Regional Water Plans. As was discussed in this report, what is not defined explicitly during this transitional stage of planning (*both regional water planning and joint planning for GCDs) is what constitutes a conflict. For reference, 31 TAC §356.2(a)(6) states a conflict is "A situation where the managed available groundwater identified in a management plan or the adopted State Water Plan is not the managed available groundwater based on the desired future conditions set*

*by the groundwater conservation districts in the groundwater management area." T*his definition will be universally applicable during *th*e 2016 Regional Water Plans and 2017 State Water Plan. However, due to the timing of submission of DFCs and calculation of MAGs by the TWDB, none of the Carrizo-Wilcox GCDs were able to provide official MAGs in time for inclusion in the 2011 Regional Water Plans. Therefore, technically, no conflict can exist at this time. For the purposes of Task 3, we did compare, on a county b*y county basis, the sum of Carrizo-Wilcox Aquifer availability and water management strategies that rely on the Carrizo-Wilcox Aquifer to the draft estimates of MAG for the Carrizo-Wilcox Aquifer from the initial round of joint planning that just concluded on September 1, 201*0. Therefore, <u>*solely*</u> for the purposes of the Study, a "potential conflict" is defined as "where, on a county-level evaluation, the sum of current water supplies available from the Carrizo-Wilcox Aquifer and water management strategies that rely on groundwater from the Carrizo-Wilcox Aquifer in a county are greater than or exceed the MAG for the same county."

<u>2.0 Methodology</u>

The primary source of information available for evaluation of science used by the three GMAs during their deliberations of potential DFCs was information provided by the representative GCD through the Study's online survey. As part of the online survey, the following question was asked:

Question 23 – Within GMA 11, 12, and 13, each groundwater conservation district that has been selected to serve as the administrator for the GMA process is asked to provide electronic copies of minutes from any meetings that have taken place since the beginning of the joint planning process during which scientific data and/or studies have been considered during the development of desired future condition recommendations. Provide electronic copies of any scientific data or presentations considered and identified in the minutes.

Information provided by the three GMAs regarding science considered during the first round of joint planning was compiled and reviewed. Additional information was provided after the survey process was completed by Post Oak Savannah GCD and reviewed for the Study.

In order to evaluate the impacts of GCD rules and plans on the entire Carrizo-Wilcox Aquifer, considering projected agricultural, industrial and municipal demands for water from the aquifer, information developed for the *Summary Report for Task 3* quantifying "potential conflicts" was correlated with socio-economic impact analysis developed for the 2011 Regional Water Plans. In the *Summary Report for Task 3*, an evaluation of the Regional and State Water Plans and MAGs resulting from the DFCs adopted by the Carrizo-Wilcox GCDs during the recently completed joint planning process was conducted in order to identify *potential conflicts* that may exist between the two planning processes. Solely for the purposes of this Study, a *potential conflict* is defined as "where, on a county-level evaluation, the sum of current water supplies available from the Carrizo-Wilcox Aquifer and water management strategies that rely on groundwater from the Carrizo-Wilcox Aquifer in a county are greater than or exceed the MAG for the same county." For a more complete description of assumptions and methodology utilized

in this evaluation, the reader is referred to the *Summary Report for Task 3* that was prepared as part of the Study.

Socio-economic impact data developed for this evaluation was provided by the TWDB. This information is required as part of the regional water planning process in Texas. 31 Texas Administrative Code §357.7(a)(4)(A) states, in part, that a Regional Water Plan shall include, "…*The social and economic impact of not meeting these needs shall be evaluated by the regional water planning groups and reported by regional water planning area and river basin. The executive administrator shall provide available technical assistance to the regional water planning groups, upon request, on water supply and demand analysis, including methods to evaluate the social and economic impacts of not meeting needs."* Information provided by the executive administrator to all of the regional water planning groups with water supplies utilized from the Carrizo-Wilcox Aquifer was utilized for this evaluation.

3.0 Results

The Carrizo-Wilcox Aquifer is present over more surface area than any other aquifer within Texas. According to the Texas State Water Plan, *Water for Texas – 2007*, the Carrizo Wilcox Aquifer covers all or parts of 66 counties in Texas, reaching from the Texas – Arkansas – Louisiana border in the northeast to Mexico in the south (Figure 1). The area, when combined, (the outcrop and subsurface extent) of the Carrizo-Wilcox Aquifer is approximately 36,595 square miles in aerial extent, which is 80 square miles larger than the surface area of largest producing aquifer in Texas, the Ogallala Aquifer, with a surface area of 36,515 square miles (*Water for Texas – 2007*).

When the TWDB delineated (by rule, 31 Texas Administrative Code §356.21-23) the boundaries of the groundwater management areas (GMAs) for Texas, as required by Senate Bill 2 (77th Texas Legislature, 2001), all or parts of 58 counties were included in the three GMAs covering the Carrizo-Wilcox Aquifer (Table 1, Figure 1). According to information from the TWDB, there are 18 GCDs within GMAs 11, 12, and 13 (Table 2). Three other GCDs with jurisdictional boundaries that include at least some area within the boundaries of the Carrizo-Wilcox Aquifer were included in other GMAs, due primarily to the relatively minor amount of Carrizo-Wilcox Aquifer resources within the three GCDs as compared to the primary aquifer for those GCDs, which in this case is the Gulf Coast Aquifer (see Figure 1). These three are the Bluebonnet GCD, Bee GCD, and the Live Oak GCD.

