ASR Feasibility in Bandera County

Prepared for:

Plateau Region Water Planning Group
and
Texas Water Development Board

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1.0 Executive Summary

The City of Bandera and many other residents of Bandera County rely on the Lower Trinity Aquifer for municipal, domestic, and irrigation water-supply needs, and the demand from the Lower Trinity is projected to increase as the population increases. Because the water level in the Lower Trinity has declined about 350 feet in City of Bandera wells since pumping started in the 1950s, there is concern that continued withdrawals from the aquifer may negatively impact the aquifer's ability to meet the long-term water supply needs of the area. The purpose of this project is to investigate the feasibility of constructing and operating an aquifer storage and recovery (ASR) facility using treated surface water from the Medina River and stored in the Lower Trinity Aquifer.

The Trinity is the most important water-bearing unit in Bandera County and is collectively referred to as the Trinity Group Aquifer. Based on their hydrologic relationships, the water-bearing rocks of the Trinity Group are organized into Upper, Middle and Lower aquifer units. The Lower Trinity Aquifer, the most important aquifer for municipal use, is comprised of the Sligo Limestone and underlying Hosston Sand.

Bandera County currently has an agreement with the Bexar-Medina-Atascosa Water Control and Improvement District #1 (BMAWCID#1) for purchase of up to 5,000 acre-feet per year of water from the Medina River. The reliability of the River diversion was calculated with a version of the Water Availability Model of the Guadalupe-San Antonio Basin dated March 2008 provided by the Texas Commission on Environmental Quality (TCEQ). The average diversion over the historical hydrologic period 1934-1989 is 3,680 acre-feet per year. Based on this assessment, a water diversion and treatment facility size of 6.7 mgd is recommended for a supply of 3,100 acre-feet per year, with an ASR injection and recovery rate of 1.0 mgd.

At the request of the Bandera County River Authority and Groundwater District (BCRAGD), LBG-Guyton conducted a modeling study of the Lower Trinity in Bandera and surrounding counties (LBG-Guyton Associates, 2009). Based on the conceptual understanding and assimilated data, a one-layer MODFLOW groundwater flow model was developed. The model was calibrated to pre-development and transient conditions from 1950 through 2005.

The Lower Trinity Aquifer model was used to evaluate ASR impacts on the aquifer system based on varying scenarios of injection rate, injection location, and annual withdrawals from the aquifer. At the higher end, an injection rate of 2.54 mgd was found to be overly excessive from a hydrogeologic perspective regardless of the level of projected water demand. If only the City of Bandera municipal wells are considered as the point of injection, the model suggests that 0.5 mgd would be the most appropriate rate of injection. Additional scenarios considered a reduced rate of injection at the City of Bandera municipal wells and an increased rate in southeast Bandera County, where new subdivisions under full buildout would increase the need for additional water supplies. Based on this scenario, the modeling results suggest a total injection of around 1.0 mgd is reasonable.

The estimated infrastructure cost for the completion of an ASR facility was prepared. The estimated capital costs for a 6.7 mgd capacity source-water treatment facility is $17,973,000 (2008 dollars) and the annual cost of operation and maintenance is $540,000, which results in a treatment unit cost of $595 per acre-foot. The cost to construct and equip a single Lower Trinity well capable of both injection and withdrawals is approximately $454,000. The total capital cost is $ 18,881,000 and the total overall unit cost of the ASR strategy is $659 per acre-foot.

2.0 Introduction

The City of Bandera and many other residents of Bandera County rely on the Lower Trinity Aquifer for municipal, domestic, and irrigation water-supply needs, and the demand from the Lower Trinity is projected to increase as the population increases. Table 2-1 shows the available water supplies and water demands for Bandera County as reported in the 2006 Plateau Region Water Plan (PRWP). Although the PRWP does not project water supply shortages for either municipal or rural (County-Other) use, the Plateau Water Planning Group members have voiced their concern that population and water demand could increase beyond projected levels. Because the water level in the Lower Trinity Aquifer has declined about 350 feet in City of Bandera wells since pumping started in the 1950s, there is concern that continued withdrawals from the Lower Trinity may negatively impact the aquifer's ability to meet the long-term water supply needs of the area.

The purpose of this project was to investigate the feasibility of constructing and operating an ASR facility in Bandera County using treated surface water from the Medina River and stored in the subsurface Lower Trinity (Hosston) Aquifer. Bandera County currently has a water supply agreement with the BMAWCID#1 for purchase of up to 5,000 acre-feet per year. The investigation considers both the availability of source-water supplies from the River and the ability of the aquifer to store and release the treated water. An estimate of infrastructure cost is also provided. The results of this investigation are intended to be used for Regional Water Planning strategy consideration and should not be considered as an in-depth engineering feasibility analysis. The BCRAGD and the City of Bandera cooperated in the performance of this project.

Table 2.1. Supply and Demand Projections for the City of Bandera and Bandera County-Other (in acre-feet per year)

	2010	2020	2030	2040	2050	2060
Supply						
City of Bandera	1,210	1,210	1,210	1,210	1,210	1,210
County-Other	11,510	11,510	11,510	11,510	11,510	11,510
Total Supply	*12,720*	*12,720*	*12,720*	*12,720*	*12,720*	*12,720*
Demand						
City of Bandera	259	284	312	332	351	371
County-Other	2,609	3,638	4,659	5,206	5,374	5,726
Total Demand	*2,868*	*3,922*	*4,971*	*5,538*	*5,725*	*6,097*

Source: 2006 Plateau Region Water Plan

3.0 ASR Water Supply Availability

This section examines the reliability of a surface water diversion of 5,000 acre-feet per year from the Medina River near the City of Bandera as a water supply source for a potential ASR operation in Bandera County. The recommended size of facilities to evaluate the feasibility of the ASR project is also presented. Treated municipal wastewater from the City of Bandera was also considered. However, at an average discharge of 0.15 MGD, this volume was not judged to be sufficient to meet the needs for the intended ASR operation.

The BMAWCID#1 owns Certificate of Adjudication (CA) No. 19-2130. This adjudication authorizes the District to divert up to 65,830 acre-feet per year for irrigation, municipal and industrial uses, up to 750 acre-feet per year specifically for domestic and livestock purposes, and up to 170 acre-feet per year specifically for municipal use.

Bandera County currently has a Water Supply Agreement with BMAWCID#1 for the purchase of up to 5,000 acre-feet per year. Water available from this contract could be used in the proposed ASR Project.

