HEADWATERS GROUNDWATER CONSERVATION DISTRICT

DISTRICT GROUNDWATER MANAGEMENT PLAN

REVISED 2013

Headwaters Groundwater Conservation District
Groundwater Management Plan – 2013

The Headwaters Groundwater Conservation District (the "District") is a governmental agency and a body politic and corporate. The District was created to serve a public use and benefit, and is essential to accomplish the objectives set forth in Section 59, Article XVI, of the Texas Constitution. The District's boundaries are coextensive with the boundaries of Kerr County, Texas, and all lands and other property within these boundaries will benefit from the works and projects that will be accomplished by the District.

Purpose of Management Plan

The 75th Texas Legislature in 1997 enacted Senate Bill 1 ("SB 1") to establish a comprehensive statewide water planning process. In particular, SB 1 contained provisions that required groundwater conservation districts to prepare management plans to identify the water supply resources and water demands that will shape the decisions of each district. SB 1 designed the management plans to include management goals for each district to manage and conserve the groundwater resources within their boundaries. In 2001, the Texas Legislature enacted Senate Bill 2 ("SB 2") to build on the planning requirements of SB 1 and to further clarify the actions necessary for districts to manage and conserve the groundwater resources of the state of Texas.

The Texas Legislature enacted significant changes to the management of groundwater resources in Texas with the passage of House Bill 1763 (HB 1763) in 2005. HB 1763 created a long-term planning process in which groundwater conservation districts (GCDs) in each Groundwater Management Area (GMA) are required to meet and determine the Desired Future Conditions (DFCs) for the groundwater resources within their boundaries by September 1, 2010. In addition, HB 1763 required GCDs, to share management plans with the other GCDs in the GMA for review by the other GCDs.

The Headwaters Groundwater Conservation District's management plan satisfies the requirements of SB 1, SB 2, HB 1763, the statutory requirements of Chapter 36 of the Texas Water Code, and the administrative requirements of the Texas Water Development Board's (TWDB) rules.

District Creation and History

Under Article XVI, Section 59, of the Texas Constitution, the Headwaters Groundwater Conservation District was created by the 72nd Legislature House Bill (HB) No. 1463 and approved by the Governor of Texas on June 16, 1991. The 77th Legislature HB 3543 amended the enabling legislation and was approved by the Secretary of State on May 23, 2001. And in accordance with Chapter 36 of the Texas Water Code, by the Act of May 25, 2009, 81st Legislature, Special District Local Laws Code, Title 6. Water and Wastewater, Subtitle H. Districts Governing Groundwater Chapter 8842 effective April 1, 2011 this plan is submitted.

District Mission

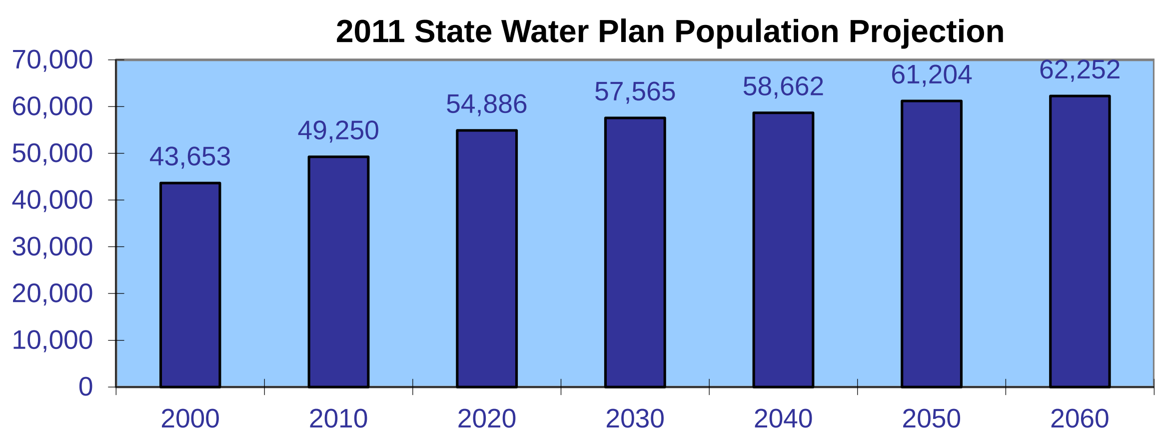
The Mission of the Headwaters Groundwater Conservation District is to develop rules to provide protection to existing wells, prevent waste, promote conservation, provide a framework that will allow availability and accessibility of groundwater for future generations, protect the quality of the groundwater in the recharge zone of the aquifer, insure that the residents of Kerr County maintain local control over their groundwater, and operate the District in a fair and equitable manner for all residents of the District. The District is committed to manage and protect the groundwater resources within its jurisdiction and to work with others to ensure a sustainable, adequate, high quality and cost effective supply of water, now and in the future. The District will strive to develop, promote, and implement water conservation, augmentation, and management strategies to protect water resources for the benefit of the citizens, economy and environment of the District. The preservation of this most valuable resource can be managed in a prudent and cost effective manner through conservation, education, and management. Any action taken by the District shall only be after full considerations and respect has been afforded to the individual property rights of all citizens of the District. This management plan is intended as a tool to focus the thoughts and actions of those given the responsibility for the execution of District activities. The District Board of Directors will review the status of all performance standards in this plan annually.

Time period for this plan

This plan will become effective upon adoption by the Headwaters Groundwater Conservation District Board of Directors and approved as administratively complete by the Texas Water Development Board. The plan will remain in effect for five (5) years after the date of approval or until a revised plan is adopted and approved.

Demographics

The District Boundaries are contiguous with that of Kerr County, Texas. Kerr County encompasses 1,106 square miles and is located in the hill country of southwest central Texas. The county is bounded on the north by Kimble and Gillespie counties, on the east by Kendall County, on the west by Edwards and Real counties and on the south by Bandera and Real counties. Kerrville, the largest city in the county, is also the county seat for Kerr County. Retirement living, private camps, resorts, hunting, medical services, and private higher education dominate the economy in Kerr County. Agriculture, light industry and manufacturing contribute to the economy to a lesser extent. The Kerr County population is displayed in the table below according to population estimates prepared by data developed and submitted by the Regional Water Planning Group (RWPG) Region J. These estimates include Ingram, Kerrville, and County-Other.



Topography and Climatic Conditions

The predominantly rough and rolling topography of Kerr County is characteristic of the Edwards Plateau or Hill Country region. In the western part of Kerr County the land surface is gently rolling, interrupted by steep slopes and narrow valleys caused by the erosion of resistant limestone beds. Extensive dissection of the plateau in the eastern part of the county has formed wide valleys separated by high hills of generally uniform altitude. The altitude of the land surface ranges from about 1,400 ft. above mean sea level (MSL) at the southeastern edge of the county to about 2,400 feet in the western part (Reeves, 1969). Historically, the vegetative cover was considered to be an oak and juniper savannah. Presently, second and third growth juniper is increasing in density to the point of being dominant.

Most of Kerr County is drained by the upper Guadalupe River (approximately 75%), which rises in the western part of the county and flows eastward for approximately 40 miles before exiting the county. The Llano and Pedernales Rivers to the north and the Medina River to the south drain small peripheral areas of the county amounting to less than 25 percent of the total area (Reeves, 1969).

Kerr County has a sub humid to semiarid climate coupled with mild winters and hot summers. Average annual rainfall recorded by the United States Department of Agriculture – Agriculture Research Service (USDA-ARS) –Knipling-Bushland US Livestock Insects Laboratory, Kerrville, TX. for the years (1982 to 2011)[1] is 31.07 inches. Net lake surface evaporation ranges from approximately 45 inches per year in the eastern part of the county to about 55 inches per year in the western part (Plateau Regional Water Plan, Fig. 1-5).

Water Resources of Kerr County

Groundwater Resources of Kerr County

The Trinity Aquifer is the principal source of groundwater in Kerr County. The Trinity Aquifer in the Hill Country is an extension of the lower part of the Edwards-Trinity Aquifer of the Edwards Plateau, with the Edwards group and its equivalents

[1] http://www.ars.usda.gov/SP2UserFiles/Place/62050000/Kerv_rf.pdf

mostly removed. The Trinity Aquifer yields water from Cretaceous limestone and sand of the Trinity Group. The Trinity Aquifer is composed of three permeable zones separated by two relatively impermeable horizontal barriers. The Upper Trinity is made up of the upper member of the Glen Rose Limestone formation. The Middle Trinity is composed of the Lower Glen Rose Limestone, the Hensell Sand, and the Cow Creek Limestone formations. The Lower Trinity consists of the Hosston and Sligo Formations. Relatively impermeable tight sediments within the Glen Rose Limestone separate the Upper and Middle Trinity. The Hammett Shale separates the Middle and Lower Trinity. Recharge of the Trinity Aquifer occurs through lateral flow of water from the Edwards Plateau, infiltration of precipitation on the outcrop area, and surface water leakage from shallow tributary streams in upland areas. Relatively impermeable inner beds in the Upper and Middle Glen Rose Limestone generally impede the downward percolation of precipitation. A second, less reliable, aquifer in Kerr County is the Fort Terrett Formation of the Edwards Group. Erosion caused by stream flow off the edge of the Edwards Plateau trending eastward across Kerr County has removed most of the Fredericksburg and Washita strata. Unconfined conditions prevail over parts of the county, varying greatly in response to diverse geologic conditions and topographic effects. The production of wells in the Fort Terrett Formation is usually confined to domestic and stock use, but the Fort Terrett is essential in maintaining stream flow of the Guadalupe River.

Surface Water Resources of Kerr County

The Guadalupe River predominately (70%) originates as spring flow from the Edwards Plateau Aquifer within Kerr County. The larger springs range in flow from 5 -15 cubic feet per second (CFS) and chemically reflect the limestone geology of Kerr County. Originally, streams in Kerr County were characterized by shallow, swift flow over bedrock, but construction of surface water impoundments has restricted this flow.

The primary surface water source available in Kerr County is the Upper Guadalupe River Basin. Considering the complexity of the diversion rights system and variations in the flows of the river, the river alone is not a sustainable long-term source for municipal, industrial and irrigation use when drought conditions or conservation plans are considered. However, prudent use of available supplies in the Guadalupe River should be made in order to protect and extend the capabilities of the groundwater system.

Headwaters Groundwater Conservation District has agreed to and signed a Memorandum of Understanding (MOU) with Kerr County, the City of Kerrville, the City of Ingram, and the Upper Guadalupe River Authority to cooperate regarding the development of regional surface water supply, treatment, storage and transmission facilities.

Municipal Water Rights for Kerrville and UGRA

<table>
<tr><th>Water Rights Permit</th><th>Authorized Diversion (ac-ft/yr)</th><th>Permit Holder</th><th>Priority Date</th><th>Storage (ac-ft)</th><th>Restrictions</th></tr>
<tr><td>1996 (amended 4/10/98)</td><td>150 (mun)
75 (irr)</td><td>Kerrville</td><td>April 4, 1914</td><td></td><td></td></tr>
<tr><td>3505</td><td>3,603</td><td>Kerrville</td><td>May 23, 1977</td><td>840</td><td>Max diversion rate = 9.7 cfs divert only when reservoir is above 1908 ft msl</td></tr>
<tr><td rowspan="2">5394 (amended 4/10/98)</td><td>2,169</td><td>Kerrville (Kerrville Municipal Use)</td><td rowspan="2">January 6, 1992</td><td rowspan="2">Utilizes the storage authorized for Permit 3505</td><td rowspan="2">Max combined diversion rate for water rights # 3505 and # 5394 = 15.5 cfs.

Minimum instream flow requirements vary from 30 to 50 cfs during year.</td></tr>
<tr><td>2,000</td><td>UGRA (County Municipal use)</td></tr>
</table>

Source: Plateau Region Water Plan 2006

Technical District Information Required by Texas Administrative Code

Estimate of Modeled Available Groundwater in the District Based on Desired Future Conditions

Texas Water Code § 36.001 defines modeled available groundwater as "the amount of water that the executive administrator determines may be produced on an average annual basis to achieve a desired future condition established under Section 36.108".

The joint planning process set forth in Texas Water Code § 36.108 must be collectively conducted by all groundwater conservation districts within the same GMA. The District is a member of GMA 9. GMA 9 adopted a DFC for the Edwards Group of Edwards-Trinity (Plateau) Aquifer August 26, 2010. In addition GMA 9 declared the Edward Group of the Edwards-Trinity (Plateau) to be "Not Relevant" in Kerr and Blanco Counties. DFC's were adopted also on August 26, 1010 for the Hill Country Trinity Aquifer, as stated in GAM Run 10-005. The adopted DFCs were then forwarded to the TWDB for development of the MAG calculations.

Draft GAM Task 10-005 & GAM Task 10-031: Supplement for DFC, s for Kerr County	Please Refer to Appendix A

GAM Run 10-049 MAG Report Version 2, for Modeled Available Groundwater for the Edwards Group of the Edwards-Trinity (Plateau).	Please refer to Appendix B

GAM Run 10-050 MAG Report Version 2, for Modeled Available Groundwater For the Trinity Aquifer.	Please refer to Appendix C

Amount of Groundwater Being Used within the District on an Annual Basis.	Please refer to Appendix D
Annual Amount of Recharge From Precipitation to the Groundwater Resources within the District.	Please refer to Appendix E
Annual Volume of Water that discharges from the Aquifer to Springs and Surface Water Bodies.	Please refer to Appendix E
Estimates of the Annual Volume of Flow into the District, out of the District, and Between aquifers in the District	Please refer to Appendix E
Projected Surface Water Supply within the District	Please refer to Appendix D
Projected Total Demand for Water within the District	Please refer to Appendix D

Water Supply Needs	Please refer to Appendix D

Water Management Strategies	Please refer to Appendix D

HGCD Monitor Well Geology	Please refer to Appendix F

Methodology to Track District Progress in Achieving Management Goals

An annual report ("Annual Report") will be created by the general manager and staff of the District and provided to the members of the Board of the District. The Annual Report will cover the activities of the District including information on the District's performance in regards to achieving the District's management goals and objectives. The Annual Report will be delivered to the Board within ninety (90) days following the completion of the District's calendar year. A copy of the Annual Report will be kept on file and will be available for public inspection at the District's offices upon adoption.

Action, Procedures, Performance and Avoidance for Plan Implementation

The District has adopted rules and policies relating to the permitting of wells and the production of groundwater. The rules and policies adopted by the District are pursuant to Texas Water Code Chapter 36 and the provisions of this plan, based on the best technical evidence available[2]. The District will strive to enforce all rules and policies in a fair and equitable way, the rules may be viewed at http://www.hgcd.org/pdf/District%20Rules%20Amended%20November%209,%202011.pdf

The District shall treat all citizens with equality. Citizens may apply to the District for discretion in enforcement of the rules on grounds of adverse economic effect or unique local conditions. In granting of discretion to any rule the District Board shall consider the potential for adverse effect on adjacent landowners. The exercise of said discretion shall not be construed as limiting the power of the District Board. The District will utilize the provisions of this management plan to determine the direction or priority for District activities. Operations of the District, agreements entered into by the District and any additional planning efforts in which the District may participate will be consistent with the provisions of this plan.

[2] HGCD Monitor Well Geology
Wm Feathergail Wilson, PG 21
April, 2008

In the implementation of this plan and the management of groundwater supplies activities of the District will be undertaken in cooperation and coordination with the appropriate state, regional or local water management entity and in compliance with State and Regional Water Plans.

Management Goals

A. Provide the most efficient use of groundwater

A.1. Objective - Implement a program to improve understanding of usable groundwater supplies in Kerr County.

A.1. Performance Standard -
The District has an ongoing program to gather data from Kerr County aquifers and supervise the drilling, logging, and completion of monitor wells. Also the District has rules in place to require aquifer tests for all new drilled Public Supply Wells and provide all monitor well data and aquifer test data to the TWDB groundwater database. The General Manager will provide a report to the District Board on an annual basis of all data gathering and drilling activity.

A.2. Objective - Establish an aquifer monitoring program.

A.2. Performance Standard -
The District has a Monitoring Well drilling program; to date HGCD has drilled 14 Monitoring Wells. Aquifer levels are monitored in the 14 District Monitoring Wells and approximately 36 private wells are monitored monthly. These wells monitor the Middle and Lower Trinity, and the Edwards Group of the Edwards-Trinity (Plateau) aquifers. A table and hydrograph of each individual monitor well as well as the number of wells measured will be reported to the District Board and displayed on the District website monthly.

A.3. Objective - Regulate and account for groundwater withdrawal in Kerr County.

A.3. Performance Standard -

Register all new wells drilled and maintain a well database. Provide an annual report to the District Board which includes the number of new wells drilled in the District during the past year. Perform well site inspections before, during, and after the drilling of each new well in the District. Require State Well Logs, certified statements of completion from water well Drillers and Pump Installers within 60 days of completion. Require non-exempt wells to be metered and the production reported annually to the District. Provide an annual groundwater report to the District Board.

B. Controlling and Preventing Waste of Groundwater

B.1. Objective - Enact policies and educational programs to ensure that groundwater is used solely for beneficial purposes and prohibit activities that contribute to waste of groundwater.

B.1. Performance Standard -

Review all well applications for intended use and production capacities (gallons per minute). The number of wells and a list of intended uses and production capacities for the previous calendar year will be included in the annual report to the District Board. Promote Public Education in conservation matters. The District will publish one article on the prevention of wasteful water practices in one newspaper within the District annually. A copy of the article will be included in the annual report. Identify and document occurrences of waste of groundwater and include in the annual report. Provide water conservation tips by way of handouts, public functions and links on the District website. Sponsor water conservation literature to area schools. Investigate reports from the public regarding waste of water.

C. Addressing conjunctive surface water management issues.

C.1. Objective - Assess the availability of surface water resources that may be used as an alternative to groundwater.

C.1. Performance Standard -
Participate in the Plateau Regional Planning group scope of work projects to promote strategies for increasing surface water use in Kerr County. Meet once a year with the City of Kerrville to enhance continued Surface Water use and ASR projects. The District will include the number of meetings that transpired in the previous year in the annual report to the District Board. The District has signed an MOU with the cities of Kerrville and Ingram, the Kerr County Commissioners, and the UGRA, to maximize surface water use in the District. Activities associated with this MOU will be included in the annual report to the District Board.

D. Address Natural Resource Issues

D.1. Objective - Prevent contamination/pollution of the aquifers from other natural resources being produced within the District.

D.1. Performance Standard -
Monitor any oil and gas drilling or mining operations for potential sources of pollution of the aquifers in the District. Make annual reports to the District Board on use of groundwater for commercial purposes. The annual report will include the number of currently existing oil and gas wells, the number of new oil and gas wells drilled, and an estimate of the total amount of groundwater being used by these operations. District Rules require any water wells drilled associated with oil and gas drilling or production be registered with the District and are required to comply with District construction standards and reporting.

E. Addressing Drought Conditions

E.1. Objective - Monitor Drought Conditions

E.1. Performance Standard -

Review aquifer data monthly and declare drought stages based on the District's defined drought triggers. When drought stages are initiated report to the District Board monthly. Inform and educate the public and permitted well owners about declared drought stages, appropriate non-essential water use restrictions and recommended restrictions during drought. Publish information when drought stages are triggered by way of the HGCD website, local newspaper notices, and mail-outs to Permitted well owners. The TWDB drought conditions section may be viewed at http://www.twdb.state.tx.us/DATA/drought/index.asp. The number of website, newspaper notices, and mail-outs will be included in the annual report to the District Board.

F. Addressing Conservation

F.1. Objective - Conservation

F.1. Performance Standard -

Distribute water conservation material by newspaper articles and the HGCD website. The District will publish a minimum of one article on conservation practices in one newspaper within the District annually. The District Conservation Plan is available to the public on the District website and at the District office. View the Water Conservation Advisory Council website at http://www.savetexaswater.org/bmp/

G. Addressing Rainwater Harvesting

G.1. Objective - Rainwater Harvesting

G.1. Performance Standard

Provide Rainwater Harvesting material to the public on the HGCD website and handouts. Publish at least one newspaper article annually discussing the benefits of rainwater harvesting.

H. Addressing in a Quantitative Manner the Desired Future Conditions of the Groundwater Resources.

H.1. Objective - to achieve the Desired Future Condition adopted by GMA 9 for the Edwards Group of the Edwards Trinity (Plateau) and the Hill Country Trinity Aquifer.

H.1. Performance Standard -

GMA 9 declared the Edwards Group of the Edwards-Trinity (Plateau) to be not relevant in Kerr County. At this time the District does not allow non-exempt wells in the Edwards Aquifer. Evaluate annually the Hill Country Trinity Aquifer water level trends in the District's Monitor Wells to track the District's progress in complying with the average drawdown as stated in GAM Task 10-005 Scenario 6 for Kerr County. Report annually to the District Board of Directors and GMA 9 committee the progress of achieving the Desired Future Condition. Complete an annual groundwater report that details groundwater production from non-exempt wells combined with exempt well pumping estimates supplied by the Texas Water Development Board. This report will be included in the annual report provided to the District's Board of Directors.

I. Management Goals Not Applicable to the District

I.1. Controlling and Preventing Subsidence -

This goal is not applicable to the District due to a rigid geologic framework. Accordingly, the District's plan does not contain a "Management Objective" or "Performance Standard" to address this issue.

I.2. Recharge Enhancement - is not within the District's ability to be cost effective. This goal is not applicable at this time.

I.3. Precipitation Enhancement is not within the District's ability to be cost effective. This goal is not applicable at this time.

I.4. Brush Control is not within the District's ability to be cost effective. This goal is not applicable at this time.

APPENDIX A

GAM TASK 10-005

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September 3, 2010

GAM Task 10-005

by William R. Hutchison, Ph.D, P.E., P.G.
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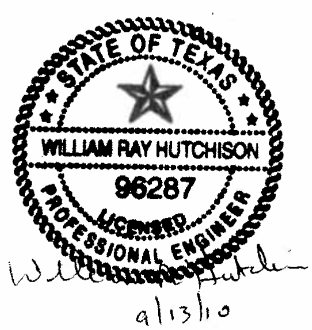
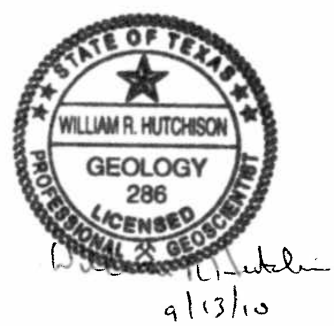
Groundwater Resources Division
(512) 463-5067
September 3, 2010

The seal appearing on this document was authorized by William R. Hutchison, P.E. 96287, P.G. 286 on September 3, 2010.





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EXECUTIVE SUMMARY

This report presents results of a GAM Task that was requested at the May 10, 2010 Groundwater Management Area 9 meeting in Kerrville. This task represents an expansion of the GAM run requested by Groundwater Management Area 9 (Chowdhury, 2010) and the supplement of that GAM run request (Hutchison, 2010), both of which were discussed at the May 10, 2010 Groundwater Management Area 9 meeting.

The simulations completed as part of this task include seven pumping scenarios of the Trinity Aquifer that range from zero pumping to about twice current pumping. Each scenario included running 387 50-year simulations. The 387 50-year simulations were developed based on tree-ring precipitation estimates from 1537 to 1972 for the Edwards Plateau (Cleaveland, 2006). The results were used to evaluate the relationships between pumping versus drawdown, spring and base flow and outflow across the Balcones Fault Zone.

Results from the Task were summarized Groundwater Management Area-wide, by county, and by three areas designated by Mr. Ron Fieseler, General Manager of the Blanco-Pedernales Groundwater Conservation District. Because each scenario consisted of 387 50-year simulations, the results can also be expressed in terms of minimum, average, and maximum, as well as values that are exceeded 5 percent of the time and values that are exceeded 95 percent of the time.

ORIGIN OF TASK:

During the course of the May 10, 2010 Groundwater Management Area 9 meeting, there was consensus to complete these 50-year simulations to provide additional information to the groundwater conservation districts in Groundwater Management Area 9

DESCRIPTION OF TASK:

The simulations completed as part of this task include seven pumping scenarios of the Trinity Aquifer that range from zero pumping to about twice current pumping. Each scenario included running 387 50-year simulations. The 387 50-year simulations were developed based on tree-ring precipitation estimates from 1537 to 1972 for the Edwards Plateau (Cleaveland, 2006). The results were used to evaluate the relationships between pumping versus drawdown, spring and base flow and outflow across the Balcones Fault Zone.

METHODS:

The original request (Chowdhury, 2010) included model runs that included predictive simulations using the Hill Country portion of the Trinity Aquifer model to assess the effects of drought and increased pumping on water levels, baseflow, and flow across the Balcones Fault Zone. The requested runs consisted of 50-year simulations, some with 50 years of average recharge, and some with 43 years of average recharge followed by 7 years of drought-of-record conditions. The runs also included various combinations of pumping at 2008 levels, one and a half times the 2008 pumping levels, and one and a half times 2008 pumping levels which were reduced to 2008 pumping levels during droughts.

The supplement (Hutchison, 2010) included seven separate scenarios. Three of the scenarios assumed constant pumping (i.e. no drought reduction), and four scenarios assumed a 33 percent pumping reduction during drought years. Each scenario included 430 7-year simulations based on tree-ring precipitation estimates from 1537 to 1972 for the Edwards Plateau (Cleaveland, 2006).

These simulations involve varying recharge based on the Cleaveland (2006) tree-ring dataset, but include 387 50-years simulations, as detailed below.

Precipitation and Recharge

The 50-year running average of the tree-ring precipitation is presented in Figure 1. Note that the precipitation for the 50-year period ending in 1593 is about 96 percent of average, and represents the driest 50 year period in the record. Aside from the generally dry conditions in the late 1500s and early 1600s, there are three other relatively dry periods in the early 1800s, the early 1900s, and the most recent period that ended in 1972 (at the end of the record).

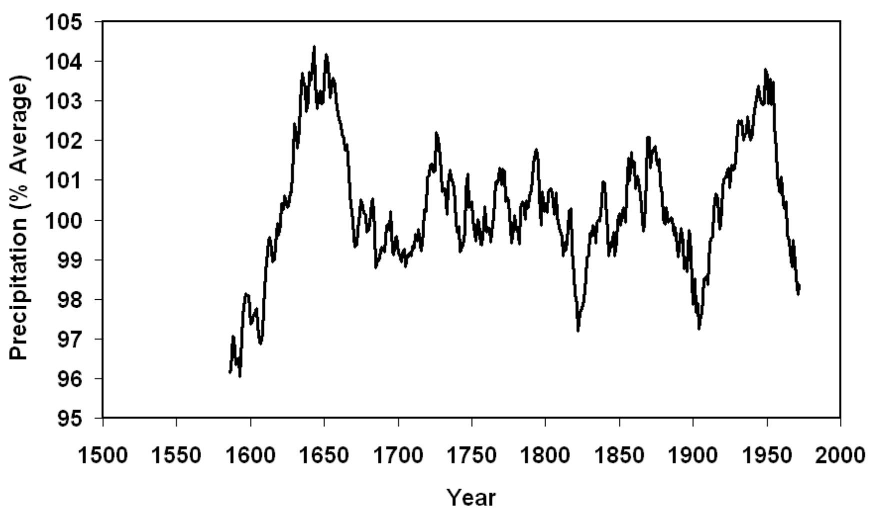

Figure 1. 50-year running average precipitation in the Edwards Plateau region of Texas based on tree-ring data (data from Cleaveland, 2006).

These tree-ring precipitation data were used to develop 387 separate recharge input files based on the relationship between precipitation and recharge during the model calibration period as shown in Figure 2.

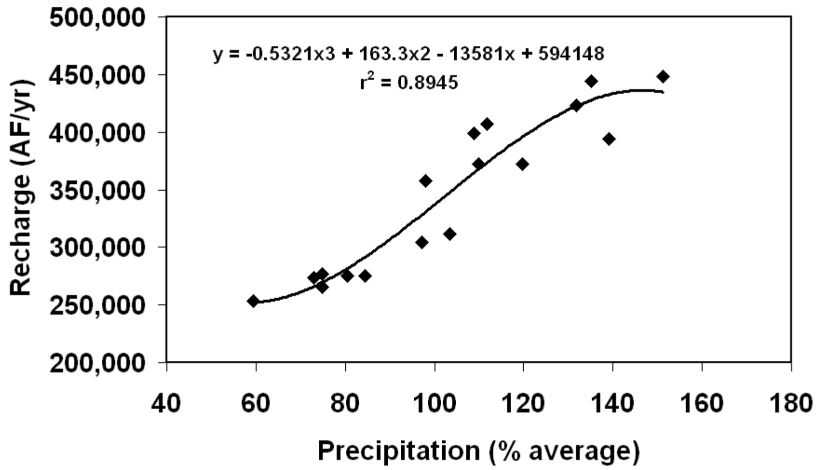

Figure 2. Precipitation versus recharge in Hill Country model from 1981 to 1997

Pumping

Pumping in the original request was based on 2008 pumping, and in some runs, was increased to one-and-a-half times the 2008 pumping. As reported in the main report (Chowdhury, 2010) 2008 pumping totaled 61,248 acre-feet per year. One-and-a-half times 2008 pumping totaled 89,921 acre-feet per year. Pumping scenarios in the supplemental runs (Hutchison, 2010) were based on an analysis of 2008 pumping and 2007 State Water Plan groundwater availability estimates. Pumping ranged from about 64,000 acre-feet per year to about 119,000 acre-feet per year.

For this Task, seven pumping scenarios were developed. The groundwater districts in Groundwater Management Area 9 updated their estimates of 2008 pumping, as detailed in Table 1. Total 2008 pumping is about 60,000 acre-feet per year.

The seven scenarios were based on varying the 2008 pumping as follows (all pumping amounts are from the Trinity Aquifer and are approximate):

- Scenario 1 = 0 acre-feet per year
- Scenario 2 = 20,000 acre-feet per year
- Scenario 3 = 40,000 acre-feet per year
- Scenario 4 = 60,000 acre-feet per year (2008 conditions)
- Scenario 5 = 80,000 acre-feet per year
- Scenario 6 = 100,000 acre-feet per year
- Scenario 7 = 120,000 acre-feet per year

Table 2. Estimated 2008 Pumping as Provided by Groundwater Conservation Districts in Groundwater Management Area 9

County	Edwards Group of the Edwards-Trinity (Plateau) Aquifer	Upper Trinity Aquifer	Middle Trinity Aquifer	Lower Trinity Aquifer	Total Pumping (County)
Bandera	631	288	3567	515	**5,000**
Bexar	0	693	14110	197	**15,000**
Blanco	0	77	1,477	0	**1,554**
Comal	0	398	5,788	0	**6,186**
Hays	0	416	4,800	449	**5,665**
Kendall	315	300	6,060	325	**7,000**
Kerr	1,035	213	6,263	5,534	**13,045**
Medina	0	0	500	1000	**1,500**
Travis	0	551	4,967	0	**5,518**
Total pumping (aquifer)	**1,981**	**2,936**	**47,532**	**8,020**	**60,468**

PARAMETERS AND ASSUMPTIONS:

- As in the requested runs and the supplemental runs, the recently updated groundwater availability model (version 2.01) for the Hill Country portion of the Trinity Aquifer developed by Jones and others (2009) was used for these simulations (see Mace and others (2000) and Jones and others (2009) for details on model construction, recharge, discharge, assumptions, and limitations of the model).

- The model has four layers: layer 1 represents the Edwards Group of the Edwards-Trinity (Plateau) Aquifer, layer 2 represents the Upper Trinity Aquifer, layer 3 represents the Middle Trinity Aquifer, and layer 4 represents the Lower Trinity Aquifer.

- The rivers, streams, and springs were simulated in the model using MODFLOW's Drain package. MODFLOW's Drain package was also used to simulate spring discharge along bedding contacts of the Edwards Group (Plateau) and the Upper

Trinity Aquifer in the northwestern parts of the model area. This resulted in the assignment of numerous drain cells along this outcrop contact.

- Seven different pumping scenarios were used as described above

- 387 recharge input files were developed as described above.

- Each simulation consisted of 50 stress periods. Initial conditions were assumed to be equivalent to 2008 conditions.

- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996)

RESULTS:

Similar to the supplemental runs (Hutchison, 2010), results from this Task focused on drawdown impacts, impacts to spring and base flow, and impacts to outflow across the Balcones Fault Zone. Results are summarized Groundwater Management Area-wide and by county. In addition, results are presented for three areas within Groundwater Management Area 9 as designated by Mr. Ron Fieseler, General Manager of the Blanco-Pedernales Groundwater Conservation District. These areas are defined as follows:

- Area 1 – Comal, Hays and Travis Counties
- Area 2 – Bexar and Medina Counties
- Area 3 – Bandera, Blanco, Kendall and Kerr Counties

Because each scenario consisted of 387 50-year simulations, the results can also be expressed in terms of minimum, average, and maximum, as well as values that are exceeded 5 percent of the time and values that are exceeded 95 percent of the time.