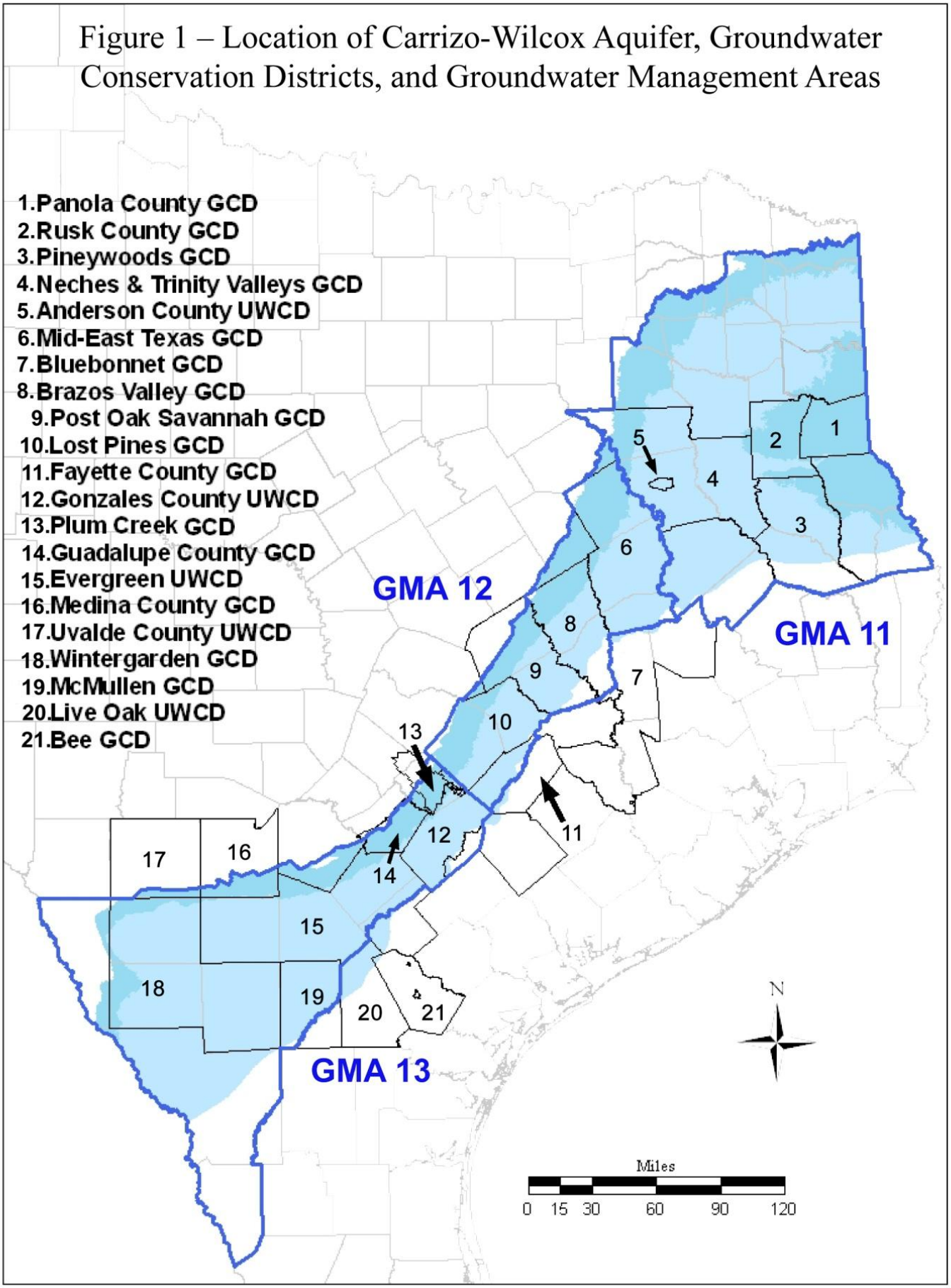
Table 1: Carrizo-Wilcox Aquifer Groundwater Management Areas and counties included (either in whole or in part)

GMA 11 (27 Counties)	*GMA 12 (14 Counties)*	*GMA 13 (17 Counties)*
Anderson	Bastrop	Atascosa
Angelina	Brazos	Bexar
Bowie	Burleson	Caldwell
Camp	Falls	Dimmit
Cass	Fayette	Frio
Cherokee	Freestone	Gonzales
Franklin	Lee	Guadalupe
Gregg	Leon	Karnes
Harrison	Limestone	La Salle
Henderson	Madison	Maverick
Hopkins	Milam	McMullen
Houston	Navarro	Medina
Marion	Robertson	Uvalde
Morris	Williamson	Webb
Nacogdoches		Wilson
Panola		Zapata
Rains		Zavala
Rusk		
Sabine		
San Augustine		
Shelby		
Smith		
Titus		
Trinity		
Upshur		
Van Zandt		
Wood		