Under CA No. 19-2130, BMAWCID#1 is authorized to divert water from Medina Lake and Diversion Dam. However, it is anticipated that the surface water purchased by Bandera County for local use and the potential ASR project will be diverted in the vicinity of the City of Bandera, upstream of Medina Lake. As a result, an amendment of the existing water right owned by BMAWCID#1 will be required and the upstream diversion point would likely be subject to additional bypass requirements. A minimum bypass equal to the 7Q2 was assumed to evaluate the reliability of this diversion. The 7Q2 is defined as the minimum average 7-day flow that has a return period of 2 years. The published 7Q2 for the Medina River at Bandera is 20 cfs (Chapter 307 - Texas Surface Water Quality Standards, TCEQ).

The reliability of the River diversion was calculated with a Run 3 version of the Water Availability Model of the Guadalupe-San Antonio Basin dated March 2008 provided by the TCEQ. Assumptions of the Run 3 version include adherence to strict prior appropriation, maximum use and storage, no return flows, and a hydrologic simulation period of 1934-1989. The version as received from the TCEQ includes updates for Lake Medina/ Diversion Lake and the addition of channel loss factors to all main stem water rights in the Guadalupe and San Antonio River Basins. At the time of this study, this version was being used by the TCEQ for evaluating water right permit applications. The results are summarized as follows:

- The average diversion over the historical hydrologic period 1934-1989 is 3,680 acre-feet per year.
- The full diversion of 5,000 acre-feet is possible for 32% of the years (about 1 every 3 years).
- 70% of the full diversion (3,500 acre-feet) is possible for 66% of the years (about 2 every 3 years).
- There is one year with no diversion.
- Annual diversions are shown in Figure 3.1.

Ideally, the ASR combined with the surface water diversion should provide the average of 3,680 acre-feet per year. To be conservative, a diversion of 85% of the average or 3,100 acre-feet per year was assumed for planning purposes. When the full supply (5,000 acre-feet per year) is available, 3,100 acre-feet per year will be treated and used directly, and 1,900 acre-feet per year will be injected in the ASR. Using a peak factor of 1.5 and the limitation on the injection rates based on hydrogeological conditions (Section 5.0), the recommended size of the facilities for a supply of 3,100 acre-feet per year (2.8 mgd) is:

- Diversion and treatment: 6.7 mgd
  (5000 acre-feet per year)(1121 mgd/acre-feet per year*1.5)
- Direct distribution: 4.1 to 5.7 mgd
  (Average supply plus excess not injected)
- Injection and recovery: Up to 1.0 mgd
  (Based on preliminary hydrogeological study)

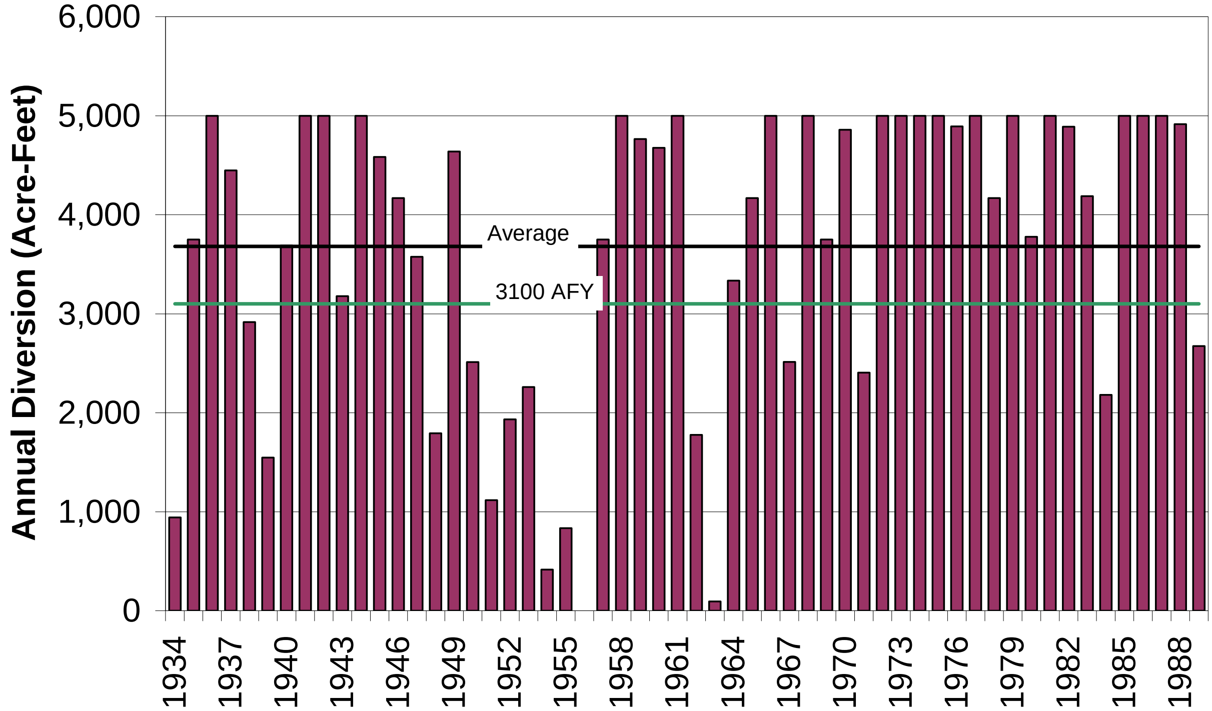

Figure 3.1 Annual diversions from the Medina River in the vicinity of the City of Bandera

4.0 Lower Trinity Aquifer

The Trinity is the most important water-bearing unit in Bandera County and is collectively referred to as the Trinity Group Aquifer (Ashworth, 1983; Bluntzer, 1992; Reeves and Lee, 1962). Based on their hydrologic relationships, water-bearing rocks of the Trinity Group are organized into Upper, Middle and Lower Trinity Aquifer units (Ashworth, 1983).

Aquifer Units of the Trinity Group

Upper Trinity Aquifer	Upper Glen Rose Limestone
Middle Trinity Aquifer	Lower Glen Rose Limestone, Hensell Sand, and Cow Creek Limestone
Confining layer	Hammett Shale
Lower Trinity Aquifer	Sligo Limestone and Hosston Sand

The Lower Trinity Aquifer is comprised of the Sligo and underlying Hosston Formations. The Sligo, a sandy to shaley, dolomitic limestone, only occurs south of an ENE to WSW line midway through Bandera County and reaches a maximum thickness of 80 feet in the southeastern part of the County (Ashworth, 1983).