All drawdown results are expressed as drawdown from 2008 initial conditions at the end of the simulation (50 years). All flow data (spring flow, baseflow, outflow across the Balcones Fault Zone) are calculated using the results from each year of the 387 50-year simulations.

Summary tables of all results (for all of Groundwater Management Area 9, by the portions of the counties located within the model, and by area) are presented in Appendix A.

Figure 3 summarizes the relationship between Groundwater Management Area 9 pumping and overall Trinity Aquifer drawdown after 50 years (averaged over the entire Groundwater Management Area) for all seven pumping scenarios. For purposes of this analysis, overall Trinity Aquifer drawdown includes the Trinity Aquifer and the Trinity portion of the Edwards-Trinity (Plateau) Aquifer.

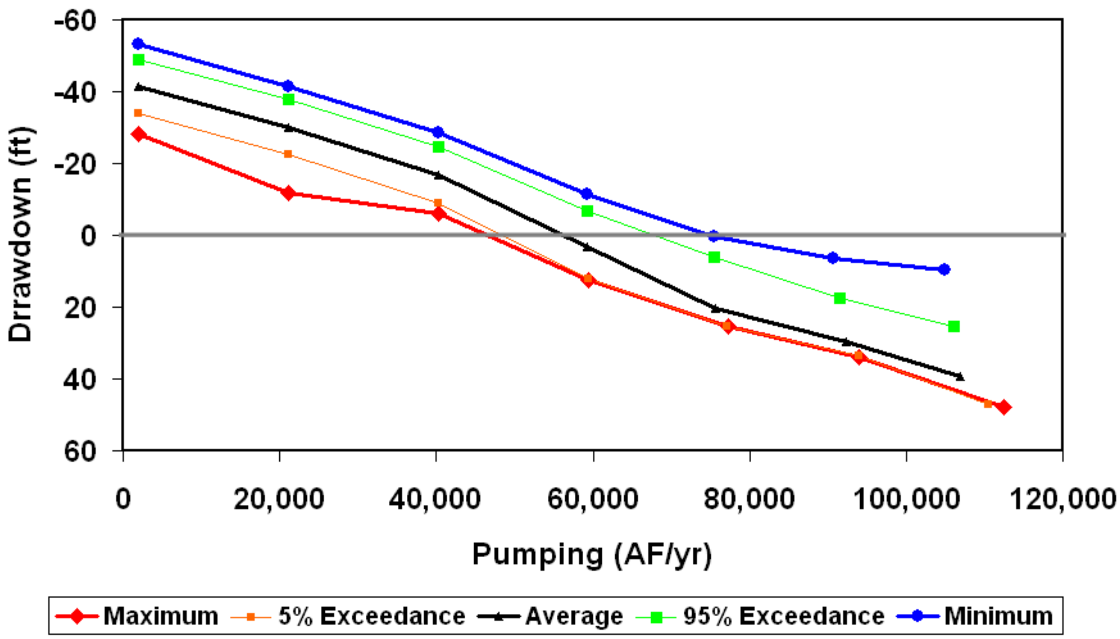

Figure 3. Pumping versus overall Trinity Aquifer drawdown after 50 years for all scenarios for Groundwater Management Area 9

Note that, as expected, increases in pumping result in increases in drawdown. The nature of these simulations provides an opportunity to evaluate drawdown in terms of the minimum value (out of all 387 simulations), 95 percent exceedance value (drawdown that is exceeded 95 percent of the time based on the 387 simulations), the average drawdown (out of all 387 simulations), 5 percent exceedance value (drawdown that is exceeded 5 percent of the time based on the 387 simulations), and the maximum value (out of all 387 simulations).

When pumping is about 60,000 acre-feet per year (the estimated 2008 pumping), average drawdown is near zero, which is expected since this pumping represents no change from 2008 conditions. However, it ranges from 12 feet of drawdown (representative of when a 50-year period ends in dry conditions) to about 12 feet of recovery (representative of when a 50-year period ends in wet conditions).

When pumping is about 1.5 times current pumping (92,000 acre-feet per year), average drawdown is about 29 feet after 50 years, with a range of between 6 to 33 feet depending on conditions at the end of the 50-year period.

Figure 4 summarizes the relationship between pumping and spring and base flow (averaged over the entire Groundwater Management Area) for all seven scenarios.

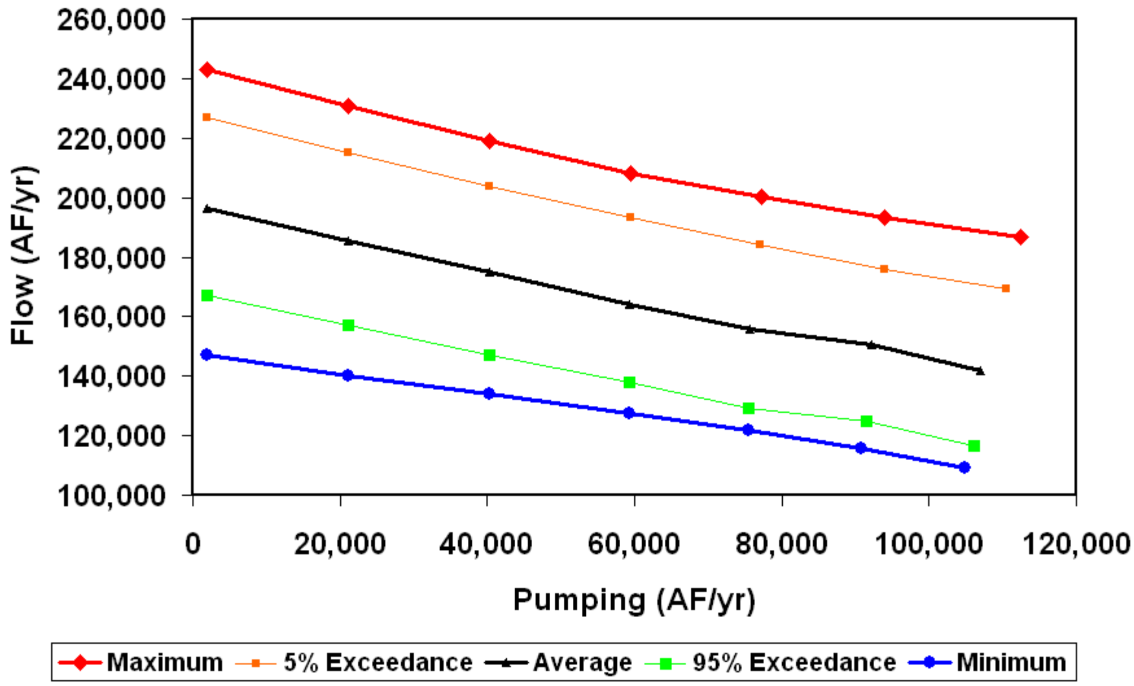

Figure 4. Pumping versus spring and base flow for all scenarios for Groundwater Management Area 9

As expected, pumping increases result in reductions in spring and base flow as the pumping captures this water prior to its discharge. It can be seen that, based on average values, 2008 pumping rates (approximately 60,000 acre-feet per year) result in an average spring and base flow of about 164,000 acre-feet per year. Zero pumping would result in a spring and base flow of about 197,000 acre-feet per year. Thus the impact of pumping 60,000 acre-feet per year includes a reduction in spring and base flow of about 33,000 acre-feet per year. If pumping were increased to 92,000 acre-feet per year (about 1.5 times the 2008 pumping rate), spring and base flow would be reduced, on average, to about 150,000 acre-feet per year. Thus an increase in pumping from 2008 levels of about 32,000 acre-feet per year would result in a reduction of 14,000 acre-feet per year in spring and base flow.

Figure 5 summarizes the relationship between pumping and outflow across the Balcones Fault Zone (averaged over the entire Groundwater Management Area) for all seven scenarios. As expected, pumping increases result in reductions in outflow across the Balcones Fault Zone as the pumping captures this water prior to its discharge. It can be seen that, based on average values, 2008 pumping rates result in an average outflow of 62,000 acre-feet per year. Zero pumping would result in a spring and base flow of about 81,000 acre-feet per year. Thus, the impact of pumping 60,000 acre-feet per year includes a reduction in Balcones Fault Zone outflow of about 19,000 acre-feet per year. If pumping were increased to 92,000 acre-feet per year (about 1.5 times the 2008 pumping rate), Balcones Fault Zone outflow would be reduced, on average, to about

50,000 acre-feet per year. Thus an increase in pumping from 2008 levels of about 32,000 acre-feet would result in a reduction of about 12,000 acre-feet per year in Balcones Fault Zone outflow.

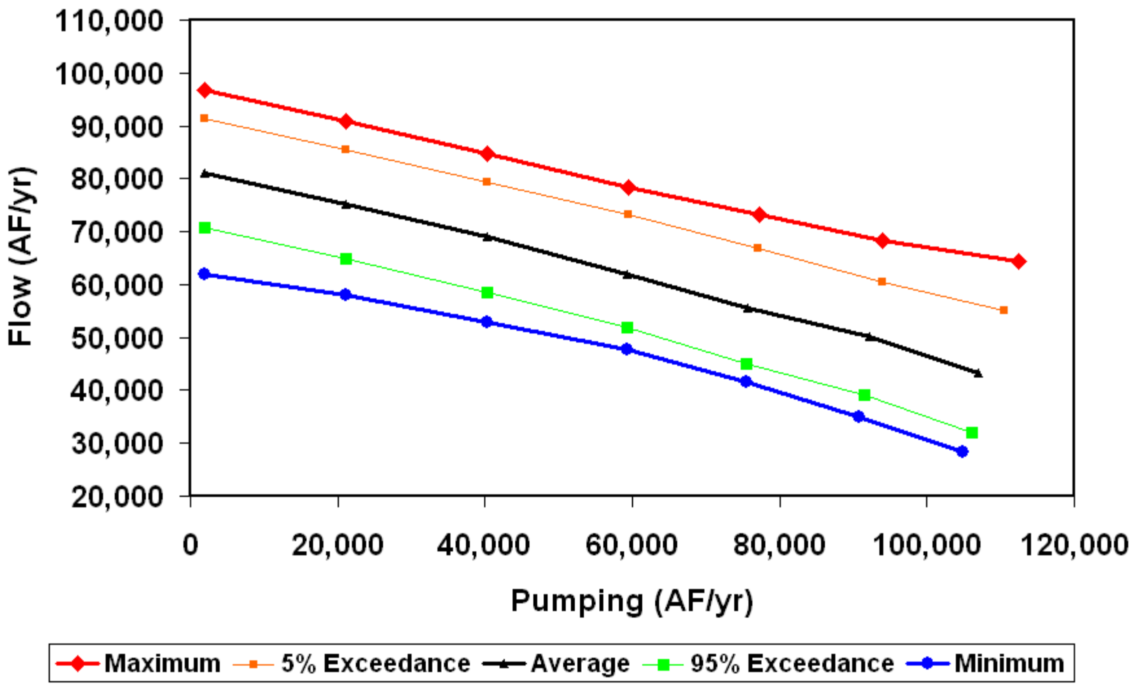

Figure 5. Pumping versus outflow across the Balcones Fault Zone for all scenarios for Groundwater Management Area 9

Figures 6, 7 and 8 summarize pumping versus the average Groundwater Management Area 9 drawdown in the upper, middle and lower Trinity Aquifer, respectively. Note that increases in pumping have less impact in the Upper Trinity Aquifer drawdown, presumably due to the buffering effect of surface water and the smaller amount of pumping in this aquifer compared with the Middle and Lower Trinity units.

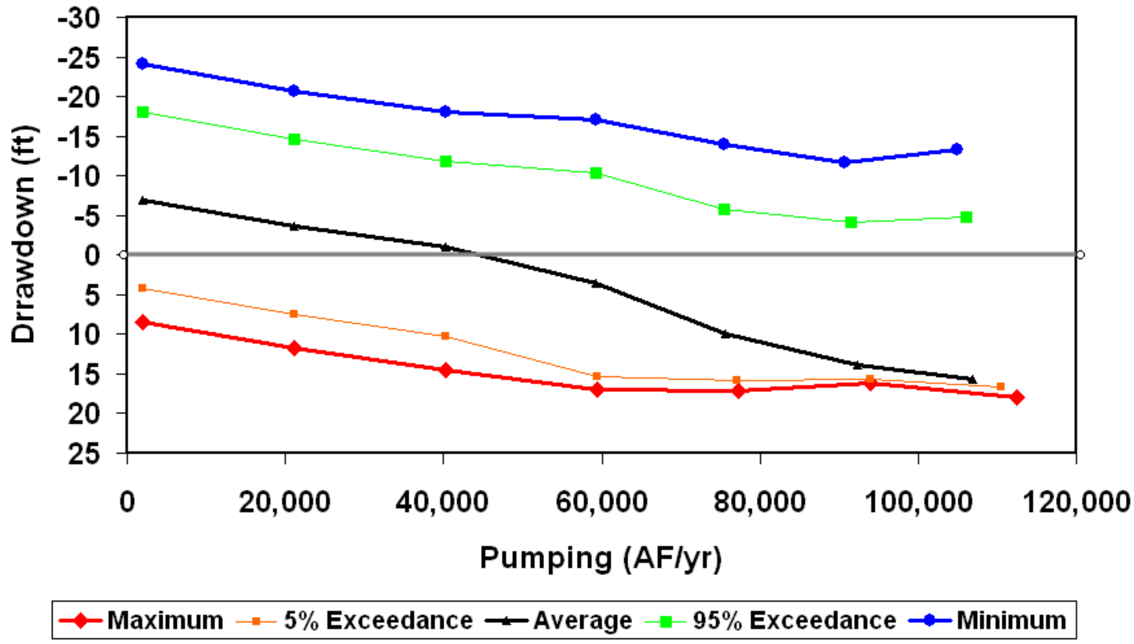

Figure 6. Pumping versus drawdown after 50 years in the Upper Trinity Aquifer for all scenarios for Groundwater Management Area 9

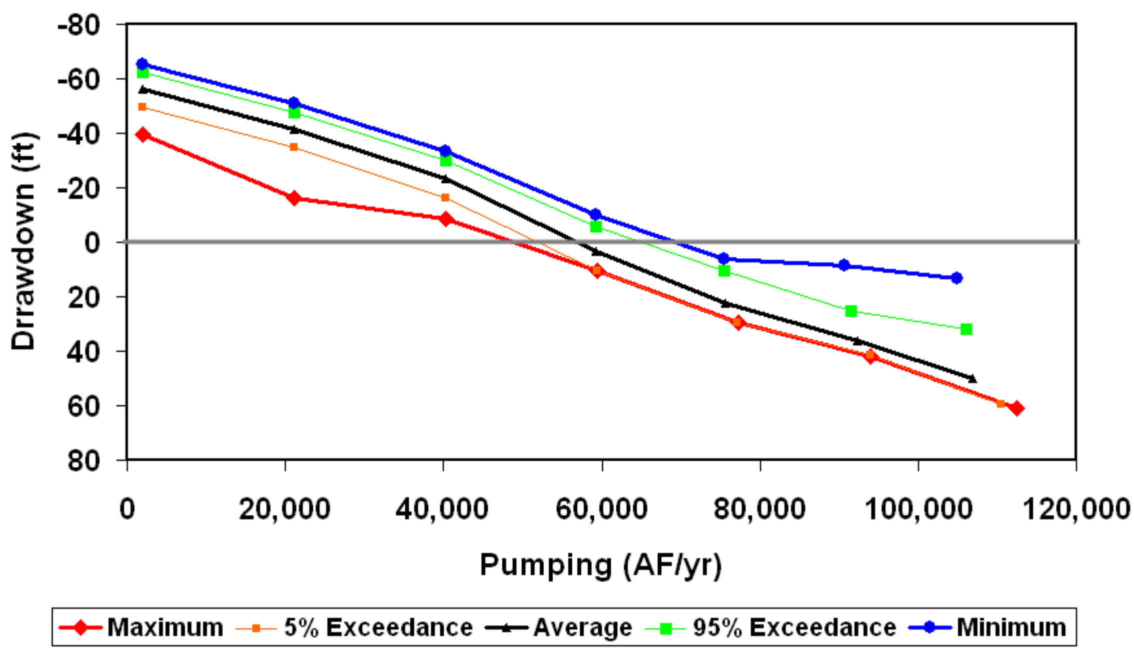

Figure 7. Pumping versus drawdown after 50 years in the Middle Trinity Aquifer for all scenarios for Groundwater Management Area 9

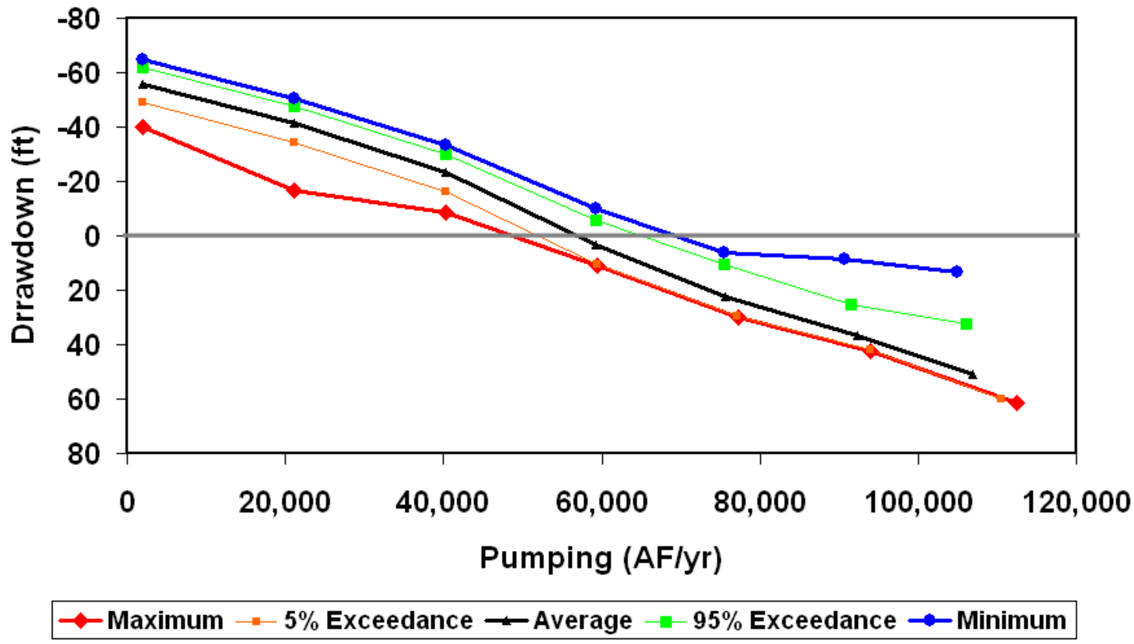

Figure 10. Pumping versus drawdown after 50 years in the Lower Trinity Aquifer for all scenarios for Groundwater Management Area 9

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Appendix A
Results Summary:
GMA 9
Bandera County
Bexar County
Blanco County
Comal County
Hays County
Kendall County
Kerr County
Medina County
Travis County
Area 1 (Comal, Hays, Travis Counties)
Area 2 (Bexar and Medina Counties)
Area 3 (Bandera, Blanco, Kendall and Kerr Counties)

GMA 9

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	1,969	21,117	40,270	59,344	75,424	90,727	104,940
	Exceeded 95% of years	1,969	21,117	40,270	59,344	75,524	91,479	106,022
	Average	1,969	21,117	40,270	59,344	75,624	92,261	106,982
	Exceeded 5% of years	1,969	21,117	40,270	59,418	77,094	94,042	110,485
	Maximum	1,969	21,117	40,270	59,418	77,193	94,042	112,454
Spring and River Base Flow (AF/yr)	Minimum	147,208	140,310	133,845	127,663	121,697	115,641	109,250
	Exceeded 95% of years	166,965	156,950	147,187	137,975	129,301	125,017	116,465
	Average	196,565	185,496	174,835	164,295	155,854	150,359	141,829
	Exceeded 5% of years	226,855	215,184	203,683	193,362	184,292	175,822	169,517
	Maximum	242,887	230,903	218,873	208,311	200,390	193,276	186,668
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	61,911	58,009	52,906	47,691	41,702	34,904	28,372
	Exceeded 95% of years	70,712	64,824	58,595	51,782	45,097	39,036	32,054
	Average	81,036	75,275	69,101	62,023	55,633	50,163	43,208
	Exceeded 5% of years	91,297	85,499	79,377	73,150	66,955	60,524	54,981
	Maximum	96,699	90,900	84,783	78,421	73,289	68,380	64,497
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-53.1	-41.6	-28.6	-11.6	0.4	6.4	9.8
	Exceeded 95% of years	-49.1	-37.8	-24.5	-6.9	6.0	17.6	25.4
	Average	-41.6	-30.1	-16.9	3.2	20.2	29.8	39.4
	Exceeded 5% of years	-33.8	-22.4	-8.8	12.0	25.4	33.7	47.0
	Maximum	-28.1	-11.8	-6.1	12.5	25.5	34.0	48.0
Edwards Group Drawdown after 50 Years (ft)	Minimum	-8.1	-8.1	-8.1	-8.1	-6.5	-6.1	-6.5
	Exceeded 95% of years	-6.2	-6.1	-6.1	-5.9	-4.8	-4.4	-4.7
	Average	-3.0	-3.0	-3.1	-2.1	0.2	0.5	0.2
	Exceeded 5% of years	0.2	0.2	0.2	0.7	3.5	2.5	3.4
	Maximum	1.7	1.3	1.7	3.3	3.9	3.4	3.9
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-24.1	-20.7	-18.0	-17.0	-14.0	-11.6	-13.3
	Exceeded 95% of years	-18.0	-14.6	-11.8	-10.4	-5.7	-4.1	-4.8
	Average	-7.0	-3.7	-1.0	3.6	9.9	13.9	15.6
	Exceeded 5% of years	4.2	7.5	10.2	15.4	15.8	15.6	16.6
	Maximum	8.4	11.8	14.5	16.9	17.2	16.2	18.0
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-65.1	-50.8	-33.4	-9.9	6.3	8.5	13.2
	Exceeded 95% of years	-62.2	-47.7	-29.9	-5.9	10.5	25.0	31.9
	Average	-56.0	-41.3	-23.4	3.1	22.4	36.4	50.2
	Exceeded 5% of years	-49.5	-34.6	-16.4	10.5	29.4	41.6	59.5
	Maximum	-39.5	-16.3	-8.6	10.7	29.6	42.0	60.9
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-64.8	-50.6	-33.4	-10.0	6.3	8.7	13.5
	Exceeded 95% of years	-61.9	-47.5	-29.9	-5.9	10.6	25.4	32.5
	Average	-55.7	-41.2	-23.4	3.1	22.6	36.7	50.8
	Exceeded 5% of years	-49.2	-34.4	-16.4	10.6	29.5	42.0	60.0
	Maximum	-40.0	-16.6	-8.8	10.8	29.8	42.3	61.5

Bandera County

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	625	2,082	3,540	4,996	6,452	7,910	9,349
	Exceeded 95% of years	625	2,082	3,540	4,996	6,452	7,910	9,361
	Average	625	2,082	3,540	4,996	6,452	7,910	9,367
	Exceeded 5% of years	625	2,082	3,540	4,996	6,452	7,910	9,367
	Maximum	625	2,082	3,540	4,996	6,452	7,910	9,367
Spring and River Base Flow (AF/yr)	Minimum	30,247	29,115	28,013	26,929	25,691	24,868	23,201
	Exceeded 95% of years	35,570	33,352	31,201	28,948	27,337	26,502	25,120
	Average	40,975	38,469	35,883	33,402	31,735	30,620	29,204
	Exceeded 5% of years	46,187	43,494	40,716	38,187	36,489	34,773	33,648
	Maximum	48,851	46,055	43,093	40,337	39,037	37,946	36,910
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	1,217	1,081	887	673	323	5	-445
	Exceeded 95% of years	1,763	1,505	1,197	819	499	165	-225
	Average	2,148	1,856	1,531	1,122	823	535	169
	Exceeded 5% of years	2,457	2,168	1,838	1,443	1,154	924	681
	Maximum	2,622	2,336	2,006	1,611	1,413	1,259	1,125
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-48.9	-39.2	-26.7	-8.0	5.5	4.5	6.7
	Exceeded 95% of years	-46.5	-36.4	-23.6	-4.2	8.8	18.6	21.6
	Average	-41.2	-31.1	-18.2	3.2	18.7	29.3	42.7
	Exceeded 5% of years	-35.9	-25.5	-12.3	9.7	24.4	34.6	51.1
	Maximum	-25.0	-8.0	-3.9	9.9	24.6	35.0	52.7
Edwards Group Drawdown after 50 Years (ft)	Minimum	-7.1	-7.1	-7.1	-7.1	-5.9	-5.4	-5.9
	Exceeded 95% of years	-5.5	-5.4	-5.4	-5.2	-4.2	-3.7	-3.9
	Average	-2.5	-2.5	-2.5	-1.5	0.6	0.8	0.6
	Exceeded 5% of years	0.5	0.5	0.5	0.9	3.1	2.4	3.0
	Maximum	1.8	1.4	1.8	3.1	3.3	3.1	3.3
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-20.7	-18.2	-15.9	-15.3	-12.6	-10.6	-12.1
	Exceeded 95% of years	-15.3	-12.7	-10.4	-9.1	-5.2	-3.8	-4.5
	Average	-5.5	-3.0	-0.8	3.5	13.7	12.6	14.2
	Exceeded 5% of years	4.6	7.1	9.6	14.2	14.5	14.1	15.1
	Maximum	8.3	11.0	13.5	15.6	15.8	14.7	16.3
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-62.2	-49.3	-32.2	-5.3	11.0	6.2	9.2
	Exceeded 95% of years	-60.8	-47.4	-29.9	-2.5	13.9	21.2	25.6
	Average	-57.6	-43.9	-26.1	3.3	21.3	37.8	58.3
	Exceeded 5% of years	-54.1	-40.2	-21.8	7.7	29.1	44.6	67.6
	Maximum	-36.8	-11.6	-5.9	8.9	29.5	45.1	70.1
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-62.2	-49.3	-32.2	-5.3	11.0	6.2	9.2
	Exceeded 95% of years	-60.8	-47.4	-29.9	-2.5	13.9	21.2	25.6
	Average	-57.6	-43.9	-26.1	3.3	21.3	37.8	58.3
	Exceeded 5% of years	-54.2	-40.2	-21.8	7.7	29.1	44.6	67.7
	Maximum	-36.8	-11.6	-5.9	8.9	29.5	45.1	70.1

Bexar County

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	0	4,970	9,943	14,913	19,884	24,856	29,246
	Exceeded 95% of years	0	4,970	9,943	14,913	19,884	24,856	29,358
	Average	0	4,970	9,943	14,913	19,884	24,856	29,589
	Exceeded 5% of years	0	4,970	9,943	14,913	19,884	24,856	29,827
	Maximum	0	4,970	9,943	14,913	19,884	24,856	29,827
Spring and River Base Flow (AF/yr)	Minimum	9,527	9,466	9,405	9,344	9,284	9,225	9,167
	Exceeded 95% of years	9,790	9,730	9,671	9,596	9,519	9,455	9,392
	Average	10,647	10,581	10,515	10,444	10,340	10,319	10,233
	Exceeded 5% of years	11,492	11,424	11,365	11,301	11,224	11,104	11,092
	Maximum	11,867	11,798	11,730	11,665	11,600	11,536	11,471
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	33,298	31,221	28,595	25,917	23,139	20,183	17,228
	Exceeded 95% of years	36,683	34,038	31,225	28,227	25,103	22,220	19,009
	Average	42,130	39,459	36,714	33,626	30,583	28,131	24,650
	Exceeded 5% of years	47,585	44,946	42,210	39,560	36,613	33,455	30,948
	Maximum	50,232	47,632	44,964	42,271	39,633	37,091	34,721
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-69.2	-56.9	-44.3	-31.0	-13.3	4.7	14.6
	Exceeded 95% of years	-59.9	-47.5	-34.5	-20.2	0.1	16.3	29.2
	Average	-43.7	-31.2	-18.2	1.5	33.7	46.0	62.9
	Exceeded 5% of years	-27.0	-13.9	-0.4	20.6	35.2	49.4	64.2
	Maximum	-20.8	-7.6	6.1	22.8	36.1	49.4	64.4
Edwards Group Drawdown after 50 Years (ft)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-24.5	-23.7	-22.9	-22.1	-17.7	-15.9	-16.1
	Exceeded 95% of years	-17.9	-16.5	-15.7	-14.0	-9.2	-6.2	-6.9
	Average	-4.2	-3.4	-2.7	3.4	16.0	15.1	17.4
	Exceeded 5% of years	10.7	11.5	12.3	17.2	18.0	17.5	19.5
	Maximum	14.8	15.6	16.4	17.6	18.3	17.7	19.8
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-87.6	-70.6	-53.0	-34.7	-11.6	13.1	27.1
	Exceeded 95% of years	-77.0	-60.0	-42.4	-21.9	3.9	25.6	44.5
	Average	-60.1	-43.0	-24.6	0.7	40.6	58.6	81.1
	Exceeded 5% of years	-42.3	-24.3	-5.5	22.1	42.3	62.5	82.6
	Maximum	-35.4	-17.1	1.9	24.9	43.4	62.6	82.8
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-87.5	-70.5	-53.0	-34.7	-11.6	13.1	27.1
	Exceeded 95% of years	-76.9	-59.9	-42.3	-21.9	3.9	25.5	44.5
	Average	-60.0	-42.9	-24.6	0.7	40.6	58.6	81.5
	Exceeded 5% of years	-42.3	-24.3	-5.5	22.1	42.3	62.5	83.0
	Maximum	-35.3	-17.1	1.9	24.9	43.4	62.6	83.2

Blanco County

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	0	515	1,029	1,544	2,059	2,573	3,088
	Exceeded 95% of years	0	515	1,029	1,544	2,059	2,573	3,088
	Average	0	515	1,029	1,544	2,059	2,573	3,088
	Exceeded 5% of years	0	515	1,029	1,544	2,059	2,573	3,088
	Maximum	0	515	1,029	1,544	2,059	2,573	3,088
Spring and River Base Flow (AF/yr)	Minimum	13,690	13,313	12,942	12,594	12,221	11,845	11,411
	Exceeded 95% of years	15,263	14,849	14,353	13,847	13,187	12,913	12,310
	Average	18,762	18,259	17,710	17,092	16,489	16,312	15,606
	Exceeded 5% of years	22,508	21,879	21,285	20,783	20,208	19,556	19,181
	Maximum	24,353	23,748	23,128	22,617	22,122	21,702	21,319
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-23.0	-19.9	-16.6	-13.1	-7.9	-1.4	-0.4
	Exceeded 95% of years	-18.1	-14.9	-11.6	-7.4	-0.2	4.1	7.4
	Average	-9.4	-6.1	-2.7	4.0	16.7	19.2	23.6
	Exceeded 5% of years	-0.1	3.0	6.7	13.3	18.5	21.0	27.1
	Maximum	2.9	6.2	9.6	14.8	18.5	22.1	27.2
Edwards Group Drawdown after 50 Years (ft)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-19.7	-19.1	-18.6	-18.1	-14.3	-12.6	-13.5
	Exceeded 95% of years	-13.2	-12.5	-11.9	-10.5	-6.2	-4.0	-5.4
	Average	-1.0	-0.5	-0.1	4.9	16.0	14.8	16.2
	Exceeded 5% of years	12.1	12.6	13.0	17.3	17.6	16.7	18.1
	Maximum	16.0	16.5	16.9	17.8	18.0	16.9	18.4
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-24.1	-20.1	-15.9	-11.3	-5.6	2.7	4.4
	Exceeded 95% of years	-20.1	-16.0	-11.7	-6.4	1.5	7.0	11.6
	Average	-12.6	-8.2	-3.6	3.5	16.7	20.6	26.0
	Exceeded 5% of years	-4.3	0.2	5.0	11.8	19.6	23.4	31.4
	Maximum	-1.8	2.7	7.5	13.7	19.7	24.5	31.4
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-24.4	-20.3	-16.0	-11.4	-5.5	2.9	4.6
	Exceeded 95% of years	-20.4	-16.1	-11.8	-6.4	1.6	7.2	11.8
	Average	-12.7	-8.3	-3.6	3.6	16.8	20.7	26.2
	Exceeded 5% of years	-4.5	0.1	4.9	11.8	19.6	23.4	31.3
	Maximum	-2.0	2.6	7.4	13.7	19.6	24.4	31.3

