REAL-EDWARDS CONSERVATION AND RECLAMATION DISTRICT

Management Plan

2014-2019

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Mission Statement

The Real-Edwards Conservation and Reclamation District (the District) was created to provide for the conservation, preservation, development and recharging of the underground waters and water-bearing formations within the District consistent with Article XVI, Section 59, of the Texas Constitution and Chapter 36 of the Texas Water Code.

Guiding Principles

The District has operated from its inception, with a strong belief in private property rights and that when some of those rights relating to the management of groundwater are relinquished for the benefit of the community, local control through an elected Board of Directors is the preferred way to manage those rights.

The District has adopted the principle of education first and regulation second in their effort to encourage conservation of groundwater. The rules of the District are designed to give landowners a fair and equal opportunity to use the groundwater underlying their property for beneficial purposes. The District will monitor groundwater quality and quantity in order to better understand the dynamics of the aquifer systems over which it has jurisdiction. This Management Plan document is intended to be used as a tool to provide continuity in the management of the District. It will be used by the District staff as a guide to insure that all aspects of the goals of the District are carried out and will be referred to by the Board of Directors for future planning.

The dynamic nature of this Management Plan shall be maintained in a manner that allows the District to best serve the needs of the constituents. At the very least, the Board of Directors will review and readopt this plan every five years.

The goals, management objectives, and performance standards put forth in this planning document have been set at a reasonable level considering existing and future fiscal and technical resources. Whatever the future holds, the following guidelines will be used to insure that the management objectives are set at a sufficient level to be realistic and effective:

- The duly elected Board of Directors will guide and direct the District staff and will gauge the achievement of the goals set forth in this document.
- The interests and needs of the District's constituency including absentee landowners shall control the direction of the management of the District.

- The Board of Directors will endeavor to maintain local control of the privately owned resource over which the District has jurisdictional authority.
- The District budget operates on an October 1st through September 30th fiscal year.
- The Board of Directors will evaluate District activities based upon the fiscal year, when considering stated goals, management objectives, and performance standards.

History

The Real-Edwards Conservation and Reclamation District was created by Senate Bill 447 in the 56th Texas Legislature in 1959. Initially the District included parts of Edwards and Real County; however during the 71st Texas Legislature in 1989, House Bill 3127 was passed modifying the District's enabling legislation to include all of Edwards and Real Counties. The District is funded through fees and a $0.025 per one hundred dollars valuation ad valorem tax on property within the District.

Planning Period

This Management Plan becomes effective upon review and approval by the Texas Water Development Board (TWDB) and remains in effect until a revised plan is approved or ten (10) years from the date of approval, whichever is earlier. The plan may be reviewed annually. The Management Plan must be reviewed by the Board of Directors, readopted with or without revisions, and be resubmitted to the TWDB for approval at least once every five years to insure that it is consistent with the applicable Regional Water Plans and the State Water Plan.

As outlined in Chapter 36.1071, Texas Water Code, the District's Management Plan is required, as applicable, to address the following management goals:

- Providing the most efficient use of groundwater §36.1071(a)(1);
- Controlling and preventing waste of groundwater §36.1071(a)(2);
- Controlling and preventing subsidence §36.1071(a)(3);
- Addressing conjunctive surface water management issues §36.1071(a)(4);
- Addressing natural resource issues that impact the use and availability of groundwater and which are impacted by the use of groundwater §36.1071(a)(5);
- Addressing drought conditions §36.1071(a)(6);
- Addressing a) conservation, b) recharge enhancement, c) rainwater harvesting, d) precipitation enhancement, and e) brush control (where appropriate and cost effective), §36.1071(a)(7) and;
- Addressing the desired future conditions established under TWC §38.108. §36.1071(a)(8)

The following goals referenced in Chapter 36.1071, Texas Water Code, have been determined not applicable to the District:

§36.1071(a)(3) Controlling and preventing subsidence;
§36.1071(a)(7) Addressing b) recharge enhancement and;
§36.1071(a)(7) Addressing d) precipitation enhancement.

General Description

The District is governed by nine Directors who are elected by local voters and serve a four-year staggered term of office. District rules were revised in July 2013 which will affect the Management Plan. The District encompasses the total of Real and Edwards Counties, which is located in the southwestern part of the Texas Hill Country with Leakey and Rocksprings as the county seats, respectively. Real and Edwards Counties economies are primarily based on agriculture, tourism and hunting industries. The rugged terrain with its winding roads, the magnificent vistas, and the crystal clear springs, streams, and rivers along with some of the best hunting in Texas; have made the area a favorite for vacationers and absentee landowners alike.

Geographical Information

The District lies within the Edwards Plateau and consists of approximately 1,810,169 acres in Real and Edwards Counties. The land is generally rolling to mountainous with elevations from 1500 to 4000 ft. The District is included in three different river basins, the Nueces, Colorado, and the Rio Grande. The headwaters of the Nueces River and Frio River and a portion of the headwaters of the Sabinal River and the South Llano River are located within the District. The western half of Edwards County slopes southwestward into the Devils River. The eastern part of Edwards County drains into the Nueces River and the northern part drains into the Llano River. Real County drains into the Nueces River on the west and into the Frio River on the east with a small northern portion draining into the South Llano River. The land also includes many shallow depressions that catch rainfall and runoff to be either evaporated or infiltrated into the soil.

Groundwater Resources

Aquifers within Edwards and Real Counties have been divided by the Texas Water Development Board (TWDB) into two types, namely, major and minor aquifers. The TWDB has classified two major aquifers within the District: the Edwards-Trinity (Plateau) Aquifer and the Trinity Aquifer in the southeast corner of Real County. The District, along with the Region J Planning Group has identified two minor aquifers in the District; the Frio River Alluvium Aquifer and the Nueces River Alluvium Aquifer. These minor aquifers were included in the last Plateau Region (Region J) Water Plan that was approved by the TWDB in January 2011. There are numerous wells completed in the alluvium, with a majority being used for domestic and/or livestock purposes; others are used for irrigation and municipal purposes. The City of Leakey's well field is completed in the Frio River Alluvium Aquifer, and the Barksdale Water Supply Corporation's wells are completed in the Nueces River Alluvium Aquifer approximately one-half mile from the Nueces River near the community of Barksdale.

Edwards-Trinity (Plateau) Aquifer

Limestone is the predominant rock underlying the Edwards Plateau soils. The permeability of the limestone is not necessarily due to inter-granular pore space as in sandstone, but more to joints, crevices, and solution openings that have been enlarged by solvent action of water charged with carbon dioxide. The Edwards-Trinity (Plateau) Aquifer covers all or part of thirty-three (33) counties or the boundary of Groundwater Management Area 7 (GMA 7). Real and Edwards Counties sit on the Southeastern edge of this aquifer. Groundwater availability data from GAM Run 10-043 MAG (Version 2) of the groundwater availability model for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley Aquifers were used for this report and show that there is approximately 13,115 acre-feet/year of water per year available to the District from this aquifer. [Appendix 3] The Pecos Valley Aquifer does not occur within the District, therefore no groundwater budget values are included in this report. Within the District, groundwater is fresh, with total dissolved solids of less than 500 milligrams per liter in most sampled wells. The permeability of the formation is such that a well's pumping capacity may vary from as little as one (1) gallon per minute (gpm) to several hundred gallons per minute in limited locations. For the most part wells completed in this formation within Edwards and Real Counties consistently yield between three (3) and 10 gpm.

Trinity Aquifer

The Trinity aquifer is composed of marine sediments (primarily limestone) deposited during the Cretaceous Period. The Trinity Group in Edwards and Real Counties includes the Glen Rose and underlying Travis Peak formations. In some areas, the Glen Rose consists of up to approximately 1,000 feet of limestone with embedded shale, marl and occasional anhydrite (gypsum) and is the primary unit in the Trinity Aquifer in the southern part of the Edwards Plateau area. The Travis Peak contains sands, clays and limestones that are subdivided into water-bearing members of the Glen Rose Limestone, Hensell Sand, Cow Creek Limestone, Sligo Limestone and Hosston Sand water-bearing formations. Samples from the Trinity aquifer have total dissolved solids (TDS) concentrations above the secondary standard of slightly saline (1,000 - 3,000 mg/l). [Plateau Region Water Plan 2011]

Groundwater availability data from GAM Run 10-043 MAG (Version 2) of the groundwater availability model for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers were used for this report and show there is approximately 52 acre-feet/year available to the District from this aquifer. [Appendix 3] Wells completed within the Trinity formation of the District (southeast Real County) tend to yield substantially more water (50 -150+ gpm). However, as noted above often the high TDS and sulfide content requires water from this formation to undergo fairly extensive treatment prior to becoming potable.