The Hosston Sand is the lower portion of the Lower Trinity Aquifer and is often referred to by local water well drillers as the "Lower Trinity Sand." The Hosston consists of a basal conglomerate grading upward to sandstone, claystone, shale, dolomite, and limestone. The thickness of the Hosston is variable because of the uneven surface in the underlying Paleozoic rocks on which it was deposited, but generally ranges from approximately 300 feet in southeastern Bandera County to the area where the Hosston pinches out in northern Kerr County. Generally, the most productive section of the Hosston Sand is the basal conglomerate zone (LBG-Guyton Associates, 2001).

Most wells, especially domestic wells, located in the study area are completed in the Middle Trinity Aquifer, as the Middle Trinity Aquifer usually supplies sufficient water to meet the users' needs without the expense of drilling deeper wells. Wells previously drilled into the Lower Trinity are often screened in both the Middle and Lower Trinity aquifers in order to get the maximum production possible out of the well. However, to prevent potential cross contamination, new groundwater conservation district regulations in Bandera and Kerr counties no longer allow this type of dual completion. In the vicinity of the Cities of Kerrville and Bandera, many of the public-supply wells have been completed only in the Lower Trinity Aquifer (LBG-Guyton Associates, 2001).

Figure 4.1 shows hydrographs for three City of Bandera wells (state well numbers 6924102 - Dallas Street well; 6924202 - Mulberry Street well; and 6924221 - Indian Water well). The graph indicates consistent declines from the 1950s through the 1990s, with a total of approximately 350 feet of water-level decline. Water levels in the wells have slightly increased during the last 10 years. The reason for this water level increase is unknown, as the amount of production from City of Bandera wells has not decreased.

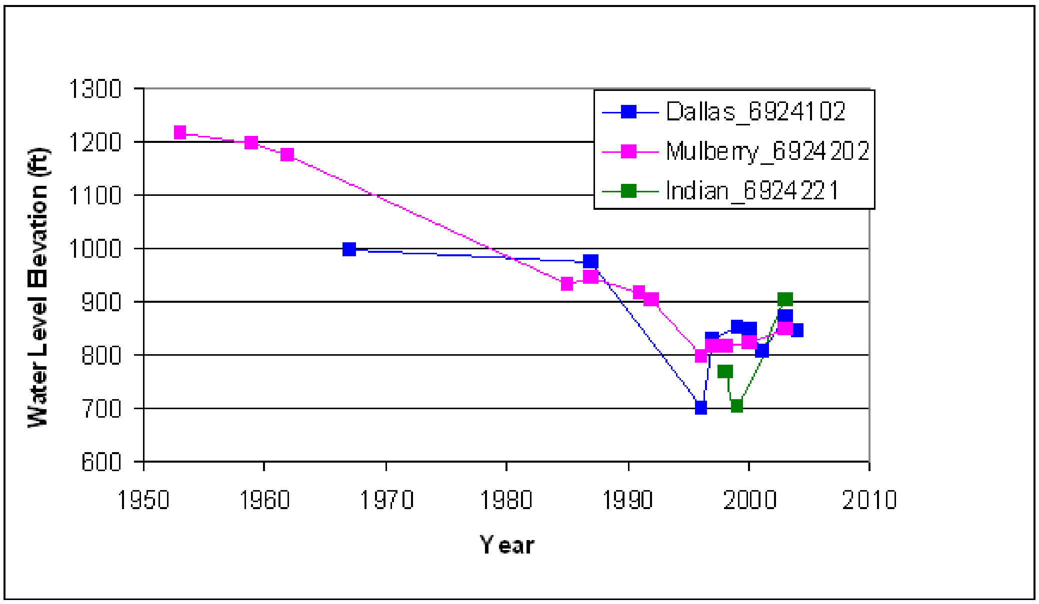

Figure 4.1 Historical water levels in City of Bandera Lower Trinity wells

The amount of storage depletion in the Lower Trinity Aquifer resulting from the water level decline between the years 1950 and 1997 as calculated by a Lower Trinity Aquifer model (see Section 5.1) is approximately 9,800 acre-feet. The total amount of pumping from the Lower Trinity in Bandera County during this time period was 13,758 acre-feet. The difference between these two volumes represents the amount of leakage back into the depleted part of the Lower Trinity from laterally adjacent areas of the aquifer and possibly from vertical downward leakage from the overlying Middle Trinity Aquifer.

5.0 Lower Trinity Aquifer Model Analysis

5.1 Lower Trinity Model

At the request of the Bandera County River Authority and Groundwater District, LBG-Guyton conducted a modeling study of the Lower Trinity in Bandera and surrounding counties (LBG-Guyton Associates, 2009). The main objective was to build a Lower Trinity Aquifer model that could be used as a water supply management tool by the BCRAGD and the City of Bandera to evaluate aquifer response to projected water demands.

The study consisted of: (1) the development of a conceptual model of the Lower Trinity Aquifer, (2) assimilation of relevant data into a format that can be used in the numerical model, (3) calibration of a steady-state model, which represents pre-development conditions, (4) calibration of a transient model from 1950 to 2005, and (5) predictive simulations from 2006 to 2060.

Based on the conceptual understanding and assimilated data, a one-layer MODFLOW groundwater flow model was developed. The code used to develop the Lower Trinity Aquifer model is MODFLOW-2000 (Harbaugh, et al., 2000). Pre- and post-processing of the model data uses Groundwater Vistas (Version 5). The model was calibrated to pre-development conditions and the transient conditions from 1950 through 2005. Calibration statistics indicate the model simulates the historical water level trends reasonably well.

Two predictive scenarios were simulated with the calibrated model. The model indicates that the water level near the City of Bandera will experience continued decline at a similar rate to the historical trend if future pumping is consistent with the 2006 PRWP water demand projections. If pumping is increased to account for an assumed "full build-out" of the currently platted and approved subdivisions in Bandera County as estimated by the BCRAGD, the model indicates an accelerated water level decline to a level that decreases the saturated thickness of the Lower Trinity to less than 100 percent and thus a loss of artesian pressure in high demand areas.

5.2 Model Analysis Results

For this regional planning project, six additional scenarios are presented that incorporate an ASR concept. For each scenario, background pumping uses either PRWP projected water demands or necessary pumping to meet water demands resulting from full county buildout of subdivisions platted through 2007. Injection is assumed to start in 2010 and continue through 2060 for all scenarios. Water levels are compared to the scenario of continuing PRWP demands without future ASR. The ASR concept is described below.

1. Injection uses three City of Bandera wells. Total amount of injection varies.
   a) Total injection of 2.54 mgd. Continue PRWP demands.
   b) Total injection of 2.54 mgd. Continue full buildout demand.
   c) Total injection of 0.50 mgd. Continue PRWP demands.