Comal County

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	0	2,042	4,086	6,128	8,170	10,214	11,924
	Exceeded 95% of years	0	2,042	4,086	6,128	8,170	10,214	12,068
	Average	0	2,042	4,086	6,128	8,170	10,214	12,225
	Exceeded 5% of years	0	2,042	4,086	6,128	8,170	10,214	12,256
	Maximum	0	2,042	4,086	6,128	8,170	10,214	12,256
Spring and River Base Flow (AF/yr)	Minimum	5,309	3,693	1,918	124	-1,730	-3,623	-5,496
	Exceeded 95% of years	8,017	5,663	3,509	1,592	-576	-2,387	-4,498
	Average	12,794	10,322	7,883	5,319	3,114	1,477	-823
	Exceeded 5% of years	17,638	15,165	12,669	10,228	7,669	5,079	3,287
	Maximum	19,973	17,503	15,001	12,558	10,192	8,010	6,277
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	33,808	32,833	31,781	30,711	29,604	28,442	27,279
	Exceeded 95% of years	35,331	34,298	33,261	32,094	30,871	29,689	28,480
	Average	39,283	38,316	37,292	36,131	34,913	33,948	32,577
	Exceeded 5% of years	43,101	42,124	41,128	40,215	39,082	37,888	36,897
	Maximum	44,814	43,864	42,898	41,927	40,960	40,011	39,046
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-27.8	-23.6	-19.4	-15.0	-7.9	-1.3	2.3
	Exceeded 95% of years	-22.8	-18.6	-14.3	-9.2	-0.7	5.9	10.8
	Average	-14.2	-10.1	-5.3	2.9	19.2	23.9	31.1
	Exceeded 5% of years	-4.9	-0.3	4.6	14.4	20.3	25.7	31.9
	Maximum	-1.7	3.1	8.5	15.2	20.7	25.7	32.0
Edwards Group Drawdown after 50 Years (ft)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-21.8	-21.1	-20.5	-19.9	-16.0	-14.3	-14.8
	Exceeded 95% of years	-14.8	-14.0	-13.5	-11.9	-7.5	-4.2	-5.2
	Average	-1.4	-0.9	-0.3	5.4	16.4	15.4	17.5
	Exceeded 5% of years	12.6	13.1	13.7	17.9	18.5	17.9	19.6
	Maximum	16.3	16.8	17.4	17.9	18.5	17.9	19.6
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-29.1	-24.2	-19.1	-13.9	-6.3	1.6	5.9
	Exceeded 95% of years	-24.6	-19.6	-14.6	-8.7	0.6	8.4	14.3
	Average	-17.0	-11.9	-6.4	2.4	19.8	25.5	33.7
	Exceeded 5% of years	-8.9	-3.2	2.8	13.6	20.7	27.5	34.3
	Maximum	-5.7	0.1	6.6	14.7	21.2	27.5	34.4
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-29.1	-24.2	-19.1	-13.9	-6.3	1.6	6.0
	Exceeded 95% of years	-24.7	-19.7	-14.6	-8.7	0.6	8.4	14.4
	Average	-17.0	-11.9	-6.4	2.4	19.7	25.5	34.3
	Exceeded 5% of years	-9.0	-3.2	2.8	13.6	20.7	27.5	35.1
	Maximum	-5.7	0.1	6.5	14.7	21.2	27.5	35.3

Hays County

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	0	1,826	3,652	5,478	7,304	9,115	10,486
	Exceeded 95% of years	0	1,826	3,652	5,478	7,304	9,115	10,492
	Average	0	1,826	3,652	5,478	7,304	9,115	10,938
	Exceeded 5% of years	0	1,826	3,652	5,478	7,304	9,130	10,956
	Maximum	0	1,826	3,652	5,478	7,304	9,130	10,956
Spring and River Base Flow (AF/yr)	Minimum	17,976	17,239	16,474	15,709	14,913	14,104	13,345
	Exceeded 95% of years	18,900	18,203	17,417	16,552	15,690	14,938	14,154
	Average	21,917	21,133	20,364	19,599	18,694	18,025	17,140
	Exceeded 5% of years	25,016	24,230	23,451	22,686	21,850	20,971	20,286
	Maximum	26,427	25,620	24,832	24,080	23,346	22,630	21,854
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	5,832	5,290	4,623	3,894	3,046	2,155	1,418
	Exceeded 95% of years	6,889	6,029	5,235	4,355	3,371	2,600	1,838
	Average	8,252	7,409	6,557	5,668	4,774	3,995	3,179
	Exceeded 5% of years	9,628	8,772	7,907	7,105	6,214	5,335	4,665
	Maximum	10,263	9,405	8,542	7,743	7,039	6,509	5,978
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-21.5	-16.8	-12.1	-7.3	-1.3	5.4	6.6
	Exceeded 95% of years	-18.3	-13.6	-8.8	-3.5	3.9	9.2	12.2
	Average	-12.5	-7.7	-3.0	4.0	15.1	19.2	23.5
	Exceeded 5% of years	-6.6	-1.9	3.2	10.2	15.9	20.3	24.5
	Maximum	-4.7	0.2	5.2	10.9	15.9	20.8	24.6
Edwards Group Drawdown after 50 Years (ft)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-12.0	-11.7	-11.3	-11.0	-8.2	-7.3	-7.8
	Exceeded 95% of years	-8.0	-7.1	-6.7	-5.8	-2.9	-1.1	-2.2
	Average	0.5	0.9	1.2	4.8	12.2	11.4	12.7
	Exceeded 5% of years	9.4	9.7	10.1	13.0	13.4	12.9	14.0
	Maximum	12.0	12.3	12.7	13.1	13.5	13.0	14.1
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-25.4	-19.0	-12.6	-6.0	1.5	8.2	11.8
	Exceeded 95% of years	-22.8	-16.3	-9.7	-2.9	6.2	13.5	17.4
	Average	-17.9	-11.4	-4.7	3.7	16.0	22.4	27.5
	Exceeded 5% of years	-12.7	-6.1	0.9	9.1	17.6	23.8	29.2
	Maximum	-11.1	-4.3	2.6	10.0	17.6	24.3	29.4
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-25.4	-19.0	-12.6	-6.0	1.5	8.2	11.8
	Exceeded 95% of years	-22.8	-16.3	-9.7	-2.9	6.2	13.5	17.5
	Average	-17.9	-11.4	-4.7	3.7	16.0	22.4	27.7
	Exceeded 5% of years	-12.7	-6.1	0.9	9.1	17.6	23.8	29.5
	Maximum	-11.1	-4.4	2.6	10.0	17.6	24.4	29.6

Kendall County

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	310	2,539	4,766	6,994	9,223	11,450	13,678
	Exceeded 95% of years	310	2,539	4,766	6,994	9,223	11,450	13,678
	Average	310	2,539	4,766	6,994	9,223	11,450	13,678
	Exceeded 5% of years	310	2,539	4,766	6,994	9,223	11,450	13,678
	Maximum	310	2,539	4,766	6,994	9,223	11,450	13,678
Spring and River Base Flow (AF/yr)	Minimum	25,159	23,558	22,071	20,736	19,214	17,848	15,899
	Exceeded 95% of years	29,988	27,651	25,150	22,814	20,790	19,421	17,739
	Average	36,424	33,737	31,034	28,183	26,184	24,753	22,688
	Exceeded 5% of years	43,318	40,422	37,390	34,466	32,253	30,160	28,629
	Maximum	47,156	44,178	40,989	38,030	36,010	34,442	32,978
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-41.3	-35.0	-28.0	-20.0	-11.5	-0.2	2.7
	Exceeded 95% of years	-34.5	-27.9	-21.1	-12.9	-0.9	7.7	13.5
	Average	-22.0	-15.7	-8.6	3.4	23.5	28.6	36.8
	Exceeded 5% of years	-9.1	-2.8	4.4	17.1	26.6	31.7	41.9
	Maximum	-5.0	1.5	8.6	19.6	26.6	32.5	42.0
Edwards Group Drawdown after 50 Years (ft)	Minimum	-3.5	-3.5	-3.5	-3.5	-3.1	-2.3	-3.1
	Exceeded 95% of years	-2.3	-2.3	-2.3	-2.3	-1.4	-1.1	-1.2
	Average	-0.3	-0.4	-0.3	0.2	2.1	2.0	2.0
	Exceeded 5% of years	1.7	1.7	1.7	2.1	2.7	2.3	2.7
	Maximum	2.3	2.3	2.3	2.7	2.7	2.7	2.7
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-45.0	-42.8	-41.0	-39.5	-32.9	-27.1	-31.4
	Exceeded 95% of years	-30.6	-28.3	-26.5	-24.3	-14.9	-11.5	-12.6
	Average	-7.1	-5.2	-3.7	5.2	29.1	26.3	30.3
	Exceeded 5% of years	17.9	19.4	21.0	30.4	31.1	30.3	32.4
	Maximum	26.1	28.0	29.4	33.3	33.9	31.0	34.9
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-40.2	-32.3	-23.9	-14.1	-4.3	7.4	11.1
	Exceeded 95% of years	-35.6	-27.8	-19.2	-8.8	3.7	13.6	22.5
	Average	-27.0	-19.1	-10.4	3.1	21.3	29.3	38.8
	Exceeded 5% of years	-18.2	-10.0	-0.8	12.5	25.6	32.8	45.7
	Maximum	-15.3	-7.0	2.2	14.9	25.6	33.3	45.8
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-40.1	-32.3	-23.9	-14.2	-4.3	7.4	11.2
	Exceeded 95% of years	-35.5	-27.8	-19.3	-8.8	3.7	13.7	22.5
	Average	-26.9	-19.0	-10.4	3.0	21.3	29.4	39.0
	Exceeded 5% of years	-18.1	-9.9	-0.8	12.6	25.6	32.9	45.8
	Maximum	-15.2	-6.9	2.2	15.0	25.6	33.4	45.9

Kerr County

Component	Case	Scenario 1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	1,033	5,030	9,029	13,026	14,180	14,594	15,656
	Exceeded 95% of years	1,033	5,030	9,029	13,026	14,180	15,170	16,614
	Average	1,033	5,030	9,029	13,026	14,180	15,952	16,614
	Exceeded 5% of years	1,033	5,030	9,029	13,026	15,650	17,468	18,935
	Maximum	1,033	5,030	9,029	13,026	15,650	17,468	20,755
Spring and River Base Flow (AF/yr)	Minimum	31,354	31,284	31,168	31,102	31,097	31,127	31,040
	Exceeded 95% of years	34,569	33,772	33,361	33,242	33,121	33,421	33,125
	Average	39,213	38,159	37,582	37,349	37,351	37,559	37,294
	Exceeded 5% of years	44,116	42,936	42,155	42,132	41,972	41,641	41,844
	Maximum	46,635	45,388	44,438	44,272	44,256	44,225	44,193
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-103.0	-78.8	-49.0	-9.0	11.6	5.6	9.8
	Exceeded 95% of years	-100.1	-75.4	-45.2	-5.2	13.4	21.0	25.1
	Average	-94.7	-70.2	-40.1	2.7	21.3	39.2	58.5
	Exceeded 5% of years	-89.1	-64.4	-33.8	7.9	33.1	46.6	69.2
	Maximum	-57.2	-18.5	-9.8	11.5	33.6	47.5	72.0
Edwards Group Drawdown after 50 Years (ft)	Minimum	-9.0	-9.0	-9.0	-9.0	-7.1	-6.9	-7.1
	Exceeded 95% of years	-7.0	-6.9	-6.9	-6.6	-5.4	-5.2	-5.3
	Average	-3.5	-3.5	-3.6	-2.5	-0.2	0.2	-0.2
	Exceeded 5% of years	0.1	0.1	0.1	0.4	3.7	2.6	3.5
	Maximum	1.6	1.1	1.6	3.4	4.2	3.6	4.2
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-27.3	-19.0	-12.5	-10.5	-9.1	-7.2	-8.7
	Exceeded 95% of years	-23.7	-15.4	-9.1	-6.9	-4.6	-3.7	-3.8
	Average	-17.0	-9.0	-2.8	0.7	6.9	6.7	7.1
	Exceeded 5% of years	-10.3	-2.2	3.7	6.9	9.4	8.3	9.6
	Maximum	-3.1	-0.1	5.9	9.4	9.7	9.5	10.1
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-142.2	-109.5	-67.6	-8.1	13.2	8.3	14.4
	Exceeded 95% of years	-139.9	-106.3	-64.5	-4.8	21.0	27.6	34.1
	Average	-135.1	-101.8	-59.4	3.6	29.1	56.8	86.6
	Exceeded 5% of years	-130.1	-96.1	-52.1	9.5	45.1	66.4	99.8
	Maximum	-84.1	-27.0	-14.1	16.9	45.8	68.1	103.5
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-142.7	-110.4	-68.5	-8.2	13.8	8.6	15.0
	Exceeded 95% of years	-140.2	-107.2	-65.4	-4.8	21.3	28.5	35.5
	Average	-135.6	-102.8	-60.2	3.8	29.7	58.2	88.8
	Exceeded 5% of years	-130.7	-97.1	-53.0	9.7	46.0	68.0	102.4
	Maximum	-86.7	-28.3	-14.8	17.2	46.7	69.8	106.3

Medina County

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	0	500	1,000	1,500	2,000	2,500	3,000
	Exceeded 95% of years	0	500	1,000	1,500	2,000	2,500	3,000
	Average	0	500	1,000	1,500	2,000	2,500	3,000
	Exceeded 5% of years	0	500	1,000	1,500	2,000	2,500	3,000
	Maximum	0	500	1,000	1,500	2,000	2,500	3,000
Spring and River Base Flow (AF/yr)	Minimum	4,991	4,985	4,978	4,971	4,965	4,955	4,943
	Exceeded 95% of years	5,112	5,096	5,083	5,070	5,056	5,049	5,037
	Average	5,463	5,443	5,428	5,413	5,398	5,395	5,378
	Exceeded 5% of years	5,810	5,789	5,773	5,776	5,750	5,734	5,729
	Maximum	5,961	5,940	5,922	5,911	5,904	5,896	5,889
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	10,930	9,947	8,705	7,361	5,365	3,375	915
	Exceeded 95% of years	14,040	12,286	10,422	8,214	6,305	4,318	2,065
	Average	16,304	14,499	12,538	10,236	8,380	6,647	4,483
	Exceeded 5% of years	18,400	16,589	14,611	12,344	10,570	8,903	7,233
	Maximum	19,533	17,731	15,726	13,475	12,099	10,924	9,948
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-24.2	-18.9	-12.7	-4.9	1.6	5.0	7.4
	Exceeded 95% of years	-22.4	-17.0	-10.9	-2.9	4.3	10.7	15.4
	Average	-18.9	-13.6	-7.4	1.6	10.8	16.1	22.1
	Exceeded 5% of years	-15.3	-9.9	-3.8	5.7	12.4	17.9	25.0
	Maximum	-13.7	-6.8	-2.5	5.8	12.4	17.9	25.4
Edwards Group Drawdown after 50 Years (ft)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-8.2	-8.0	-7.8	-7.5	-6.0	-5.3	-5.7
	Exceeded 95% of years	-5.5	-5.2	-4.9	-4.4	-2.6	-1.7	-2.2
	Average	-0.5	-0.3	-0.1	2.0	6.8	6.4	7.0
	Exceeded 5% of years	5.0	5.2	5.4	7.3	7.5	7.2	7.9
	Maximum	6.6	6.9	7.1	7.6	7.7	7.2	7.9
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-32.5	-24.6	-15.7	-4.1	5.4	7.3	10.9
	Exceeded 95% of years	-31.1	-23.2	-14.1	-2.4	7.5	16.0	20.8
	Average	-28.4	-20.4	-11.3	1.5	12.8	21.0	30.3
	Exceeded 5% of years	-25.5	-17.5	-8.3	4.8	15.3	23.5	34.2
	Maximum	-21.4	-10.4	-5.4	4.9	15.4	23.8	34.8
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-32.6	-24.7	-15.7	-4.1	5.5	7.3	10.9
	Exceeded 95% of years	-31.2	-23.3	-14.2	-2.4	7.5	16.1	20.9
	Average	-28.5	-20.5	-11.3	1.5	12.8	21.1	30.4
	Exceeded 5% of years	-25.6	-17.5	-8.3	4.8	15.4	23.6	34.3
	Maximum	-21.4	-10.5	-5.4	4.9	15.4	23.9	34.9

Travis County

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	0	1,814	3,629	5,368	6,958	8,521	9,405
	Exceeded 95% of years	0	1,814	3,629	5,368	7,058	8,521	9,561
	Average	0	1,814	3,629	5,368	7,158	8,697	9,692
	Exceeded 5% of years	0	1,814	3,629	5,443	7,158	8,947	10,437
	Maximum	0	1,814	3,629	5,443	7,257	8,947	10,736
Spring and River Base Flow (AF/yr)	Minimum	13,039	12,019	10,762	9,511	8,171	6,895	5,915
	Exceeded 95% of years	14,452	12,938	11,495	10,032	8,549	7,343	6,337
	Average	16,216	14,699	13,180	11,666	10,197	9,050	7,959
	Exceeded 5% of years	18,024	16,480	14,936	13,469	12,022	10,687	9,792
	Maximum	18,883	17,348	15,798	14,389	13,230	12,312	11,359
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	1,565	1,377	1,132	855	521	171	-147
	Exceeded 95% of years	1,966	1,643	1,314	973	613	290	-28
	Average	2,341	2,006	1,672	1,321	980	670	341
	Exceeded 5% of years	2,717	2,377	2,034	1,700	1,384	1,057	777
	Maximum	2,914	2,571	2,226	1,917	1,695	1,510	1,324
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-24.8	-18.4	-11.7	-5.1	2.9	11.1	12.5
	Exceeded 95% of years	-21.3	-14.8	-8.1	-1.0	8.9	16.6	19.1
	Average	-15.2	-8.6	-1.9	6.9	20.7	27.6	31.5
	Exceeded 5% of years	-9.0	-2.6	4.4	13.4	22.0	28.8	32.9
	Maximum	-7.1	-0.6	6.3	13.9	22.0	29.4	33.4
Edwards Group Drawdown after 50 Years (ft)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-14.2	-12.6	-11.0	-9.5	-4.3	-0.1	-3.8
	Exceeded 95% of years	-6.6	-5.0	-3.4	-1.3	4.9	8.0	6.4
	Average	5.9	7.4	8.9	14.8	28.0	28.2	29.4
	Exceeded 5% of years	18.7	20.3	21.8	28.1	29.3	29.7	31.0
	Maximum	23.5	25.1	26.7	28.3	29.6	30.8	32.9
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-28.7	-20.6	-12.2	-3.8	5.7	11.3	16.1
	Exceeded 95% of years	-26.6	-18.3	-9.8	-1.1	9.7	19.8	23.3
	Average	-22.8	-14.5	-5.9	4.1	17.8	27.6	31.5
	Exceeded 5% of years	-18.9	-10.6	-1.8	8.1	19.8	29.0	33.5
	Maximum	-17.8	-9.4	-0.6	8.7	19.8	29.5	33.8
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-28.9	-20.7	-12.3	-3.9	5.4	11.4	16.1
	Exceeded 95% of years	-26.8	-18.5	-9.9	-1.3	9.6	19.4	23.3
	Average	-23.0	-14.6	-5.9	4.0	17.8	27.6	32.5
	Exceeded 5% of years	-19.0	-10.6	-1.7	8.2	19.9	29.0	34.8
	Maximum	-17.9	-9.4	-0.5	8.8	19.9	29.5	35.3

Area 1 (Comal, Hays and Travis Counties)

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	0	5,682	11,367	16,974	22,432	27,850	31,828
	Exceeded 95% of years	0	5,682	11,367	16,974	22,532	27,850	32,131
	Average	0	5,682	11,367	16,974	22,632	28,026	32,855
	Exceeded 5% of years	0	5,682	11,367	17,049	22,632	28,291	33,649
	Maximum	0	5,682	11,367	17,049	22,731	28,291	33,948
Spring and River Base Flow (AF/yr)	Minimum	36,382	33,020	29,161	25,397	21,452	17,392	13,798
	Exceeded 95% of years	41,415	36,777	32,250	28,088	23,579	19,904	15,872
	Average	50,919	46,177	41,514	36,563	32,043	28,588	24,313
	Exceeded 5% of years	60,615	55,827	51,004	46,460	41,599	36,704	33,352
	Maximum	65,283	60,471	55,624	51,000	46,618	42,766	39,484
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	41,232	39,579	37,536	35,479	33,228	30,775	28,578
	Exceeded 95% of years	44,158	41,949	39,692	37,286	34,837	32,611	30,270
	Average	49,847	47,750	45,517	43,107	40,642	38,643	36,144
	Exceeded 5% of years	55,375	53,220	51,036	48,980	46,694	44,199	42,358
	Maximum	57,991	55,840	53,666	51,582	49,641	47,778	46,271
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-24.5	-19.6	-14.5	-9.4	-2.6	4.8	6.5
	Exceeded 95% of years	-20.4	-15.4	-10.4	-4.7	3.6	10.0	13.4
	Average	-13.6	-8.8	-3.6	4.3	18.0	23.0	28.1
	Exceeded 5% of years	-6.7	-1.4	4.1	12.5	18.6	24.3	29.0
	Maximum	-4.3	1.0	6.6	13.1	18.6	24.5	29.3
Edwards Group Drawdown after 50 Years (ft)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-15.1	-14.4	-13.6	-12.9	-9.0	-7.2	-8.3
	Exceeded 95% of years	-9.7	-8.3	-7.5	-6.0	-1.9	0.7	-0.8
	Average	1.4	2.1	2.9	7.7	17.6	17.0	18.6
	Exceeded 5% of years	12.8	13.5	14.2	18.4	19.0	18.7	20.0
	Maximum	16.2	16.9	17.7	18.5	19.2	19.0	20.6
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-27.5	-21.2	-14.8	-8.3	-0.4	8.7	11.4
	Exceeded 95% of years	-24.4	-18.0	-11.5	-4.6	5.1	13.1	18.0
	Average	-18.7	-12.3	-5.6	3.3	17.9	24.7	30.8
	Exceeded 5% of years	-12.8	-6.2	0.8	10.5	19.0	26.1	32.1
	Maximum	-10.9	-4.2	3.0	11.4	19.0	26.7	32.1
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-27.6	-21.3	-14.8	-8.3	-0.5	8.6	11.4
	Exceeded 95% of years	-24.5	-18.1	-11.6	-4.6	5.1	13.0	18.2
	Average	-18.8	-12.4	-5.7	3.3	18.0	24.8	31.4
	Exceeded 5% of years	-12.9	-6.3	0.8	10.5	19.0	26.1	32.7
	Maximum	-11.0	-4.2	3.0	11.4	19.0	26.7	32.8

Area 2 (Medina and Bexar Counties)

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	0	5,470	10,943	16,413	21,884	27,356	32,246
	Exceeded 95% of years	0	5,470	10,943	16,413	21,884	27,356	32,358
	Average	0	5,470	10,943	16,413	21,884	27,356	32,589
	Exceeded 5% of years	0	5,470	10,943	16,413	21,884	27,356	32,827
	Maximum	0	5,470	10,943	16,413	21,884	27,356	32,827
Spring and River Base Flow (AF/yr)	Minimum	14,518	14,451	14,383	14,315	14,249	14,183	14,119
	Exceeded 95% of years	14,893	14,824	14,752	14,649	14,574	14,501	14,429
	Average	16,113	16,027	15,946	15,865	15,737	15,718	15,612
	Exceeded 5% of years	17,305	17,216	17,134	17,078	16,977	16,841	16,825
	Maximum	17,828	17,738	17,652	17,576	17,504	17,432	17,360
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	44,228	41,198	37,300	33,278	28,805	23,593	18,313
	Exceeded 95% of years	50,933	46,428	41,743	36,416	31,309	26,651	21,169
	Average	58,350	53,918	49,236	43,765	38,878	34,722	29,275
	Exceeded 5% of years	65,785	61,372	56,704	51,861	47,188	42,165	37,851
	Maximum	69,765	65,363	60,690	55,746	51,732	47,886	44,669
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-54.3	-44.3	-33.8	-22.4	-8.4	6.1	14.5
	Exceeded 95% of years	-47.5	-37.2	-26.6	-14.1	1.5	14.4	25.1
	Average	-35.6	-25.4	-14.6	1.6	26.2	36.3	49.2
	Exceeded 5% of years	-23.1	-12.6	-1.6	15.6	27.4	38.9	50.8
	Maximum	-18.6	-8.0	3.2	17.1	27.4	39.0	51.1
Edwards Group Drawdown after 50 Years (ft)	Minimum	NA	NA	NA	NA	NA	NA	NA
	Exceeded 95% of years	NA	NA	NA	NA	NA	NA	NA
	Average	NA	NA	NA	NA	NA	NA	NA
	Exceeded 5% of years	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-18.6	-18.0	-17.4	-16.8	-13.3	-12.0	-12.2
	Exceeded 95% of years	-13.4	-12.4	-11.8	-10.4	-6.8	-4.5	-5.2
	Average	-2.9	-2.3	-1.8	2.9	12.6	11.9	13.7
	Exceeded 5% of years	8.6	9.2	9.8	13.6	14.2	13.7	15.2
	Maximum	11.8	12.4	13.0	13.9	14.4	13.9	15.5
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-70.2	-56.0	-41.1	-24.8	-6.2	14.0	26.3
	Exceeded 95% of years	-62.6	-48.3	-33.5	-15.8	5.2	23.1	38.9
	Average	-50.2	-35.8	-20.5	0.9	31.9	46.9	64.4
	Exceeded 5% of years	-37.1	-22.4	-6.4	16.5	33.4	50.1	67.0
	Maximum	-32.1	-17.1	-1.1	18.6	33.5	50.2	67.3
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-70.1	-56.0	-41.1	-24.8	-6.2	14.0	26.4
	Exceeded 95% of years	-62.6	-48.3	-33.4	-15.8	5.2	23.1	39.0
	Average	-50.2	-35.8	-20.5	0.9	31.9	46.9	65.0
	Exceeded 5% of years	-37.1	-22.3	-6.4	16.5	33.4	50.1	67.6
	Maximum	-32.0	-17.1	-1.1	18.6	33.5	50.2	67.8

Area 3 (Bandera, Blanco, Kendall and Kerr Counties)

Component	Case	Scenario						
		1	2	3	4	5	6	7
Pumping (AF/yr)	Minimum	1,968	10,166	18,364	26,560	31,914	36,527	41,771
	Exceeded 95% of years	1,968	10,166	18,364	26,560	31,914	37,103	42,741
	Average	1,968	10,166	18,364	26,560	31,914	37,885	42,747
	Exceeded 5% of years	1,968	10,166	18,364	26,560	33,384	39,401	45,068
	Maximum	1,968	10,166	18,364	26,560	33,384	39,401	46,888
Spring and River Base Flow (AF/yr)	Minimum	100,461	97,270	94,255	91,435	88,684	86,241	82,052
	Exceeded 95% of years	115,607	109,855	104,205	98,851	94,460	92,528	88,258
	Average	135,508	128,712	122,144	116,054	111,785	109,241	104,792
	Exceeded 5% of years	155,874	148,542	141,290	135,155	130,583	126,108	122,824
	Maximum	166,200	158,564	150,900	144,514	140,649	137,187	134,241
Outflow Across the Balcones Fault Zone (AF/yr)	Minimum	1,217	1,081	887	673	323	5	-445
	Exceeded 95% of years	1,763	1,505	1,197	819	499	165	-225
	Average	2,148	1,856	1,531	1,122	823	535	169
	Exceeded 5% of years	2,457	2,168	1,838	1,443	1,154	924	681
	Maximum	2,622	2,336	2,006	1,611	1,413	1,259	1,125
Overall Trinity Drawdown after 50 Years (ft)	Minimum	-62.3	-49.1	-33.1	-11.4	2.5	5.0	7.9
	Exceeded 95% of years	-58.8	-45.4	-29.0	-6.8	7.1	19.6	24.6
	Average	-51.5	-38.0	-21.7	3.2	20.0	31.1	42.6
	Exceeded 5% of years	-43.9	-30.4	-13.8	11.2	27.3	36.3	52.2
	Maximum	-32.7	-11.9	-6.3	11.6	27.5	36.6	53.7
Edwards Group Drawdown after 50 Years (ft)	Minimum	-8.1	-8.1	-8.1	-8.1	-6.5	-6.1	-6.5
	Exceeded 95% of years	-6.2	-6.1	-6.1	-5.9	-4.8	-4.4	-4.7
	Average	-3.0	-3.0	-3.1	-2.1	0.2	0.5	0.2
	Exceeded 5% of years	0.2	0.2	0.2	0.7	3.5	2.5	3.4
	Maximum	1.7	1.3	1.7	3.3	3.9	3.4	3.9
Upper Trinity Drawdown after 50 Years(ft)	Minimum	-27.3	-22.8	-19.3	-18.2	-15.5	-12.8	-14.8
	Exceeded 95% of years	-21.3	-16.8	-13.2	-10.9	-6.9	-5.2	-5.9
	Average	-9.8	-5.5	-2.1	2.8	14.4	13.2	15.0
	Exceeded 5% of years	1.8	5.9	9.8	14.9	15.5	15.1	16.0
	Maximum	5.8	10.4	13.9	16.9	17.2	15.8	17.7
Middle Trinity Drawdown after 50 Years(ft)	Minimum	-77.6	-60.7	-39.3	-9.1	9.7	7.0	11.1
	Exceeded 95% of years	-74.9	-57.6	-35.9	-4.9	13.0	24.4	29.1
	Average	-69.4	-51.8	-29.9	3.2	22.5	38.9	56.7
	Exceeded 5% of years	-63.6	-45.7	-23.5	9.6	32.2	45.8	67.3
	Maximum	-46.0	-16.4	-8.6	10.6	32.6	46.3	69.5
Lower Trinity Drawdown after 50 Years (ft)	Minimum	-78.1	-61.2	-39.8	-9.1	10.0	7.2	11.4
	Exceeded 95% of years	-75.4	-58.2	-36.4	-4.9	13.2	24.8	29.8
	Average	-69.9	-52.4	-30.4	3.3	22.8	39.6	57.9
	Exceeded 5% of years	-64.2	-46.3	-24.0	9.7	32.6	46.7	68.7
	Maximum	-47.1	-16.9	-8.9	10.7	33.0	47.1	70.9

GAM Task 10-031:
Supplement to GAM Task 10-005

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January 25, 2011

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January 25, 2011

The seals appearing on this document were authorized by William R. Hutchison, P.E. 96287, P.G. 286 and Mohammad Masud Hassan, P.E. 95699 on January 25, 2011.

DESCRIPTION OF TASK:

This report presents additional results associated with the analysis described in GAM Task 10-005. The simulations used as part of this task include four of the seven pumping scenarios (GAM Task 10-005) of the Trinity Aquifer that range from current estimated pumping representing 2008 to about twice the estimated 2008 level of pumping. Each scenario included running 387 50-year simulations. The 387 50-year simulations were developed based on tree-ring precipitation estimates from 1537 to 1972 for the Edwards Plateau (Cleaveland, 2006). The results were used to evaluate averaged water budgets per county and to develop contour maps of average drawdown in water levels for each scenario.

METHODS:

The seven pumping scenarios in GAM Task 10-005 (Hutchison, 2010) ranged from no pumping in the Trinity Aquifer (Scenario 1), to 2008 levels of pumping (about 60,000 acre-feet in Scenario 4) to about twice the pumping experienced in 2008 (about 120,000 acre-feet in Scenario 7) as summarized below:.

- Scenario 1 = 0 acre-feet per year
- Scenario 2 = 20,000 acre-feet per year
- Scenario 3 = 40,000 acre-feet per year
- Scenario 4 = 60,000 acre-feet per year (2008 conditions)
- Scenario 5 = 80,000 acre-feet per year
- Scenario 6 = 100,000 acre-feet per year
- Scenario 7 = 120,000 acre-feet per year

Table 1 summarizes the estimated pumping by county and by aquifer in 2008. These estimates were provided by groundwater conservation districts in Groundwater Management Area 9.

Table 1. Estimated 2008 pumping as provided by the groundwater conservation districts in Groundwater Management Area 9

County	Edwards Group of the Edwards-Trinity (Plateau) Aquifer	Upper Trinity Aquifer	Middle Trinity Aquifer	Lower Trinity Aquifer	Total Pumping (County)
Bandera	631	288	3567	515	**5,000**
Bexar	0	693	14110	197	**15,000**
Blanco	0	77	1,477	0	**1,554**
Comal	0	398	5,788	0	**6,186**
Hays	0	416	4,800	449	**5,665**
Kendall	315	300	6,060	325	**7,000**
Kerr	1,035	213	6,263	5,534	**13,045**
Medina	0	0	500	1000	**1,500**
Travis	0	551	4,967	0	**5,518**
Total pumping (aquifer)	**1,981**	**2,936**	**47,532**	**8,020**	**60,468**

PARAMETERS AND ASSUMPTIONS:

- See GAM Task 10-005 (Hutchison, 2010) for additional information of the assumptions used for recharge, starting conditions, and pumping for the 387 50 year simulations.