Frio River Alluvial Aquifer

The Frio River Alluvium Aquifer in central Real County extends over an area of approximately 9,530 acres. The alluvium (clay, silt, gravel, etc. deposited by running water) generally follows the flood plain of the Frio River in Real County. The aquifer's width varies from almost nonexistent to over a mile. As with the width, the aquifer's thickness varies but is thought to not exceed 42 feet. Wells in the Frio River Alluvium Aquifer are generally shallow and provide water in small quantities for domestic and livestock purposes within Real County. However, as mentioned above, there are several large capacity wells completed in this zone and the City of Leakey's well field is completed in this aquifer. Because of the limited extent of this aquifer and its shallow water table, the aquifer system is potentially susceptible to contamination from surface sources. Recharge to the aquifer is from stream loss and direct infiltration of precipitation. Estimates indicate there is approximately 2,145 acre-feet/year available within this aquifer. [Plateau Region Water Plan 2011 Appendix 5]

Nueces River Alluvial Aquifer

The Nueces River Alluvium Aquifer lies between Edwards and Real Counties and extends over an area of approximately 24,450 acres. As with the Frio Alluvium Aquifer, the Nueces River Alluvium Aquifer is readily susceptible to diminished supplies during drought conditions, potentially from over-pumping, and from contaminated surface sources. Recharge of this aquifer is much like that of the Frio River Alluvium Aquifer, from stream loss and direct infiltration of precipitation. Alluvial deposits of Pleistocene and Recent age materials occur along nearly all the stream courses on the Edwards Plateau. These deposits consist of sand, gravel, silt and clay derived from the erosion of the underlying rocks, and occur primarily as terrace and flood plain alluvium. As with the defined Frio River Alluvium Aquifer, the alluvium deposits along the flood plains of the Nueces, West Nueces and South Llano Rivers vary in width and thickness. The thickness is thought not to exceed 35 feet. There appears to be some hydraulic connection between the alluvial formations and the rivers and streams that meander through them. For the most part wells in the alluvium within the District are generally shallow and provide water in small quantities for domestic and livestock purposes. The Barksdale Water Supply Corporation (serving the community of Barksdale), has its well field completed within the alluvium approximately one-half mile from the Nueces River. Estimates indicate there is approximately 3,574 acre-feet/year available within this aquifer. [Plateau Region Water Plan 2011 Appendix 5]

Estimated Available Groundwater

All estimates of groundwater availability, usage, supply, recharge, storage and future demands are from data supplied by the Texas Water Development Board unless otherwise noted. Tables 1 thru 5 herein are taken from the TWDB GAM Run 13-023, December 18th, 2013. [Appendix 1] The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. While the District is required to use these estimates, it is hoped that the TWDB will continue to improve the models and the data use herein. The District contends that the methodology used by the TWDB to project current and future water use is flawed in that it fails to consider factors including but not limited to; absentee landowners, vacationers, hunters, wildlife management, and exotic game. [Appendix 4]

Desired Future Conditions (DFC)

House Bill (HB) 1763 passed by the 79th Legislature became effective and incorporated into Chapter 36 of the Texas Water Code. This Bill regionalizes decisions of groundwater availability, requires regional water planning groups to use groundwater availability numbers, DFC, from groundwater conservation districts, and defines a permitting target for groundwater production Modeled Available Groundwater (MAG)." Groundwater conservation districts, in accordance with HB-1763 must establish their Respective DFCs of how their aquifer will be managed for 50 years, starting in 2010 through 2060.

TWC § 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 TWC § 36.108 must be collectively conducted by all groundwater conservation districts within the same GMA. The District is a member of GMA 7, which along with the other districts in the GMA did establish a comprehensive DFC. Appendix 3 contains the GAM run (GAM Run: 10.043 (Version 2)) [Appendix 3] used to establish the DFC of 7 feet of drawdown or 449,400 acre-feet/year from 2010 to 2060.

Natural and/or Artificial Recharge

Recharge is the addition of water to an aquifer. The principal source of groundwater recharge in Edwards and Real Counties is precipitation that falls on the outcrop of the various aquifers. In addition, seepage from streams located on the outcrop and possibly inter-formation leakage are sources of groundwater recharge. Recharge is a limiting factor in the amount of water that can be developed from an aquifer, as it must balance discharge over a long period of time or the water in storage in the aquifer will eventually be depleted. Among the factors that influence the amount of recharge received by an aquifer are: the amount and frequency of precipitation; the extent of the outcrop or intake area; topography, type and amount of vegetation, the condition of soil cover in the outcrop area; and the ability of the aquifer to accept recharge and transmit it to areas of discharge. On aquifer outcrops where vegetation is dense, the removal of underbrush and non-beneficial plants will reduce evaporation and transpiration losses, making more water available for groundwater recharge. According to estimates from the TWDB GAM Run 13-023, December 18th, 2013, [Appendix 1] the District receives approximately 76,462 acre-feet/year of recharge annually from precipitation. See Table 1.

Table 1: ESTIMATED ANNUAL AMOUNT OF RECHARGE FROM PRECIPITATION TO THE DISTRICT. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Aquifers or Confining Units	Results (acre-feet/year)
Edwards and associated limestone	75,382
Undifferentiated Trinity Units	1,080
Total	76,462

In the Edwards Plateau region, the annual rate of evaporation is three times greater than the annual rate of precipitation, thus creating perpetual low soil moisture content that retards percolation except under the most ideal conditions. Percolation usually occurs during relatively short periods after rainfall. Soil permeability is an expression of the ability of water to pass through pore spaces of the soil and varies throughout the Edwards Plateau from less than 0.06 to 0.63 inches per hour. This information is derived from a 1979 report by Lloyd Walker titled "Occurrence, Availability, and Chemical Quality of Ground Water in the Edwards Plateau Region of Texas, Report 235, Texas Department of Water Resources."

Additional Recharge

The estimate of the annual amount of additional natural or artificial recharge of groundwater within the District that could result from implementation of feasible methods for increasing the natural or artificial recharge is difficult to determine due to the direct correlation to rainfall. There are several feasible methods of additional recharge:

Flood Prevention Sites- Along the headwaters of the Frio and Nueces River there are numerous privately owned dams that catch and retain water. On the Nueces, there is a public dam along the Uvalde and Real County line. There are a few privately owned dams on the Llano River as well. Construction of small dams to slow down runoff may be beneficial to the recharge of the aquifers within the District.

Range Management through Brush Control; Real and Edwards Counties have a coverage of approximately 65% Ash Juniper or cedar. [Natural Resource Conservation Service, Edwards County, 1999] Brush control can be accomplished by mechanical control, prescribed burning, a combination of mechanical and burn, or chemical application. Brush control may be considered more of a conservation method than an additional recharge method. Recent studies indicate in certain instances over certain terrain and with proper techniques, brush control may enhance recharge as well as serve as a water conservation measure. [Redecker et al. (1998)]

Natural and Artificial Discharge

Discharge is the loss of water from an aquifer. The discharge may be either artificial or natural. Artificial discharge takes place from flowing and pumped water wells, drainage ditches, gravel pits, and other excavations that intersect the water table. Natural discharge occurs as seepage, springs, evaporation, transpiration, and inter-formational leakage. Groundwater moves from areas of recharge to areas of discharge, or from points of higher hydraulic head to points of lower hydraulic head. Movement is in the direction of the hydraulic gradient just as in the case of surface water flow. Under normal artesian conditions movement of groundwater usually is in the direction of the aquifer's regional dip. The slope of the water-table, and consequently the direction of groundwater movement, is closely related to the slope of the land surface. However, for both artesian and water-table conditions, local anomalies are developed in areas of pumping and some water moves toward the point of artificial discharge. The rate of groundwater movement in an aquifer is usually very slow, being in the magnitude of a few feet to a few hundred feet per year. While it appears that substantial recharge occurs via precipitation, approximately 41,232 acre-feet/year of water per year is discharged from the aquifer to springs, streams and rivers within the District. See Table 2.

TABLE 2: ESTIMATED ANNUAL VOLUME OF WATER THAT DISCHARGES FROM THE AQUIFER TO SPRINGS, STREAMS, AND RIVERS. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Aquifers or Confining Units	Results (acre-feet/year)
Edwards and associated limestone	41,232
Undifferentiated Trinity Units	0
Total	41,232

In planning for future use and availability, it is necessary to look at the amount of water coming into the District from each aquifer. The TWDB estimates that there is a total of 25,653 acre-feet/year flowing into the District. This estimate is made from the TWDB GAM Run 13-023, December 18th, 2013. [Appendix 1] See Table 3.

TABLE 3: ESTIMATED ANNUAL VOLUME OF FLOW INTO THE DISTRICT WITHIN EACH AQUIFER IN THE DISTRICT. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Aquifers or Confining Units	Results (acre-feet/year)
Edwards and associated limestone	25,004
Undifferentiated Trinity Units	649
Total	25,653

Likewise it is equally important to know how much water is leaving the District and how much flow there is between the different aquifers. The section above addressed the issue relating to discharges to springs, streams and rivers. However if there is water entering into the District through the aquifers there is also water leaving the District via the aquifers. According to the TWDB, there is 80,462 acre-feet/year flowing out of the District annually. See Table 4. There also appears to be a limited amount of flow between the Edwards formation and the Trinity units. This amounts to about 272 acre-feet/year. See Table 5.