2. Injection uses three City of Bandera wells and additional wells in the southeast part of Bandera County. The total amount of injection varies. The amount that is injected into three City of Bandera wells is the same as PRWP projected demand for the City of Bandera (0.28 mgd on average) and remains the same for all three scenarios. The rest of the total is injected into the wells in southeast Bandera County. Demands outside of the City of Bandera assume full county buildout of subdivisions.
   a) Total injection of 2.54 mgd.
   b) Total injection of 1.27 mgd.
   c) Total injection of 0.64 mgd.

Because the transmissivity of the Lower Trinity is relatively small, water levels near the injection wells increase significantly if injection rates are too high. Scenarios were deemed infeasible if the resulting potentiometric surface (water level) is above ground surface. The amount of injection for each scenario is shown in Table 5.1.

Table 5.1. Average injection over time in each of ASR scenarios (in mgd)

Scenario	Injection in City of Bandera wells (mgd)	Injection in SE Bandera County wells (mgd)	Pumping Demand
1a	2.54	0	PRWP
1b	2.54	0	Full Buildout
1c	0.50	0	PRWP
2a	0.28	2.26	Full Buildout
2b	0.28	0.99	Full Buildout
2c	0.28	0.36	Full Buildout

Scenario 1a represents 2.54 mgd injection in three City of Bandera wells. Figure 5.1 shows the water level elevation in the Lower Trinity 50 years after injection begins (2060), and Figure 5.2 shows the resulting water level change. The contours indicate that the water level around the City of Bandera injection wells would increase over 2,000 feet. The surface elevation in the City of Bandera is around 1,400 feet (amsl). The results indicate that a total injection of 2.54 mgd is not feasible because the Lower Trinity water level in the wells around the City of Bandera would be above ground surface. The same conclusion holds true even if a full buildout water demand in the southeast area of Bandera County is considered (Scenario 1b).

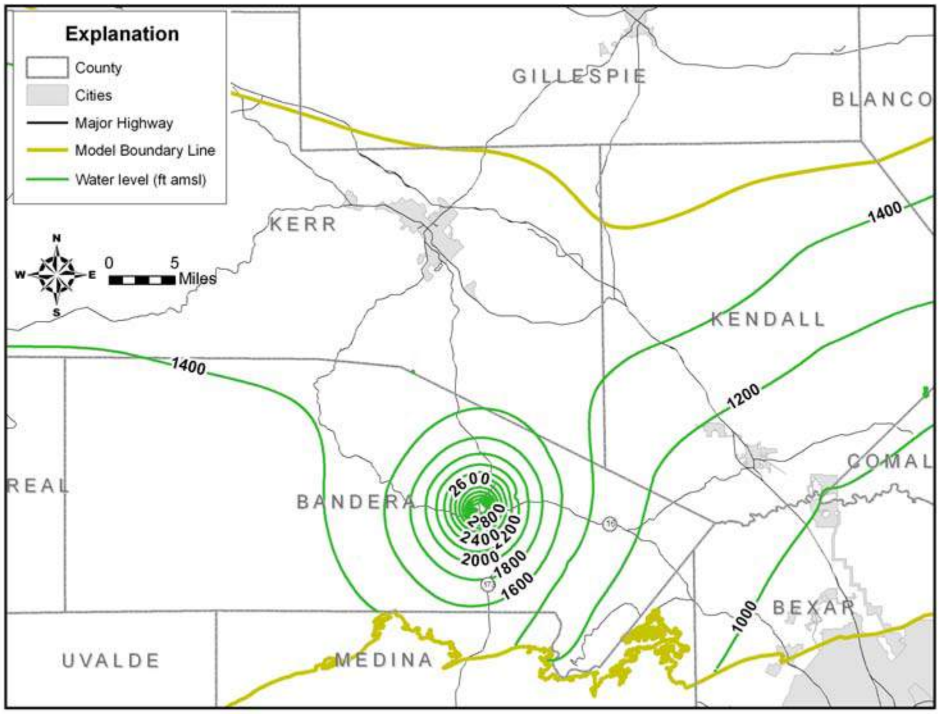

Figure 5.1 Water level elevation in the Lower Trinity in 2060 after injection of 2.54 mgd for 50 years for Scenario 1a

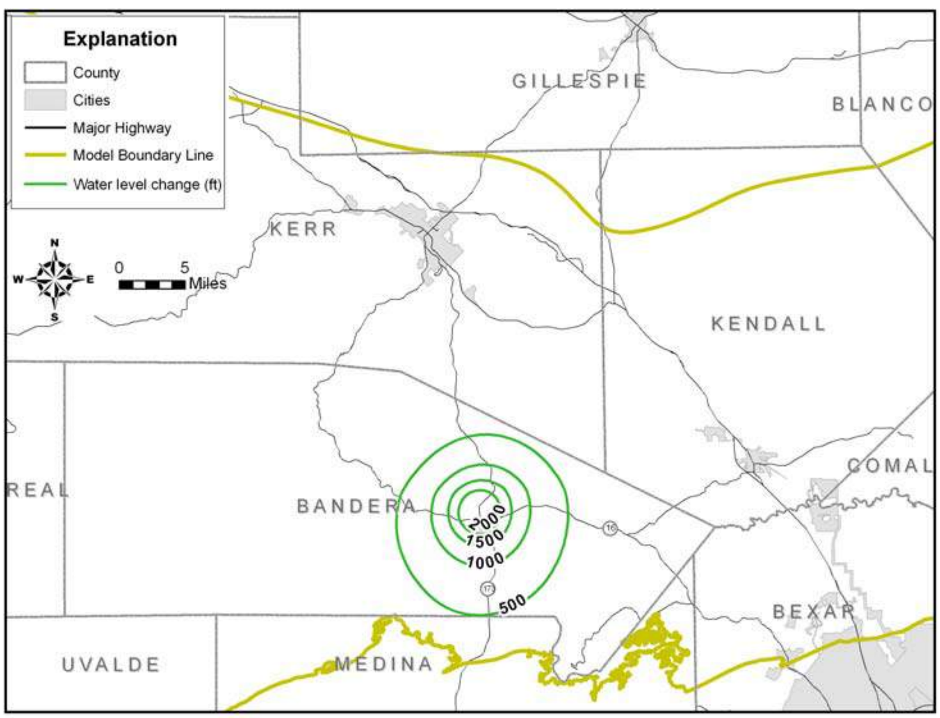

Figure 5.2 Water level change from 2010 to 2060 for Scenario 1a

Scenario 1c represents 0.5 mgd injection in three City of Bandera wells. Figure 5.3 shows the water level elevation in the Lower Trinity after 50 years of injection. The potentiometric surface is generally below land surface and thus indicates injection at this level is feasible from a hydrogeologic perspective. Figure 5.4 shows the impact on water levels in a City of Bandera well under Scenario 1c.