- The recently updated Hill Country portion of the Trinity Aquifer developed by Jones and others (2009) was used for these simulations. See Mace and others (2000) and Jones and others (2009) for details on model construction, recharge distribution, discharge, assumptions, and limitations of the model.

- Pumping scenarios 4, 5, 6, and 7 were used as described above

- The model has four layers: layer 1 represents the Edwards Group of the Edwards-Trinity (Plateau) Aquifer, layer 2 represents the Upper Trinity Aquifer, layer 3 represents the Middle Trinity Aquifer, and layer 4 represents the Lower Trinity Aquifer.

- The rivers, streams, and springs were simulated in the model using MODFLOW's Drain package. MODFLOW's Drain package was also used to simulate spring discharge along bedding contacts of the Edwards Group (Plateau) and the Upper

Trinity Aquifer in the northwestern parts of the model area. This resulted in the assignment of numerous drain cells along this outcrop contact.

- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Drawdowns were calculated by subtracting the final;water levels at the end of the 50 year simulations from the 2008 initial conditions..

RESULTS:

Summary tables of all groundwater budget results (by county and aquifer are presented in Appendix A. Because each scenario consisted of 387 50-year simulations, the groundwater budget results are expressed in terms of average of all 387 simulations for each scenario.

Figures 1 through 4 show the contour maps of the average drawdown for the Trinity Aquifer within Groundwater Management Area 9. In scenario 4 the drawdown is a maximum of about 14.5 feet to a minimum of 3.3 feet water rise in elevation compared to 2008 starting water level elevations. In scenario 5, 6 and 7 the drawdown ranges from:

- zero feet to 54.6 feet,
- zero feet to 74.0 feet, and
- zero feet to 87.9 feet respectively.

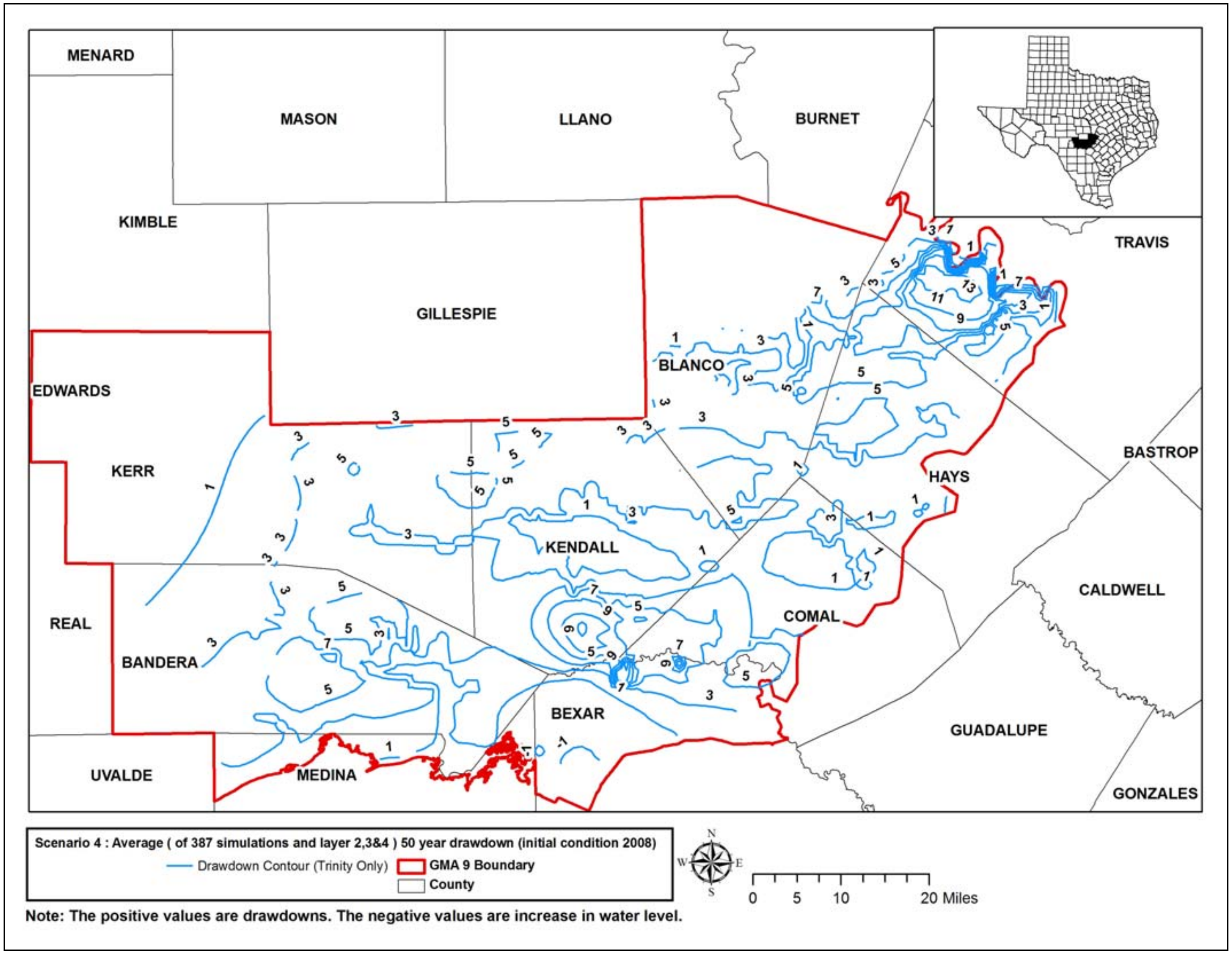

Figure 13: Average water level drawdown contour map for scenario 4 for Groundwater Management Area (GMA) 9 using 2008 water levels for the calculation.

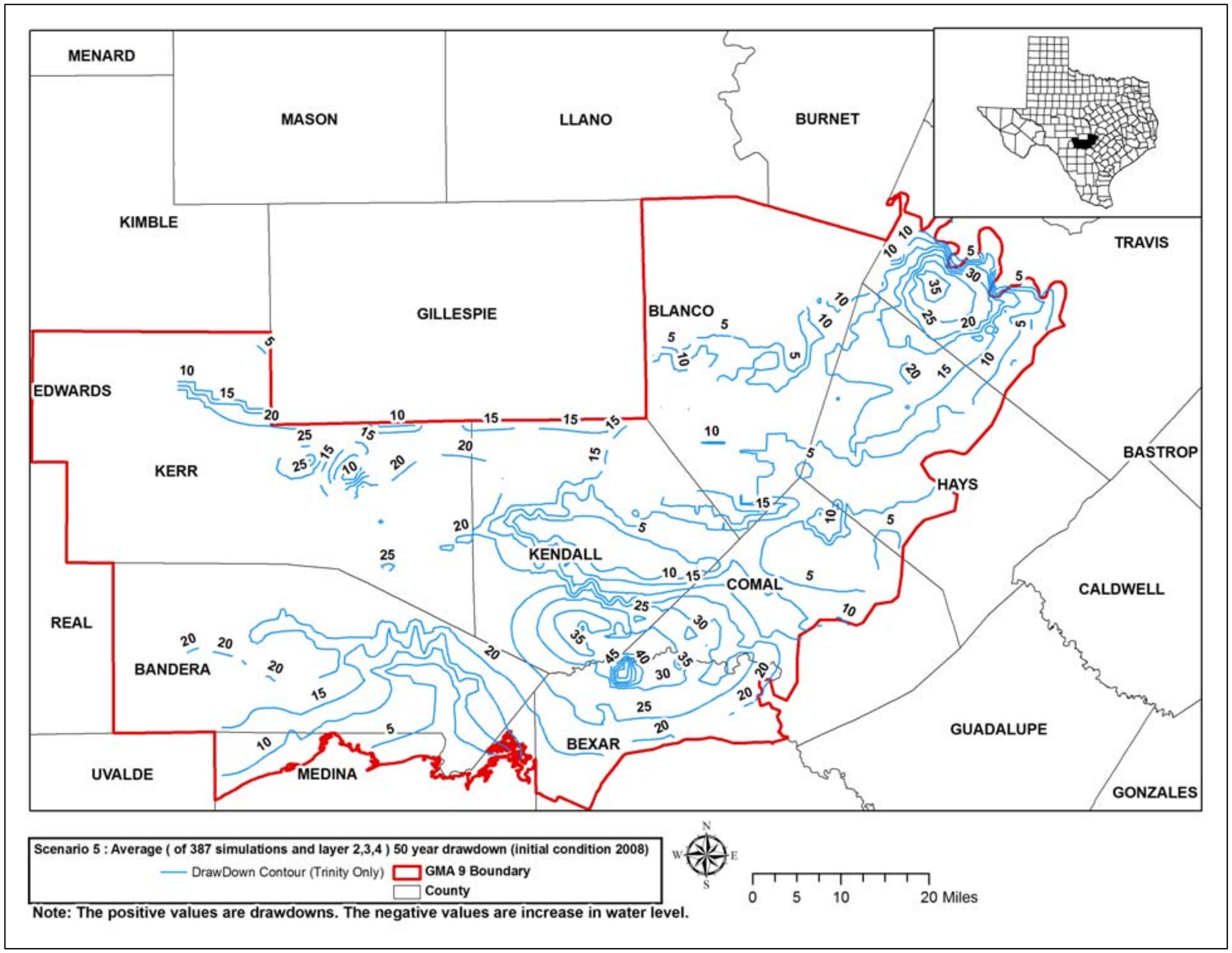

Figure 14: Average water level drawdown contour map for scenario 5 for Groundwater Management Area (GMA) 9 using 2008 water levels for the calculation.

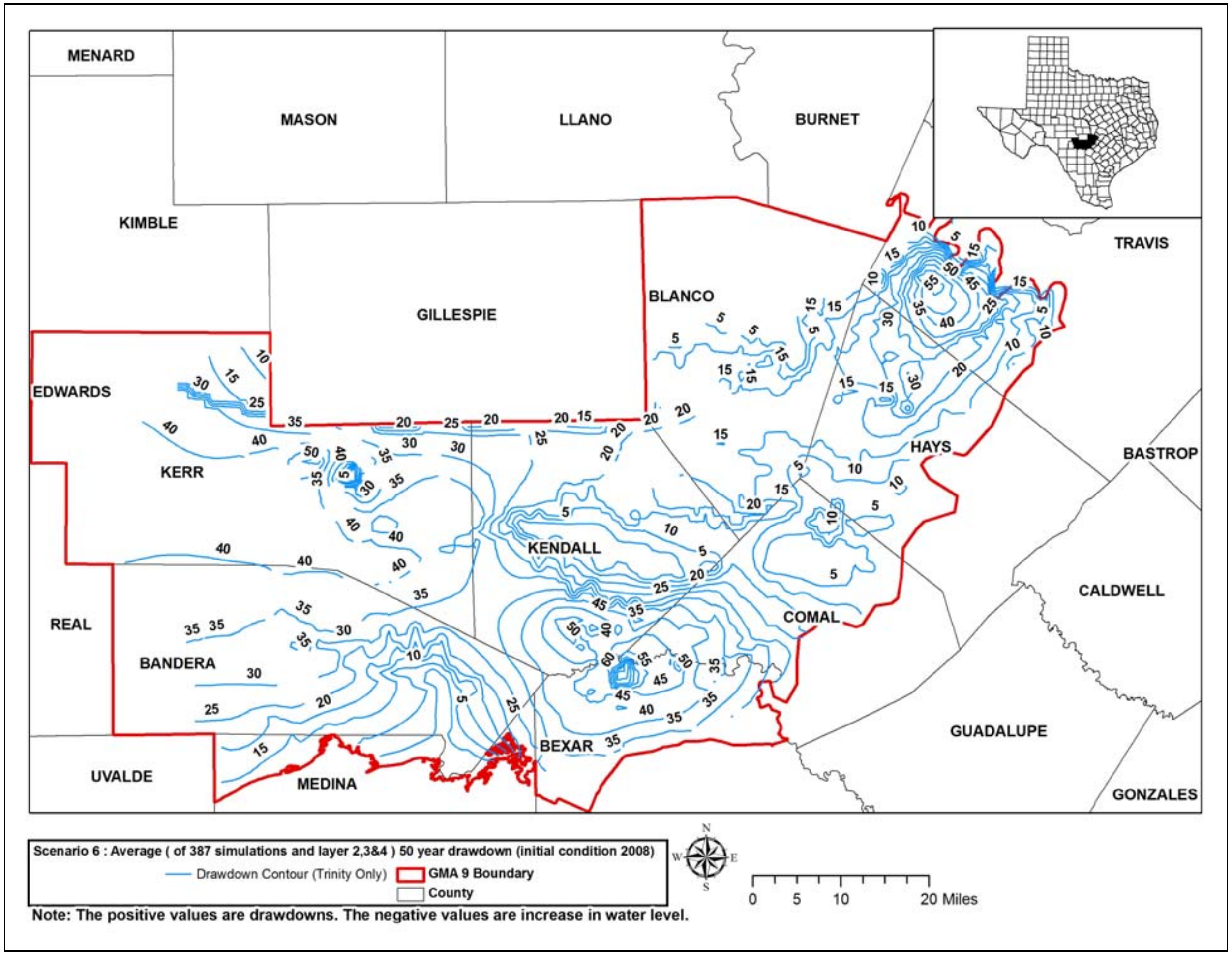

Figure 15: Average water level drawdown contour map for scenario 6 for Groundwater Management Area (GMA) 9 using 2008 water levels for the calculation.

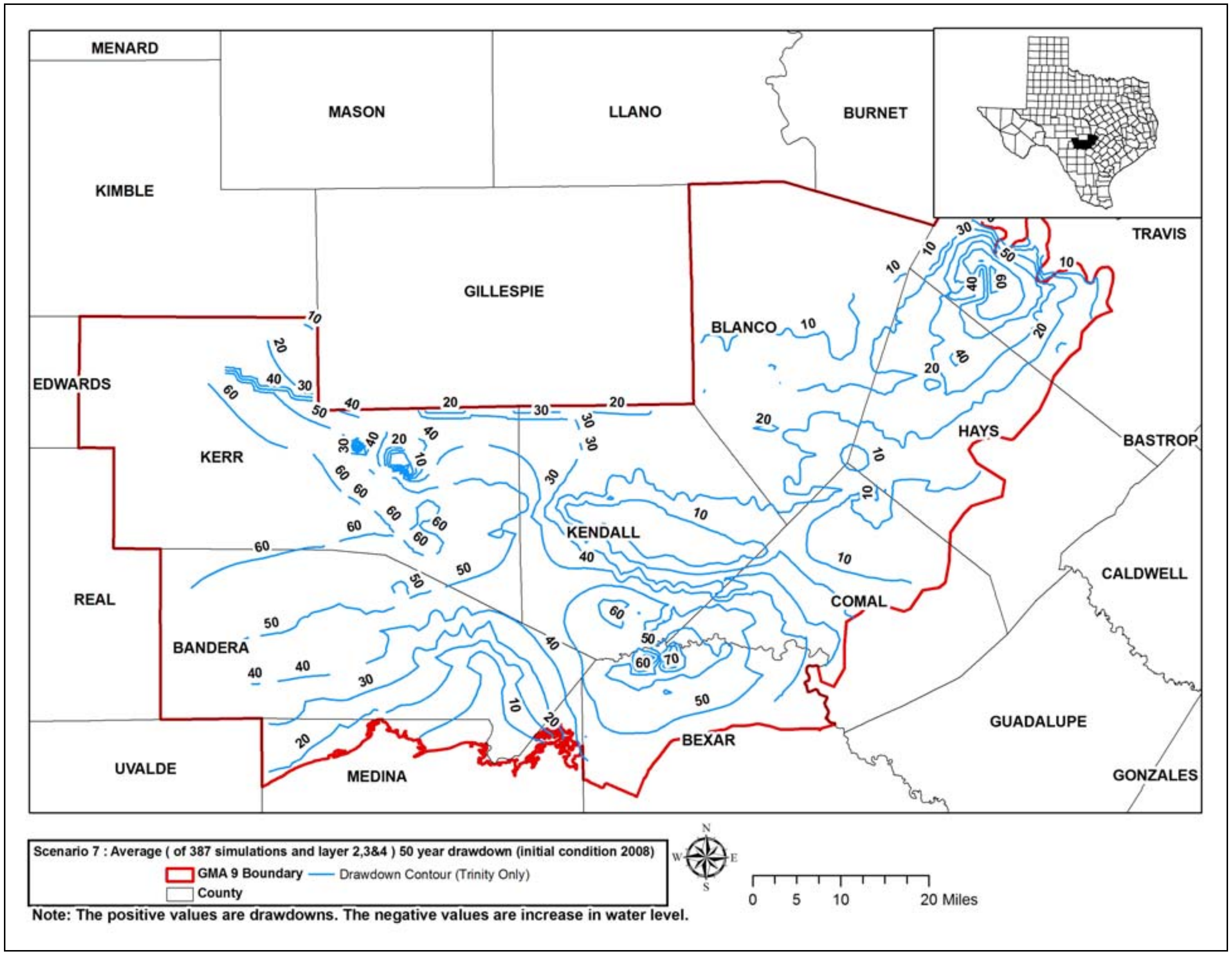

Figure 16: Average water level drawdown contour map for scenario 7 for Groundwater Management Area (GMA) 9 using 2008 water levels for the calculation.

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Appendix A
Water budgets per county for:

Bandera County
Bexar County
Blanco County
Comal County
Hays County
Kendall County
Kerr County
Medina County
Travis County

Table: Bandera County (Edward Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	9,604	9,460	9,435	9,405
INFLOW FROM KERR COUNTY	3,422	3,392	3,386	3,383
TOTAL INFLOW	13,026	12,852	12,821	12,788
OUTFLOW				
PUMPING	626	626	626	626
OUTFLOW TO SURFACE WATER	11,678	11,568	11,560	11,535
OUTFLOW TO TRINITY AQUIFER	707	704	704	703
TOTAL OUTFLOW	13,011	12,898	12,890	12,864
TOTAL INFLOW- TOTAL OUTFLOW	15	-46	-69	-76
STORAGE CHANGE	15	-45	-68	-75
MODEL ERROR	0	-1	-1	-1

Table: Bandera County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	31,787	31,310	31,227	31,129
INFLOW FROM KENDALL COUNTY	5,686	5,391	5,165	4,906
INFLOW FROM KERR COUNTY	7,415	6,655	6,070	5,459
INFLOW FROM EDWARD AQUIFER	707	704	704	703
TOTAL INFLOW	45,595	44,060	43,166	42,197
OUTFLOW				
PUMPING	4,373	5,831	7,290	8,746
OUTFLOW TO SURFACE WATER	21,680	19,892	18,672	17,436
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	1,118	807	543	217
OUTFLOW TO OTHER AREA	470	381	324	237
OUTFLOW TO BEXAR COUNTY	1,742	1,754	1,775	1,779
OUTFLOW TO MEDINA COUNTY	16,295	15,870	15,579	15,033
TOTAL OUTFLOW	45,678	44,535	44,183	43,448
TOTAL INFLOW- TOTAL OUTFLOW	-83	-475	-1,017	-1,251
STORAGE CHANGE	-82	-475	-1,018	-1,251
MODEL ERROR	-1	0	1	0

Table: Bexar County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	41,294	40,673	40,566	40,439
INFLOW FROM BANDERA COUNTY	1,742	1,754	1,775	1,779
INFLOW FROM COMAL COUNTY	10,621	11,273	11,896	12,446
INFLOW FROM KENDALL COUNTY	10,392	10,086	9,844	9,480
INFLOW FROM MEDINA COUNTY	4,831	5,788	6,688	7,583
TOTAL INFLOW	68,880	69,574	70,769	71,727
OUTFLOW				
PUMPING	14,922	19,897	24,872	29,682
OUTFLOW TO SURFACE WATER	10,412	10,285	10,214	10,139
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	33,705	30,389	27,484	24,436
OUTFLOW TO OTHER AREA	9,878	9,216	8,638	8,028
TOTAL OUTFLOW	68,917	69,787	71,208	72,285
TOTAL INFLOW- TOTAL OUTFLOW	-37	-213	-439	-558
STORAGE CHANGE	-37	-209	-434	-554
MODEL ERROR	0	-4	-5	-4

Table: Blanco County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	23,316	22,966	22,906	22,834
INFLOW FROM OTHER AREA	1,796	1,761	1,731	1,696
INFLOW FROM KENDALL COUNTY	2,738	2,704	2,690	2,670
TOTAL INFLOW	27,850	27,431	27,327	27,200
OUTFLOW				
PUMPING	1,545	2,060	2,575	3,090
OUTFLOW TO SURFACE WATER	17,127	16,380	15,928	15,419
OUTFLOW TO COMAL COUNTY	3,799	3,683	3,597	3,487
OUTFLOW TO HAYS COUNTY	5,434	5,482	5,532	5,558
TOTAL OUTFLOW	27,905	27,605	27,632	27,554
TOTAL INFLOW- TOTAL OUTFLOW	-55	-174	-305	-354
STORAGE CHANGE	-46	-164	-297	-344
MODEL ERROR	-9	-10	-8	-10

Table: Comal County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	39,793	39,195	39,092	38,969
INFLOW FROM SURFACE WATER	0	0	0	959
INFLOW FROM BLANCO COUNTY	3,799	3,683	3,597	3,487
INFLOW FROM KENDALL COUNTY	7,799	7,823	7,855	7,822
TOTAL INFLOW	51,391	50,701	50,544	51,237
OUTFLOW				
PUMPING	5,716	7,622	9,527	11,380
OUTFLOW TO SURFACE WATER	5,492	3,044	1,055	0
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	15,384	14,796	14,315	13,803
OUTFLOW TO OTHER AREA	8,208	8,202	8,232	8,254
OUTFLOW TO BEXAR COUNTY	10,621	11,273	11,896	12,446
OUTFLOW TO HAYS COUNTY	6,016	5,958	5,890	5,809
TOTAL OUTFLOW	51,437	50,895	50,915	51,692
TOTAL INFLOW- TOTAL OUTFLOW	-46	-194	-371	-455
STORAGE CHANGE	-47	-192	-370	-452
MODEL ERROR	1	-2	-1	-3

Table: Hays County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	24,363	23,997	23,934	23,859
INFLOW FROM BLANCO COUNTY	5,434	5,482	5,532	5,558
INFLOW FROM COMAL COUNTY	6,016	5,958	5,890	5,809
TOTAL INFLOW	35,813	35,437	35,356	35,226
OUTFLOW				
PUMPING	5,397	7,196	8,985	10,620
OUTFLOW TO SURFACE WATER	19,490	18,462	17,658	16,837
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	2,610	1,782	1,073	412
OUTFLOW TO OTHER AREA	2,417	2,330	2,252	2,180
OUTFLOW TO TRAVIS COUNTY	5,951	5,863	5,770	5,624
TOTAL OUTFLOW	35,865	35,633	35,738	35,673
TOTAL INFLOW- TOTAL OUTFLOW	-52	-196	-382	-447
STORAGE CHANGE	-51	-195	-382	-447
MODEL ERROR	-1	-1	0	0

Table: Kendall County (Edwards Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	5,446	5,364	5,350	5,333
INFLOW FROM KERR COUNTY	101	101	101	101
TOTAL INFLOW	5,547	5,465	5,451	5,434
OUTFLOW				
PUMPING	311	311	311	311
OUTFLOW TO SURFACE WATER	4,879	4,833	4,838	4,820
OUTFLOW TO OTHER AREA	217	216	216	215
OUTFLOW TO TRINITY AQUIFER	153	153	153	152
TOTAL OUTFLOW	5,560	5,513	5,518	5,498
TOTAL INFLOW- TOTAL OUTFLOW	-13	-48	-67	-64
STORAGE CHANGE	-13	-47	-66	-65
MODEL ERROR	0	-1	-1	1

Table: Kendall County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	52,346	51,559	51,424	51,262
INFLOW FROM OTHER AREA	4,087	4,048	4,034	4,009
INFLOW FROM KERR COUNTY	3	0	0	0
INFLOW FROM EDWARD AQUIFER	153	153	153	152
TOTAL INFLOW	56,589	55,760	55,611	55,423
OUTFLOW				
PUMPING	6,688	8,919	11,147	13,376
OUTFLOW TO SURFACE WATER	23,405	21,129	19,477	17,704
OUTFLOW TO BANDERA COUNTY	5,686	5,391	5,165	4,906
OUTFLOW TO BEXAR COUNTY	10,392	10,086	9,844	9,480
OUTFLOW TO BLANCO COUNTY	2,738	2,704	2,690	2,670
OUTFLOW TO COMAL COUNTY	7,799	7,823	7,855	7,822
OUTFLOW TO KERR COUNTY	0	223	404	619
TOTAL OUTFLOW	56,708	56,275	56,582	56,577
TOTAL INFLOW- TOTAL OUTFLOW	-119	-515	-971	-1,154
STORAGE CHANGE	-118	-511	-971	-1,153
MODEL ERROR	-1	-4	0	-1

Table: Kerr County (Edward Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	35,483	34,950	34,858	34,748
INFLOW FROM OTHER AREA	973	969	971	968
TOTAL INFLOW	36,456	35,919	35,829	35,716
OUTFLOW				
PUMPING	1,034	1,034	1,034	1,034
OUTFLOW TO SURFACE WATER	26,268	26,040	26,036	25,977
OUTFLOW TO BANDERA COUNTY	3,422	3,392	3,386	3,383
OUTFLOW TO KENDALL COUNTY	101	101	101	101
OUTFLOW TO TRINITY AQUIFER	5,494	5,473	5,470	5,466
TOTAL OUTFLOW	36,319	36,040	36,027	35,961
TOTAL INFLOW- TOTAL OUTFLOW	137	-121	-198	-245
STORAGE CHANGE	137	-121	-198	-245
MODEL ERROR	0	0	0	0

Table: Kerr County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	16,952	16,697	16,653	16,601
INFLOW FROM OTHER AREA	7,962	7,905	7,923	7,827
INFLOW FROM KENDALL COUNTY	0	223	404	619
INFLOW FROM EDWARD AQUIFER	5,494	5,473	5,470	5,466
TOTAL INFLOW	30,408	30,298	30,450	30,513
OUTFLOW				
PUMPING	12,001	13,544	15,302	16,428
OUTFLOW TO SURFACE WATER	11,063	10,863	10,826	10,746
OUTFLOW TO BANDERA COUNTY	7,415	6,655	6,070	5,459
OUTFLOW TO KENDALL COUNTY	3	0	0	0
TOTAL OUTFLOW	30,482	31,062	32,198	32,633
TOTAL INFLOW- TOTAL OUTFLOW	-74	-764	-1,748	-2,120
STORAGE CHANGE	-74	-762	-1,748	-2,118
MODEL ERROR	0	-2	0	-2

Table: Medina County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	6,084	5,993	5,977	5,958
INFLOW FROM BANDERA COUNTY	16,295	15,870	15,579	15,033
TOTAL INFLOW	22,379	21,863	21,556	20,991
OUTFLOW				
PUMPING	1,405	1,873	2,341	2,810
OUTFLOW TO SURFACE WATER	6,275	6,243	6,232	6,217
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	7,998	6,486	5,185	3,619
OUTFLOW TO OTHER AREA	1,874	1,503	1,175	844
OUTFLOW TO BEXAR COUNTY	4,831	5,788	6,688	7,583
TOTAL OUTFLOW	22,383	21,893	21,621	21,073
TOTAL INFLOW- TOTAL OUTFLOW	-4	-30	-65	-82
STORAGE CHANGE	-6	-31	-66	-84
MODEL ERROR	2	1	1	2

Table: Travis County (Trinity Aquifer. 2008 to 2060)				
INFLOW	Scen 4	Scen 5	Scen 6	Scen 7
RECHARGE FROM PRECIPITATION	11,194	11,026	10,997	10,963
INFLOW FROM HAYS COUNTY	5,951	5,863	5,770	5,624
TOTAL INFLOW	17,145	16,889	16,767	16,587
OUTFLOW				
PUMPING	5,375	7,120	8,714	9,890
OUTFLOW TO SURFACE WATER	7,419	6,466	5,748	5,201
OUTFLOW TO EDWARD AQUIFER (BALCONES FALT ZONE)	1,327	969	657	354
OUTFLOW TO OTHER AREA	3,079	2,513	2,001	1,547
TOTAL OUTFLOW	17,200	17,068	17,120	16,992
TOTAL INFLOW- TOTAL OUTFLOW	-55	-179	-353	-405
STORAGE CHANGE	-43	-166	-341	-393
MODEL ERROR	-12	-13	-12	-12

APPENDIX B

GAM Run 10-049 Mag Version 2

By Mohammad Masud Hassan, P. E.
Edited by Marius Jigmond to reflect statutory
Changes effective September 1, 2011

Updated to version 2 by Wade Oliver and Radu Boghici to reflect refined modeled available groundwater estimates

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463- 8499

March 28, 2012

GAM Run 10-049 MAG Version 2

By Mohammad Masud Hassan, P.E.

Edited by Marius Jigmond to reflect statutory
changes effective September 1, 2011

Updated to version 2 by Wade Oliver and Radu Boghici to reflect refined
modeled available groundwater estimates

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-8499
March 28, 2012

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on March 28, 2012

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EXECUTIVE SUMMARY:

The modeled available groundwater for the Edwards Group of the Edwards-Trinity (Plateau) Aquifer as a result of the desired future condition adopted by the members of Groundwater Management Area 9 is approximately 1,001 acre-feet per year between 2010 and 2060. This is shown divided by county, regional water planning area, and river basin in Table 1 for use in the regional water planning process. Modeled available groundwater is summarized by county, regional water planning area, river basin, and groundwater conservation district in tables 2 through 5. The estimates were extracted from the previous Groundwater Availability Model Run 08-90mag (Chowdhury, 2009), which meets the desired future condition adopted by the members of Groundwater Management Area 9.

The first version of this report showed modeled available groundwater for Bandera, Kendall, and Kerr counties based on the pumping assumed in the groundwater availability model simulation. However, Groundwater Management Area 9 declared Kerr County "not relevant" for joint planning purposes. Since modeled available groundwater only applies to areas with a specified desired future condition, we updated this report to only depict modeled available groundwater in Kendall and Bandera counties.

REQUESTOR:

Mr. Ronald G. Fieseler of the Blanco Pedernales Groundwater Conservation District on behalf of Groundwater Management Area 9

DESCRIPTION OF REQUEST:

In a letter dated August 26, 2010 and received August 30, 2010, Mr. Ronald G. Fieseler provided the Texas Water Development Board (TWDB) with the desired future condition of the Edwards Group of Edwards-Trinity (Plateau) Aquifer adopted by the members of Groundwater Management Area 9. As described in Resolution #072610-01, the desired future condition for the Edwards Group of the Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 9 is:

"[…] Allow for no net increase in average drawdown in the Edwards Group of the Edward-Trinity (Plateau) Aquifer in Kendall and Bandera [c]ounties.

In addition, GMA 9 declared the Edward Group of the Edward-Trinity (Plateau) to be "Not Relevant" in Kerr and Blanco [c]ounties"

In response to receiving the adopted desired future condition, the Texas Water Development Board has estimated the modeled available groundwater for the Edwards Group of the Edwards-Trinity (Plateau) Aquifer for Kendall and Bandera counties.

METHODS:

The Texas Water Development Board previously completed Groundwater Availability Model (GAM) Run 08-90mag (Chowdhury, 2009) containing "managed available groundwater" information based on the desired future conditions adopted on August 28, 2008 by the groundwater conservation districts in Groundwater Management Area 9. Subsequent to the release of GAM Run 08-90mag, the desired future conditions for the Edwards Group of the Edwards-Trinity (Plateau) Aquifer were petitioned, and presented to the Texas Water Development Board at a special meeting on January 21, 2010. At that meeting, the Board found that the adopted desired future condition of zero drawdown was not reasonable. The Board further recommended that the desired future condition in Kerr County be 9 feet of drawdown and that the Edwards Group of the Edwards-Trinity (Plateau) Aquifer be found not relevant in Bandera and Kendall counties. The Board's recommended desired future condition was discussed at a meeting for Groundwater Management Area 9 on February 22, 2010, and a public hearing was held during that same meeting. At their July 26, 2010, meeting, the districts adopted new desired future conditions for the Edwards Group of the Edwards-Trinity (Plateau) Aquifer. In Bandera and Kendall counties, the new desired future condition is the same as the original desired future condition: zero drawdown. Because no changes were made to the desired future condition in Bandera and Kendall counties, the results in the GAM Run 08-90mag report were still applicable to the "new" desired future condition.