Table 2: Carrizo-Wilcox Aquifer Groundwater Management Areas, Groundwater Conservation Districts, and Constituent Counties

GMA 11	GMA 12	GMA 13
Anderson County GCD	**Brazos Valley GCD**	**Evergreen UWCD**
Anderson	Robertson	Atascosa
Neches & Trinity Valleys GCD	Brazos	Frio
Anderson	**Fayette County GCD**	Karnes
Cherokee	Fayette	Wilson
Henderson	Burleson	**McMullen County GCD**
Panola County GCD	**Lost Pines GCD**	McMullen
Panola	Lee	**Medina County GCD**
Pineywoods GCD	Bastrop	Medina
Angelina	**Mid-East Texas GCD**	**Gonzales County UWCD**
Nacogdoches	Freestone	Gonzales
Rusk County GCD	Leon	**Guadalupe County GCD**
Rusk	Madison	Guadalupe
	Post Oak Savannah GCD	**Plum Creek GCD**
	Burleson	Caldwell
	Milam	**Uvalde UWCD**
		Uvalde
		Wintergarden GCD
		Dimmit
		La Salle
		Zavala

Figure 1 – Location of Carrizo-Wilcox Aquifer, Groundwater Conservation Districts, and Groundwater Management Areas



In response to the survey questionnaire developed for the Study, the Carrizo-Wilcox GCD designated as the administrator for GMA 11, 12, and 13 provided information regarding any science considered by the Carrizo-Wilcox GCDs throughout the joint planning process. The detail provided through the survey on this question was quite variable. Tables 3 – 5 provide a summary of the science considered throughout the joint planning process in GMA 11 – 13, respectively.

Table 3: GMA 11*Information submitted by GMA 11 regarding science considered during the recently completed joint planning process.*

Date	Description (*Italics indicate a presentation was included with meeting minutes).*
5/25/2006	Rima Petrossian, TWDB, made presentation on joint planning under TWC 36.108
6/22/2006	Len Luscomb, Rusk County GCD, discussion of Martin Lake impacts to the DFC's of GMA 11.
7/27/2006	Dr. MacDonald, Stephen F. Austin University: ARC GIS utility presentation.
7/27/2006	Len Luscomb, Rusk County GCD: Again raised issue of Martin Lake impacts to the GMA 11 DFC's.
6/25/2007	Len Luscomb, Rusk County GCD, made recommendation regarding approach to obtain best available data for monitoring all counties in GMA-11 (including unprotected counties).
11/29/2007	Shirley Wade, TWDB, made presentation on results from Groundwater Availability Model (GAM) Run 07-20 for GMA 11.
11/29/2007	Len Luscomb, Rusk County GCD, made recommendation to adopt a DFC of near sustainability for the Carrizo-Wilcox Aquifer, allowing a 10 foot drawdown.
10/15/2008	Roy Rodgers, Neches & Trinity Valleys GCD, made recommendation regarding possible action on exempt well pumping in determining MAG.
5/19/2009	Len Luscomb, Rusk County, made recommendation regarding possible action on exempt well pumping in determining MAG.
10/20/2009	Dr. William Hutchinson, TWDB, made presentation on GAM Run 08-23.
10/20/2009	Len Luscomb, Rusk County GCD, made recommendation to set initial DFCs for the Carrizo-Wilcox Aquifer in GMA 11
11/24/2009	David Alford, Pineywoods GCD, led discussion of setting a DFC.
11/24/2009	Dr. William Hutchinson, TWDB, presented additional analysis of GAM Run 08-23

Table 4 : GMA 12

Information submitted by GMA 12 regarding science considered during the recently completed joint planning process.