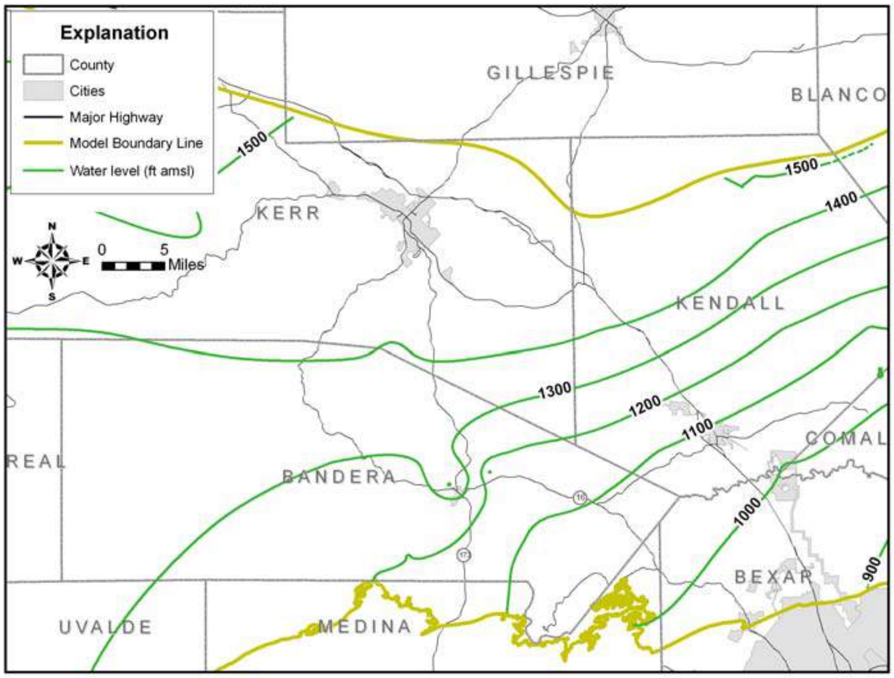

Figure 5.3 Water level elevation in the Lower Trinity in 2060 after injection of 0.5 mgd for 50 years for Scenario 1c

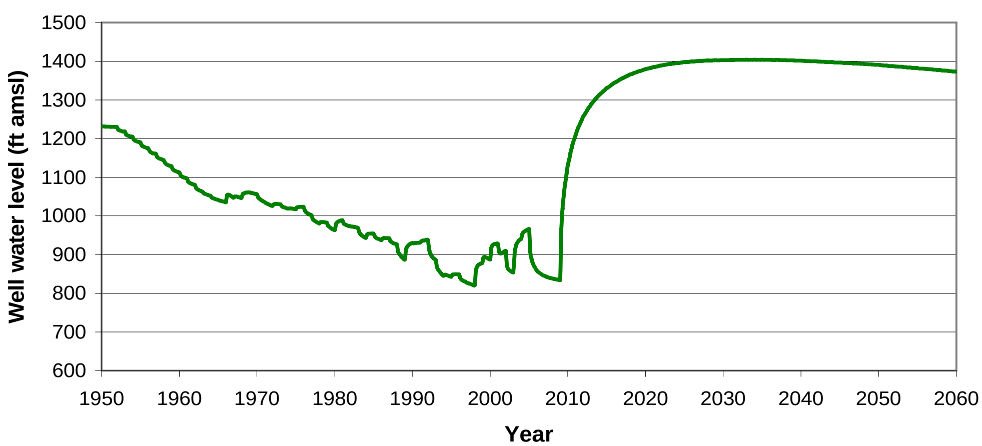

Figure 5.4 Hydrograph of water level elevation in a City of Bandera well after injection of 0.5 mgd for 50 years for Scenario 1c

Scenarios 2a, 2b, and 2c consider a reduced rate of injection at three City of Bandera wells and an increased rate of injection in southeast Bandera County, where new subdivisions increase demand projections under the full buildout scenario. Scenario 2a (Figure 5.5) represents a total injection of 2.54 mgd and the results indicate the injection at this level is too high. Scenario 2b and 2c represent total injection of 1.27 mgd and 0.64 mgd, respectively. Figure 5.6 and Figure 5.8 show water level elevations in the Lower Trinity after 50 years (2060) of injection for Scenarios 2b and 2c, respectively. Figure 5.7 and Figure 5.9 show the water level change resulting from these scenarios. The results suggest a total injection of around 1.0 mgd is reasonable.

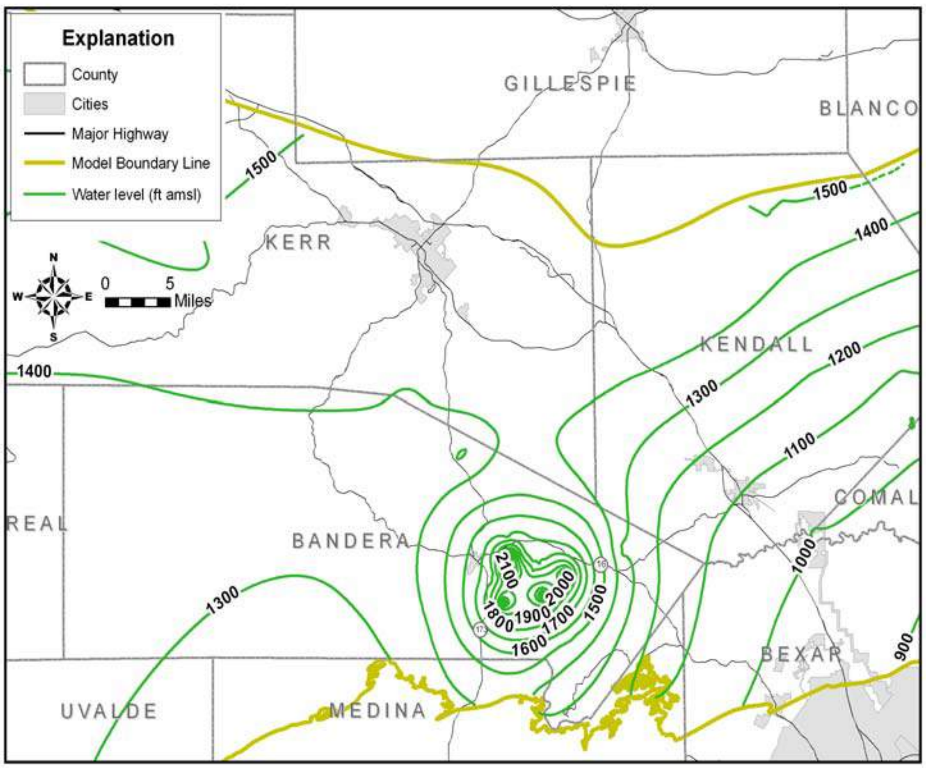

Figure 5.5 Water level elevation in the Lower Trinity in 2060 after injection of 2.54 mgd for 50 years for Scenario 2a