The location of Groundwater Management Area 9, the Edwards Group of the Edwards-Trinity (Plateau) Aquifer, and the groundwater availability model cells that represent the aquifer are shown in Figure 1. The pumping was divided by county, regional water planning area, river basin, and groundwater conservation district (Figure 2).

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the model run using the groundwater availability model for the Hill Country portion of the Trinity Aquifer, which contains a portion representing the Edwards Group of the Edwards-Trinity (Plateau) Aquifer, are described below:

- Version 1.03 of the groundwater availability model for the Hill Country portion of the Trinity Aquifer developed by Mace and others (2000) was used for this analysis. See Mace and others (2000) for details on model construction, recharge, discharge, assumptions and limitations of the model.
- The model has three layers: layer 1 represents the Edwards Group, layer 2 represents the Upper Trinity Aquifer, and layer 3 represents the Middle Trinity Aquifer.
- The model has a total of 79 stress periods with 2 stress periods representing pre-development conditions, 24 monthly stress periods for representing transient conditions (1996 to 1997), and 53 predictive annual stress periods (2008 to 2060).
- The root-mean squared error of the model (a measure of the difference between simulated and measured water levels) is approximately 56 feet. This represents 5 percent of the range of measured water levels across the model area.
- We assigned the baseline pumping to the first predictive stress period in the model to represent 2008 pumping conditions based on the assumption that the aquifers in the area recharge rapidly and groundwater movement is fast enough to quickly bring about a dynamic equilibrium. Comparisons of water level changes in selected hydrographs in the

predictive period suggest that the aquifer attains a dynamic equilibrium within a year (Chowdhury, 2009).

- Average recharge was used throughout the predictive period for this model run. Average recharge in the model was estimated for normal climatic conditions by using the average precipitation for the period 1960 to 1990 and the recharge coefficients estimated from baseflow analyses for each model cell (Mace and others, 2000).
- The model was run in Processing MODFLOW for Windows (version 5.3; Chiang and Kinzelbach, 1998).

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. This is distinct from "managed available groundwater," shown in the draft version of this report dated January 31, 2011, which was a permitting value and accounted for the estimated use of the aquifer exempt from permitting. This change was made to reflect changes in statute by the 82nd Texas Legislature, effective September 1, 2011.

Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits. The estimated amount of pumping exempt from permitting, which the Texas Water Development Board is now required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

RESULTS:

The modeled available groundwater for the Edwards Group of the Edward-Trinity (Plateau) Aquifer consistent as a result of the desired future condition adopted by the members of Groundwater Management Area 9 is approximately 1,001 acre-feet per year between 2010 and 2060. This is subdivided by county, regional water planning area, and river basin as shown in Table 1. The modeled available groundwater is also summarized by county, regional water planning area, river basin, and groundwater conservation district as shown in tables 2, 3, 4, and 5, respectively.

LIMITATIONS:

The groundwater model used in developing estimates of modeled available groundwater is the best available scientific tool that can be used to estimate the pumping that will achieve the desired future conditions. Although the groundwater model used in this analysis is the best available scientific tool for this purpose, it, like all models, has limitations. 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."

A key aspect of using the groundwater model to develop estimates of modeled available groundwater is the need to make assumptions about the location in the aquifer where future pumping will occur. As actual pumping changes in the future, it will be necessary to evaluate the amount of that pumping as well as its location in the context of the assumptions associated with this analysis. Evaluating the amount and location of future pumping is as important as evaluating the changes in groundwater levels, spring flows, and other metrics that describe the condition of the groundwater resources in the area that relate to the adopted desired future condition(s).

Given these limitations, users of this information are cautioned that the modeled available groundwater numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. 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.

It is important for groundwater conservation districts to monitor future groundwater pumping as well as whether or not they are achieving their desired future conditions. Because of the limitations of the model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine the modeled available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

REFERENCES:

Chiang, W.H. and Kinzelbach, W., 1998, Processing Modflow: A simulation system for modeling groundwater flow and pollution: Hamburgh, Zurich, variously paginated.

Chowdhury, A.H., 2009, GAM Run 08-090mag, Texas Water Development Board, GAM Run 09-80mag Report, 8 p.

Mace, R.E., Chowdhury, A.H., Anaya, R., and Way, S-C., 2000, Groundwater availability of the Trinity Aquifer, Hill Country Area, Texas—Numerical simulations through 2050: Texas Water Development Board Report 353, 119 p.

Table 1. Modeled available groundwater for the Edwards Group of Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 9. Results are in acre-feet per year and are divided by county, regional water planning area, and river basin.

County	Regional Water Planning Area	River Basin	Year					
			2010	2020	2030	2040	2050	2060
Bandera	J	Guadalupe	21	21	21	21	21	21
		Nueces	101	101	101	101	101	101
		San Antonio	561	561	561	561	561	561
Kendall	L	Colorado	46	46	46	46	46	46
		Guadalupe	103	103	103	103	103	103
		San Antonio	169	169	169	169	169	169
Total			**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**

Table 2. Modeled available groundwater for the Edwards Group of Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 9. Results are in acre-feet per year and are summarized by county.

County	Year					
	2010	2020	2030	2040	2050	2060
Bandera	683	683	683	683	683	683
Kendall	318	318	318	318	318	318
Total	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**

Table 3. Modeled available groundwater for the Edwards Group of Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 9. Results are in acre-feet per year and are summarized by regional water planning area.

Regional Water Planning Area	Year					
	2010	2020	2030	2040	2050	2060
J	683	683	683	683	683	683
L	318	318	318	318	318	318
Total	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**

Table 4: Modeled available groundwater for the Edwards Group of Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 9. Results are in acre-feet per year and summarized by river basin.

River Basin	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Colorado	46	46	46	46	46	46
Guadalupe	124	124	124	124	124	124
Nueces	101	101	101	101	101	101
San Antonio	730	730	730	730	730	730
Total	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**

Table 5: Modeled available groundwater for the Edwards Group of Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 9. Results are in acre-feet per year and summarized by groundwater conservation district (GCD). RA refers to River Authority. GWD refers to Groundwater District.

Groundwater Conservation District	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Bandera County RA & GWD	683	683	683	683	683	683
Cow Creek GCD	318	318	318	318	318	318
Total	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**

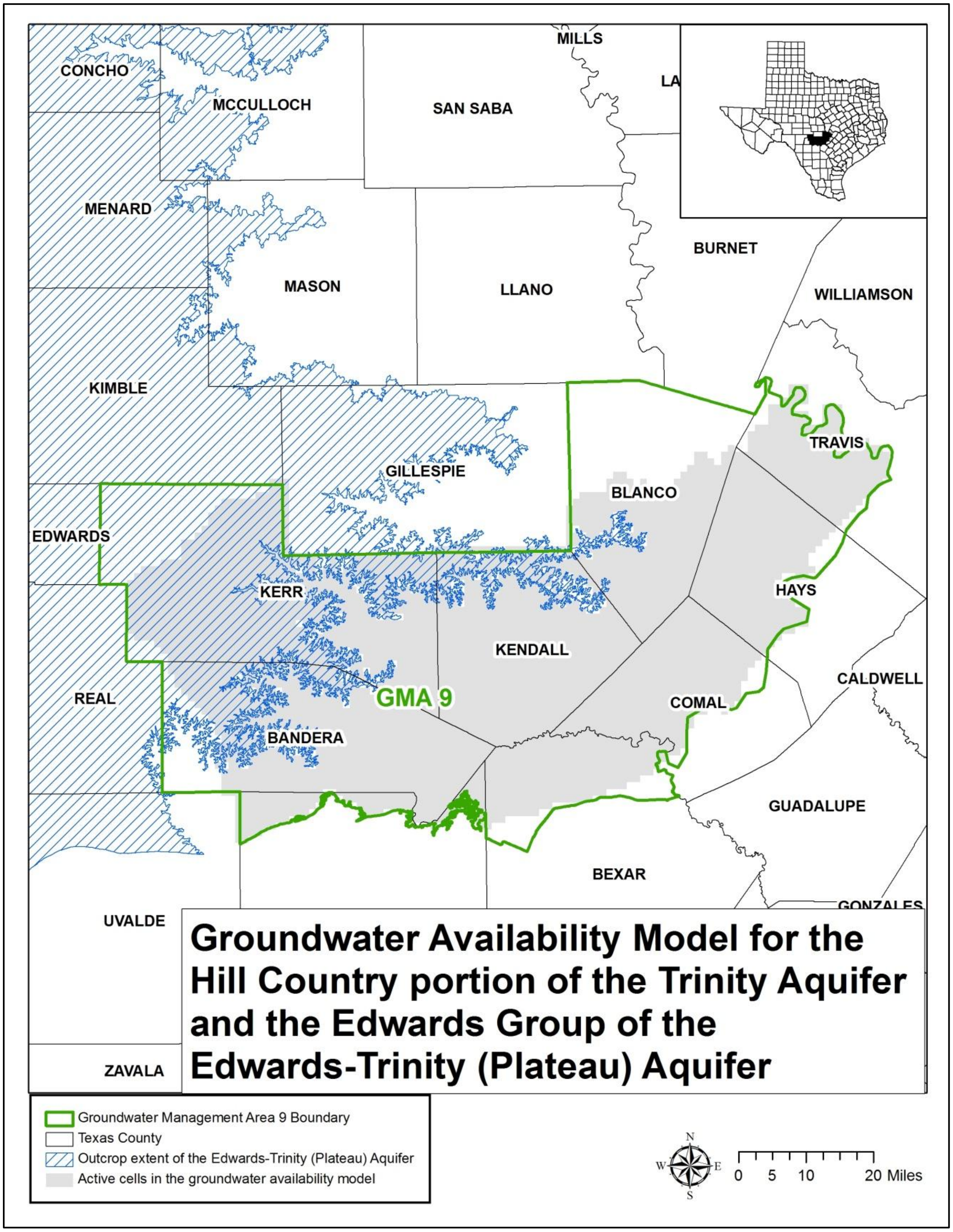

Figure 1: Map showing the areas covered by the groundwater availability model for the Hill Country portion of the Trinity Aquifer, which also contains the Edwards group of the Edwards-Trinity (Plateau) Aquifer.

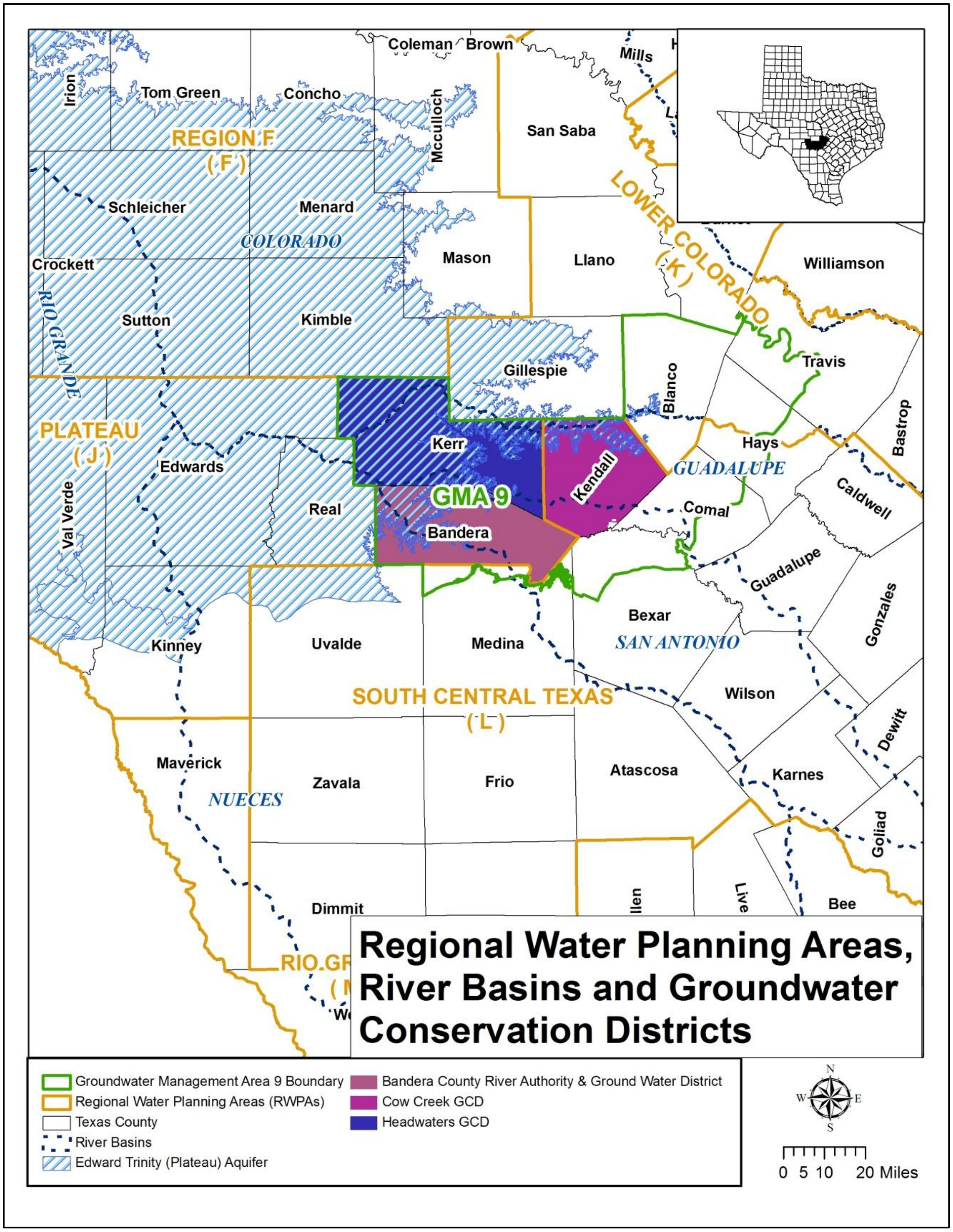

Figure 2: Map showing regional water planning areas (RWPAs), groundwater conservation districts (GCDs), counties, and river basins in Groundwater Management Area 9.

APPENDIX C

GAM Run 10-050 MAG version 2

By Mohammad Masud Hassan, P. E.

Edited and finalized by Radu Boghici to reflect statutory changes effective September 1, 2011

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-5808

March 30, 2012

GAM Run 10-050 MAG version 2

By Mohammad Masud Hassan, P.E.

Edited and finalized by Radu Boghici to reflect statutory changes effective September 1, 2011

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-5808
March 30, 2012

Cynthia K. Ridgeway, the Manager of the Groundwater Availability Modeling Section is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on March 30, 2012

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EXECUTIVE SUMMARY:

The modeled available groundwater for the Trinity Aquifer as a result of the desired future condition adopted by the members of Groundwater Management Area 9 declines from approximately 93,000 acre-feet per year to approximately 90,500 acre-feet per year between 2010 and 2060. This is shown divided by county, regional water planning area, and river basin in Table 1 for use in the regional water planning process. Modeled available groundwater is summarized by county, regional water planning area, river basin, and groundwater conservation district in tables 2 though 5. The estimates were extracted from Scenario 6 of Groundwater Availability Modeling Task 10-005 (Hutchison, 2010), which meets the desired future condition adopted by the members of Groundwater Management Area 9.

REQUESTOR:

Mr. Ronald G. Fieseler of the Blanco Pedernales Groundwater Conservation District on behalf of Groundwater Management Area 9

DESCRIPTION OF REQUEST:

In a letter dated August 26, 2010 and received August 30, 2010, Mr. Ronald G. Fieseler provided the Texas Water Development Board (TWDB) with the desired future condition of the Trinity Aquifer adopted by the members of Groundwater Management Area 9. The desired future condition for the Trinity Aquifer in Groundwater Management Area 9, as described in Resolution No. 07-26-10-1, is:

"Hill Country Trinity Aquifer - allow for an increase in average drawdown of approximately 30 feet through 2060 consistent with "Scenario 6" in TWDB Draft GAM Task 10-005"

The TWDB has used this adopted desired future condition to estimate the modeled available groundwater for the Trinity Aquifer for each groundwater conservation district within Groundwater Management Area 9.

METHODS:

The TWDB previously completed several predictive groundwater availability model simulations of the Trinity Aquifer to assist the members of Groundwater Management Area 9 in developing a desired future condition. The location of Groundwater Management Area 9, the Trinity Aquifer, and the groundwater availability model cells that represent the aquifer are shown in Figure 1. As stated in Resolution No. 07-26-10-1, the management area considered Groundwater Availability Modeling (GAM) Task 10-005 (Hutchison, 2010) when developing a desired future condition for the Trinity Aquifer. Since the desired future condition above is met in Scenario 6 of GAM Task 10-005, the modeled available groundwater for Groundwater Management Area 9 presented here was taken directly from that simulation. Please note that in GAM Task 10-005 the pumping was presented as an average of all years (2010 to 2060). We have reported this pumping by decade in the results shown in tables 1-5. The modeled available groundwater was then divided by county, regional water planning area, river basin, and groundwater conservation district (Figure 2).

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the model run using the groundwater availability model for the Trinity Aquifer are described below:

- The results presented in this report are based on Scenario 6 of GAM Task 10-005 (Hutchison, 2010). See Hutchison (2010) for a full description of the methods, assumptions, and results of the model simulations.
- The recently updated groundwater availability model (version 2.01) for the Hill Country portion of the Trinity Aquifer developed by Jones and others (2009) was used for the simulations in GAM Task 10-005. See Mace and others (2000) and Jones and others (2009) for details on model construction, recharge, discharge, assumptions, and limitations.
- The model has four layers: Layer 1 represents the Edwards Group of the Edwards-Trinity (Plateau) Aquifer, Layer 2 represents the Upper Trinity Aquifer, Layer 3 represents the Middle Trinity Aquifer, and Layer 4 represents the Lower Trinity Aquifer. Each scenario in GAM Task 10-005 consisted of a series of 387 separate 50-year model simulations, each with a different recharge configuration. Though the pumping input to the model was the same for each of the 387 simulations, the pumping output differed depending on the occurrence of inactive (or dry) cells. The results below represent the average pumping for the year shown among the simulations comprising Scenario 6 in Hutchison (2010).

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. This is distinct from "managed available groundwater", shown in the draft version of this report dated December 1, 2010, which was a permitting value, and accounted for the estimated use of the aquifer exempt from permitting.

Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors the districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits. The estimated amount of pumping exempt from permitting, which the Texas Water Development Board is now required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

RESULTS:

The modeled available groundwater for the Trinity Aquifer in Groundwater Management Area 9 consistent with the desired future condition decreases from 93,052 acre-feet per year in 2010 to 90,503 acre-feet per year in 2060. The modeled available groundwater has been divided by county, regional water planning area, and river basin for each decade between 2010 and 2060 for use in the regional water planning process (Table 1).

The modeled available groundwater is also summarized by county, regional water planning area, river basin, and groundwater conservation district as shown in tables 2, 3, 4, and 5, respectively. In Table 5, note that modeled available groundwater is totaled for both groundwater conservation district areas and areas without groundwater conservation districts.

REFERENCES:

Hutchison, William R., 2010, GAM Task 10-005, Texas Water Development Board GAM Task 10-005 Report, 13 p.

Jones, I.C., Anaya, R. and Wade, S., 2009, Groundwater Availability Model for the Hill Country portion of the Trinity Aquifer System, Texas, Texas Water Development Board unpublished report,193 p.

Mace, R.E., Chowdhury, A.H., Anaya, R., and Way, S-C., 2000, Groundwater availability of the Trinity Aquifer, Hill Country Area, Texas—Numerical simulations through 2050: Texas Water Development Board Report 353, 119 p.

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 9 DIVIDED BY COUNTY, REGIONAL WATER PLANNING AREA, AND RIVER BASIN. RESULTS ARE IN ACRE-FEET PER YEAR.

County	Regional Water Planning Area	River Basin	Year					
			2010	2020	2030	2040	2050	2060
Bandera	J	Guadalupe	76	76	76	76	76	76
		Nueces	903	903	903	903	903	903
		San Antonio	6,305	6,305	6,305	6,305	6,305	6,305
Bexar	L	San Antonio	24,856	24,856	24,856	24,856	24,856	24,856
Blanco	K	Colorado	1,322	1,322	1,322	1,322	1,322	1,322
		Guadalupe	1,251	1,251	1,251	1,251	1,251	1,251
Comal	L	Guadalupe	6,906	6,906	6,906	6,906	6,906	6,906
		San Antonio	3,308	3,308	3,308	3,308	3,308	3,308
Hays	K	Colorado	4,721	4,710	4,707	4,706	4,706	4,706
	L	Guadalupe	4,410	4,410	4,410	4,410	4,410	4,410
Kendall	L	Colorado	135	135	135	135	135	135
		Guadalupe	6,028	6,028	6,028	6,028	6,028	6,028
		San Antonio	4,976	4,976	4,976	4,976	4,976	4,976
Kerr	J	Colorado	318	318	318	318	318	318
		Guadalupe	15,646	14,129	14,056	13,767	13,450	13,434
		Nueces	0	0	0	0	0	0
		San Antonio	471	471	471	471	471	471
Medina	L	Nueces	1,575	1,575	1,575	1,575	1,575	1,575
		San Antonio	925	925	925	925	925	925
Travis	K	Colorado	8,920	8,672	8,655	8,643	8,627	8,598
Total			**93,052**	**91,276**	**91,183**	**90,881**	**90,548**	**90,503**

TABLE 2: MODELED AVAILABLE GROUNDWATER FOR THE TRINITY AQUIFER SUMMARIZED BY COUNTY IN GROUNDWATER MANAGEMENT AREA 9 FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

County	Year					
	2010	2020	2030	2040	2050	2060
Bandera	7,284	7,284	7,284	7,284	7,284	7,284
Bexar	24,856	24,856	24,856	24,856	24,856	24,856
Blanco	2,573	2,573	2,573	2,573	2,573	2,573
Comal	10,214	10,214	10,214	10,214	10,214	10,214
Hays	9,131	9,120	9,117	9,116	9,116	9,116
Kendall	11,139	11,139	11,139	11,139	11,139	11,139
Kerr	16,435	14,918	14,845	14,556	14,239	14,223
Medina	2,500	2,500	2,500	2,500	2,500	2,500
Travis	8,920	8,672	8,655	8,643	8,627	8,598
Total	**93,052**	**91,276**	**91,183**	**90,881**	**90,548**	**90,503**

TABLE 3: MODELED AVAILABLE GROUNDWATER FOR THE TRINITY AQUIFER SUMMARIZED BY REGIONAL WATER PLANNING AREA IN GROUNDWATER MANAGEMENT AREA 9 FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

Regional Water Planning Area	Year					
	2010	2020	2030	2040	2050	2060
J	23,719	22,202	22,129	21,840	21,523	21,507
K	16,214	15,955	15,935	15,922	15,906	15,877
L	53,119	53,119	53,119	53,119	53,119	53,119
Total	**93,052**	**91,276**	**91,183**	**90,881**	**90,548**	**90,503**

TABLE 4: MODELED AVAILABLE GROUNDWATER FOR THE TRINITY AQUIFER SUMMARIZED BY RIVER BASIN IN GROUNDWATER MANAGEMENT AREA 9 FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

River Basin	Year					
	2010	2020	2030	2040	2050	2060
Colorado	15,416	15,157	15,137	15,124	15,108	15,079
Guadalupe	34,317	32,800	32,727	32,438	32,121	32,105
Nueces	2,478	2,478	2,478	2,478	2,478	2,478
San Antonio	40,841	40,841	40,841	40,841	40,841	40,841
Total	**93,052**	**91,276**	**91,183**	**90,881**	**90,548**	**90,503**

TABLE 5: MODELED AVAILABLE GROUNDWATER FOR THE TRINITY AQUIFER SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) IN GROUNDWATER MANAGEMENT AREA 9 FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR. RA REFERS TO RIVER AUTHORITY. GWD REFERS TO GROUNDWATER DISTRICT.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Bandera County RA & GWD	7,284	7,284	7,284	7,284	7,284	7,284
Blanco-Pedernales GCD	2,573	2,573	2,573	2,573	2,573	2,573
Cow Creek GCD	10,622	10,622	10,622	10,622	10,622	10,622
Hays Trinity GCD	9,109	9,098	9,095	9,094	9,094	9,094
Headwaters GCD	16,435	14,918	14,845	14,556	14,239	14,223
Medina County GCD	2,500	2,500	2,500	2,500	2,500	2,500
Trinity Glen Rose GCD	25,511	25,511	25,511	25,511	25,511	25,511
Total (district areas)	**74,034**	**72,506**	**72,430**	**72,140**	**71,823**	**71,807**
No District	19,018	18,770	18,753	18,741	18,725	18,696
Total (including non-district areas)	**93,052**	**91,276**	**91,183**	**90,881**	**90,548**	**90,503**

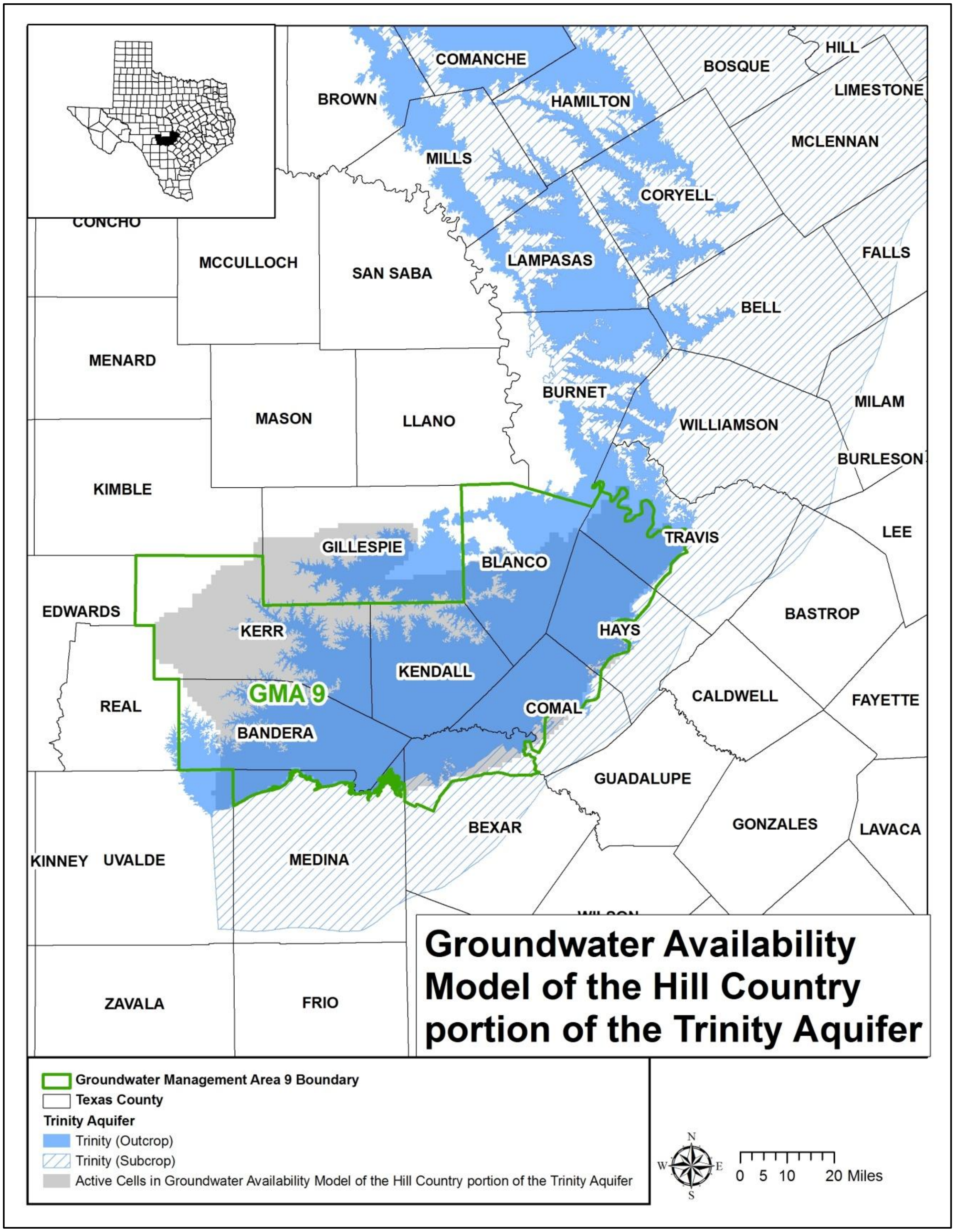

Figure 1: Map showing the areas covered by the groundwater availability model for the Trinity Aquifer.

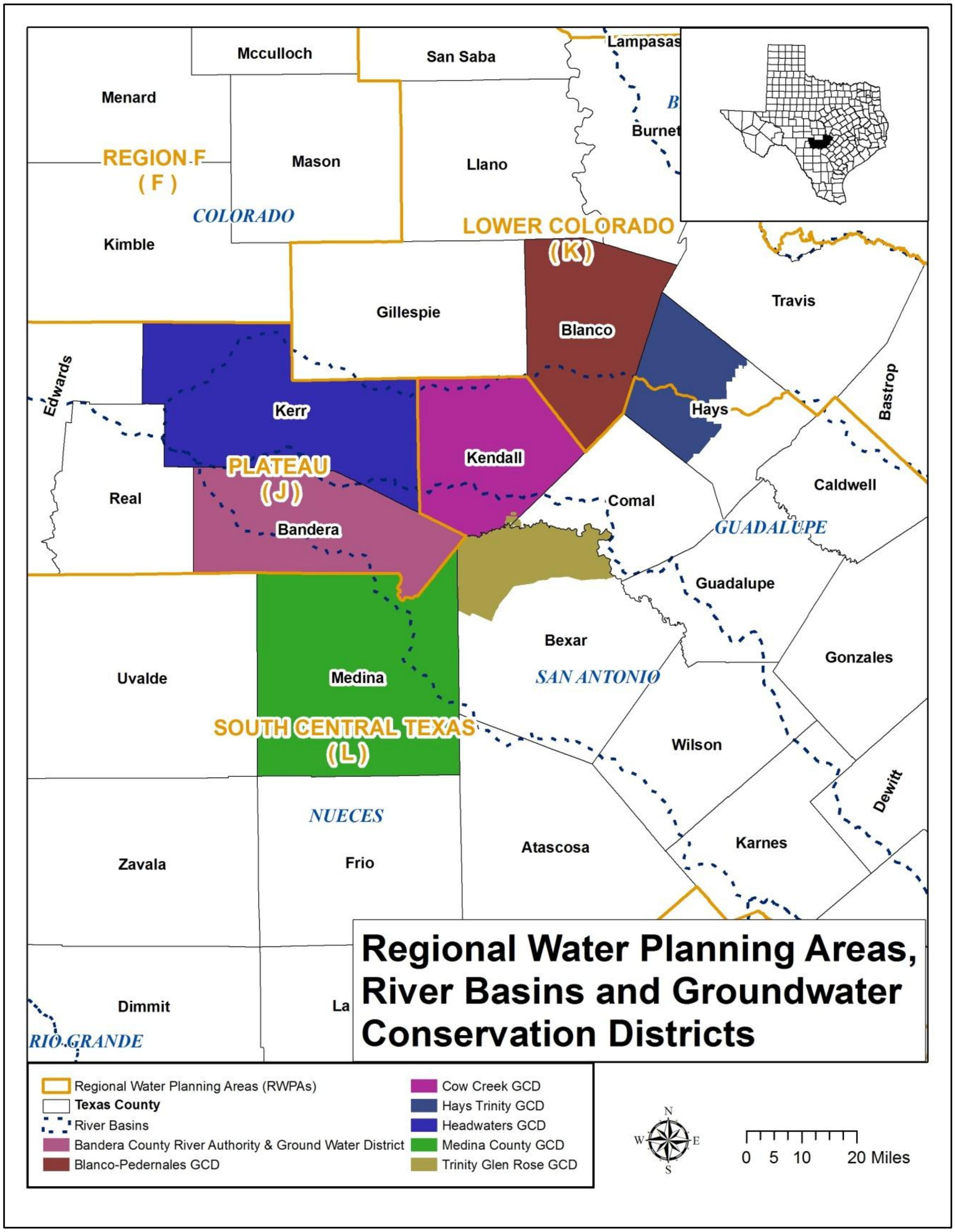

Figure 2: Map showing regional water planning areas (RWPAs), groundwater conservation districts (GCDs), counties, and river basins in Groundwater Management Area 9.