TABLE 4: ESTIMATED ANNUAL VOLUME OF FLOW OUT OF THE DISTRICT WITHIN EACH AQUIFER IN THE DISTRICT. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Aquifers or Confining Units	Results (acre-feet/year)
Edwards and associated limestone	79,007
Undifferentiated Trinity Units	1,455
Total	80,462

TABLE 5: ESTIMATED NET ANNUAL VOLUME OF FLOW BETWEEN EACH AQUIFER IN THE DISTRICT. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Aquifers or Confining Units	Results (acre-feet/year)
Edwards & associated limestone flowing into undifferentiated Trinity Units	272
Total	272

Surface Water Resources and Availability

Surface water sources within the District include the Nueces River, the Frio River, and the Llano River along with numerous small streams and hundreds of springs. Major springs include; Seven Hundred Springs, Evans Springs and Old Faithful Springs. The City of Camp Wood, in Real County, uses Old Faithful Springs as it sole source of municipal water. During the Drought of Record in the 1950's Old Faithful Spring still flowed at a rate that was adequate for the City of Camp Wood's municipal use. The current drought has put a strain on Old Faithful Springs, but as of publication of this document the spring has sufficiently supplied the City of Camp Wood with municipal water. According to projections, the City of Camp Wood may be short as much as 172 acre-feet of water per year thru 2060. [Appendix 2] Knowing this, the District asked the Plateau Planning Group to include a strategy relating to the City of Camp Wood drilling one or more wells to supplement community's water supply. Surface water from the Frio, Nueces and South Llano Rivers as well as springs contribute 2,520 acre-feet/year. [Appendix 2] However, this cannot be considered available as surface water does not fall under the jurisdiction of the District. Flow data on most of the springs is sparse. The District has been monitoring the flow of the Nueces and Frio Rivers in an effort to gather data to be used to set future conditions as well as used for specific drought triggers when combined with other data. The flow of Old Faithful Springs and Evans Springs will be major components in the establishment and monitoring of DFC's for the District. As mentioned above the aquifers discharge approximately 41,232 acre-feet/year to numerous springs, streams and rivers within the District. See Table 2 Above.

Current and Projected Use

As previously mentioned, artificial discharge is considered the amount of water from flowing and pumped water wells, drainage ditches, gravel pits, and other excavations that intersect the water table. According to the TWDB, the projected total water demand in 2010 was estimated to be 2,422 acre-feet. [Appendix 2] and estimates from the Plateau Region Water Plan indicate a decline in water use in the District thru the year 2060. These figures are based primarily upon population thru census and livestock use. The District feels these figures do not take into consideration the large number of absentee landowners in the District (approximately 65-70%), nor do the figures consider the rapid change from normal livestock to Game Management and Exotic Game ranches. Other factors the District feels were not considered in these estimates are the abundance of wild game such as hog, axis deer, blackbuck antelope, mouflon and aoudad, nor do these figures take the large amount of tourism and summer homes.

Projected Water Supply

According to data from the Plateau Region Water Plan,(January 2011), there are approximately 23,055 acre-feet/year of water available for District use. See Table 6. However since a part of this water is surface water and for the most part is permitted by TCEQ and not under District control, that number should be lowered to 20,707 acre-feet /year.

TABLE 6: WATER SOURCE AVAILABILITY (ACRE-FEET/YEAR).

COUNTY	AQUIFER/RIVER	RIVER BASIN	SOURCE AVAILABILITY
Edwards	Edwards-Trinity (Plateau)	Colorado	2,610
	Edwards-Trinity (Plateau)	Nueces	3,480
	Edwards-Trinity (Plateau)	Rio Grande	2,609
	Nueces River Alluvium	Nueces	1,787
	Livestock Local Supply	Colorado	61
	Livestock Local Supply	Nueces	62
	Nueces River	Nueces	138
	West Nueces River	Nueces	5
	South Llano River	Colorado	43
	County Total		**10,796**

Real	Edwards-Trinity (Plateau)	Colorado	200
	Edwards-Trinity (Plateau)	Nueces	5,537
	Trinity	Nueces	380
	Frio River Alluvium	Nueces	2,145
	Nueces River Alluvium	Nueces	1,787
	Livestock Local Supply	Colorado	24
	Livestock Local Supply	Nueces	25
	Old Faithful Springs	Nueces	0
	Nueces River	Nueces	648
	Frio River	Nueces	1,514
	County Total		**12,260**

Management of Groundwater Supplies

The District will work with other agencies and entities including but not limited to the Texas Water Development Board, The Plateau Region (Region J) Planning Group and the Groundwater Management Area 7 (GMA 7) to establish and monitor the Managed Available Groundwater within the District. On an annual basis, the District will make an assessment of water supply and groundwater storage conditions and will report those conditions to the Board of Directors and to the public through the District website and news articles.

The District has, or will amend as necessary, Rules to regulate groundwater withdrawals by means of spacing and/or production limits.

The relevant factors to be considered in making the determination to grant a permit or limit groundwater withdrawal will include:

- The equitable conservation and preservation of the resource;
- The economic hardship resulting from granting or denying a permit or the terms prescribed by the rules;
- The modeled available groundwater (MAG) for use in the District; and
- The Desired Future Conditions (DFC) of the Aquifer.

In pursuit of the District's mission of protecting the resource, the District may require reduction of groundwater withdrawals to amounts which will not cause harm to the aquifer. To achieve this purpose, the District may, at the Board of Directors' discretion, amend or revoke any permits after notice and a public hearing. The determination to seek the amendment or revocation of a permit by the District will be based on aquifer conditions observed by the District. The District will enforce the terms and conditions of permits and the Rules of the District by enjoining the permit holder in a court of competent jurisdiction as provided for in TWC 36.102.

Actions, Procedures, Performance and Avoidance for Plan Implementation

The District will implement this Plan and will utilize this Plan as a guidepost for determining the direction or priority for all District activities. All operations of the District, all agreements entered into by the District, and any additional planning efforts in which the District may participate will be consistent with this Plan. The District has adopted and will amend, as necessary, rules relating to the implementation of this Plan. The rules adopted by the District shall be pursuant to TWC Chapter 36 and this Plan. All rules will be adhered to and enforced. The promulgation and enforcement of the Rules will be based on the best technical evidence available. The District shall treat all citizens with equality. Citizens may apply to the District for variance in enforcement of the Rules on grounds of adverse economic effect or unique local characteristics. In granting of discretion to any rule, the Board of Directors shall consider the potential for adverse effect on adjacent owners and aquifer conditions. The exercise of said discretion by the Board of Directors shall not be construed as limiting the power of the Board of Directors. Current District Rules may be found on the District website at www.recrd.org/reports/

Methodology for Tracking Progress

Prior to the first quarterly Board of Directors meeting of the fiscal year, the District Manager will prepare an annual report on District performance in achieving the management goals for the preceding year. This report will be presented to the Board of Directors during the first quarterly Board of Directors meeting annually. The report will include the number of instances in which each of the activities specified in the Districts management objectives was engaged in during the fiscal year. The Board of Directors will maintain the report on file, for public inspection at the Districts offices upon adoption. This methodology will apply to all management goals contained within this plan.

Goals, Management Objectives and Performance Standards

Goal 1 – Providing for the most Efficient Use of Groundwater (36.1071(a)(1))

Management Objective
1.1: Registration of Wells - The District will review all new well applications and may conduct site visits prior to any new well construction. The District will encourage the registration of existing well through news articles and other means.

Performance Standards
1.1 (a): Within five days of the receipt of an application for a new well, staff will review the application and may contact the applicant to arrange for a site visit.

1.1 (b): Staff may conduct an onsite inspection of the well location prior to any new construction.

1.1 (c): Data will be entered into the District's computer system and a well number will be issued within five days of the receipt of the well log/report from the Driller.

1.1 (d): Staff will furnish a report to the Board of Directors on the number of wells currently listed in the District's computer system on a quarterly basis. The report will include at a minimum; the total number of wells in the data base, the completed number of wells, and the number of pending well files.

1.1 (e): At least 2 times per year, the District will publish an article on the need to register existing wells.

Management Objective
1.2: Operating Permits, Transport Permits, and Other Permits - The District will review and act upon all requests for all permits as outlined in the District's Rules.

Performance Standards
1.2 (a): The District will follow procedures as outlined in District rules for permitting.

1.2 (b): On a quarterly basis the staff will furnish the Board of Directors with the number of active permits and the number of permits pending.

Management Objective
1.3: Improve/Enhance Water Level Monitoring Program - The District will improve its water level monitoring network by identifying additional wells to be monitored, and by annually measuring the depth to water in those wells; record all measurements and/or observations; enter all measurements into District's computer data base. Establish a baseline by using existing wells, preferably those for which the District already has some historical data, in all major and minor aquifers where wells are available.

Performance Standards
1.3 (a): Annually report to the Board of Directors on the percent of water level monitoring wells for which measurements were recorded each year; the number of data records entered into District's data base each year; the number of wells in the water level measurement network each year; the number of wells added to the network each year.

Goal 2 - Controlling and Preventing Waste of Groundwater (36.1071(a)(2))

Management Objective
2.1: Control and Prevention of Water Waste - The District will investigate identified wasteful practices within a reasonable number of working days of identification or complaint received. The District will publish at least three (3) articles per year via the local newspapers regarding the prevention of waste.

Performance Standards
2.1 (a): Annually report to the Board of Directors on the number of wasteful practices identified and the average number of days District personnel took to respond or investigate after identification or complaint received. The actions taken to resolve the identification or complaint received.

2.1 (b): Annually report to the Board of Directors on the number of news articles published.