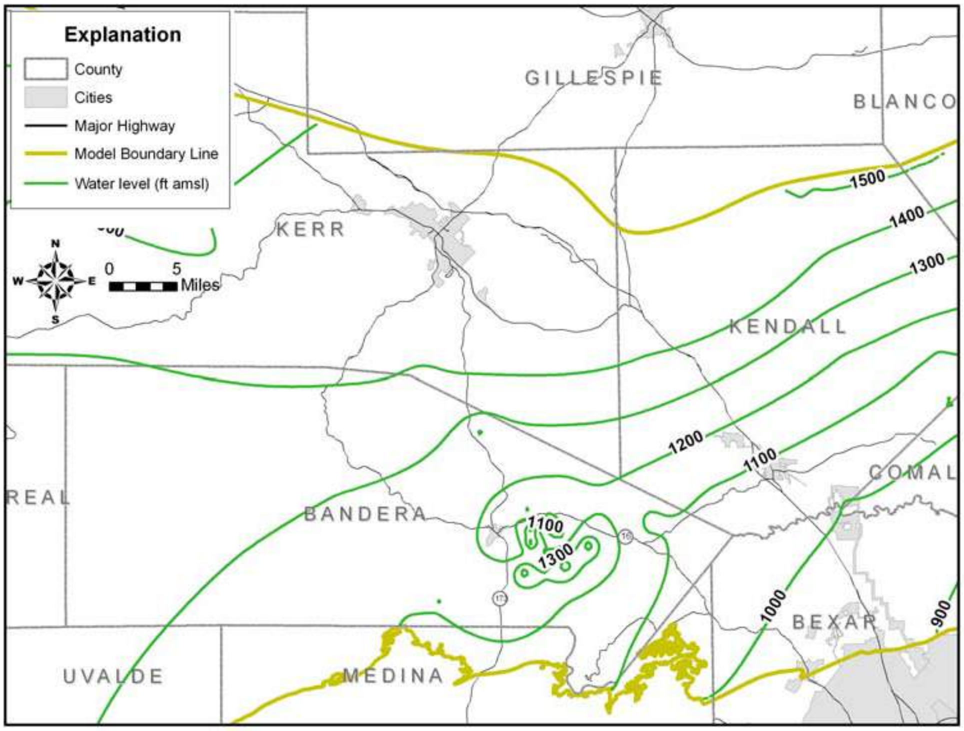

Figure 5.6 Water level elevation in the Lower Trinity in 2060 after injection of 1.27 mgd for 50 years for Scenario 2b