APPENDIX D

Estimated Historical Water Use And 2012 State Water Plan Datasets:

Headwaters Groundwater Conservation District

By Stephen Allen
Texas Water Development Board
Groundwater Technical Assistance Section
(512) 463-7317

October 11, 2012

Estimated Historical Groundwater Use And 2012 State Water Plan Datasets:

Headwaters Groundwater Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Resources Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
October 11, 2012

GROUNDWATER MANAGEMENT PLAN DATA:

This package of water data reports (part 1 of a 2-part package of information) is being provided to groundwater conservation districts to help them meet the requirements for approval of their five-year groundwater management plan. Each report in the package addresses a specific numbered requirement in the Texas Water Development Board's groundwater management plan checklist. The checklist can be viewed and downloaded from this web address:

http://www.twdb.texas.gov/groundwater/docs/GCD/GMPchecklist0911.pdf

The five reports included in part 1 are:

1. Estimated Historical Groundwater Use (checklist Item 2)

   from the TWDB Historical Water Use Survey (WUS)

2. Projected Surface Water Supplies (checklist Item 6)
3. Projected Water Demands (checklist Item 7)
4. Projected Water Supply Needs (checklist Item 8)
5. Projected Water Management Strategies (checklist Item 9)

   reports 2-5 are from the 2012 State Water Plan (SWP)

Part 2 of the 2-part package is the groundwater availability model (GAM) report. The District should have received, or will receive, this report from the Groundwater Availability Modeling Section. Questions about the GAM can be directed to Dr. Shirley Wade, shirley.wade@twdb.texas.gov, (512) 936-0883.

DISCLAIMER:

The data presented in this report represents the most updated Historical Groundwater Use and 2012 State Water Planning data available as of 10/11/2012. Although it does not happen frequently, neither of these datasets are static and are subject to change pending the availability of more accurate data (Historical Water Use Survey data) or an amendment to the 2012 State Water Plan (2012 State Water Planning data). District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The Historical Water Use dataset can be verified at this web address:

http://www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/

The 2012 State Water Planning dataset can be verified by contacting Wendy Barron (wendy.barron@twdb.texas.gov or 512-936-0886).

The values presented in the data tables of this report are county-based. In cases where groundwater conservation districts cover only a portion of one or more counties the data values are modified with an apportioning multiplier to create new values that more accurately represent district conditions. The multiplier used as part of the following formula is a land area ratio: (data value * (land area of district in county / land area of county)). For two of the four State Water Plan tables (Projected Surface Water Supplies and Projected Water Demands) only the county-wide water user group (WUG) data values (county other, manufacturing, steam electric power, irrigation, mining and livestock) are modified using the multiplier. WUG values for municipalities, water supply corporations, and utility districts are not apportioned; instead, their full values are retained when they are located within the district, and eliminated when they are located outside (we ask each district to identify these locations).

The two other SWP tables (Projected Water Supply Needs and Projected Water Management Strategies) are not apportioned because district-specific values are not statutorily required. Each district needs only “consider” the county values in those tables.

In the Historical Groundwater Use table every category of water use (including municipal) is apportioned. Staff determined that breaking down the annual municipal values into individual WUGs was too complex.

TWDB recognizes that the apportioning formula used is not perfect but it is the best available process with respect to time and staffing constraints. If a district believes it has data that is more accurate it has the option of including those data in the plan with an explanation of how the data were derived. Apportioning percentages are listed above each applicable table.

For additional questions regarding this data, please contact Stephen Allen (stephen.allen@twdb.texas.gov or 512-463-7317) or Rima Petrossian (rima.petrossian@twdb.texas.gov or 512-936-2420).

Estimated Historical Groundwater Use
TWDB Historical Water Use Survey (WUS) Data

Groundwater use estimates are currently unavailable for 2005. TWDB staff anticipates the calculation and posting of these estimates at a later date.

KERR COUNTY *100.00 % (multiplier)* All values are in acre-feet/year

Year	Source	Municipal	Manufacturing	Steam Electric	Irrigation	Mining	Livestock	Total
1974	GW	3,636	136	0	95	4	1,012	4,883
1980	GW	4,764	19	0	500	0	433	5,716
1984	GW	2,991	1	0	374	81	355	3,802
1985	GW	2,910	2	0	204	81	327	3,524
1986	GW	2,571	2	0	136	0	246	2,955
1987	GW	2,129	0	0	136	71	271	2,607
1988	GW	2,471	1	0	136	78	313	2,999
1989	GW	2,925	2	0	191	73	309	3,500
1990	GW	2,607	2	0	187	73	307	3,176
1991	GW	2,552	2	0	187	176	320	3,237
1992	GW	3,019	9	0	187	176	421	3,812
1993	GW	3,272	27	0	396	173	390	4,258
1994	GW	3,164	10	0	406	173	393	4,146
1995	GW	3,404	42	0	355	173	378	4,352
1996	GW	3,897	10	0	396	173	345	4,821
1997	GW	3,359	9	0	396	173	358	4,295
1998	GW	3,510	9	0	396	173	342	4,430
1999	GW	3,565	9	0	396	173	400	4,543
2000	GW	3,138	10	0	107	173	389	3,817
2001	GW	3,535	111	0	113	161	186	4,106
2002	GW	3,524	4	0	113	161	171	3,973
2003	GW	3,068	3	0	77	161	171	3,480
2004	GW	4,071	2	0	47	161	171	4,452
2006	GW	4,470	7	0	120	0	328	4,925
2007	GW	4,521	23	0	133	0	327	5,004
2008	GW	5,101	24	0	72	0	367	5,564
2009	GW	4,280	23	0	246	16	343	4,908
2010	GW	4,660	23	0	447	17	428	5,575

Projected Surface Water Supplies
TWDB 2012 State Water Plan Data

KERR COUNTY *100.00 % (multiplier)* All values are in acre-feet/year

RWPG	WUG	WUG Basin	Source Name	2010	2020	2030	2040	2050	2060
J	COUNTY-OTHER	GUADALUPE	UPPER GUADALUPE RIVER COMBINED RUN-OF-RIVER	15	15	15	15	15	15
J	IRRIGATION	GUADALUPE	UPPER GUADALUPE RIVER COMBINED RUN-OF-RIVER	958	958	958	958	958	958
J	KERRVILLE	GUADALUPE	UPPER GUADALUPE RIVER COMBINED RUN-OF-RIVER	150	150	150	150	150	150
J	LIVESTOCK	COLORADO	OTHER LOCAL SUPPLY	20	20	20	20	20	20
J	LIVESTOCK	GUADALUPE	OTHER LOCAL SUPPLY	73	73	73	73	73	73
J	LIVESTOCK	SAN ANTONIO	OTHER LOCAL SUPPLY	12	12	12	12	12	12
J	MANUFACTURING	GUADALUPE	UPPER GUADALUPE RIVER COMBINED RUN-OF-RIVER	9	9	9	9	9	9
J	MINING	GUADALUPE	UPPER GUADALUPE RIVER COMBINED RUN-OF-RIVER	89	89	89	89	89	89
	Sum of Projected Surface Water Supplies (acre-feet/year)			1,326	1,326	1,326	1,326	1,326	1,326

Projected Water Demands
TWDB 2012 State Water Plan Data

Please note that the demand numbers presented here include the plumbing code savings found in the Regional and State Water Plans.

KERR COUNTY

100.00 % (multiplier)

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
J	COUNTY-OTHER	COLORADO	58	62	63	60	56	52
J	MINING	COLORADO	13	12	12	12	12	12
J	LIVESTOCK	COLORADO	125	125	125	125	125	125
J	INGRAM	GUADALUPE	220	238	242	229	212	200
J	KERRVILLE	GUADALUPE	4,362	4,746	4,918	4,937	5,152	5,262
J	MANUFACTURING	GUADALUPE	30	33	36	39	41	44
J	MINING	GUADALUPE	154	153	152	151	150	149
J	IRRIGATION	GUADALUPE	1,821	1,761	1,706	1,652	1,599	1,548
J	LIVESTOCK	GUADALUPE	324	324	324	324	324	324
J	COUNTY-OTHER	GUADALUPE	2,651	2,866	2,917	2,918	3,025	3,087
J	LIVESTOCK	NUECES	4	4	4	4	4	4
J	COUNTY-OTHER	SAN ANTONIO	18	19	19	18	17	16
J	LIVESTOCK	SAN ANTONIO	34	34	34	34	34	34
	Sum of Projected Water Demands (acre-feet/year)		9,814	10,377	10,552	10,503	10,751	10,857

Projected Water Supply Needs
TWDB 2012 State Water Plan Data

Negative values (in red) reflect a projected water supply need, positive values a surplus.

KERR COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
J	COUNTY-OTHER	COLORADO	193	189	188	191	195	199
J	COUNTY-OTHER	GUADALUPE	9,415	9,200	9,149	9,148	9,041	8,979
J	COUNTY-OTHER	SAN ANTONIO	734	733	733	734	735	736
J	INGRAM	GUADALUPE	365	347	343	356	373	385
J	IRRIGATION	GUADALUPE	0	60	115	169	222	273
J	KERRVILLE	GUADALUPE	-1,322	-1,706	-1,878	-1,897	-2,112	-2,222
J	LIVESTOCK	COLORADO	0	0	0	0	0	0
J	LIVESTOCK	GUADALUPE	31	31	31	31	31	31
J	LIVESTOCK	NUECES	8	8	8	8	8	8
J	LIVESTOCK	SAN ANTONIO	0	0	0	0	0	0
J	MANUFACTURING	GUADALUPE	21	18	15	12	10	7
J	MINING	COLORADO	0	1	1	1	1	1
J	MINING	GUADALUPE	98	99	100	101	102	103
	Sum of Projected Water Supply Needs (acre-feet/year)		-1,322	-1,706	-1,878	-1,897	-2,112	-2,222

Projected Water Management Strategies
TWDB 2012 State Water Plan Data

KERR COUNTY

WUG, Basin (RWPG)

All values are in acre-feet/year

Water Management Strategy	Source Name [Origin]	2010	2020	2030	2040	2050	2060
COUNTY-OTHER, GUADALUPE (J)							
CONSERVATION: BRUSH MANAGEMENT	CONSERVATION [KERR]	10,500	10,500	10,500	10,500	10,500	10,500
CONSERVATION: PUBLIC INFORMATION	CONSERVATION [KERR]	14	15	15	15	16	16
SURFACE WATER ACQUISITION, TREATMENT AND ASR	UPPER GUADALUPE RIVER COMBINED RUN-OF-RIVER [KERR]	0	1,124	1,124	1,124	1,124	1,124
SURFACE WATER STORAGE	UPPER GUADALUPE RIVER COMBINED RUN-OF-RIVER [KERR]	0	1,121	1,121	1,121	1,121	1,121
KERRVILLE, GUADALUPE (J)							
CONSERVATION: PUBLIC INFORMATION	CONSERVATION [KERR]	44	47	49	49	52	53
CONSERVATION: SYSTEM WATER AUDIT AND WATER LOSS AUDIT	CONSERVATION [KERR]	436	475	492	494	515	526
INCREASED WATER TREATMENT AND ASR CAPACITY	UPPER GUADALUPE RIVER COMBINED RUN-OF-RIVER [KERR]	2,240	2,240	2,240	2,240	2,240	2,240
PURCHASE WATER FROM UGRA	UPPER GUADALUPE RIVER RUN-OF-RIVER [KERR]	0	0	3,840	3,840	3,840	5,450
Sum of Projected Water Management Strategies (acre-feet/year)		13,234	15,522	19,381	19,383	19,408	21,030

APPENDIX E

GAM Run 12-021
Headwaters Groundwater Conservation District Management Plan

By Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6641

September 4, 2012

GAM RUN 12-021: HEADWATERS GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

by Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6641
September 4, 2012

The seal appearing on this document was authorized by Ian C. Jones, Ph.D., P.G. 477 on September 4, 2012.

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GAM Run 12-021: Headwaters Groundwater Conservation District Management Plan

by Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6641
September 4, 2012

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, groundwater conservation districts shall use groundwater availability modeling information provided by the executive administrator of the Texas Water Development Board in conjunction with any available site-specific information provided by the district for review and comment to the executive administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

- the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
- for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers; and
- the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

This report supersedes the revised Groundwater Availability Model (GAM) Run 08-07 (Ridgeway, 2008). The results presented in this report differ from those in GAM Run 08-07, in which the water budgets represent groundwater flow through the model layers representing the Trinity and Edwards groups. In this report (GAM Run 12-021), the water budgets represent groundwater flow through the official aquifers in Headwaters Groundwater Conservation District—the Edwards-Trinity (Plateau) and Trinity aquifers. The purpose of this report is to provide information to Headwaters Groundwater Conservation District for its groundwater management plan.

The groundwater management plan for Headwaters Groundwater Conservation District is due for approval by the executive administrator of the Texas Water Development Board before December 4, 2013.

This report discusses the methods, assumptions, and results from model runs using a groundwater model for the Edwards-Trinity (Plateau) and Trinity aquifers. Tables 1 and 2 summarize the groundwater model data required by the statute, and figures 1 and 2 show the area of each model from which the values in the respective tables were extracted. If after review of the figures, Headwaters Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the Texas Water Development Board immediately.

The Hickory and Ellenburger-San Saba aquifers also underlie the Hill Country Underground Water Conservation District; however, a groundwater availability model for these aquifer has not been completed at this time. If the district would like information for the Hickory and Ellenburger-San Saba aquifers, they may request it from the Groundwater Technical Assistance Section of the Texas Water Development Board.

METHODS:

A groundwater model for the Edwards-Trinity (Plateau) Aquifer that also includes the Hill Country portion of the Trinity Aquifer was run for this analysis. Water budgets for selected years of the transient model period were extracted using ZONEBUDGET Version 3.01 (Harbaugh, 2009) and the average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow for the portions of the aquifers located within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Edwards-Trinity (Plateau) Aquifer

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer. See Anaya and Jones (2009) for assumptions and limitations of this model.
- The Edwards-Trinity (Plateau) Aquifer model includes two layers representing the Edwards Group and equivalent limestone

hydrostratigraphic units (Layer 1) and the undifferentiated Trinity Group hydrostratigraphic units (Layer 2) in the district.

- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) of the Edwards-Trinity (Plateau) groundwater availability model for the period of 1980 to 2000 is 143 feet, or six percent of the range of measured water levels (Anaya and Jones, 2009).
- We elected to use the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer instead of the groundwater availability model for the Hill Country portion of the Trinity Aquifer because the model for the Edwards-Trinity (Plateau) Aquifer covers the entire district. Because the two models are aligned in slightly different orientations, we could not combine the results from each without either double accounting or omitting important information.
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected components were extracted from the groundwater budget for the aquifers located within the district and averaged over the duration of the calibration and verification portion of the model runs in the district, as shown in tables 1 and 2. The components of the modified budget shown in tables 1 and 2 include:

- Precipitation recharge—The spatially-distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.
- Surface water outflow—The total water discharging from the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).
- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent counties.
- Flow between aquifers—The flow between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer or confining

unit and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

The information needed for the District's management plan is summarized in tables 1 and 2. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as district or county boundaries, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located (see figures 1 and 2).

LIMITATIONS

The groundwater model(s) used in completing this analysis is the best available scientific tool 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."

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historic time period.

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.

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

TABLE 1: SUMMARIZED INFORMATION FOR THE EDWARD-TRINITY (PLATEAU) AQUIFER THAT IS NEEDED FOR HEADWATERS GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	26,325
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	17,646
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	19,805
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	37,378
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer to the Edwards-Trinity (Plateau) Aquifer	5,846

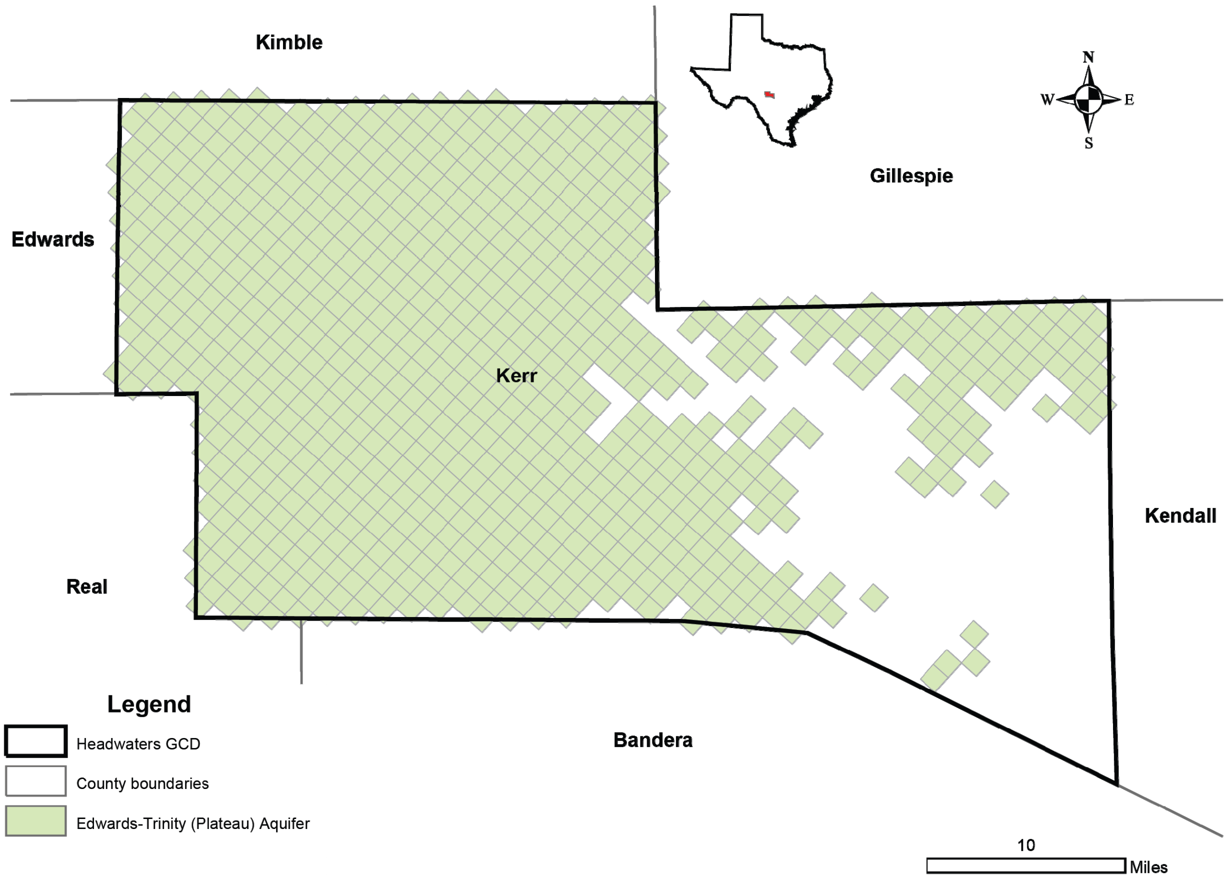

FIGURE 1: AREA OF THE GROUNDWATER MODEL FOR THE EDWARD-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER THAT IS NEEDED FOR HEADWATERS GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	21,243
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	18,291
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	19,547
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	19,745
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer to the Edwards-Trinity (Plateau) Aquifer	27,213

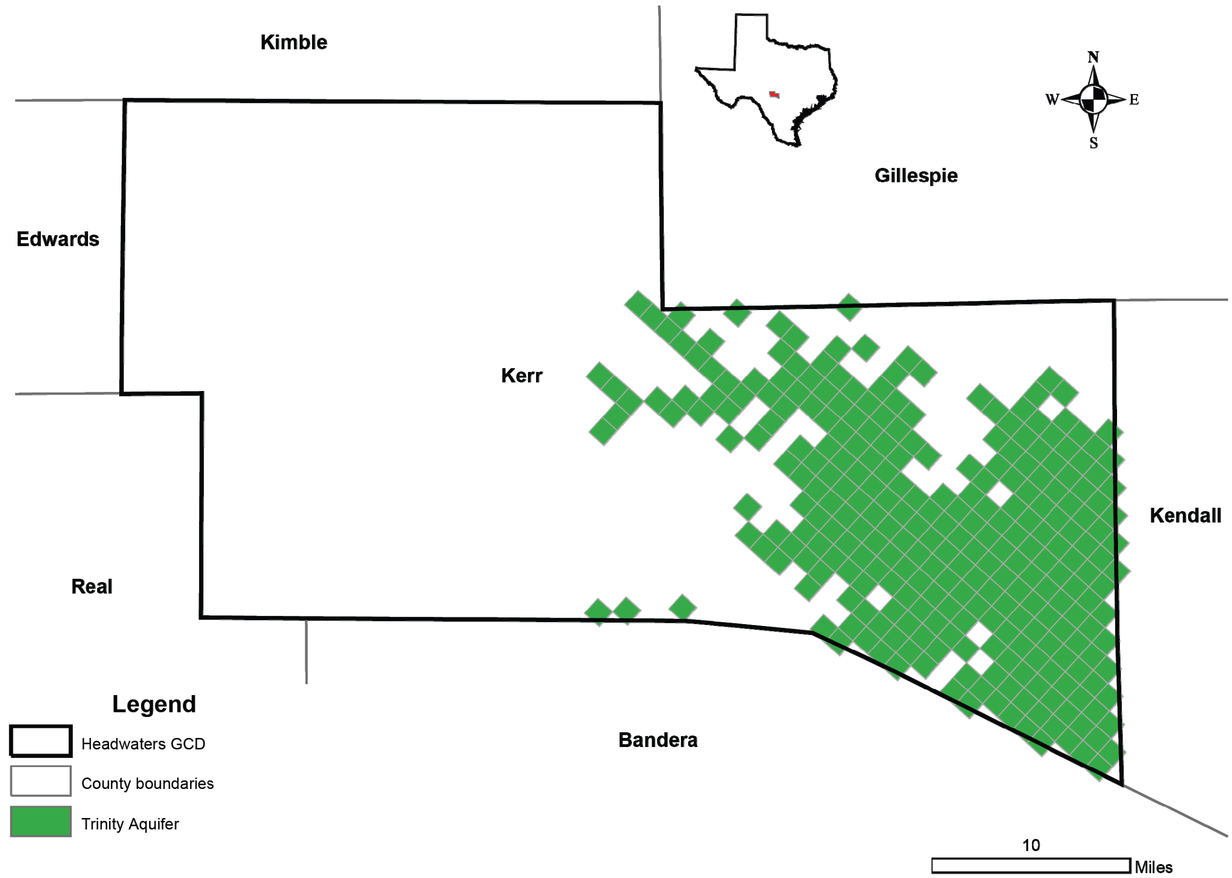

FIGURE 2: AREA OF THE GROUNDWATER MODEL FOR THE TRINITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

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Anaya, R., and Jones, I., 2009, Groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers of Texas: Texas Water Development Board, Report 373, 103 p.

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APPENDIX F

HGCD Monitor Well Geology

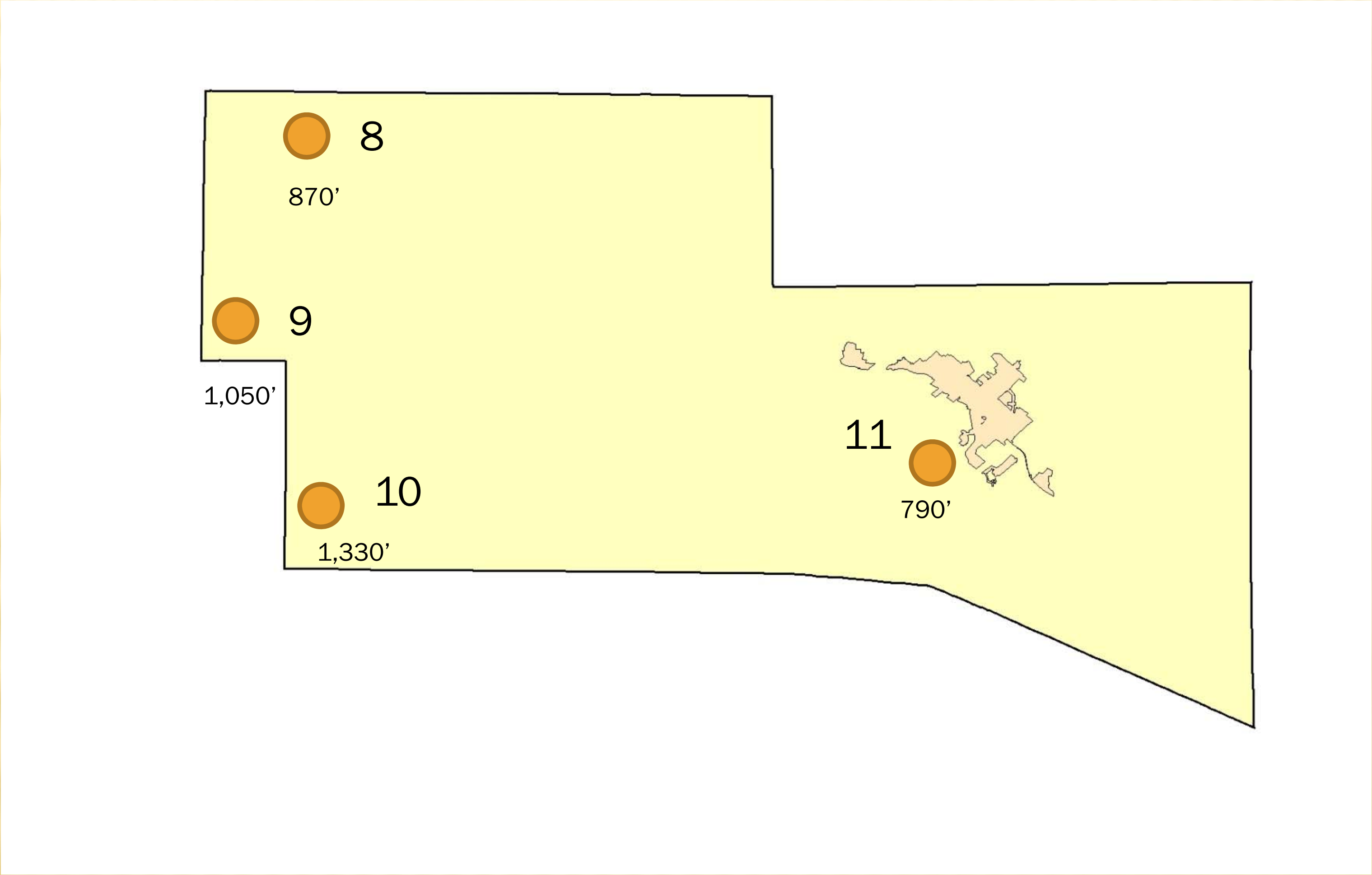
Wm Feathergail Wilson, PG 21

April, 2008

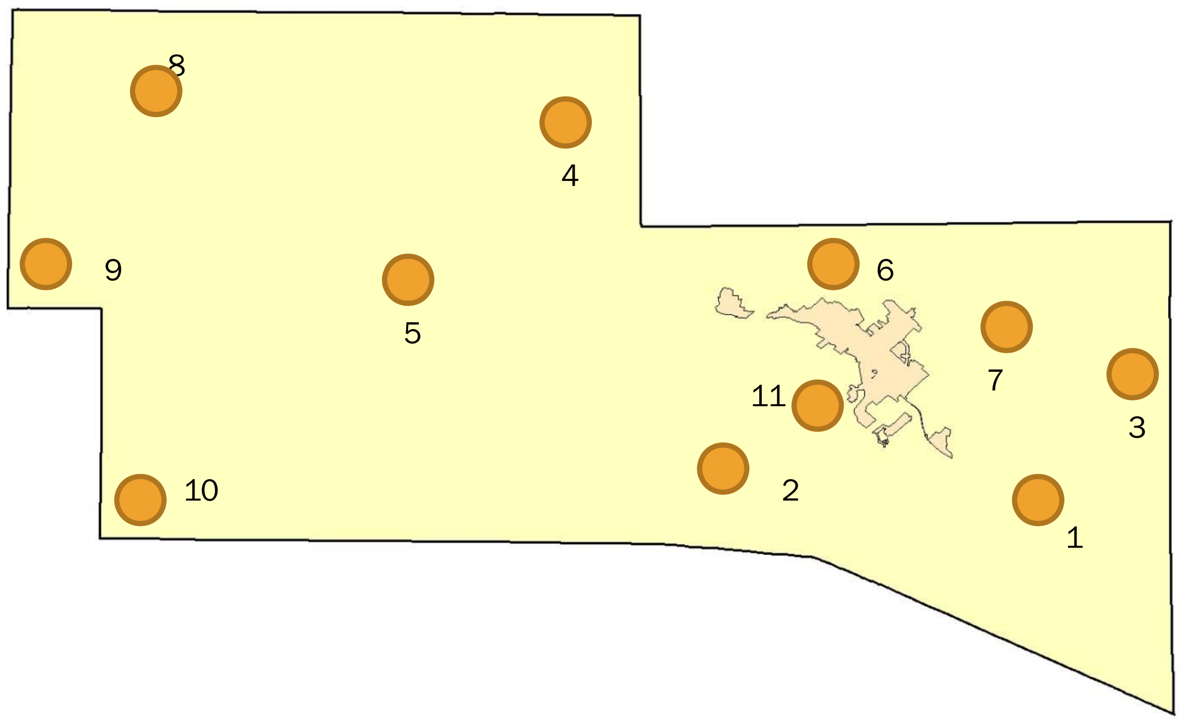
HGCD MONITOR WELL GEOLOGY
Wm Feathergail Wilson, PG 21
April, 2008

KERR COUNTY 2007-2008 DRILLING

NEW WELL LOCATIONS



ALL DRILLED HGCD LOCATIONS (11)



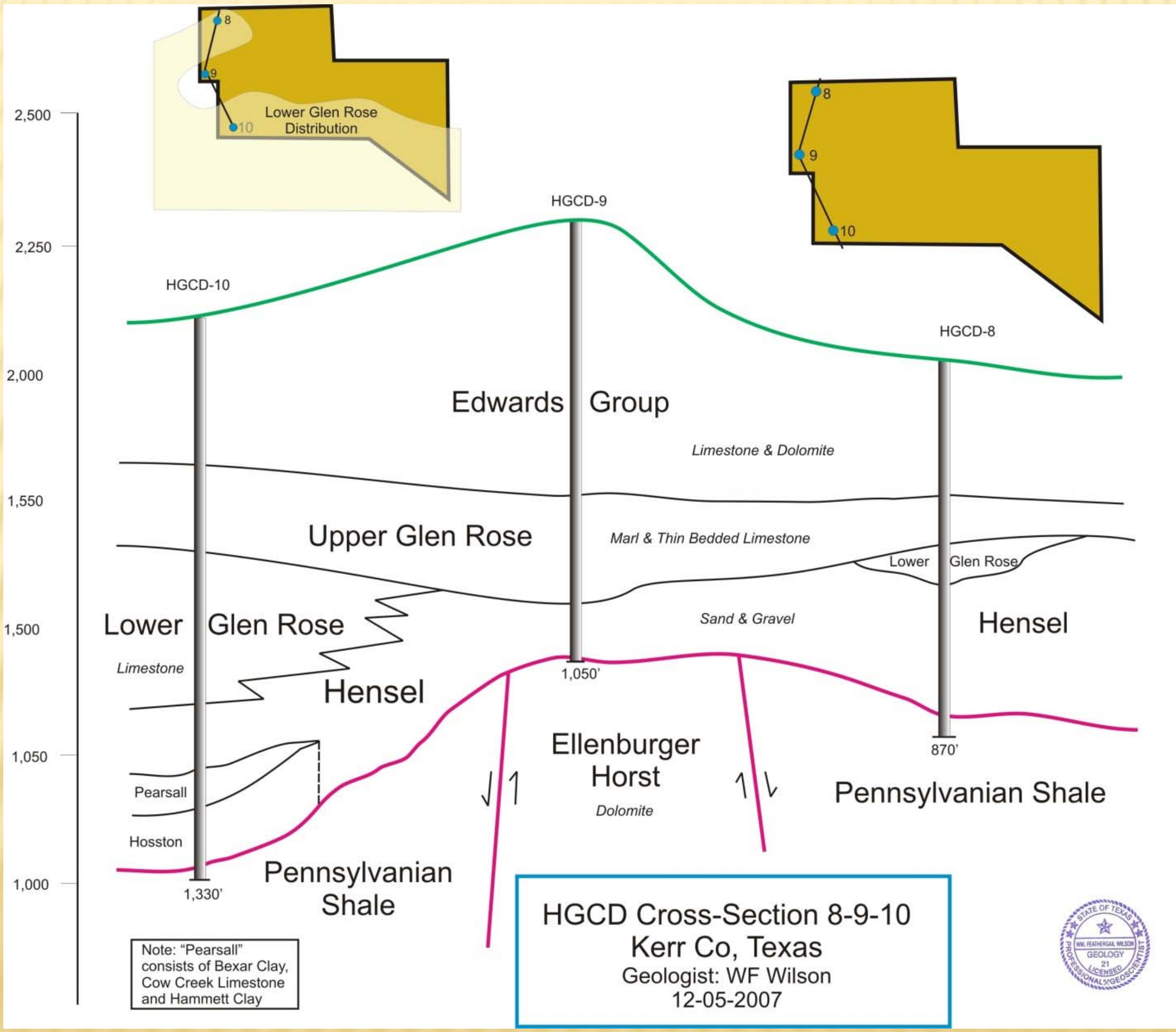
CRETACEOUS STRATIGRAPHY

Period	Age	Formations	Members	Trinity
Cretaceous	99 Albian	Edwards		
		Glen Rose	Upper	Upper
	112		Lower	Middle
	Aptian	Pearsall	Hensel	
			Bexar	
			Cow Creek	
	121		Hammett	
	Neocomian	Sligo		Lower
	144	Hosston		