Goal 3 - Addressing Conjunctive Surface Water Management Issues (36.1071(a)(4))

Except as provided in Chapter 36 of the Texas Water Code, the District has no jurisdiction over surface water. The District shall consider the effects of surface water resources as required by Section 36.113 and other state law. However, the Headwaters to the Nueces, Frio and to some extent the South Llano Rivers initiate in the District and the District is well aware of the ecological and economic impact of these rivers. The Nueces River Authority is the predominant agency in dealing with the Nueces River and Frio River, and the District works with that entity in promoting water conservation and the prevention of waste and contamination of ground and surface water. Currently one member of the District Staff serves on the Nueces Bay and Estuary Advisory Council. The District also promotes the Clean Rivers Program initiated by the Nueces River Authority. A newly formed Stake Holders Group has been started to address the concerns along the Llano River and the District has been and will continue to be active with that group.

Management Objective
3.1: The District will work in conjunction with the Nueces River Authority and other stakeholders groups to promote the Clean Rivers Program and will include information about that program.

Performance Standards
3.1 (a): Annually report the number of programs, meetings etc. participated in.

3.1 (b): Annually report the number of articles relating to the Clean Rivers program.

Management Objective
3.2: The District will include information regarding the need to prevent contamination of the springs, streams and rivers within the District.

Performance Standards
3.2 (a): Annually report the number of news articles relating to contamination.

Management Objective
3.3: Upon request and in conjunction with the Nueces River Authority, the District will conduct school and/or public presentations relating to the impact of contamination on the Nueces River Basin Watershed.

Performance Standards
3.3 (a): Annually report the number of requests and number of programs participated in.

Goal 4 – Addressing Natural Resource Issues that Impact the Use and Availability of Groundwater and Which are Impacted by the Use of Groundwater (36.1071(a)(5))

Management Objective
4.1: The District will investigate any reported contamination and work with the Railroad Commission, the Texas Commission on Environmental Quality, and/or other entities/agencies to insure that any contamination is minimized or eliminated.

Performance Standards
4.1 (a): Investigate any report of potential contamination.

4.1 (b): Annually report the number of potential contamination incidents and the location of such incidents to the Board of Directors

Management Objective
4.2: During the next round of Regional Planning, the District will again work to include Strategies relating to the investigation and/or impact of the contamination of wells in Southwestern Edwards County and the potential contamination of aquifers due to unlined pits and/or improperly closed lined pits.

Performance Standards
4.2 (a): Annually report to the Board of Directors on the progress and/or the success of the objective.

Goal 5 –Addressing Drought Conditions (36.1071(a)(6))

Management Objective
5.1: Curtailment of Groundwater Withdrawal - The annual amount of groundwater permitted by the District for withdrawal from the portion of the aquifers located

within the District may be curtailed during periods of extreme drought in the recharge zones of the aquifers or because of other conditions that cause significant declines in groundwater surface elevations. Such curtailment may be triggered by the District's Board of Directors based on the groundwater elevation measured in the District's monitoring well(s) and/or stream flow measurements along with other indices such as rainfall and soil moisture. District staff currently monitors five locations along the Frio River and its tributaries, and two locations on the Nueces River.

Performance Standards
5.1 (a): Flow measurements will be taken monthly on the Frio and Nueces Rivers. The information will be published on the District's webpage for public viewing and in local papers.

5.1 (b): Upon declaration of a change in drought stage, all permit holders will be notified of the need to curtail production.

5.1 (c): Upon declaration of a change in drought stage, staff will submit an article to the local papers. Said article will describe the drought stage and the conditions and request that the public initiate conservation measures.

5.1. (d): The District will annually review its drought contingency plan to see what if any changes need to be made.

5.1. (e): District staff will report quarterly to the Board of Directors on local drought conditions. Such reports may be oral or written and presented at Board of Directors Meetings. Data for this report may be drawn from information contained on the TWDB web site: http://www.twdb.state.tx.us/data/drought/ or from other sites as deemed relevant by District staff.

Goal 6 – Addressing: a) Conservation, b) Recharge Enhancement, c) Rainwater Harvesting, d) Precipitation Enhancement, and e) Brush Control Where Appropriate and Cost Effective (36.1071(a)(7))

Management Objective
6.1: Emphasize Water Conservation through Public Education - The District will sponsor the "Water Wise" conservation education curriculum, available upon request for all 5th Grade Classrooms within the District. The District will furnish book covers to the schools within the District. These covers will reflect water related topics such as waste, contamination and conservation.

Performance Standards
6.1(a): Annually report to the Board of Directors on the number of schools districts and number of students instructed in the "Water Wise" conservation education curriculum, and the number of water conservation articles presented to the public.

6.1 (b): Annually document the number of schools that received the book covers, and the number distributed to each school.

Management Objective
6.2: Public Education – Provide and distribute literature on water conservation by publishing news articles.

Performance Standards
6.2 (a): Annually document number of news articles published.

6.2 (b): Promote rainwater harvesting, xeriscaping and brush control where appropriate and cost-effective. Promotion of these projects may be accomplished through news articles and/or the District's webpage.

6.2 (c): Update District Webpage with informative links that relate to conservation, waste prevention and enhancement of groundwater. The District web page is a direct link to a large number of individuals who reside in or own property within the District. Links on the District webpage will be reviewed regularly to insure they are current and that the linked information reflects the management objective. Annually document that the District webpage was reviewed and/or updated.

Management Objective
6.3: Addressing Rainwater Harvesting - The District believes that the harvesting of rainwater is a viable way to both conserve groundwater and to supplement domestic supply in areas within the District where groundwater is in sparse supply. The District will promote rainwater harvesting through news articles and through the District's website.

Performance Standards
6.3 (a): Information regarding rainwater harvesting will be included in news articles.

6.3 (b): On at least a quarterly basis the District web page will be reviewed to insure that links to information on rainwater harvesting are current.

Management Objective
6.4: Addressing Brush and Invasive plant control. The District is supportive of activities related to brush and invasive plant control as it relates to the recharge of the aquifers. The District will promote brush and invasive plant control through newspaper articles and through links on the District's webpage.

Performance Standards
6.4 (a): The control of brush and/or other invasive plants will be included in news articles. The Board of Directors will be informed when such articles are published.

6.4 (b): On at least a quarterly basis the District web page will be reviewed to insure that links to information on brush control are current.

Goal 7 – Addressing the Desired Future Conditions (36.1071(a)(8))

The District actively participates in developing the desired future conditions for the aquifers within the District's boundaries and within the boundaries of Groundwater Management Area (GMA) 7.

Management Goals Not Applicable to the District

Goal 6 – Addressing: a) Conservation, b) Recharge Enhancement, c) Rainwater Harvesting, d) Precipitation Enhancement, and e) Brush Control Where Appropriate and Cost Effective (36.1071(a)(7))

Addressing Recharge Enhancement - This management goal is not applicable to the operations of the District as it is cost prohibitive at this time, nor is it thought that the karst formation of the aquifer is readily conducive to this issue.

While the District is supportive of Precipitation Enhancement such a program is costly, thus making it prohibitive. Therefore this portion of Management Goal 6 is not applicable to the operations of the District at this time.

Goal 8 - Controlling and Preventing Subsidence (36.1071(a)(3))

The geologic framework, the population level, and the current groundwater demands of the District preclude any significant subsidence from occurring. This management goal is not applicable to the operations of the District.

Definitions and Concepts

In the administration of its duties, the Real-Edwards Conservation and Reclamation District follows the definitions of terms set forth in the District Act, Chapter 36 of the Texas Water Code, and other definitions as follows:

"Acre" means the unit of measure used to calculate the total land surface area. One acre is equal to 42,560 square-feet.

"**Acre-foot"** means the amount of water necessary to cover one acre of land one foot deep, or about 325,851 gallons of water.

Agricultural Use or Purpose" means any use or activity involving agriculture, including irrigation.

"Alluvial/Alluvium" means a geological deposit composed of sediment deposited by a stream or river. The alluvium may be in direct hydraulic connection with the rivers and streams that meander through the area.

"Alluvial Aquifer" means a minor aquifer(s) in the District that is mostly composed of gravel and sands eroded from the surrounding limestone hills and deposited along the flood plains near rivers and streams.

"Aquifer" means a geologic formation, group of formations, or part of a formation that is capable of yielding a sufficient amount of groundwater to make the production from this formation feasible for beneficial use.

"Board" means the Board of Directors of the District.

"Conservation" means those water saving practices, techniques, and technologies that will reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses.

"Desired Future Conditions" (DFC's) means a quantitative description, adopted in accordance with Section 36.108 of the Texas Water Code, of the desired condition of the groundwater resources in a management area at one or more specified future times.

"Discharge" means the amount of water that leaves an aquifer by natural or artificial means.

"Director" means a person elected or appointed to serve on the Board of

Directors of the District.

“District” means the Real-Edwards Conservation and Reclamation District.

“District Act” means Chapter 341, Acts of the 56th Legislature, Regular Session, 1959 (Article 8280-233, Vernon's Texas Civil Statutes), including all amendments thereto, and the non-conflicting provisions of Chapter 36, Texas Water Code.

"District boundaries" means the boundaries of the District, and such boundaries that are coexisting with the outside boundary lines of Edwards and Real Counties.

“District Official” means District Directors and Officers.

“District Office” means the office of the District as established by the Board.

“Drought” means that term as defined in the District’s Drought Contingency Plan.