Date	Description (*Italics indicate a presentation was included with meeting minutes.)*
1/26/2006	***Larry French, URS, Process Necessary to Identify the Desired Future Conditions of the Aquifers in GMA12***
4/27/2006	Robert Gresham, Mid-East Texas GCD, Presentation on DFC for Groundwater.
4/27/2006	Rodney Willis, Fayette County GCD, Presentation on DFC for Groundwater.
4/27/2006	Larry French, URS for Post Oak Savannah GCD, Presentation on DFC for Groundwater.
4/27/2006	Robert Kier, Lost Pines GCD, Presentation on DFC for Groundwater.
4/27/2006	John Seifert, Brazos Valley GCD, Presentation on DFC for Groundwater.
10/30/2006	Discussion of HB 1763 and Dialogue on Desired Future Conditions.
12/12/2006	***Larry French, URS, Proposed Initial DFC Statement for GMA 12 Planning***
03/01/2007	Member GCD's review LBG- Guyton, GAM information
03/01/2007	***James Beach, LBG-Guyton, Carrizo-Wilcox GAMs for GMA12 and GMA-1.***
05/10/2007	***Dan Opdyke, Texas Parks & Wildlife, Possible Impact of GMA 12 GAM***
05/10/2007	***LBG-Guyton, GAM Run Considerations***
10/30/2008	***Steve Box, Environmental Stewardship, Groundwater & Surface Water Crossroads.***
10/30/2008	Frank Limer, Russ Johnson, Mike Thornhill, Stacy Reeves, Ends Ops LP & Brazos River Alliance, Property Owner Rights and How DFC's adopted by GMA 12 would affect
10/30/2008	***David Dunn, HDR Engineers, Impact of large groundwater withdrawals on the economies of Brazos and Robertson Counties.***
10/30/2008	***Dan Opdyke, Texas Parks and Wildlife, A Groundwater Perspective on Surface Water Resources for GMA 12.***
10/30/2008	Ridge Kaiser, R.W. Hardin, Stakeholder Comments regarding DFC & MAG Process.
10/30/2008	Frank Limer, Russ Johnson, Mike Thornhill, Stacy Reeves, Ends Ops LP & Brazos River Alliance, Property Owner Rights and How DFC's Adopted by GMA 12 Would Affect Those Rights.
6/24/2009	Matt Uliana, Mid-East Texas GCD, Presentation on DFC for Groundwater.
6/24/2009	David Van Dresar, Fayette County GCD, Presentation on DFC for Groundwater.
Saunders	***Steve Young, Post Oak Savannah GCD, Presentation on DFC for Groundwater.***
6/24/2009	Robert Kier, Lost Pines GCD, Presentation on DFC for Groundwater.
6/24/2009	John Seifert, Brazos Valley GCD, Presentation on DFC for Groundwater.
6/24/2009	Meeting Minutes Indicate that the LBG-Guyton and URS were selected as Consultants
6/24/2009	***Environmental Stewardship, Protection of Rivers, Streams, and Springs through DFC.***
6/24/2009	***Geoffrey P. Saunders, LCRA, Low-Flow Gain-Loss Study of the Colorado River in Bastrop County, Texas.***
6/24/2009	Response to Comments from the GMA-12 Stakeholder Meeting on October 30, 2008.
6/24/2009	Primary Estimates of Desired Future Conditions for Brazos Valley Groundwater Conservation District.
8/28/2009	***James Beach, LBG Guyton, History of Groundwater Management.***
8/28/2009	John Seifort, Brazos Valley GCD, Presentation on Estimated Groundwater Use in GMA 12.
8/28/2009	Predicted Changes in Groundwater Levels.

Table 5: GMA 13

Information submitted by GMA 13 regarding science considered during the recently completed joint planning process.

Date	Presentations *Italics indicate a presentation was included with meeting minutes.*
1/11/2006	***Robert Bradley, TWDB, Groundwater Availability Modeling***
3/22/2006	***Robert Bradley, TWDB, Groundwater Availability Modeling***
3/2/2007	***Robert Bradley, TWDB, Groundwater Availability Modeling***
11/20/2007	***Andrew Donnelly, TWDB, Discussion of DFC of the Aquifers of GMA 13.***
1/9/2008	***Andrew Donnelly, TWDB, Discussion of DFC of the Aquifers of GMA 13.***
3/31/2008	Groundwater Management Area 13 Stakeholder Group Report
9/26/2008	***San Antonio Water System, Recommended Desired Future Conditions (DFC) for GMA-13***
10/15/2008	***Sarah Backhouse, Shirley Wade, TWDB, GAM MODELS***
8/13/2009	***Sarah Backhouse, Shirley Wade, TWDB, GAM MODELS***
9/19/2009	***Charles Kreitler, LBG-Guyton, Presentation on the Desired Future Conditions***
9/19/2009	***Shirley Wade, TWDB, Groundwater Budgets, Inflows, Outflows, and Storage Changes.***
2/19/2010	***Dr. William Hutchinson, Texas Water Development Board, Groundwater Available Model***
4/9/2010	***Resolution to Adopt Scenario 4 with a 23' drawdown across GMA 13.***
	Additional Texas Water Development Board Documents
9/29/2008	Shirley Wade, TWDB, DRAFT GAM RUN 08-43
1/22/2008	Peter George, et al , TWDB, Desired Future Conditions and Aquifer Slivers in GMA's
4/24/2008	Texas Water Development Board, Appendix for GAM RUN 07-17
8/29/2008	Shirley Wade. Texas Water Development Board, GAM RUN 08-41
9/16/2008	Shirley Wade, Texas Water Development Board, Amended GAM RUN 08-41
9/25/2008	Shirley Wade, Texas Water Development Board, Amended GAM RUN 08-41; 08-42;08-43
7/7/2009	Andrew Donnelly, Texas Water Development Board, GAM RUN 06-29

Our review of the science considered during the joint planning process for GMAs 11, 12, and 13, based on information provided by the Carrizo-Wilcox GCDs for the Study, has documented that in each GMA, the core science considered in the adoption of DFCs was science developed by the TWDB as part of the GAM Program. The degree to which the results from additional scientific information was considered ranges from no additional substantive information being considered by in GMA 11 to multiple scientific presentations that were local or sub-GMA in scope for GMAs 12 and 13. For example, in GMA 12, results from scientific studies regarding surface water/groundwater interactions were considered as the different possible DFCs were being evaluated. Our review of meeting minutes from GMA 12 documented 11 other presentations by interested stakeholders and consultants including: Environmental Defense Fund, Environmental Stewardship, LBG-Guyton, City of Bryan, Lower Colorado River Authority, HDR Engineers, Texas Parks and Wildlife, and URS. Also, there were multiple occasions when stakeholders submitted letters to GMA 12 for consideration during the DFC process including: Ends Ops. LP., Brazos River Alliance, and private property owners.