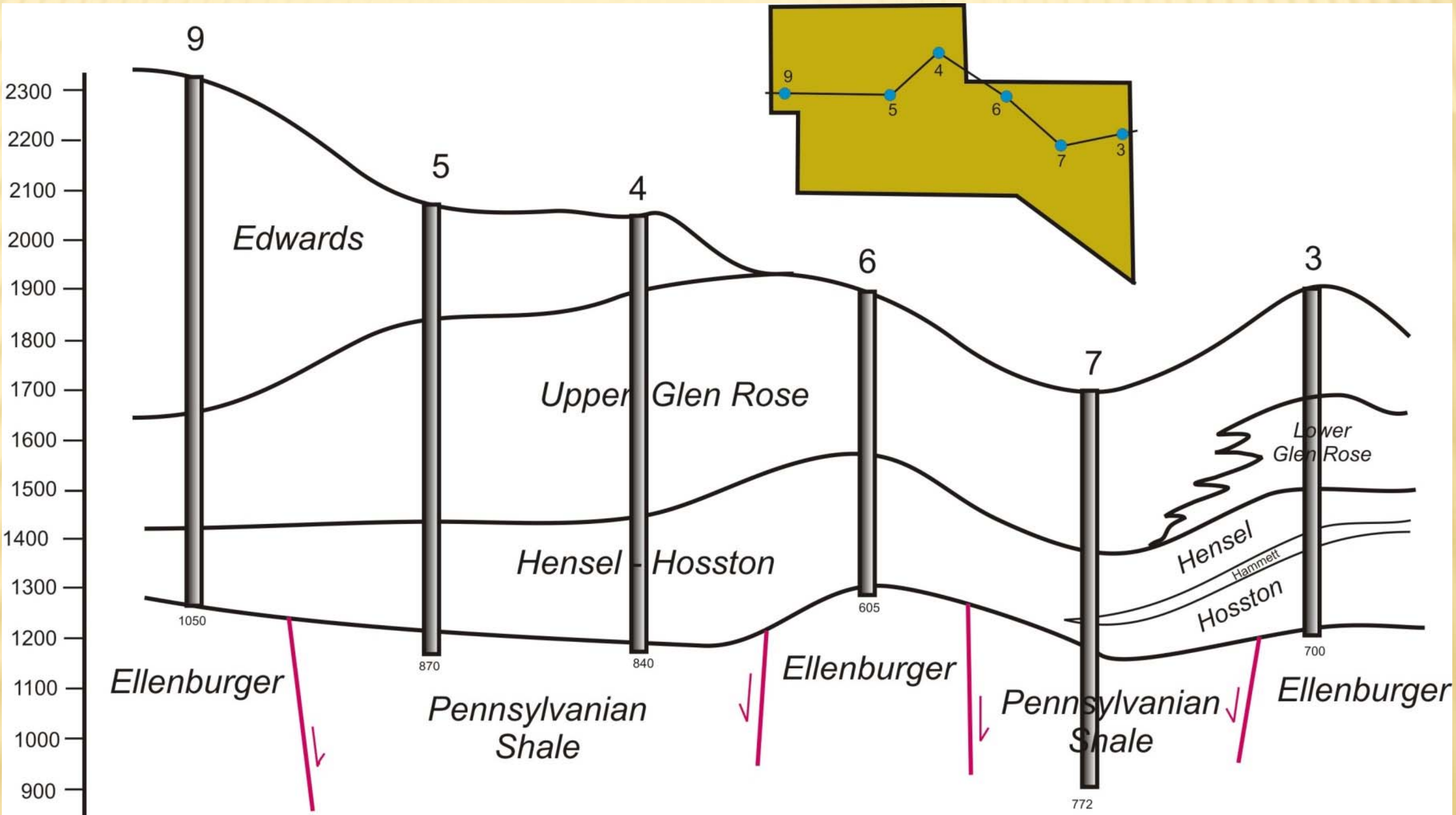
HGCD MONITOR WELL PROGRAM

- Long term drilling, monitoring, sampling, pump testing
- Each well drilled through the entire Cretaceous System
- Detailed lithologic & geophysical logs
- Provides a series of index wells across county
- Benefit to policy makers, business, ranchers, cities, county, geologists, state & federal agencies, surrounding counties
- Classic geological data points that will be utilized far into the future

CROSS SECTION 8-9-10

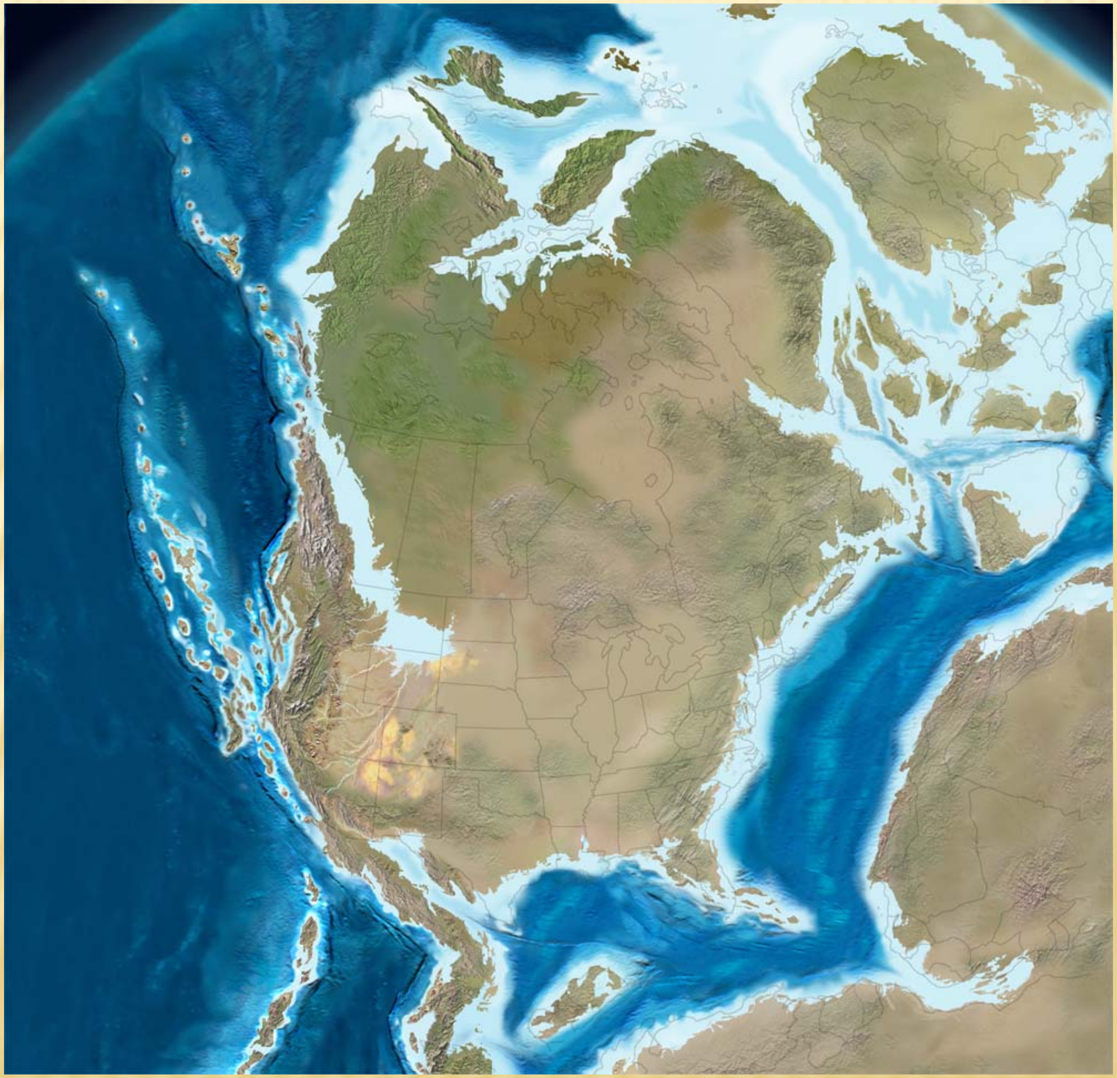


CROSS-SECTION 3-7-6-4-5-9



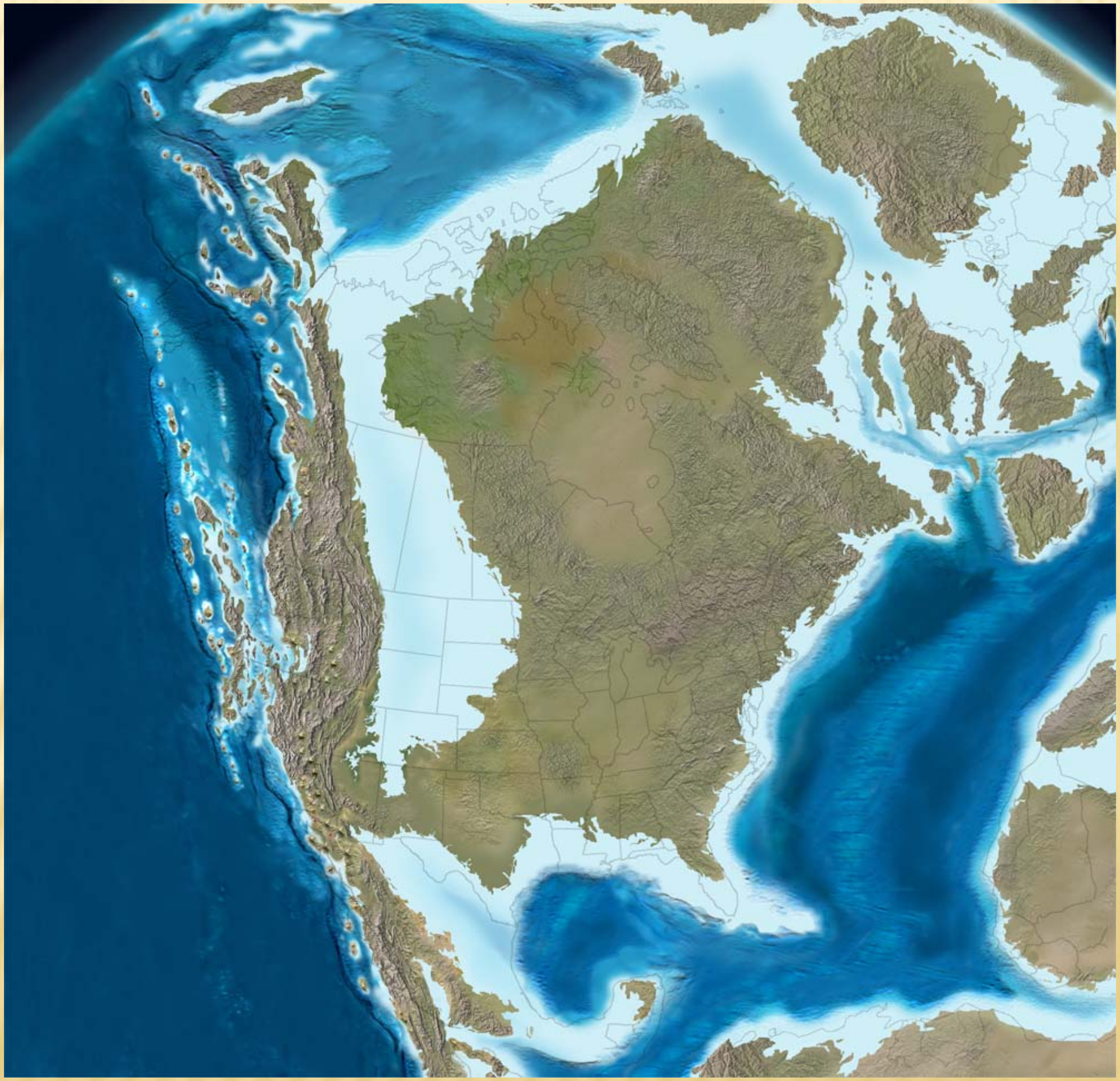
Cross-Section 3-7-6-4-5-9
Geol: W.F. Wilson, PG 21
12-27-2007

JURASSIC 150 MA

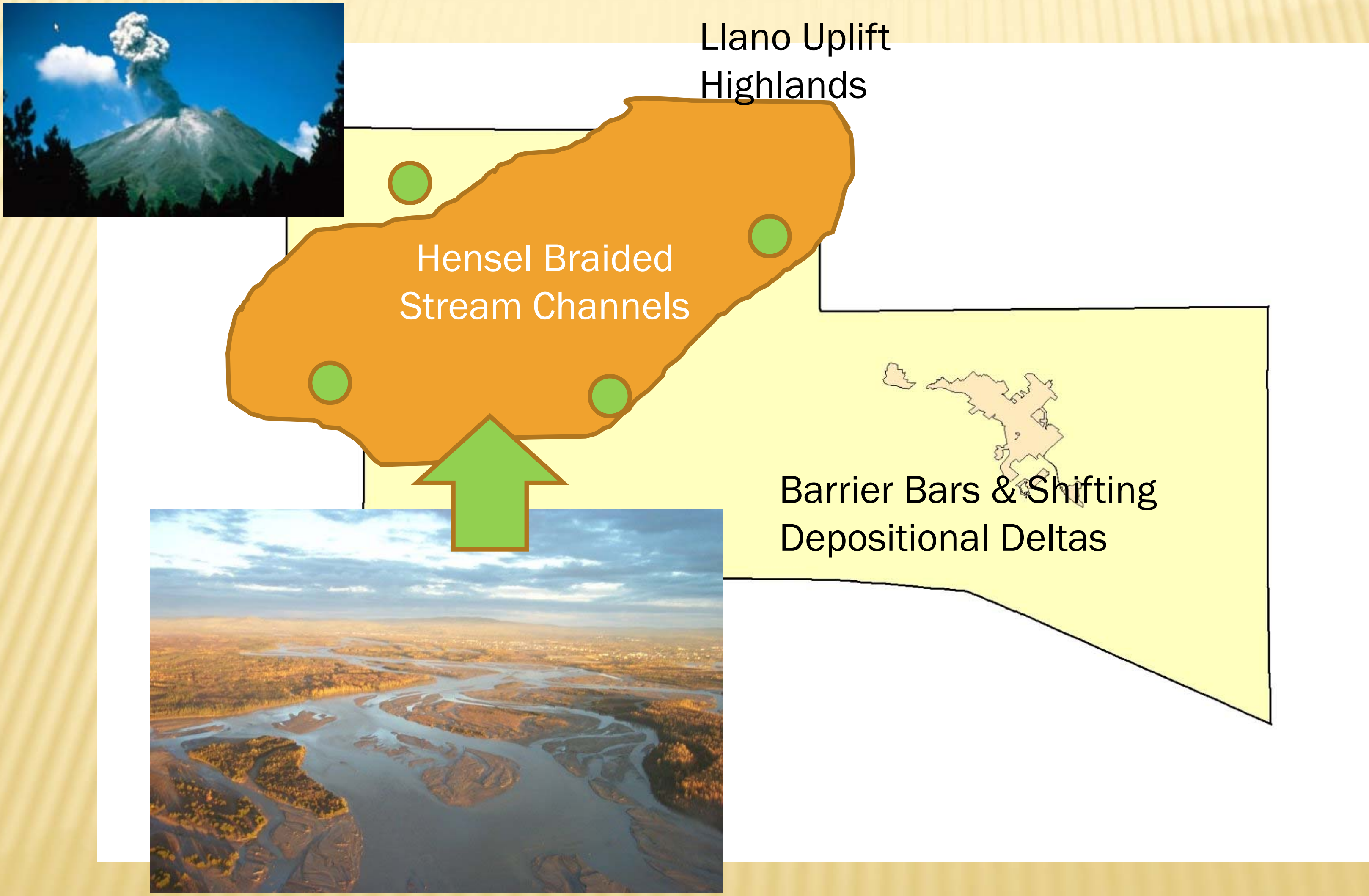


CRETACEOUS 144 MA HOSSTON

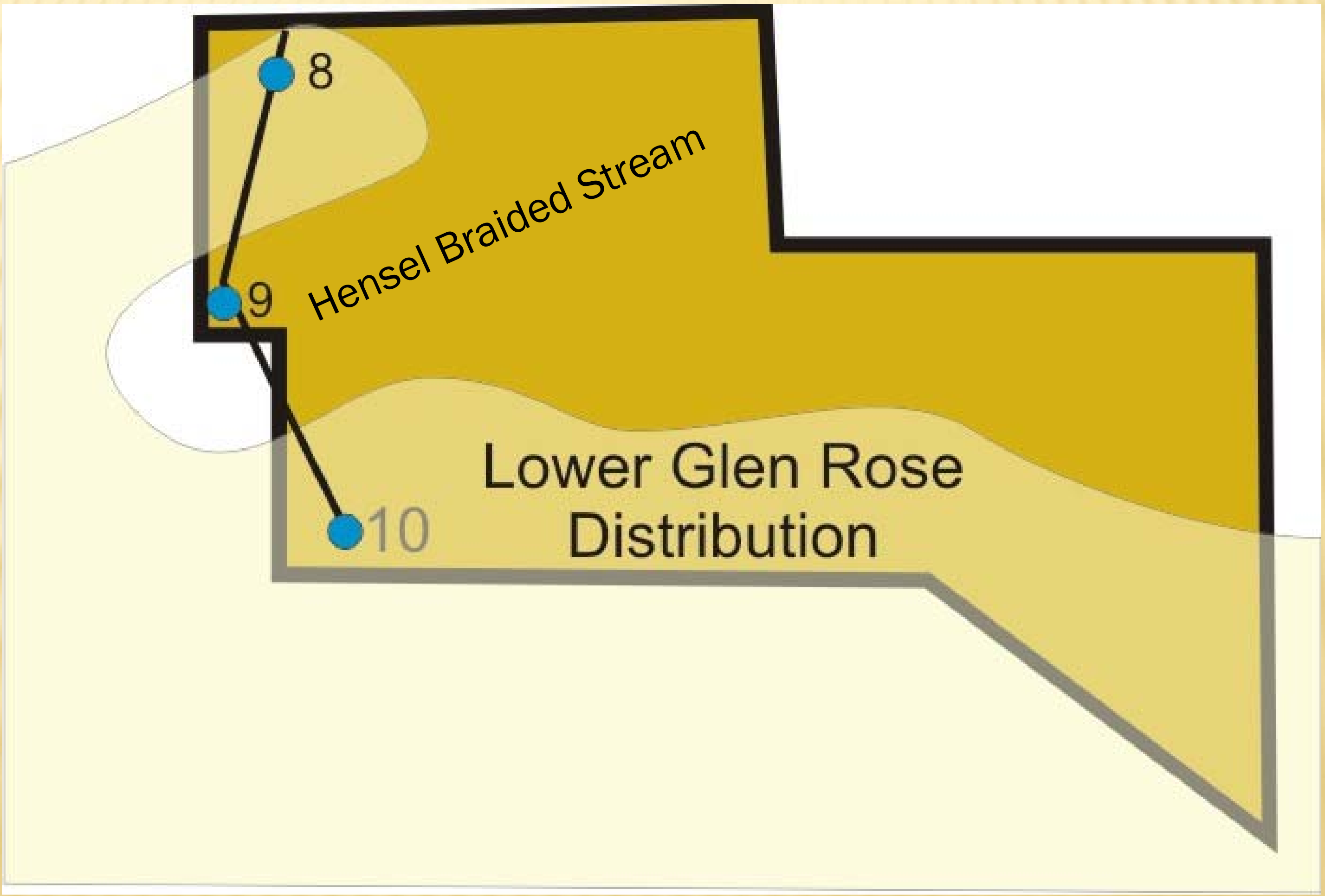
CRETACEOUS 115 MA EDWARDS



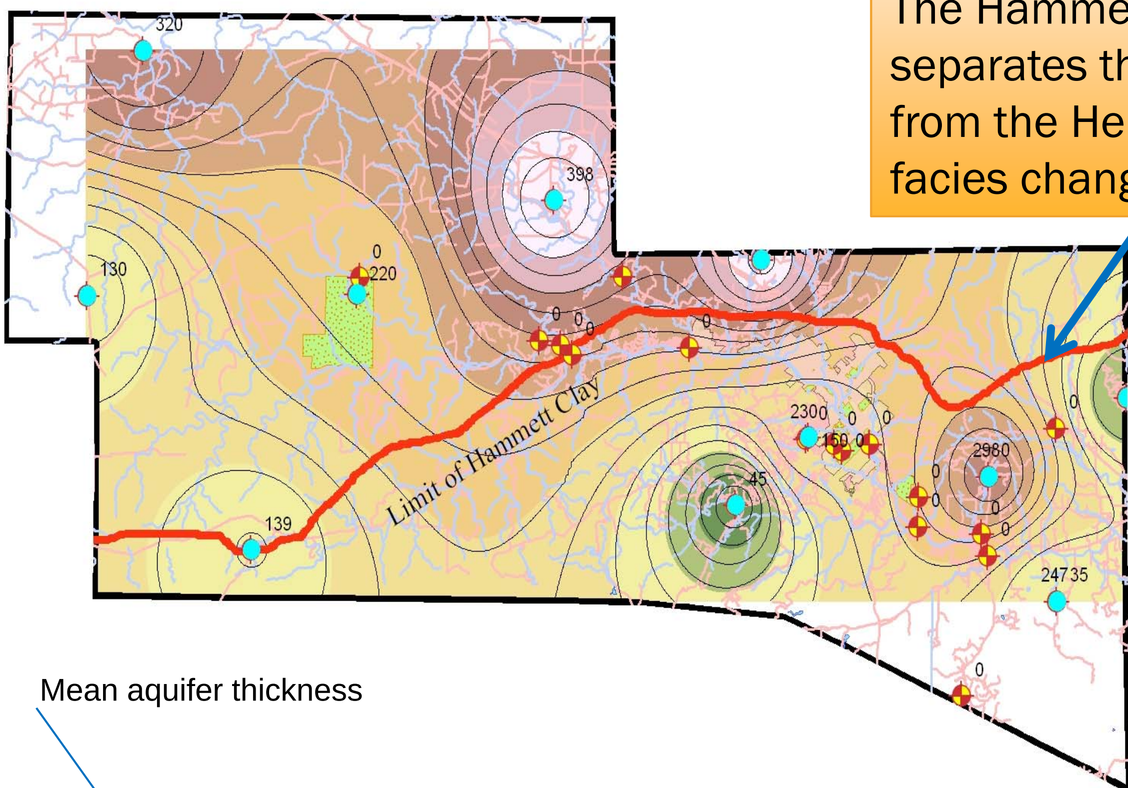
HENSEL BRAIDED STREAM DELTA



FACIES (MAJOR AQUIFER AREA)



HENSEL SAND ISOPACH MAP



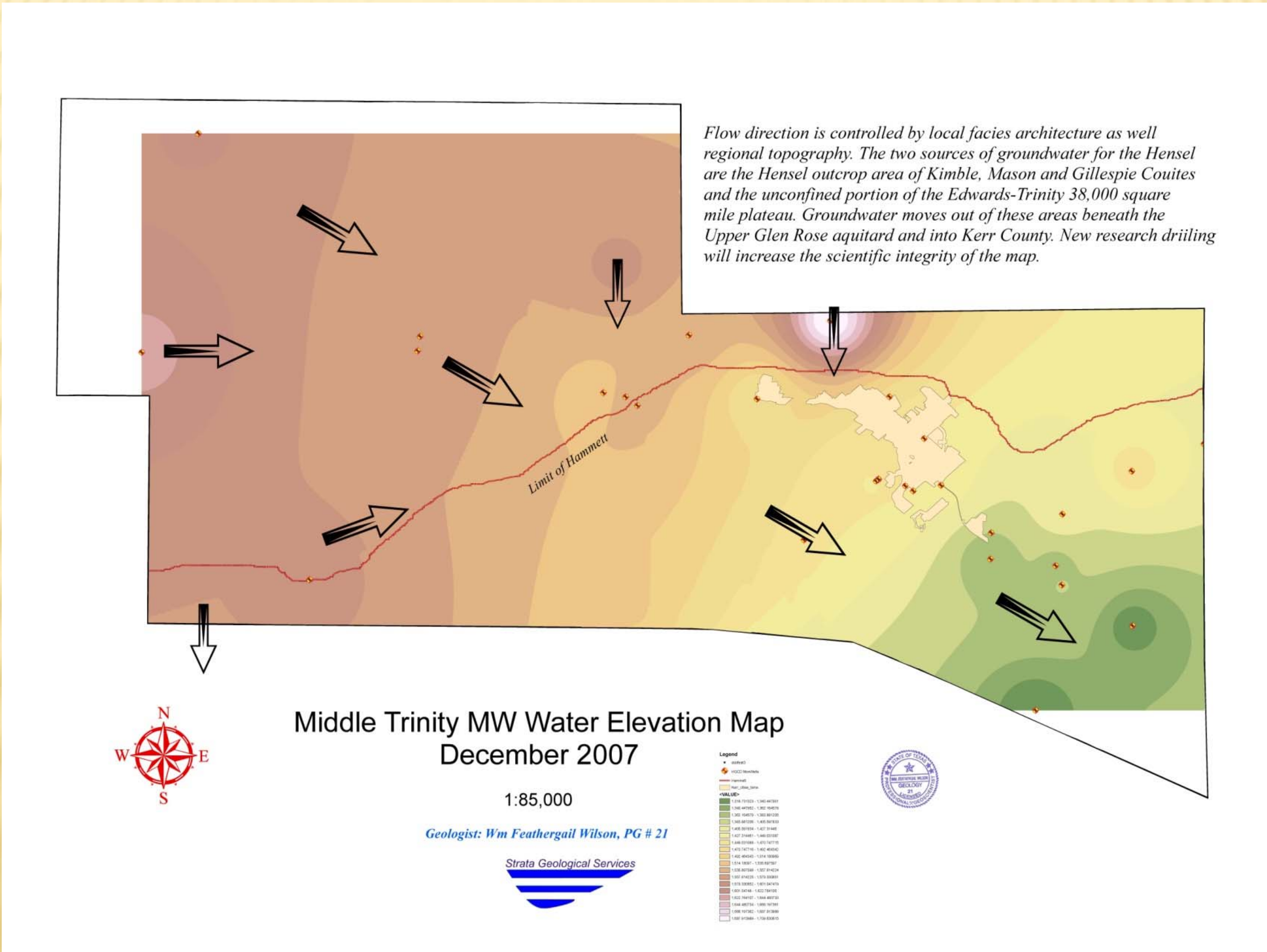
The Hammett clay wedge separates the Hensel South from the Hensel North via facies change

11,986 ac ft recoverable sans annual recharge 15,981 ac ft using 20% recovery

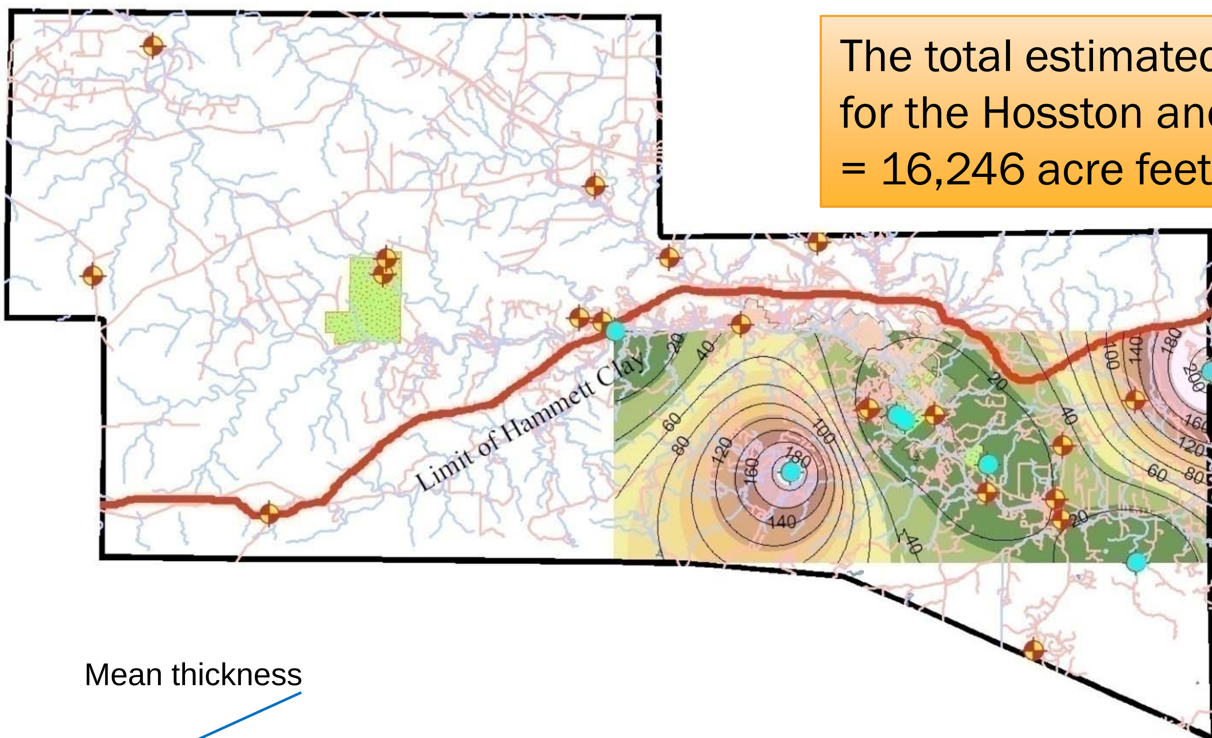
Mean aquifer thickness

$$225.44' \, x \, 5E-4 \, S_c \, x \, 708,902 \, acres \, x \, 0.15 \, rec = 11,986 \, ac \;\; ft$$

HENSEL WATER LEVEL DEC 2007



HOSSTON ISOPACH MAP



The total estimated recoverable water for the Hosston and Hensel = 16,246 acre feet sans recharge

If 20% recovery is utilized it will increase the total to ~ 20,308 ac ft the 15% factor is more realistic

Mean thickness

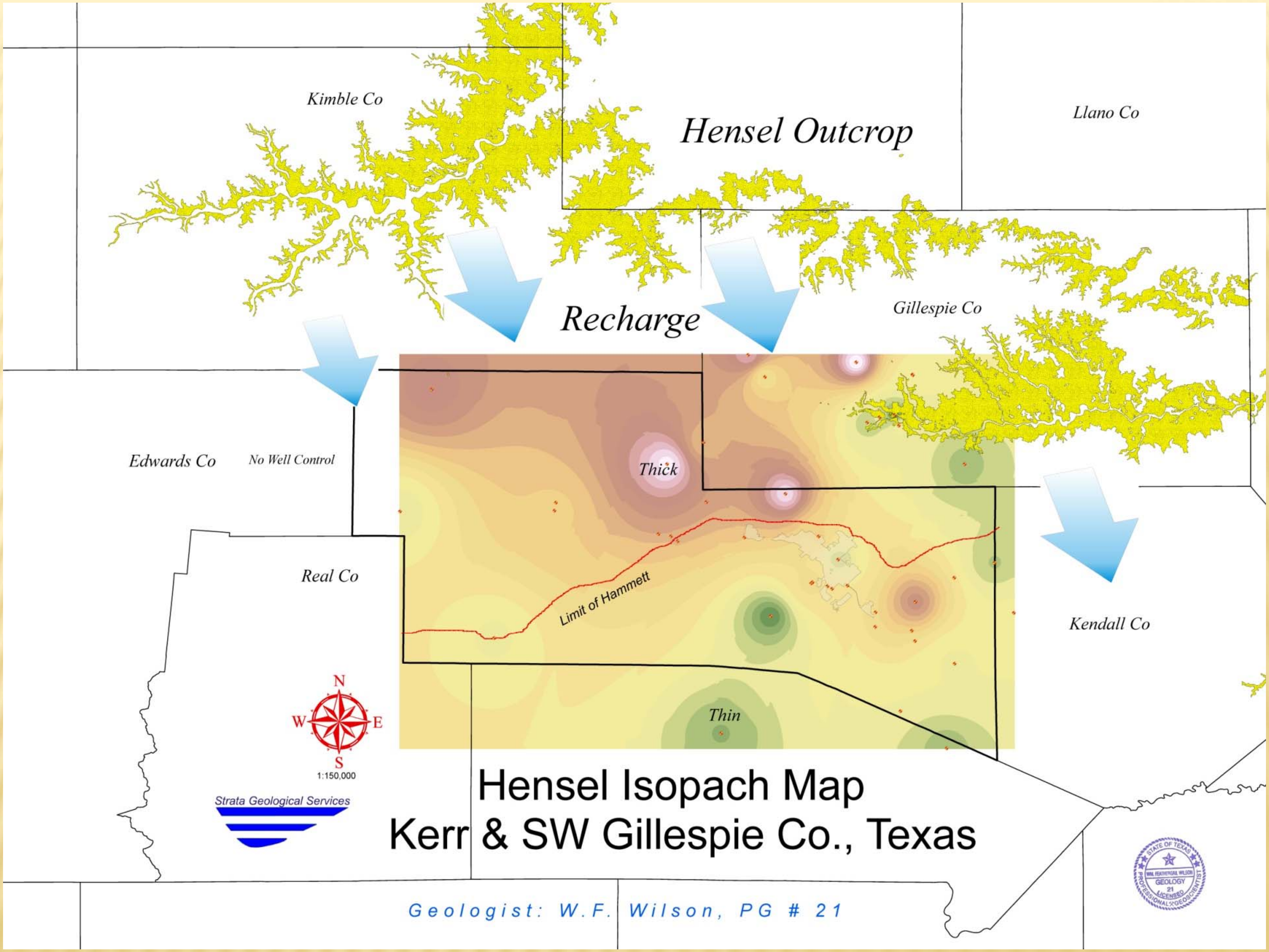
$$160.25' \, x \, 5E - 4 \, S_c \;\; x \, 354{,}451 \, acres \; x \; 0.15 \; rec = 4{,}260 \; ac \;\; ft$$

HENSEL-HOSSTON GROUNDWATER

- The combined Hensel-Hosston storage is 16,246 acre feet.
- This figure represents ~ 95% of the recoverable groundwater in *confined* storage in Kerr Co. Does not include the Edwards *unconfined* aquifer.
- Isotope age dates tell us that groundwater is thousands of years old in Kerr County
- Annual recharge remains an enigma.