“**Drought Contingency Plan**” **(DCP)** means a plan by the District that is designed to reduce demand on the available water supply through a process that becomes more restrictive as drought conditions worsen.

“**Drought Stage**” means one of the designated drought conditions listed in the District’s Drought Contingency Plan.

“Edwards Trinity (Plateau) Aquifer” means the major aquifer within the District. The Edwards Trinity Aquifer extends from the Texas Hill Country to the Trans-Pecos area of West Texas.

“Frio River Alluvial Aquifer” means the minor aquifer in central Real County that extends over an area of approximately 1,220 acres and is mostly composed of gravel and sands eroded from the surrounding limestone hills and deposited along the floodplain of the Frio River.

“**Groundwater”** means water percolating beneath the surface of the earth.

“Modeled Available Groundwater” (MAG) means 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 of the Texas Water Code.

“Municipal or Public Water Supply Use” means the use of groundwater through public water systems that are authorized for providing potable water to the public by the State of Texas.

“Nueces River Alluvial Aquifer” means the minor aquifer within the District extending into both Edwards and Real Counties that extends over an area of approximately 17,115 acres and is mostly composed of gravel and sands eroded from the surrounding limestone hills and deposited along the floodplain of the Nueces River.

“**Pollution”** means the alteration of the physical, thermal, chemical, or biological quality of, or the contamination of any water in the District that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property or to public health, safety, or welfare, or impairs the usefulness or public enjoyment of the water for any lawful or reasonable purpose including the alteration of groundwater by saltwater or other deleterious matter admitted from another stratum or from the surface of the ground.

“Recharge” means the amount of water that infiltrates into the water table of an aquifer from the surface of the ground or from other underground formations.

"Registration" means a certificate issued by the District for an exempt or excluded well, or the initial registration of a well that upon completion is to be determined by the District to be non-exempt.

“Rules” means the rules of the District compiled in this document and as may be supplemented, repealed or amended from time to time.

“Spring” means a point of natural discharge from an aquifer.

“Waste” means any one or more of the following:

(a) withdrawal of groundwater from a groundwater reservoir at a rate and in an amount that causes or threatens to cause intrusion into the reservoir of water unsuitable for agricultural use, gardening, domestic or stock watering purposes;

(b) the flowing or producing of wells from a groundwater reservoir if the water produced is not used for a beneficial purpose;

(c) escape of groundwater from a groundwater reservoir to any other reservoir or geologic strata that does not contain groundwater;

(d) pollution or harmful alteration of groundwater in a groundwater reservoir by saltwater or by other deleterious matter admitted from another stratum or from the surface of the ground;

(e) willfully or negligently causing, suffering, or allowing groundwater to escape into any river, creek, natural watercourse, depression, lake, reservoir, drain, sewer, street, highway, road, or ditch, or onto any land other than that of the owner of the well, unless such discharge is authorized by permit, rule, or order issued by the Texas Commission on Environmental Quality under Chapter 26, Texas Water Code;

(f) groundwater pumped for irrigation that escapes as irrigation tail water onto land other than that of the owner of the well, unless the occupant of the land receiving the discharge has granted permission;

(g) for water produced from an artesian well, "waste" has the meaning assigned by Section 11.205 of the Texas Water Code.

In event of a conflict between "Beneficial Use" or "Beneficial Purposes" and "Waste", "Beneficial Use" or "Beneficial Purposes" shall be subordinate to "Waste".

"Water Table" means the upper boundary of the saturated zone in an unconfined aquifer.

"Well" means any facility, device, or method used to withdraw groundwater; or any artificial excavation or borehole constructed for the purposes of exploring for or producing groundwater, or for injection, monitoring, or dewatering purposes, or a leachate or remediation well.

"Well Registration" means the creation of a record of a well, as determined by its use, and a well identification number for purposes of registering the well as to its geographic location, and for notification to the well owner in cases of spills or accidents, data collection, record keeping, or future planning purposes.

"Xeriscape" means a landscape practice combining the use of low water use plants, design, conservation, and other landscaping principles to conserve water and energy.

Appendix 1

GAM Run 13-023:
Real-Edwards Conservation and Reclamation District Management Plan

GAM Run 13-023: Real-Edwards Conservation and Reclamation District Management Plan

by Radu Boghici, P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-5808

December 18, 2013

The seal appearing on this document was authorized by Radu Boghici, P.G. 482 on December 18, 2013.

GAM RUN 13-023: REAL-EDWARDS CONSERVATION AND RECLAMATION DISTRICT MANAGEMENT PLAN

by Radu Boghici, P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-5808
December 18, 2013

EXECUTIVE SUMMARY:

Texas Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the executive administrator of the Texas Water Development Board (TWDB) 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 (Part 2 of a two-part package of information from the TWDB to Real-Edwards Conservation and Reclamation District) fulfills the requirements noted above. Part 1 of the two-part package is the Historical Water Use/State Water Plan data report. The District will receive this data report from the TWDB Groundwater Technical Assistance Section. Questions about the data report can be directed to Mr. Stephen Allen, Stephen.Allen@twdb.texas.gov, (512) 463-7317.

The groundwater management plan for the Real-Edwards Conservation and Reclamation District should be adopted by the district on or before May 12, 2014 and submitted to the executive administrator of the TWDB on or before June 11, 2014. The current management plan for Real-Edwards Conservation and Reclamation District expires on August 10, 2014. This report discusses the methods, assumptions, and results from model runs using the groundwater availability model (version 1.01) for the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Anaya and Jones, 2009). Tables 1 and 2 summarize the groundwater availability model data required by the statute, and Figure 1 shows the area of the model from which the values in the tables were extracted. GAM Run 13-023 meets current standards. If after review of the figures, the Real-Edwards Conservation and Reclamation District determines that the district boundaries used in the assessment do not reflect current conditions, the District should notify the Texas Water Development Board immediately. Per statute, TWDB is required to provide the districts with data from the official groundwater availability models; however, the TWDB has also approved, for planning purposes, an alternative model that can have water budget information extracted for the district. The alternative model is the 1-layer alternative model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Hutchison and others, 2011). Please contact the author of this report if a comparison table using this model is desired.

METHODS:

In accordance with the provisions of the Texas Water Code, Section 36.1071, Subsection (h), the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers was run for this analysis. Real-Edwards Conservation and Reclamation District water budgets for the historical model periods were extracted using ZONEBUDGET Version 3.01 (Harbaugh, 2009) The average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow (upper), and net inter-aquifer flow (lower) 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) and Pecos Valley aquifers. See Anaya and Jones (2009) for assumptions and limitations of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers. The Pecos Valley Aquifer does not occur within the Real-Edwards Conservation and Reclamation District and, therefore, no groundwater budget values are included for it in this report.
- This groundwater availability model includes two layers within Real-Edwards Conservation and Reclamation District, which generally represent the Edwards Group (Layer 1) and the Trinity Group (Layer 2) of the Edwards-Trinity (Plateau) Aquifer. Individual water budgets for the District were determined for the Edwards-Trinity (Plateau) Aquifer (Layer 1 and Layer 2 combined).
- Water budgets for the Trinity Aquifer (Hill Country portion) were determined from layer 2.
- Within the Real-Edwards Conservation and Reclamation District, groundwater in the Edwards-Trinity (Plateau) Aquifer is fresh, with total dissolved solids of less than 500 milligrams per liter in all wells sampled by the TWDB from 2005 onwards. (TWDB Groundwater Database, queried in November 2013).
- 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 groundwater budget components listed below were extracted from the model results 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.

- Precipitation recharge—The areally-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 net vertical 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. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer.

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 a district or county boundary, 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 (Figure 1). Also, due to differences in water budget-computing methodologies, certain budget components such as recharge and aquifer leakage to streams are now different from those reported to the Real-Edwards Conservation and Reclamation District in the past.

TABLE 1: SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER THAT IS NEEDED FOR THE REAL-EDWARDS CONSERVATION AND RECLAMATION 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	75,382
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	41,232
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	25,004
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	79,007
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer into the Edwards-Trinity (Plateau) Aquifer	272

TABLE 2: SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER THAT IS NEEDED FOR THE REAL-EDWARDS CONSERVATION AND RECLAMATION 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	1,080
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	649
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	1,455
Estimated net annual volume of flow between each aquifer in the district	From the Trinity Aquifer into the Edwards-Trinity (Plateau) Aquifer	272