On January 26, 2006, for example, Larry French, Senior Hydrogeologist for URS, submitted a letter detailing the process necessary to identify the desired future conditions for the aquifers in GMA 12. On December 12th 2006, Larry French, Senior Hydrogeologist for URS, submitted a technical memorandum and listed the Draft DFC's for all of all segments of the Carrizo-Wilcox Aquifer. As the DFC process continued comments and presentations were received concerning the impact of establishing a DFC for the GMA 12 Carrizo-Wilcox GCDs. During March and May of 2007, LBG-Guyton provided groundwater availability models to GMA 12 for review. Texas Parks and Wildlife Department, Environmental Stewardship, the Lower Colorado River Authority, and Environmental Defense Fund presented information detailing the relationship between surface water and groundwater in the region and the impact that groundwater production has on the regions hydrogeology.

Though multiple comments and presentations were heard by the Board of GMA12, there were materials from for only five of the presentations prepared by the GMA 12 consultants submitted to the Study for review.

For GMA 13, we documented 12 presentations by the TWDB, the San Antonio Water System and by LBG-Guyton. There were six additional TWDB documents that were mentioned in the meeting minutes of GMA 13, which consisted of GAMs that were conducted and presented to GMA 13.

As part of the Study in Task 1, the BEG was asked to review and evaluate the adequacy of science utilized by Carrizo-Wilcox GCDs in the development of management plans and rules. The results of this review and evaluation are presented in the *Summary Report for Task 1b*. Based on the review contained in the *Summary Report for Task 1b*, the following conclusion was made, "*Therefore, it is clear in statute that it is the intent of the Texas Legislature that one of the primary sources of groundwater science to be utilized by GCDs during their development of management plans and their adoption of desired future conditions is to be the groundwater availability models and groundwater science developed and made publically available by the executive administrator of the Texas Water Development Board."*

The evaluation for this report leads to a similar conclusion. Based on information provided through the survey for the Study, the primary source of science utilized by two of the three GMAs (11 and 13) was information derived from the three Carrizo-Wilcox GAMs. The TWDB provided a number of model simulation results to these two GMAs based on draft DFC requests from the GMAs throughout the DFC process. By design, this was an iterative process, whereby TWDB staff would present model results to the GMAs, and then the GMAs would modify the modeling requests to better understand the potential MAGs that could result from the draft DFCs being considered. Further, there is no record in the meeting minutes from GMA 12 that the TWDB independently presented any GAM results during the joint planning process.

In summary, with respect to our review and evaluation of science considered during the joint planning process and the adoption of DFCs, based on information provided by the three GMAs, one of the primary sources of science considered in GMA 11 and 13 was information provided by TWDB staff. In the survey developed for the Study, GCDs serving as administrator during the

joint planning process for each of the three GMAs were asked, *"…to provide electronic copies of minutes from any meetings that have taken place since the beginning of the joint planning process during which scientific data and/or studies have been considered during the development of desired future condition recommendations. Provide electronic copies of any scientific data or presentations considered and identified in the minutes.*" Meeting minutes were provided by the responsible Carrizo-Wilcox GCDs, and presentations identified in the meeting minutes are listed in tables 3 – 5. In some instances, a copy of a PowerPoint presentation was attached with the meeting minutes. However, no electronic copies of any scientific data considered by the Carrizo-Wilcox GCDs during the joint planning process were submitted in the survey. While a PowerPoint presentation can be an effective means of communicating the results of a scientific study, the reality is that a PowerPoint presentation is rarely adequate to fully document the nature and scope of the science considered in a decision-making process such as the joint planning process. Our conclusion from this review is that one of the primary sources of science considered in the joint planning process was information from the TWDB, especially information from the three GAMs that have been developed for the Carrizo-Wilcox Aquifer.

A fundamental component of the regional water planning process is the evaluation of what are the socio-economic impacts at the regional, county, and sector (municipal, manufacturing, mining, etc.) level, of not meeting future water supply needs. During this evaluation, several impacts are modeled and quantified, including social impacts such as population, school enrollment, and economic impacts such as regional income, state and local business taxes, and the number of full and part time jobs. These evaluations are modeled for the major water use sectors; municipal, agricultural, livestock, steam-electric power generation, and mining. One of the outputs from the socio-economic impact analysis that is included in all Regional Water Plans is the total monetary losses per acre foot of water need that is not met by a water management strategy. In other words, what is the monetary impact to a water use sector if future water supply needs are not met?