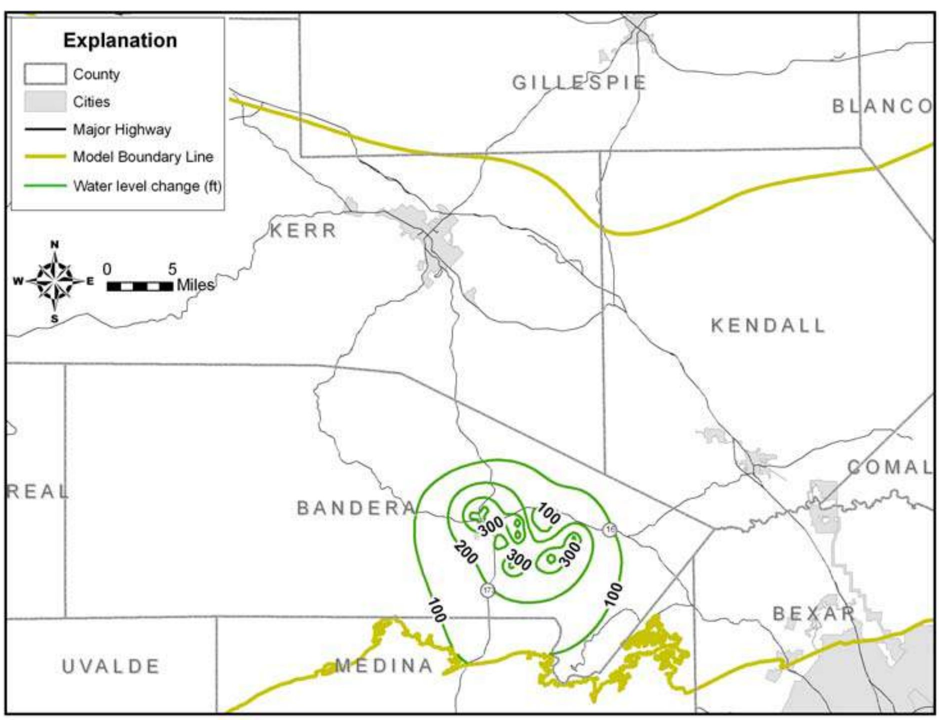

Figure 5.7 Water level change from 2010 to 2060 for Scenario 2b

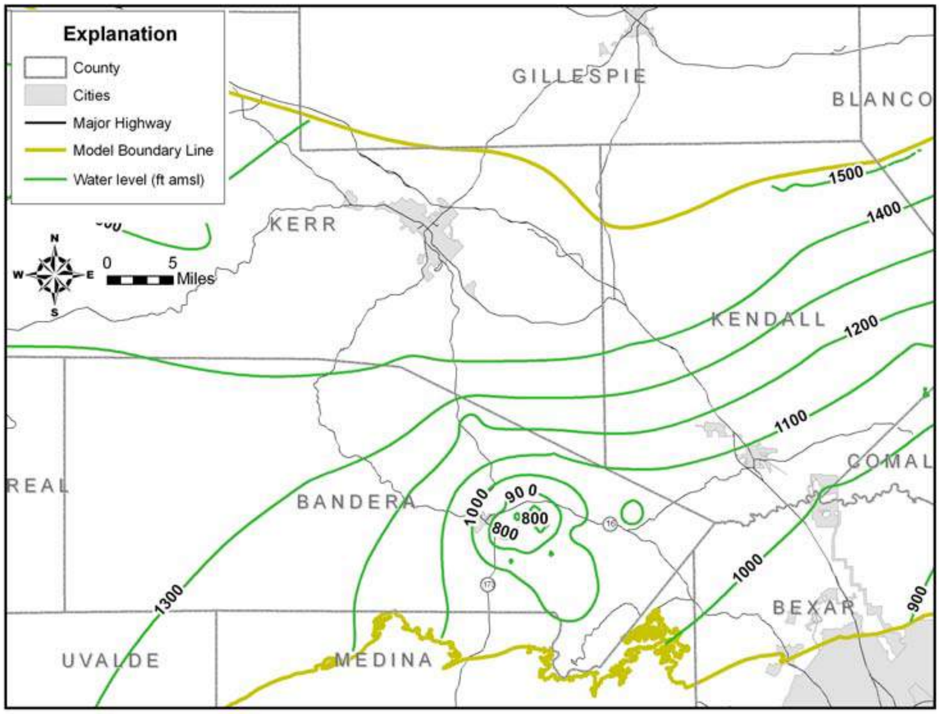

Figure 5.8 Water level elevation in the Lower Trinity in 2060 after injection of 0.64 mgd for 50 years for Scenario 2c

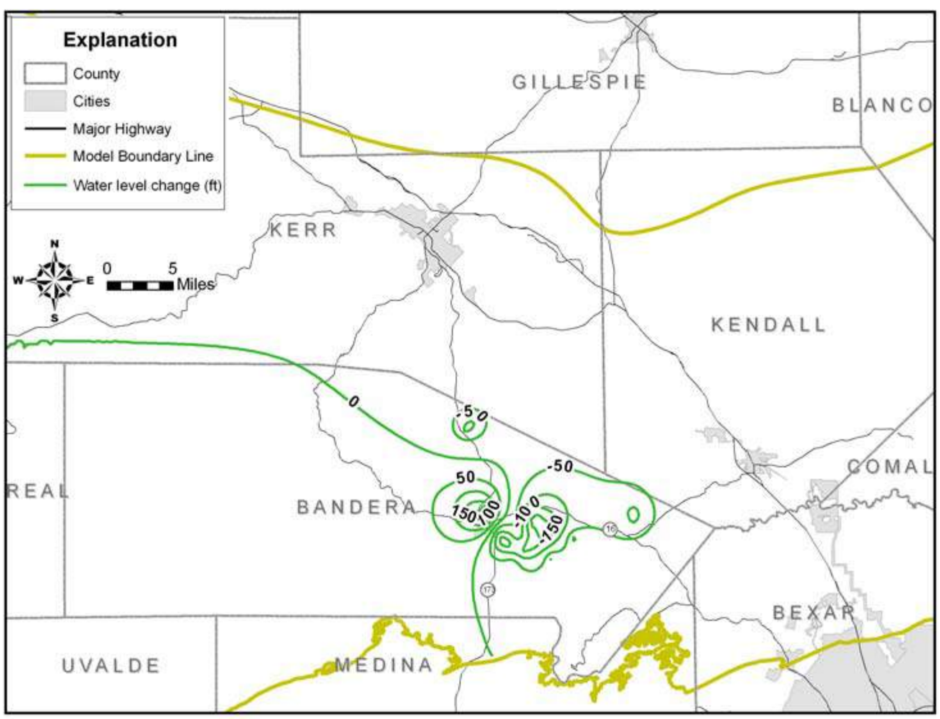

Figure 5.9 Water level change from 2010 to 2060 for Scenario 2c

6.0 Infrastructure Cost

Source Water Treatment Facility

This plant will be treating water from the Medina River near the City of Bandera and will have an approximate capacity of 6.7 mgd. Water quality data from a USGS station in the Medina River near Bandera shows high variability of turbidity. The dissolved solids are very low and softening is recommended. Cost estimates assume a low pressure membrane treatment process for particle removal (microfiltration) and a second stage treatment with high pressure membranes (nanofiltration) for softening 50% of the flow. A 27 million-gallon terminal reservoir is recommended to buffer high turbidity peaks from the Medina River. The estimated capital cost for this plant is $17,973,000 (2008 dollars). This cost includes the raw water pump station, terminal storage reservoir, residuals handling facilities (solid storage lagoon), high service pump station, clearwell, engineering and contingencies. The annual cost of operation and maintenance is $540,000.

Volume of water treated:	5,000 acre-feet per year	Wet years
	0 acre-feet per year	Dry years
	3,680 acre-feet per year	Average
Capital Cost	$ 17,973,000	
Annual Cost		
Average Annual Volume Treated	3,680 acre-feet	3.28 mgd
Unit Cost O&M	$ 146.6/acre-foot	$0.45/1000 gal
Cost O&M	$ 540,000	
Debt Service (6%. 30 years)	$ 1,306,000	
Total Annual Cost	**$ 1,846,000**	
Unit Cost		
Supply	3,100 acre-feet per year	(85% of average diversion)
Unit cost	**$ 595 per acre-foot**	($1.82 per 1000 gallons)

Injection and Recovery Well

The following cost estimates are based on a single Lower Trinity well capable of both injection and withdrawals and is based on average 2008 itemized drilling contractor bid estimates. Contractor prices can vary widely for individual items, but the aggregate prices are often similar.

ASR Well Components

- Mobilization
- Pilot Hole
- Geophysical Logs
- Reaming 16”
- 12” Casing
- Cement Casing
- Reaming 12”
- 10” Casing
- 10” Screen
- Well Development
- Pumping Test
- Water Quality Samples
- Surface Slab
- Appurtenances
- Pumps, Piping and Installation
- Motor Controls

Total Well Cost: $454,000

Table 6.1 shows the capital and unit cost of the overall ASR strategy. The total capital cost is $ 18,881,000 and the total unit cost is $659 per acre-foot.

Table 6.1. Capital and Unit Cost of ASR in Bandera County

Supply (AFY)	**3,100**
Capital Cost	
Water Treatment Plant	$ 17,973,000
Wells (2)	$ 908,000
Total Capital Cost	***$ 18,881,000***
Annual Cost	
Debt Service	$ 1,372,000
Treatment	$ 540,000
Wells	$ 131,000
Total	***$ 2,043,000***
ASR Unit Cost	***$ 659***

7.0 Conclusions

The principal municipal water supply source in Bandera County is the Lower Trinity Aquifer. Water level declines of up to 350 feet in the Lower Trinity have caused concern that continued withdrawals from the aquifer may negatively impact the aquifer's ability to meet the long-term water supply needs of the area. However, this water level decline suggests that there may be vacated pore space within the aquifer's rock matrix to store injected water. The purpose of this project was to investigate the feasibility of constructing and operating an ASR facility in Bandera County using treated surface water from the Medina River and stored in the subsurface Lower Trinity Aquifer. This ASR conjunctive use project could provide additional water supplies to help meet the long-term supply demands in the area and lessen the reliance on the natural groundwater from the aquifer.