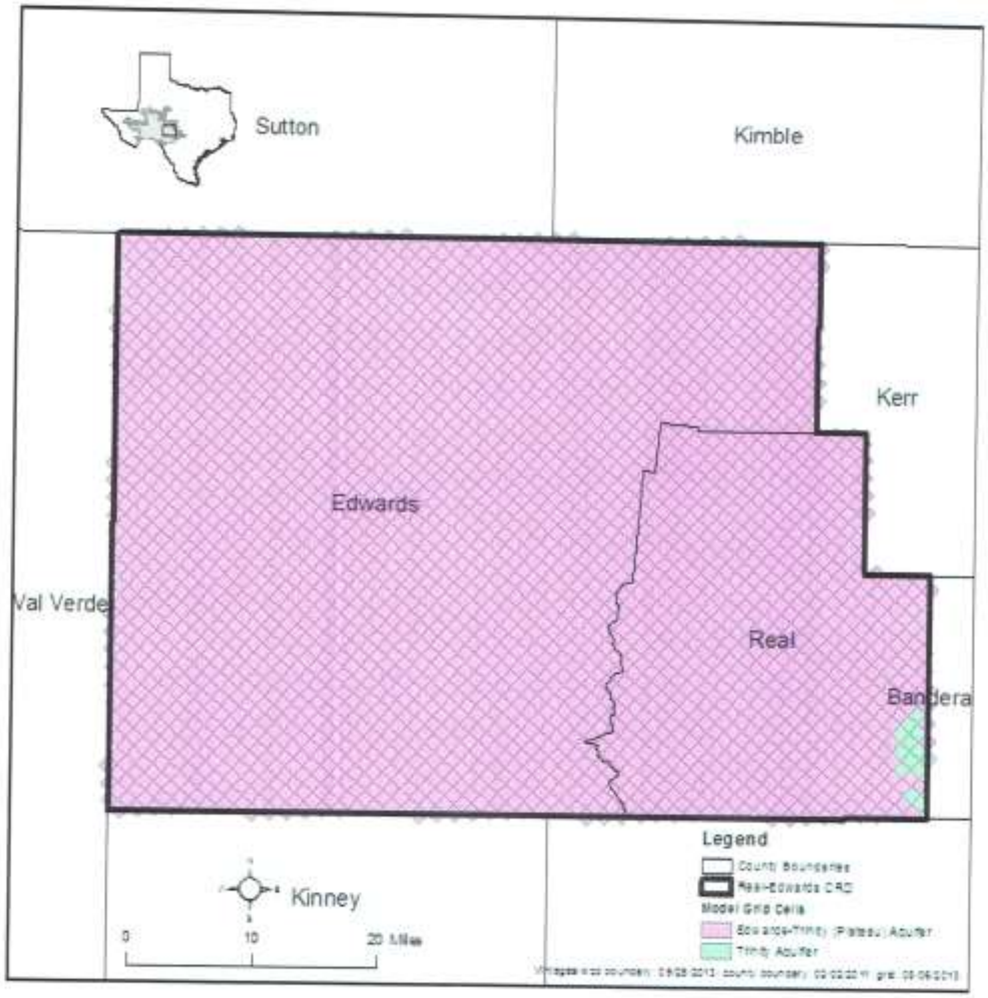

FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL (GAM) FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED FOR THE EXTENT OF THE EDWARDS-TRINITY (PLATEAU) AQUIFER. DATA FOR THE TRINITY (HILL COUNTRY PORTION) AQUIFER WITHIN THE DISTRICT BOUNDARY IS FOUND IN TABLE 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 interaction with streams are specific to particular historic time periods.

Because the application of the groundwater models was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations related 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.

REFERENCES:

Anaya, R., and Jones, I., 2009, Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers, 103 p., http://www.twdb.texas.gov/groundwater/models/gam/eddt_p/ET-Plateau_Full.pdf

Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models, U.S. Geological Survey Groundwater Software.

Harbaugh, A. W., and McDonald, M. G., 1996, User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference groundwater-water flow model: U.S. Geological Survey Open-File Report 96-485, 56 p.

Hutchison, W. R., Jones, I., and Anaya, R., 2011, Update of the Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas, 60 p., http://www.twdb.texas.gov/groundwater/models/alt/eddt_p_2011/alt1_eddt_p.asp

National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p.

TWDB Groundwater Database, 2013, Texas Water Development Board, http://www.twdb.texas.gov/groundwater/data/index.asp, queried November 2013.

Appendix 2

Estimated Historical Water Use
And 2012 State Water Plan Datasets:
Real-Edwards Conservation
And Reclamation District, February 12, 2014

Estimated Historical Water Use And 2012 State Water Plan Datasets:

Real-Edwards Conservation and Reclamation District

by Stephen Allen
Texas Water Development Board
Groundwater Resources Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
February 12, 2014

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/GMPChecklist0113.pdf

The five reports included in part 1 are:

1. Estimated Historical Water 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 Texas 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 up-to-date WUS and 2012 SWP data available as of 2/12/2014. Although it does not happen frequently, neither of these datasets are static so they are subject to change pending the availability of more accurate WUS data or an amendment to the 2012 SWP. District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The WUS dataset can be verified at this web address:

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

The 2012 SWP dataset can be verified by contacting Sabrina Anderson (sabrina.anderson@twdb.texas.gov or 512-936-0886).

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 Water Use

TWDB Historical Water Use Survey (WUS) Data

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2012. TWDB staff anticipates the calculation and posting of these estimates at a later date.

EDWARDS COUNTY

All values are in acre-fee/year

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2011	GW	397	0	13	0	257	427	1,094
	SW	0	0	1	0	61	47	109
2010	GW	269	0	30	0	33	434	766
	SW	0	0	4	0	133	48	185
2009	GW	334	0	27	0	0	469	830
	SW	0	0	4	0	121	52	177
2008	GW	355	0	24	0	57	471	907
	SW	0	0	4	0	60	52	116
2007	GW	291	0	0	0	104	281	676
	SW	0	0	0	0	23	31	54
2006	GW	352	0	0	0	359	353	1,064
	SW	0	0	0	0	58	39	97
2005	GW	352	0	0	0	347	417	1,116
	SW	0	0	0	0	53	47	100
2004	GW	310	0	0	0	315	121	746
	SW	0	0	0	0	63	318	381
2003	GW	292	0	0	0	137	122	551
	SW	0	0	0	0	188	324	512
2002	GW	341	0	0	0	202	126	669
	SW	0	0	0	0	0	334	334
2001	GW	380	0	0	0	130	143	653
	SW	0	0	0	0	0	377	377
2000	GW	369	0	0	0	160	450	979
	SW	0	0	0	0	0	112	112

REAL COUNTY

All values are in acre-fee/year

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2011	GW	575	0	0	0	203	209	987
	SW	136	0	0	0	122	52	310
2010	GW	529	0	0	0	95	202	826
	SW	136	0	0	0	148	51	335
2009	GW	515	0	1	0	0	106	622
	SW	136	0	0	0	166	27	329
2008	GW	513	0	1	0	54	101	669
	SW	0	0	1	0	348	25	374
2007	GW	442	0	0	0	0	114	556
	SW	0	0	0	0	160	29	189
2006	GW	498	0	0	0	308	101	907
	SW	0	0	0	0	0	25	25
2005	GW	466	0	0	0	100	128	694
	SW	0	0	0	0	100	32	132
2004	GW	413	0	0	0	78	80	571
	SW	0	0	0	0	97	56	153
2003	GW	418	0	0	0	18	82	518
	SW	0	0	0	0	282	59	341
2002	GW	409	0	0	0	24	93	526
	SW	0	0	0	0	144	67	211
2001	GW	425	0	0	0	24	92	541
	SW	0	0	0	0	144	66	210
2000	GW	434	0	0	0	23	140	597
	SW	303	0	0	0	120	36	459

Projected Surface Water Supplies
TWDB 2012 State Water Plan Data

EDWARDS COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	Source Name	2010	2020	2030	2040	2050	2060
J	IRRIGATION	COLORADO	SOUTH LLANO RIVER COMBINED RUN-OF-RIVER	43	43	43	43	43	43
J	IRRIGATION	NUECES	NUECES RIVER COMBINED RUN-OF-RIVER	138	138	138	138	138	138
J	IRRIGATION	NUECES	WEST NUECES RIVER COMBINED RUN-OF-RIVER	5	5	5	5	5	5
J	LIVESTOCK	COLORADO	OTHER LOCAL SUPPLY	61	61	61	61	61	61
J	LIVESTOCK	NUECES	OTHER LOCAL SUPPLY	62	62	62	62	62	62
	Sum of Projected Surface Water Supplies (acre-feet/year)			**309**	**309**	**309**	**309**	**309**	**309**

REAL COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	Source Name	2010	2020	2030	2040	2050	2060
J	CAMP WOOD	NUECES	OLD FAITHFUL SPRINGS RIVER RUN-OF-RIVER	0	0	0	0	0	0
J	COUNTY-OTHER	NUECES	NUECES RIVER COMBINED RUN-OF-RIVER	0	0	0	0	0	0
J	IRRIGATION	NUECES	FRIO RIVER COMBINED RUN-OF-RIVER	1,514	1,514	1,514	1,514	1,514	1,514
J	IRRIGATION	NUECES	NUECES RIVER COMBINED RUN-OF-RIVER	648	648	648	648	648	648
J	LIVESTOCK	COLORADO	OTHER LOCAL SUPPLY	24	24	24	24	24	24
J	LIVESTOCK	NUECES	OTHER LOCAL SUPPLY	25	25	25	25	25	25
	Sum of Projected Surface Water Supplies (acre-feet/year)			**2,211**	**2,211**	**2,211**	**2,211**	**2,211**	**2,211**

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.