The water supply shortages that may result as a consequence of the adopted DFCs in GMAs 11, 12, and 13, were quantified in the *Summary Report for Task 3*. Readers are encouraged to refer to this report for a full explanation of methodologies and results. However, due to the nature of the evaluation process required to understand the potential socio-economic impacts of the adopted DFCs, Table 6 (Table 1 in *Summary Report on Task 3*) is reproduced in this report for those counties for which a "potential conflict" has been quantified. Solely for the purpose of the Study, these potential conflicts are a result of the amount of groundwater from the Carrizo-Wilcox Aquifer for current water supplies plus water management strategies included in the recently adopted 2011 Regional Water Plans being greater at some point in the 50-year planning horizon than the MAG for the Carrizo-Wilcox Aquifer for the county in question. Next, monetary losses per acre-foot of water supply need for the 20 counties was derived from the socio-economic impact analysis conducted by the TWDB as part of the regional water planning process. These results, by regional water planning group, by county, by water use sector, and by decade are presented in Table 7.

It is important to note that it is not possible to determine which water use sector would be impacted by the "potential conflicts" if the 2016 Regional Water Plans are not able to develop additional water management strategies to meet these needs. Therefore, if the *potential conflicts* are not resolved, the economic impacts will be dependent upon which water use sector(s) has the unmet need. For example, the total monetary losses per acre foot of water needs in 2020 for Bastrop County ranges from $125 for irrigation use to $4,277 for municipal use. Therefore, if all unmet needs are realized by the irrigation water use sector in Bastrop County, and the unmet need is 4,263 acre-feet in 2010 (see table 6), then the economic impact as expressed by the total monetary loss is estimated to be $532,875. However, if the unmet needs are evenly divided between the irrigation water use sector and the municipal water use sector, then the total monetary loss for 2010 would be $9,382,863 ((2,131.5 acre-feet x $125 for irrigation water use sector) + (2,131.5x$4,277 for municipal water use sector)). Practically speaking however, if a repeat of drought of record conditions were to occur, it is very difficult to make categorical projections of which water use sector will be asked or expected to realize what portion of the shortage. For example, would manufacturers or power generators be asked to cut back on production, or would businesses and homes be expected to reduce water use in order to meet total demands? These types of modeling assumptions have a very significant impact on the final analysis of total monetary loss, and are clearly beyond the scope of the Study.

Table 6 (Part of Table 1 Summary Report on Task 3): Comparison of draft estimates of MAG from first round of joint planning with sum of currently available supplies and water management strategies recommended in recently adopted 2011 regional water plans. Due to the absence of quantified values for exempt use at this time, for the purposes of this report only, the values for MAG equal the total amount of pumping consistent with the adopted DFC. A potential conflict, as defined in the Study, exists when the sum of currently available supplies and water management strategies is greater than the MAG for any decade during the 50-year planning horizon. These instances are illustrated in this table in parentheses (xxxx), i.e. negative numbers. All values are in acre-feet per year.

Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
I	11	Angelina	MAG	26,414	26,414	26,414	26,414	26,414	26,414
		Angelina	Supplies + Strategies	22,569	22,533	24,339	24,599	26,679	27,051
			Difference	***3,845***	***3,881***	***2,075***	***1,815***	***(265)***	***(637)***
L	13	Atascosa	MAG	67,949	68,776	70,369	71,947	73,786	75,808
		Atascosa	Supplies + Strategies	67,872	69,043	69,921	69,987	70,051	72,526

Table 6 (Part of Table 1 Summary Report on Task 3): Comparison of draft estimates of MAG from first round of joint planning with sum of currently available supplies and water management strategies recommended in recently adopted 2011 regional water plans. Due to the absence of quantified values for exempt use at this time, for the purposes of this report only, the values for MAG equal the total amount of pumping consistent with the adopted DFC. A potential conflict, as defined in the Study, exists when the sum of currently available supplies and water management strategies is greater than the MAG for any decade during the 50-year planning horizon. These instances are illustrated in this table in parentheses (xxxx), i.e. negative numbers. All values are in acre-feet per year.

Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
			Difference	***77***	***(267)***	***448***	***1,960***	***3,735***	***3,282***
K	**12**	**Bastrop**	MAG	16,866	19,979	20,666	24,833	28,018	28,498
		Bastrop	Supplies + Strategies	21,129	31,489	38,622	46,388	54,275	58,321
			Difference	***(4,263)***	***(11,510)***	***(17,956)***	***(21,555)***	***(26,257)***	***(29,823)***
G	**12**	**Brazos**	MAG	33,925	38,835	44,847	49,421	53,970	57,169
		Brazos	Supplies + Strategies	44,380	44,502	44,386	47,432	47,439	47,434
			Difference	***(10,455)***	***(5,667)***	***461***	***1,989***	***6,531***	***9,735***

Table 6 (Part of Table 1 Summary Report on Task 3): Comparison of draft estimates of MAG from first round of joint planning with sum of currently available supplies and water management strategies recommended in recently adopted 2011 regional water plans. Due to the absence of quantified values for exempt use at this time, for the purposes of this report only, the values for MAG equal the total amount of pumping consistent with the adopted DFC. A potential conflict, as defined in the Study, exists when the sum of currently available supplies and water management strategies is greater than the MAG for any decade during the 50-year planning horizon. These instances are illustrated in this table in parentheses (xxxx), i.e. negative numbers. All values are in acre-feet per year.

Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
G	**12**	**Burleson**	MAG	3,750	23,249	28,047	32,518	36,492	38,701
		Burleson	Supplies + Strategies	4,369	4,369	4,669	27,433	30,053	31,557
			Difference	***(619)***	***18,880***	***23,378***	***5,085***	***6,439***	***7,144***
L	**13**	**Dimmit**	MAG	3,359	3,359	3,359	3,359	3,359	3,359
		Dimmit	Supplies + Strategies	13,536	13,536	13,536	13,536	13,536	13,536
			Difference	***(10,177)***	***(10,177)***	***(10,177)***	***(10,177)***	***(10,177)***	***(10,177)***

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Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
12	**C**	**Freestone**	MAG	5,138	5,305	5,317	5,315	5,262	5,259
		Freestone	Supplies + Strategies	5,783	5,223	5,223	5,223	5,223	5,223
			Difference	***(645)***	***82***	***94***	***92***	***39***	***36***
13	**L**	**Frio**	MAG	81,551	79,089	76,734	74,439	72,222	70,030
		Frio	Supplies + Strategies	246,645	246,645	246,645	246,645	246,645	246,645
			Difference	***(165,094)***	***(167,556)***	***(169,911)***	***(172,206)***	***(174,423)***	***(176,615)***
13	**L**	**Gonzales**	MAG	52,483	62,316	70,317	75,791	75,970	75,970

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Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
		Gonzales	Supplies + Strategies	15,740	35,648	44,928	55,561	67,821	80,540
			Difference	***36,743***	***26,668***	***25,389***	***20,230***	***8,149***	***(4,570)***
13	**L**	**Guadalupe**	MAG	10,241	10,833	11,283	13,021	13,541	14,041
		Guadalupe	Supplies + Strategies	19,832	23,162	25,779	26,384	28,029	29,570
			Difference	***(9,591)***	***(12,329)***	***(14,496)***	***(13,363)***	***(14,488)***	***(15,529)***
11	**C&I**	**Henderson**	MAG	9,253	9,186	9,186	9,186	9,186	9,186
		Henderson	Supplies + Strategies	8,833	9,565	9,567	9,851	9,853	9,895

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Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
			Difference	***420***	***(379)***	***(381)***	***(665)***	***(667)***	***(709)***
L	**13**	**Karnes**	MAG	1,059	1,117	1,182	1,231	1,259	1,280
		Karnes	Supplies + Strategies	1,141	1,141	1,141	1,141	1,141	1,141
			Difference	***(82)***	***(24)***	***41***	***90***	***118***	***139***
L	**13**	**La Salle**	MAG	6,454	6,454	6,454	6,454	6,454	6,454
		La Salle	Supplies + Strategies	8,013	8,013	8,013	8,013	8,013	8,013
			Difference	***(1,559)***	***(1,559)***	***(1,559)***	***(1,559)***	***(1,559)***	***(1,559)***

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Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
M	**13**	**Maverick**	MAG	2,043	2,043	2,024	1,677	1,570	1,532
		Maverick	Supplies + Strategies	1,792	2,056	2,058	2,060	2,073	2,444
			Difference	***251***	***(13)***	***(34)***	***(383)***	***(503)***	***(912)***
L	**13**	**Medina**	MAG	2,568	2,545	2,533	2,533	2,533	2,533
		Medina	Supplies + Strategies	7,597	7,597	7,597	7,597	7,597	7,597
			Difference	***(5,029)***	***(5,052)***	***(5,064)***	***(5,064)***	***(5,064)***	***(5,064)***

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Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
C	**12**	**Navarro**	MAG	15	15	15	15	15	15
		Navarro	Supplies + Strategies	88	88	88	88	88	88
			Difference	***(73)***	***(73)***	***(73)***	***(73)***	***(73)***	***(73)***
L	**12**	**Uvalde**	MAG	2,971	1,230	828	828	828	828
		Uvalde	Supplies + Strategies	2,846	2,846	2,846	2,846	2,846	2,846
			Difference	***125***	***(1,616)***	***(2,018)***	***(2,018)***	***(2,018)***	***(2,018)***
D	**11**	**Van Zandt**	MAG	10,614	10,283	10,283	10,283	10,283	10,051

Table 6 (Part of Table 1 Summary Report on Task 3): Comparison of draft estimates of MAG from first round of joint planning with sum of currently available supplies and water management strategies recommended in recently adopted 2011 regional water plans. Due to the absence of quantified values for exempt use at this time, for the purposes of this report only, the values for MAG equal the total amount of pumping consistent with the adopted DFC. A potential conflict, as defined in the Study, exists when the sum of currently available supplies and water management strategies is greater than the MAG for any decade during the 50-year planning horizon. These instances are illustrated in this table in parentheses (xxxx), i.e. negative numbers. All values are in acre-feet per year.

Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
		Van Zandt	Supplies + Strategies	7,499	8,170	8,645	8,982	9,645	10,292
			Difference	***3,115***	***2,113***	***1,638***	***1,301***	***638***	***(241)***
M	**13**	**Webb**	MAG	916	916	916	916	916	916
		Webb	Supplies + Strategies	3,882	6,824	9,138	9,712	9,711	9,710
			Difference	***(2,966)***	***(5,908)***	***(8,222)***	***(8,796)***	***(8,795)***	***(8,794)***
G	**12**	**Williamson**	MAG	7	7	7	7	7	7
		Williamson	Supplies + Strategies	8,412	8,412	8,412	8,522	8,522	8,522

Table 6 (Part of Table 1 Summary Report on Task 3): Comparison of draft estimates of MAG from first round of joint planning with sum of currently available supplies and water management strategies recommended in recently adopted 2011 regional water plans. Due to the absence of quantified values for exempt use at this time, for the purposes of this report only, the values for MAG equal the total amount of pumping consistent with the adopted DFC. A potential conflict, as defined in the Study, exists when the sum of currently available supplies and water management strategies is greater than the MAG for any decade during the 50-year planning horizon. These instances are illustrated in this table in parentheses (xxxx), i.e. negative numbers. All values are in acre-feet per year.

Regional Water Planning Area (RWPA)	Groundwater Management Area (GMA)	County	Calculations	2010	2020	2030	2040	2050	2060
			Difference	*(8,405)*	*(8,405)*	*(8,405)*	*(8,515)*	*(8,515)*	*(8,515)*

Table 7: Socio-economic impacts results from 2011 Regional Water Plans (* - denotes county that did not have any water supply needs during the 50-year planning horizon, therefore, no monetary losses have been calculated)

Region C		Total Monetary Losses Per Acre-Foot of Water Supply Need					
County	**Sector**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Freestone	Steam-electric	$0	$0	$0	$0	$24,617	$24,617
Freestone	Municipal	$0	$40,561	$40,569	$23,452	$17,637	$15,461
Navarro	Steam-electric	$0	$98,083	$98,083	$98,083	$98,083	$98,083
Navarro	Municipal	$0	$1,766	$1,620	$1,699	$3,084	$5,845
Navarro	Manufacturing	$0	$81,977	$81,967	$82,005	$163,979	$163,974
Region D							
County	**Sector**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Van Zandt	Municipal	$941	$957	$1,011	$1,459	$8,131	$18,473
Region G							
County	**Sector**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Brazos	Municipal	$119	$2,221	$3,170	$8,637	$9,389	$10,770
Williamson	Municipal	$6,205	$10,545	$15,826	$23,391	$30,033	$31,340
Williamson	Manufacturing	$107,880	$107,880	$107,880	$107,880	$107,880	$107,880
Williamson	Mining	$24,139	$24,139	$24,139	$24,139	$24,139	$24,139
Region I							
County	**Sector**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Angelina	Livestock	$0	$0	$0	$60,362	$60,362	$60,362
Angelina	Steam-electric	$72,631	$72,631	$72,631	$72,631	$72,631	$72,631
Angelina	Mining	$76,776	$82,394	$0	$0	$0	$0
Angelina	Manufacturing	$12,474	$24,942	$24,941	$49,883	$49,883	$49,883
Angelina	Municipal	$5,067	$18,406	$18,297	$18,020	$30,419	$23,349
Henderson	Livestock	$0	$60,362	$60,362	$60,362	$60,362	$60,362
Henderson	Steam-electric	$0	$0	$160,127	$160,127	$160,127	$160,127
Henderson	Municipal	$2,456	$10,609	$8,808	$12,159	$19,747	$24,469
Region K							
County	**Sector**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Bastrop	Municipal	$576	$4,277	$7,214	$11,737	$14,765	$21,624
Bastrop	Irrigation	$125	$125	$125	$125	$125	$125
Bastrop	Manufacturing	$63,229	$63,229	$63,229	$63,229	$63,229	$126,458
Bastrop	Steam-electric	$0	$0	$0	$27,719	$27,719	$27,719

Table 7 (Continued): Socio-economic impacts results from 2011 Regional Water Plans

Region L		Total Monetary Losses Per Acre-Foot of Water Supply Need					
County	**Sector**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Atascosa	Municipal	$6,578	$8,445	$6,869	$7,037	$7,842	$9,232
Atascosa	Irrigation	$194	$194	$194	$194	$194	$194
Atascosa	Steam-electric	$7,760	$0	$0	$0	$7,760	$7,760
	Needs	*	*	*	*	*	*
Dimmit	Satisfied						
	Needs	*	*	*	*	*	*
Frio	Satisfied						
	Needs	*	*	*	*	*	*
Gonzales	Satisfied						
Guadalupe	Municipal	$11,780	$13,865	$18,150	$32,188	$30,322	$25,502
Karnes	Municipal	$9,011	$18,867	$28,839	$31,147	$32,065	$34,289
	Needs	*	*	*	*	*	*
La Salle	Satisfied						
Medina	Municipal	$9,493	$7,342	$7,545	$10,195	$10,721	$10,845
Medina	Irrigation	$174	$174	$174	$174	$174	$0
Uvalde	Municipal	$14,089	$14,139	$14,180	$14,202	$14,220	$14,247
Region M							
County	**Sector**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Maverick	Municipal	$833	$1,285	$1,622	$5,772	$6,348	$7,040
Maverick	Irrigation	$397	$200	$200	$200	$200	$200
Webb	Municipal	$899	$1,387	$5,941	$12,445	$14,410	$23,944
Webb	Irrigation	$293	$293	$293	$293	$293	$293
Webb	Steam-electric	$0	$0	$0	$0	$9,645	$9,645