POPULATION & WATER USE

- ~ 46,000 people live in Kerr County
- If they consume 150 gallons per day per person, they would use ~ 7,728 ac feet/year
- Kerr County population is expected to rise to 92,000 people by 2050
- Recharge is the big question!
- Will recharge allow sustainability?
- What will be an acceptable drawdown?

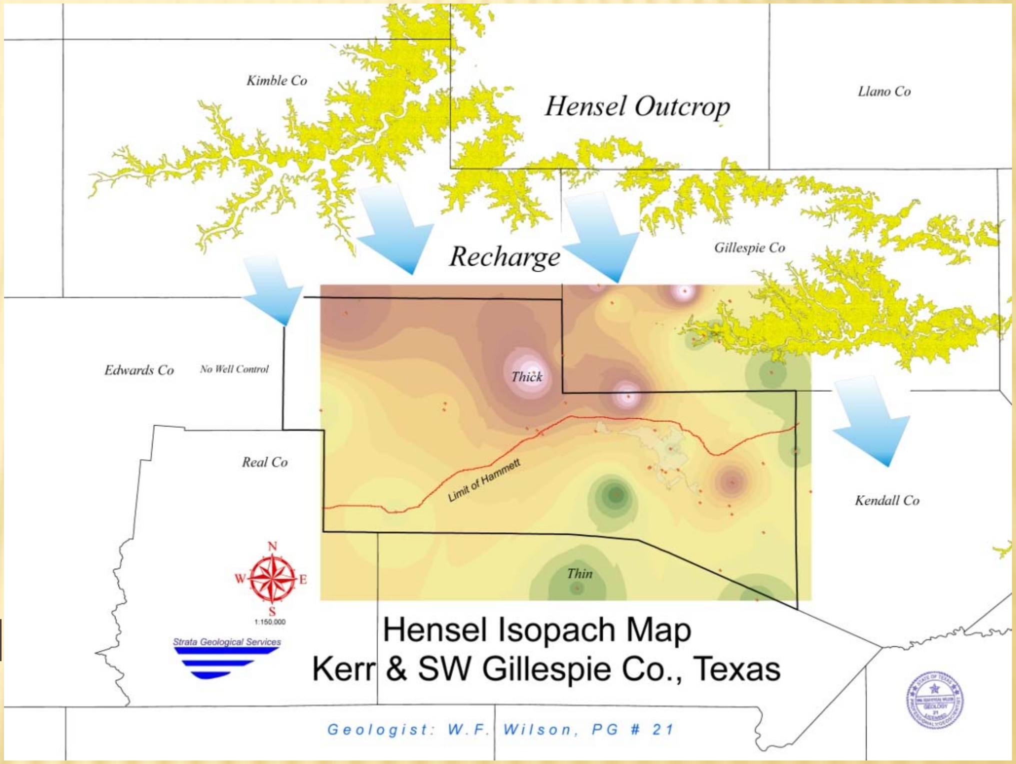

Kimble Co
Hensel Outcrop
Llano Co
Recharge
Gillespie Co
Edwards Co
No Well Control
Thick
Real Co
Limit of Hammett
Kendall Co
Thin
N
W
E
S
1:150,000
Strata Geological Services
Hensel Isopach Map
Kerr & SW Gillespie Co., Texas
Geologist: W.F. Wilson, PG # 21

RECHARGE ISSUES

- Rain falls on the Hensel Outcrop and moves beneath the Upper Glen Rose aquitard
- The Edwards Group is a rainfall sponge and only acts as unconfined aquifer and spring flow drain
- TWDB Trinity-Hill Country GAM should be expanded to include the Hensel Outcrop and the recharge concept should be changed to accommodate geological reality

RECHARGE ISSUES

- *Obviously recharge does occur*
- Questions such as provenance, rate and quantity per annum may be answered via isotope studies
- Outcrop de-watering may be a factor in Kimble and Gillespie Counties



RECHARGE

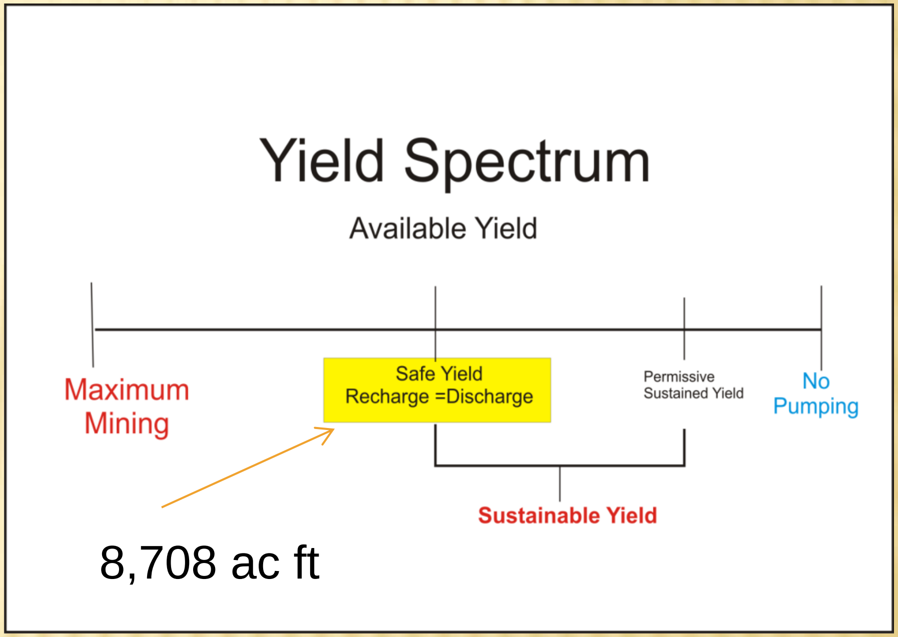
- Effective Hensel outcrop = ~ 53,750 acres
- Assume 3% of the annual rainfall saturates the outcrop
- Then annual recharge would =~19,350 ac feet during a normal year
- Assume ~ 45% of that recharge is vectored toward Kerr Co. or 8,708ac feet
- Recall the estimate of 7,728 ac ft production today

CONJUNCTIVE USE OF RIVER WATER

- The City of Kerrville pulled 2,973 acre feet from the river in 2007
- 7,728-2,973 = ~4,755 acre feet is pumped from wells today
- ~ 4,133 ac feet additional annual well production will bring the county to an equilibrium point; i.e. recharge = discharge in the confined units

RECHARGE AND SUSTAINABILITY

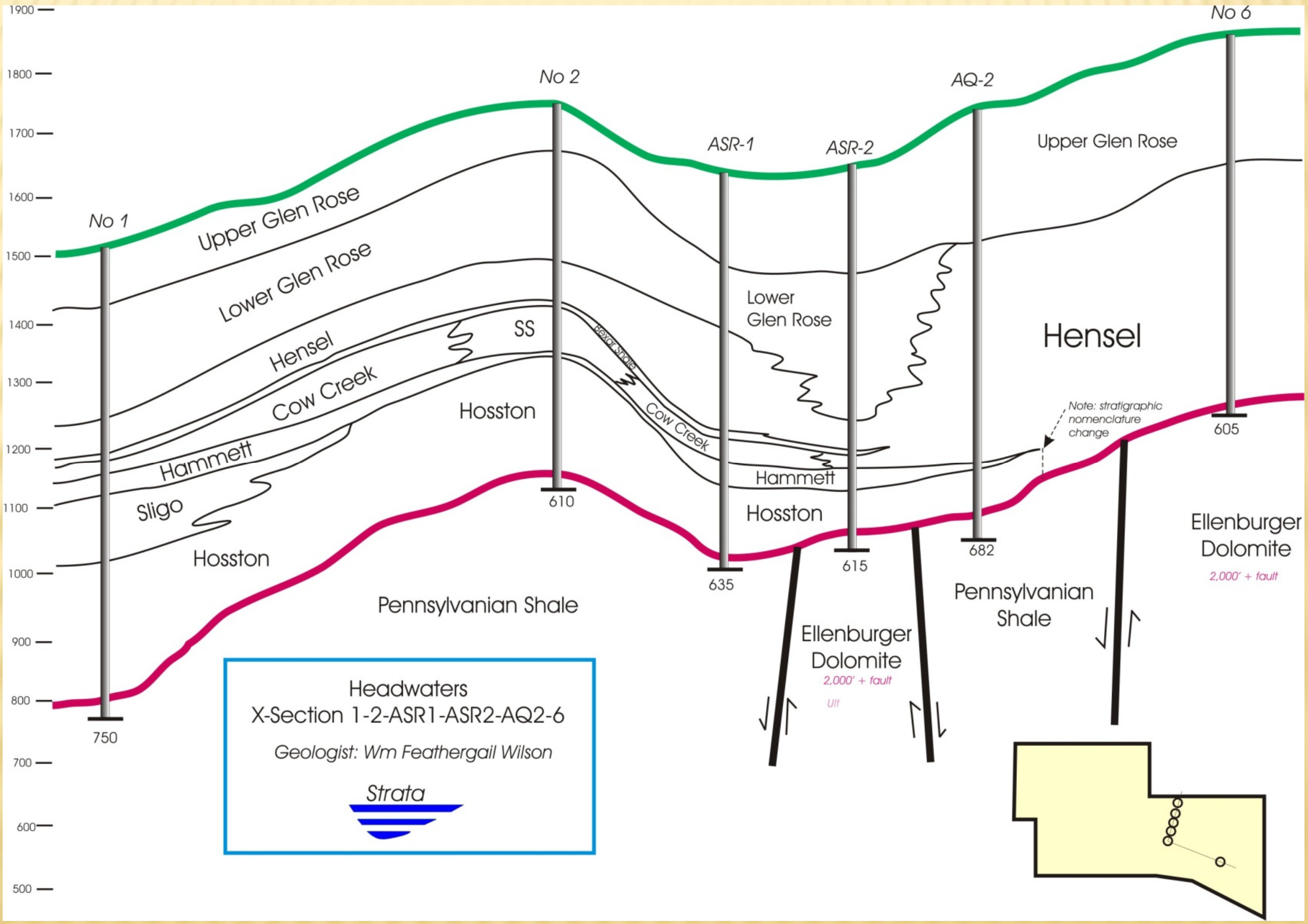
- When the population of Kerr County reaches ~55,000-60,000 people, what will happen?
- It depends upon conjunctive use of the river and groundwater



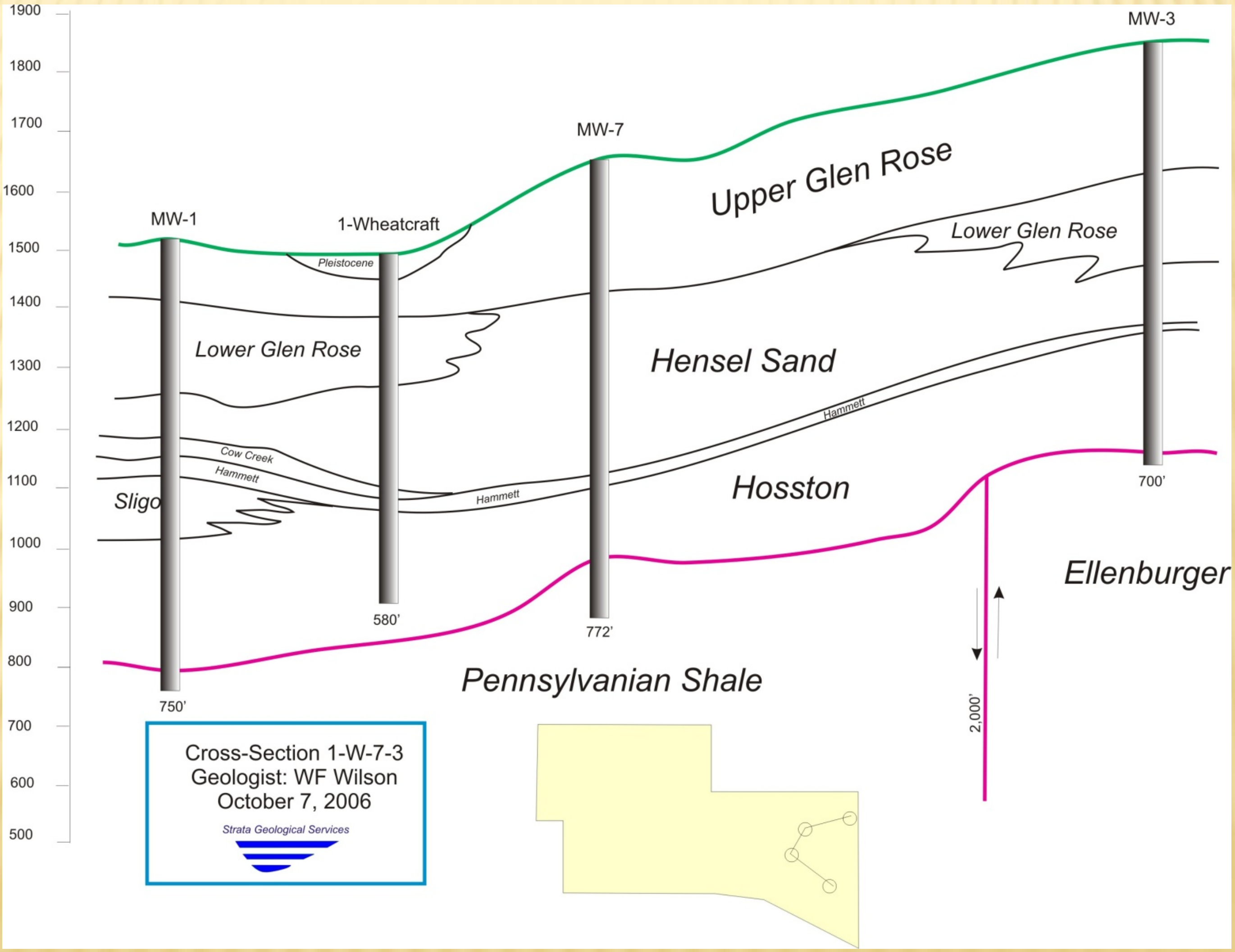
CONJUNCTIVE USE: RIVER & GROUNDWATER

- The population number depends two factors:
  - 1. Will the city be allowed to pump more water from the river and increase their water rights? Probably not.
  - 2. Will the population develop away from the river or in the city?
- If the city is limited by water rights, then the point of equilibrium where recharge = discharge could occur between 55,000-60,000 people
- River water is spring water from the Edwards aquifer

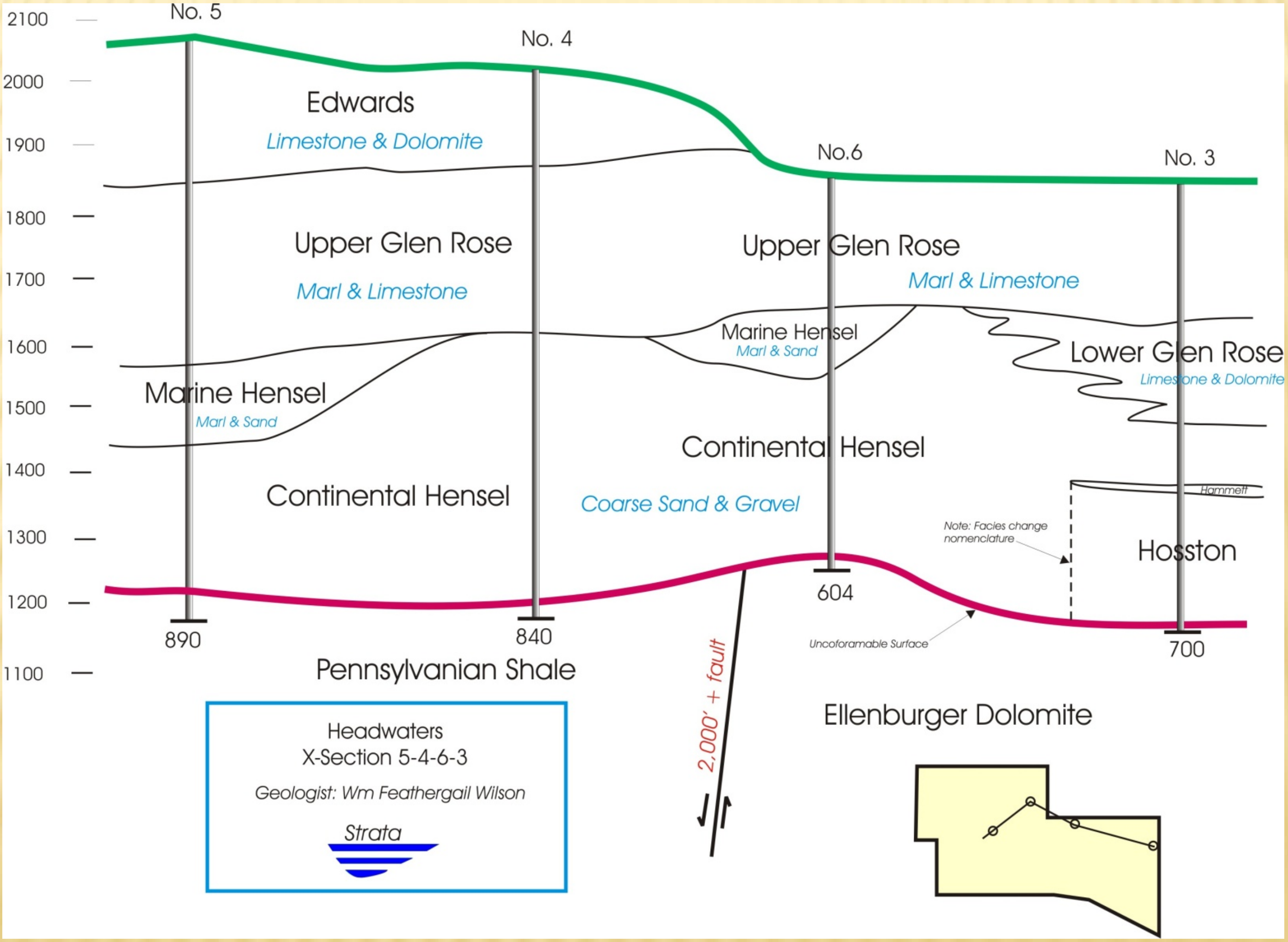
CROSS-SECTION – CENTER PT - KERRVILLE



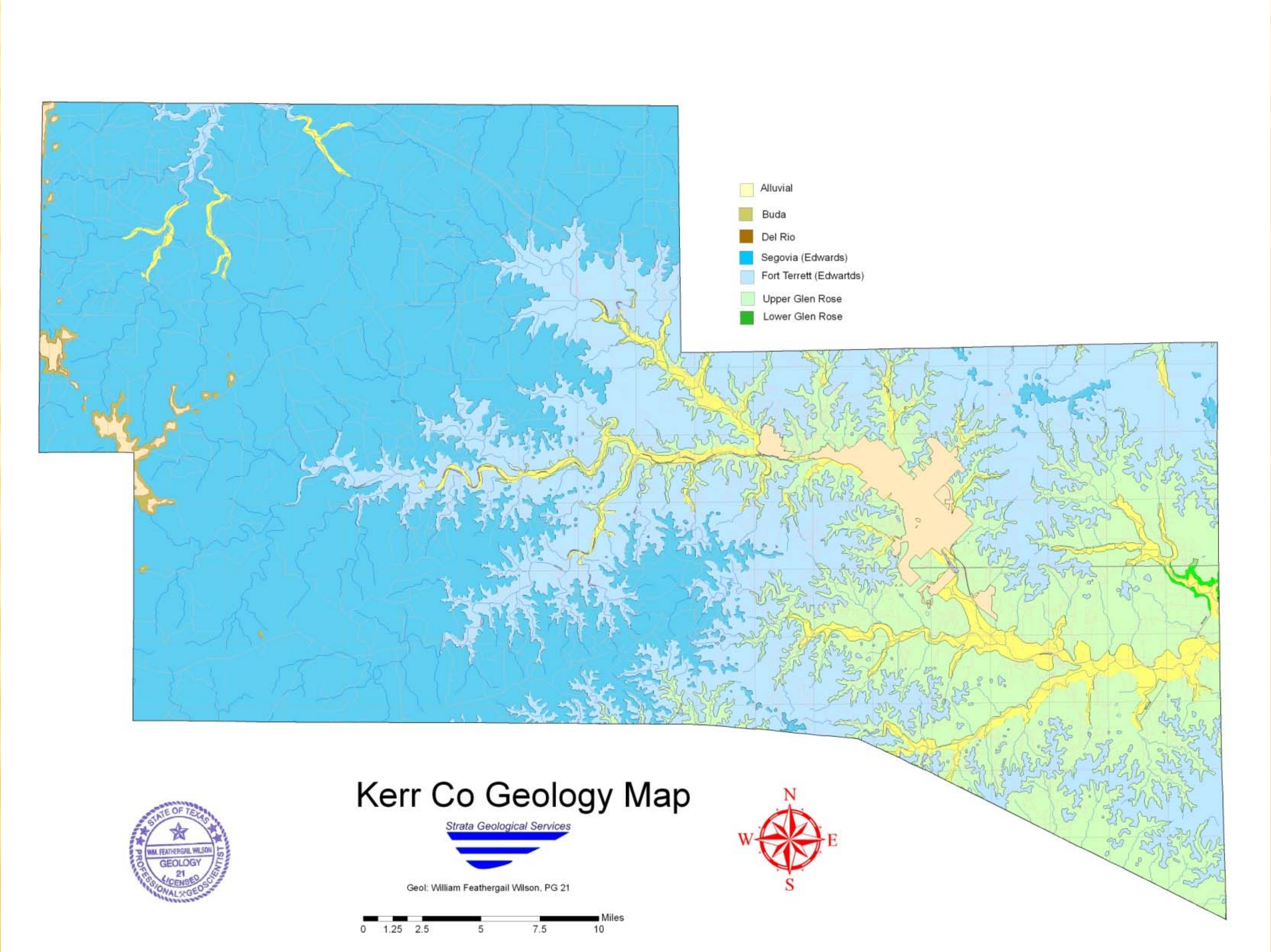
CROSS-SECTION EAST KERR COUNTY



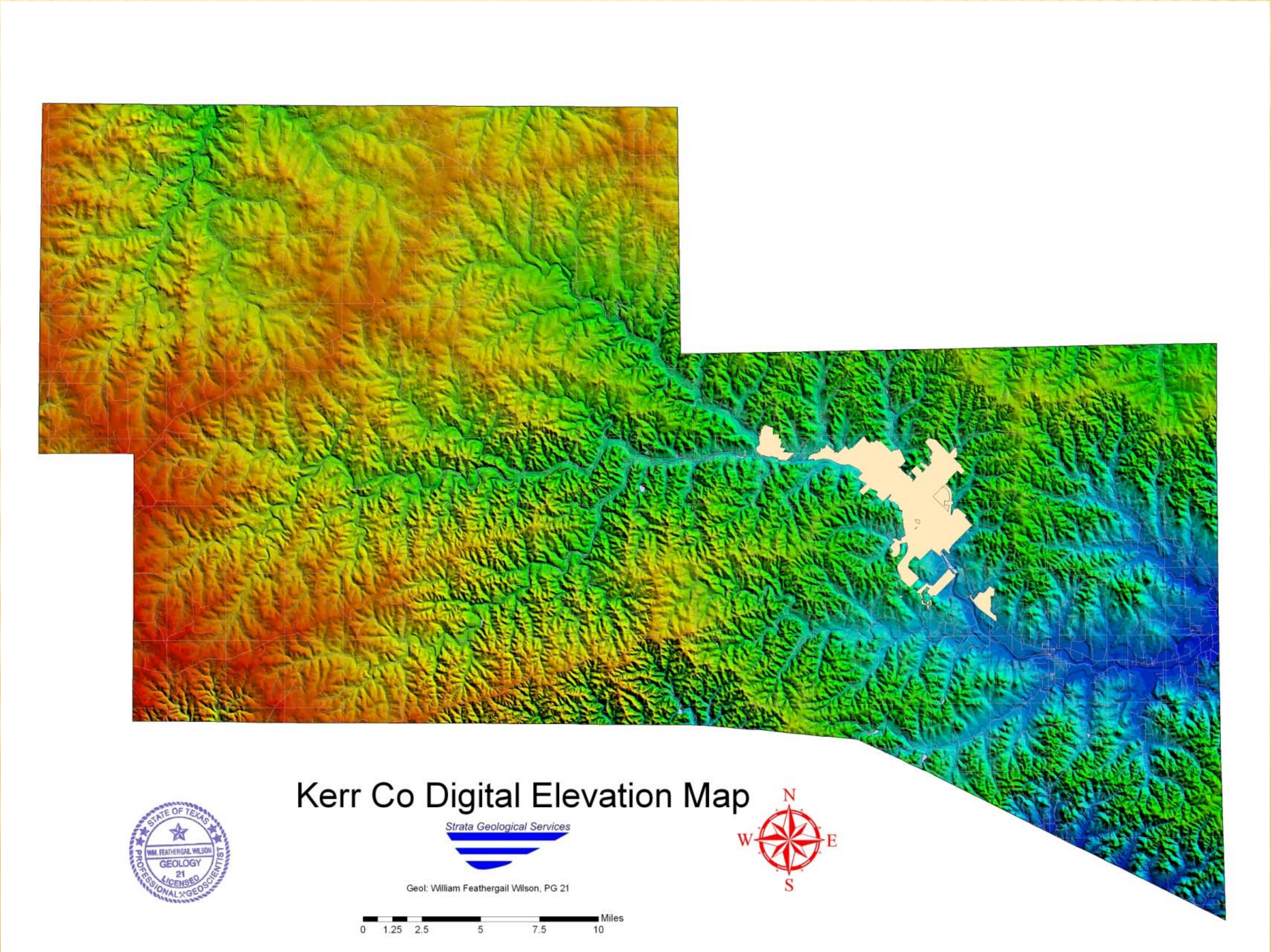
CROSS-SECTION NORTH CENTRAL KERR



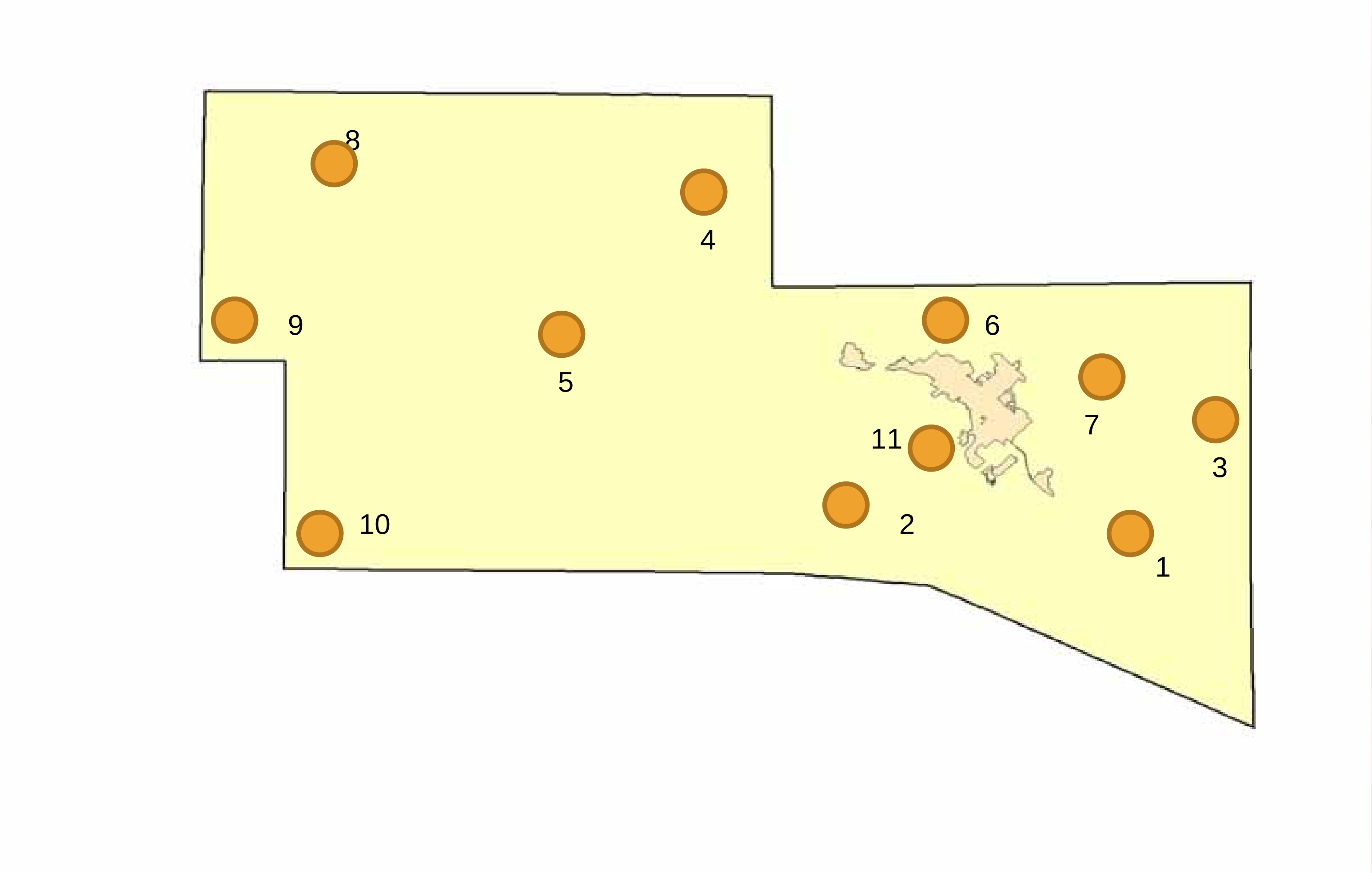
KERR CO SURFACE GEOLOGY



DEM KERR COUNTY



2008 LOCATIONS



MAJOR FINDINGS

- Detailed stratigraphic knowledge
- New water levels
- Detailed mapping of each individual aquifer and aquitard
- Integration of all types of data, i.e., age dating, stratigraphy, flow regimes, groundwater provenance
- A set of county-wide research wells distributed to statistically support validity and usefulness
- Revision and correction of pre-existing geologic literature

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Texas Water Development Board, Groundwater Resources Division
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Estimated Historical Water Use And 2012 State Water Plan Datasets:
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By Stephen Allen, Texas Water Development Board Groundwater Technical Assistance Section

GAM Run 12-021, Headwaters Groundwater Conservation District Management Plan
By Ian C. Jones, Ph.D., P.G., Texas Water Development Board, Groundwater Resources Division
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Adopted by District Board Resolution December 12, 2012

Texas Water Development Board Approval _______________, 2013

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HEADWATERS GROUNDWATER CONSERVATION DISTRICT

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