EDWARDS COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
J	ROCKSPRINGS	COLORADO	174	179	172	164	160	154
J	COUNTY-OTHER	COLORADO	35	36	34	33	32	31
J	IRRIGATION	COLORADO	43	41	39	38	36	34
J	LIVESTOCK	COLORADO	175	175	175	175	175	175
J	MINING	COLORADO	89	89	89	89	89	89
J	IRRIGATION	NUECES	87	84	81	77	74	71
J	ROCKSPRINGS	NUECES	98	100	96	92	90	86
J	LIVESTOCK	NUECES	230	230	230	230	230	230
J	COUNTY-OTHER	NUECES	118	121	116	111	108	104
J	IRRIGATION	RIO GRANDE	23	22	21	20	19	18
J	LIVESTOCK	RIO GRANDE	157	157	157	157	157	157
J	COUNTY-OTHER	RIO GRANDE	20	20	19	19	18	17
	Sum of Projected Water Demands (acre-feet/year)		**1,249**	**1,254**	**1,229**	**1,205**	**1,188**	**1,166**

REAL COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
J	COUNTY-OTHER	COLORADO	11	11	11	10	11	11
J	LIVESTOCK	COLORADO	28	28	28	28	28	28
J	MINING	COLORADO	5	5	5	5	5	5
J	COUNTY-OTHER	NUECES	417	416	400	386	394	402
J	CAMP WOOD	NUECES	172	172	166	160	163	167
J	IRRIGATION	NUECES	392	377	361	346	330	314
J	LIVESTOCK	NUECES	148	148	148	148	148	148
	Sum of Projected Water Demands (acre-feet/year)		**1,173**	**1,157**	**1,119**	**1,083**	**1,079**	**1,075**

Projected Water Supply Needs
TWDB 2012 State Water Plan Data

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

EDWARDS COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
J	COUNTY-OTHER	COLORADO	86	85	87	88	89	90
J	COUNTY-OTHER	NUECES	327	324	329	334	337	341
J	COUNTY-OTHER	RIO GRANDE	52	52	53	53	54	55
J	IRRIGATION	COLORADO	53	55	57	58	60	62
J	IRRIGATION	NUECES	110	113	116	120	123	126
J	IRRIGATION	RIO GRANDE	30	31	32	33	34	35
J	LIVESTOCK	COLORADO	50	50	50	50	50	50
J	LIVESTOCK	NUECES	0	0	0	0	0	0
J	LIVESTOCK	RIO GRANDE	7	7	7	7	7	7
J	MINING	COLORADO	0	0	0	0	0	0
J	ROCKSPRINGS	COLORADO	148	143	150	158	162	168
J	ROCKSPRINGS	NUECES	82	80	84	88	90	94
	Sum of Projected Water Supply Needs (acre-feet/year)		**0**	**0**	**0**	**0**	**0**	**0**

REAL COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
J	CAMP WOOD	NUECES	-172	-172	-166	-160	-163	-167
J	COUNTY-OTHER	COLORADO	23	23	23	24	23	23
J	COUNTY-OTHER	NUECES	1,071	1,072	1,088	1,102	1,094	1,086
J	IRRIGATION	NUECES	2,119	2,134	2,150	2,165	2,181	2,197
J	LIVESTOCK	COLORADO	11	11	11	11	11	11
J	LIVESTOCK	NUECES	57	57	57	57	57	57
J	MINING	COLORADO	1	1	1	1	1	1
	Sum of Projected Water Supply Needs (acre-feet/year)		**-172**	**-172**	**-166**	**-160**	**-163**	**-167**

Projected Water Management Strategies
TWDB 2012 State Water Plan Data

EDWARDS 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, NUECES (J)							
ADDITIONAL GROUNDWATER WELLS	OTHER AQUIFER [EDWARDS]	17	17	17	17	17	17
CONSERVATION: PUBLIC INFORMATION	CONSERVATION [EDWARDS]	2	2	2	2	2	2
REPLACE PRESSURE TANK	OTHER AQUIFER [EDWARDS]	0	0	0	0	0	0
Sum of Projected Water Management Strategies (acre-feet/year)		**19**	**19**	**19**	**19**	**19**	**19**

REAL COUNTY

WUG, Basin (RWPG) — All values are in acre-feet/year

Water Management Strategy	Source Name [Origin]	2010	2020	2030	2040	2050	2060
CAMP WOOD, NUECES (J)							
CONSERVATION: PUBLIC INFORMATION	CONSERVATION [REAL]	2	2	2	2	2	2
GROUNDWATER WELLS	EDWARDS-TRINITY-PLATEAU AQUIFER [REAL]	172	172	172	172	172	172
COUNTY-OTHER, NUECES (J)							
ADDITIONAL GROUNDWATER WELLS	TRINITY AQUIFER [REAL]	205	205	205	205	205	205
CONSERVATION: SYSTEM WATER AUDIT AND WATER LOSS AUDIT	CONSERVATION [REAL]	20	20	20	20	20	20
Sum of Projected Water Management Strategies (acre-feet/year)		**399**	**399**	**399**	**399**	**399**	**399**

Appendix 3

GAM Run 10-043 (Version 2): Modeled Available Groundwater for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley Aquifers in Groundwater Management Area 7, November 12, 2012

GAM RUN 10-043 MAG (VERSION 2): MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU), TRINITY, AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7

by Jerry Shi, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-5076
November 12, 2012

The seal appearing on this document was authorized by Jianyou (Jerry) Shi, P.G. 11113 on November 12, 2012.

GAM RUN 10-043 MAG (VERSION 2): MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU), TRINITY, AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7

by Jerry Shi, Ph.D., P.G.
Texas Water Development Board
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November 12, 2012

EXECUTIVE SUMMARY:

The modeled available groundwater values for Groundwater Management Area 7 for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers are summarized in Table 1. These values are also listed by county (Table 2), river basin (Table 3), and regional water planning area (Table 3). The modeled available groundwater values for the relevant aquifers in Groundwater Management Area 7 were initially based on Scenario 10 of GAM Run 09-035. In GAM Run 09-035, the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers were simulated and reported together. Though the desired future condition statement, specifying an average drawdown of 7 feet, only explicitly references the Edwards-Trinity (Plateau) Aquifer, it is the intent of the districts to also incorporate the Trinity and Pecos Valley aquifers. This was confirmed by Ms. Caroline Runge of Menard Underground Water District acting on behalf of Groundwater Management Area 7 in an e-mail to Ms. Sarah Backhouse at the Texas Water Development Board on June 6, 2012. The results here, therefore, contain information for each of these three aquifers. The modeled available groundwater from the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers in Groundwater Management Area 7 that achieves the requested desired future conditions is approximately 449,400 acre-feet per year from 2010 to 2060.

Earlier draft versions of this report showed modeled available groundwater for portions of the Edwards-Trinity (Plateau) Aquifer within the Lipan-Kickapoo Water Conservation District, the Lone Wolf Groundwater Conservation District, the Hickory Underground Water Conservation District No. 1, and the portion of the Trinity Aquifer within the Uvalde Underground Water Conservation District. However, Groundwater Management Area 7 declared those counties "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 depict modeled available groundwater only in counties with specified desired future conditions.

The modeled available groundwater for Kinney County Groundwater Conservation District previously reported in Draft GAM Run 10-043 MAG (Shi and Oliver, 2011) dated January 26, 2011, has been updated in a new model run and is presented in this report. The new model run is an update of Scenario 3 of Groundwater Availability Modeling Task 10-027, which meets the desired future conditions for the area adopted by the districts of Groundwater Management Area 7.

REQUESTOR:

Mr. Allan Lange of Lipan-Kickapoo Water Conservation District on behalf of Groundwater Management Area 7.

DESCRIPTION OF REQUEST:

In a letter dated August 13, 2010, Mr. Lange provided the Texas Water Development Board (TWDB) with the desired future conditions of the Edwards-Trinity (Plateau) Aquifer in Groundwater Management Area 7. On June 6, 2012 TWDB clarified through e-mail with Ms. Caroline Runge of Menard Underground Water District acting on behalf of Groundwater Management Area 7 that the intent of the districts within Groundwater Management Area 7 was to also incorporate the Trinity and Pecos Valley aquifers, except where explicitly stated as non-relevant in the desired future conditions of the Edwards-Trinity (Plateau) Aquifer. The desired future conditions for the aquifer[s], as described in Resolution # 07-29-10-9 and adopted July 29, 2010 by the groundwater conservation districts within Groundwater Management Area 7, are described below:

1) An average drawdown of 7 feet for the Edwards-Trinity (Plateau)[, Pecos Valley, and Trinity] aquifer[s], except for the Kinney County [Groundwater Conservation District], based on Scenario 10 of the TWDB [Groundwater Availability Model] run 09-35 which is incorporated in its entirety into this resolution; and

2) In Kinney County, that drawdown which is consistent with maintaining, at Las Moras Springs, an annual average flow of 23.9 [cubic feet per second] and a median flow of 24.4 [cubic feet per second] based on Scenario 3 of the Texas Water Development Board's flow model presented on July 27, 2010; and

3) the Edwards-Trinity [Aquifer] is not relevant for joint planning purposes within the boundaries of the Lipan-Kickapoo [Water Conservation District], the Lone Wolf [Groundwater Conservation District], and the Hickory Underground Water Conservation District No. 1; and

4) the Trinity (Hill Country) portion of the aquifer is not relevant for joint planning purposes within the boundaries of the Uvalde [Underground Water Conservation District] in [Groundwater Management Area] 7.