The project first addressed the potential of obtaining a raw water supply from the Medina River. Based on Bandera County's Water Supply Agreement with BMAWCID#1 and a TCEQ-WAM analysis of reliability, a facility size of 6.7 mgd is recommended for a supply of 3,100 acre-feet per year, with an injection and recovery rate of 1.0 mgd.

A Lower Trinity Aquifer model was used to evaluate ASR impacts on the aquifer system based on varying scenarios of injection rate, injection location, and annual withdrawals from the aquifer. Scenarios were designed to consider injection in City of Bandera municipal wells, as well as in other locations within the developing part of the County. Annual withdrawal rates considered both 2006 PRWP projected water demands and increased water demands based on potential full buildout of anticipated development in the County. An injection rate that caused the water level of the aquifer to exceed the elevation of the land surface was considered infeasible.

At the higher end, an injection rate of 2.54 mgd was found to be overly excessive from a hydrogeologic perspective regardless of the level of projected water demand. If only the City of Bandera municipal wells are considered as the point of injection, the model suggests that 0.5 mgd would be the most appropriate rate of injection. Additional scenarios considered a reduced rate of injection at the City of Bandera municipal wells and an increased rate in southeast Bandera County, where new subdivisions under full buildout would increase the need for additional water supplies. Based on this scenario, the modeling results suggest a total injection of around 1.0 mgd is reasonable. Conclusions reached in this analysis are based on assumptions that are conceptual. Additional scenarios should be explored as advanced facility planning and design progress.

This project demonstrates that an ASR project in Bandera County is worthy of further evaluation. We suggest that the Plateau Region Water Planning Group discuss this option with the Board of the Bandera County River Authority and Groundwater District, representatives of the City of Bandera, and other impacted parties in regard to its inclusion as a strategy in the Plateau Region Water Plan.

8.0 References

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Response to TWDB Comments

Response to TWDB Comments on Draft Final Region-Specific Study Reports

TWDB Contract No. 0704830695

Region J, Region-Specific Contract Study #2
Water Rights Analysis and ASR Feasibility in Kerr County;
ASR Feasibility in Bandera County

General Comments

1. This document includes two distinct/separate Reports that are bound together. Each report contains a separate Table of Contents (TOC), etc. Please consider either physically separating these to be two stand alone reports; or including a joint Title ("Alternative Water Supply Analyses for Kerr and Bandera Counties") and a joint TOC at the beginning of the document for clarity.

   Response: Two distinct/separate reports are created.

2. Please submit all data, maps, and functioning analytic models in an electronic format along with the final reports as stated in the contract between TWDB and Region J.

   Response: All requested material is provided.

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Specific Comments for Report 2: Preliminary ASR Feasibility Assessment in Bandera County

1. Report 2, Page 1-1 and other locations: the contract scope of work specifies the use of the "state-approved" WAM during drought of record conditions and that the TCEQ's WAM Run 3 should be used and encompass the upper Guadalupe-San Antonio Basin. In the final report, please clarify whether the "March 2008" WAM mentioned in the report meets this criteria and that this criteria is consistent with the 2006 Plateau Regional Water Plan. If the March 2008 WAM is not the version specified in the SOW, please explain its use in this study.

   Response: The correct WAM designation is provided in Section 3.0. WAM Run 3 assumptions are added to fifth paragraph of Section 3.0.

2. Report 2, Page 3-1: Since the Kerr and Bandera reports were each written as stand-alone documents, in the final report please include the definition/criteria for 7Q2 as was done in Report 1, page 3-19.

   Response: The 7Q2 definition is provided in Section 3.0.
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3. Report 2, Page 3-1 and 3-2, Section 3.0: The contract scope of work, Task 3C includes the evaluation of potential water sources including Medina River water rights and treated municipal wastewater. Please include an evaluation of treated municipal wastewater flows in the final report.

   Response: There is no significant return flow in the Medina River. The only plant is owned by the City of Bandera, which has reported an average effluent of 0.15 MGD. Statement is added to first paragraph of Section 3.0.

4. Report 2, Page 3-3, Figure3.1: Please add units to the axes of the graph in the final report.

   Response: Units are added to the graph.

5. Report 2, Page 4-1, last paragraph: Please clarify what the new regulations apply to and who developed them (the state or the local GCDs, etc) in the final report.

   Response: Groundwater conservation district is added in Section 4.0.

6. Report 2, The contract scope of work, Task 3B: Review historical water level declines in the Lower Trinity Aquifer and calculate potential available storage in the aquifer. Please include the potential available storage in the aquifer in the final report.

   Response: Volume of storage depletion is provided in a paragraph at the end of Section 4.0.

7. Report 2, Page 5-1, paragraph 4: Please consider including a water supply/demand/need table for the City of Bandera and Bandera County-Other excerpted from the 2006 Plateau Regional Water Plan (as was done for the Kerr County report).

   Response: Supply and demand projects are added as Table 2.1 in Section 2.0.

8. Report 2, Section 5 Figures: (a) pages 5-4 to 5-7, Figures 5.1 to 5.7: Please identify the year for which water levels and water level changes are shown in these figures; (b) page 5-6: Please consider including water levels and water level changes for Scenario 2a in the final report.

   Response: Figure titles have been revised to show conditions in 2060. Figure 5.5 now shows the Scenario 2a conditions.

9. Report 2, Page 6-1: Please clarify whether the infrastructure cost listed on this page includes estimates for the management of concentrates generated during the treatment process and clarify what kind of process was assumed (desalination, etc). In the final report, please clarify what the anticipated quality of water will be from the Medina River, and what the potential disposal method will be if concentrates are generated.

   Response: Concentrate management and source-water quality are addressed in Section 6.0.

10. Report 2, Page 7-1, Section 7: Please consider expanding the Conclusions section in the final report to bring together the reasons for performing this study, the study's goals, and how the goals were achieved or not achieved, and summary discussion of recommendations for the next step(s) the RWPG should *pursue in this process.*

    Response: The Conclusion section (7) is expanded to include suggested content.

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Additional Comments for Consideration

1. Report 2, Page 7-1. The report states that the option exists to add the Middle Trinity Aquifer as an additional storage unit but was not considered in the study. Please consider providing a brief explanation of why this was not included and what kind of analysis would be needed to evaluate this option in the future.

   Response: The statement about the Middle Trinity Aquifer as an additional storage unit is eliminated. The Middle Trinity is not considered an option at this time because storage in this unit cannot be protected from unintended withdrawals.