METHODS, PARAMETERS AND ASSUMPTIONS:

The desired future condition for Kinney County was evaluated in a new model run (Shi and others, 2012). The new model run is an update of Scenario 3 of Groundwater Availability Modeling (GAM) Task 10-027 (Hutchison, 2010a). Both model runs were based on the MODFLOW-2000 model developed by the TWDB to assist with the joint planning process regarding the Kinney County Groundwater Conservation District (Hutchison and others, 2011b). In both model runs, the total pumping in Kinney County, which lies within Groundwater Management Areas 7 and 10, was maintained at approximately 77,000 acre-feet per year to achieve the desired future conditions at Las Moras Springs. Details regarding this new model run are summarized in Shi and others (2012).

The desired future condition for the remaining areas in Groundwater Management Area 7 was based on Scenario 10 of GAM Run 09-035 using a MODFLOW-2000 model developed by the TWDB (Hutchison and others, 2011a). Details regarding this scenario can be found in Hutchison (2010b). In GAM Run 09-035, the Edwards-Trinity (Plateau), Trinity, Pecos Valley, and Trinity aquifers were simulated and reported together. The desired future condition statement specifying of an average drawdown of 7 feet, which is achieved in the above simulation, only explicitly references the Edwards-Trinity (Plateau) Aquifer. By stating that the above simulation is "incorporated in its entirety" into the resolution, it is the intent of the districts to also incorporate the Trinity and Pecos Valley aquifers. The results below, therefore, contain information on the Trinity and Pecos Valley aquifers in addition to the Edwards-Trinity (Plateau) Aquifer. This interpretation has been confirmed by Ms. Caroline Runge on behalf of Groundwater Management Area 7 to Ms. Sarah Backhouse at the Texas Water Development Board.

The locations of the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers are shown in Figure 1.

RESULTS:

The modeled available groundwater values from aquifers in Groundwater Management Area 7 that achieve the desired future conditions is approximately 445,000 acre-feet per year for the Edwards-Trinity (Plateau) aquifer, 2,500 acre-feet per year for the Trinity Aquifer, and 1,600 acre-feet per year for the Pecos Valley Aquifer (Tables 1, 2, and 3). These tables contain the modeled available groundwater for the aquifers subdivided by county, regional water planning area, and river basin for use in the regional water planning process. These areas are shown in Figure 2.

Tables 4, 5, and 6 show the modeled available groundwater for the Edwards-Trinity (Plateau), Trinity, and Pecos Valley aquifers summarized by county, regional water planning area, and river basin, respectively, within Groundwater Management Area 7.

The modeled available groundwater for the aquifers within and outside the groundwater conservation districts in Groundwater Management Area 7 where they were determined to be relevant for the purposes of joint planning are presented in Table 7. As shown in Table 7, the modeled available groundwater within the groundwater conservation districts in Groundwater Management Area 7 is approximately 370,000 acre-feet per year from 2010 to 2060.

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.

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. Texas Water Development Board 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 groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with Texas Water Development Board to refine these 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:

Hutchison, William R., 2010a, GAM Task 10-027: Texas Water Development Board, GAM Task 10-027 Report, 7 p.

Hutchison, William R., 2010b, GAM Run 09-035 (version 2): Texas Water Development Board, GAM Run 09-035 Report, 10 p.

Hutchison, William R., Jones, Ian, and Anaya, Roberto, 2011a, Update of the Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas, Texas Water Development Board, 59 p.

Hutchison, William R., Shi, Jerry, and Jigmond, Marius, 2011b, Groundwater Flow Model of the Kinney County Area, Texas Water Development Board, 138 p.

Shi, Jerry, Ridgeway, Cindy, and French, Larry, 2012, Draft GAM Task Report 12-002: Modeled Available Groundwater in Kinney County (April 11, 2012).

Shi, Jerry and Oliver, Wade, 2011, GAM Run 10-043 MAG (January 26, 2011).

Texas Water Development Board, 2007, Water for Texas - 2007—Volumes I-III; Texas Water Development Board Document No. GP-8-1, 392 p.

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA 7. 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
Coke	F	Colorado	998	998	998	998	998	998
Crockett	F	Colorado	19	19	19	19	19	19
		Rio Grande	5,407	5,407	5,407	5,407	5,407	5,407
Ector	F	Colorado	4,918	4,918	4,918	4,918	4,918	4,918
		Rio Grande	504	504	504	504	504	504
Edwards	J	Colorado	2,306	2,306	2,306	2,306	2,306	2,306
		Nueces	1,632	1,632	1,632	1,632	1,632	1,632
		Rio Grande	1,700	1,700	1,700	1,700	1,700	1,700
Gillespie	K	Colorado	2,378	2,378	2,378	2,378	2,378	2,378
		Guadalupe	136	136	136	136	136	136
Glasscock	F	Colorado	65,213	65,213	65,213	65,213	65,213	65,213
Irion	F	Colorado	2,293	2,293	2,293	2,293	2,293	2,293
Kimble	F	Colorado	1,283	1,283	1,283	1,283	1,283	1,283
Kinney	J	Nueces	12	12	12	12	12	12
		Rio Grande	70,326	70,326	70,326	70,326	70,326	70,326
McCulloch	F	Colorado	4	4	4	4	4	4
Menard	F	Colorado	2,194	2,194	2,194	2,194	2,194	2,194
Midland	F	Colorado	23,251	23,251	23,251	23,251	23,251	23,251
Nolan	G	Brazos	302	302	302	302	302	302
		Colorado	391	391	391	391	391	391
Pecos	F	Rio Grande	115,938	115,938	115,938	115,938	115,938	115,938
Reagan	F	Colorado	68,250	68,250	68,250	68,250	68,250	68,250
		Rio Grande	28	28	28	28	28	28
Real	J	Colorado	278	278	278	278	278	278
		Guadalupe	3	3	3	3	3	3
		Nueces	7,196	7,196	7,196	7,196	7,196	7,196
Schleicher	F	Colorado	6,410	6,410	6,410	6,410	6,410	6,410
		Rio Grande	1,640	1,640	1,640	1,640	1,640	1,640
Sterling	F	Colorado	2,497	2,497	2,497	2,497	2,497	2,497
Sutton	F	Colorado	386	386	386	386	386	386
		Rio Grande	6,052	6,052	6,052	6,052	6,052	6,052

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA 7. 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
Taylor	G	Brazos	331	331	331	331	331	331
		Colorado	158	158	158	158	158	158
Terrell	E	Rio Grande	1,421	1,421	1,421	1,421	1,421	1,421
Tom Green	F	Colorado	426	426	426	426	426	426
Upton	F	Colorado	21,257	21,257	21,257	21,257	21,257	21,257
		Rio Grande	1,122	1,122	1,122	1,122	1,122	1,122
Uvalde	L	Nueces	1,635	1,635	1,635	1,635	1,635	1,635
Val Verde	J	Rio Grande	24,988	24,988	24,988	24,988	24,988	24,988
Grand Total			**445,283**	**445,283**	**445,283**	**445,283**	**445,283**	**445,283**

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE TRINITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 7. 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
Gillespie	K	Colorado	2,482	2,482	2,482	2,482	2,482	2,482
Real	J	Nueces	52	52	52	52	52	52
Total			**2,534**	**2,534**	**2,534**	**2,534**	**2,534**	**2,534**

TABLE 3. MODELED AVAILABLE GROUNDWATER FOR THE PECOS VALLEY AQUIFER IN GROUNDWATER MANAGEMENT AREA 7. 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
Crockett	F	Rio Grande	31	31	31	31	31	31
Ector	F	Rio Grande	113	113	113	113	113	113
Pecos	F	Rio Grande	1,448	1,448	1,448	1,448	1,448	1,448
Upton	F	Rio Grande	2	2	2	2	2	2
Total			**1,594**	**1,594**	**1,594**	**1,594**	**1,594**	**1,594**

TABLE 4. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU), TRINITY, AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 BY COUNTY FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

County	2010	2020	2030	2040	2050	2060
Coke	998	998	998	998	998	998
Crockett	5,457	5,457	5,457	5,457	5,457	5,457
Ector	5,535	5,535	5,535	5,535	5,535	5,535
Edwards	5,638	5,638	5,638	5,638	5,638	5,638
Gillespie	4,996	4,996	4,996	4,996	4,996	4,996
Glasscock	65,213	65,213	65,213	65,213	65,213	65,213
Irion	2,293	2,293	2,293	2,293	2,293	2,293
Kimble	1,283	1,283	1,283	1,283	1,283	1,283
Kinney	70,338	70,338	70,338	70,338	70,338	70,338
Mcculloch	4	4	4	4	4	4
Menard	2,194	2,194	2,194	2,194	2,194	2,194
Midland	23,251	23,251	23,251	23,251	23,251	23,251
Nolan	693	693	693	693	693	693
Pecos	117,386	117,386	117,386	117,386	117,386	117,386
Reagan	68,278	68,278	68,278	68,278	68,278	68,278
Real	7,529	7,529	7,529	7,529	7,529	7,529
Schleicher	8,050	8,050	8,050	8,050	8,050	8,050
Sterling	2,497	2,497	2,497	2,497	2,497	2,497
Sutton	6,438	6,438	6,438	6,438	6,438	6,438

TABLE 4. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU), TRINITY, AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 BY COUNTY FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

County	2010	2020	2030	2040	2050	2060
Taylor	489	489	489	489	489	489
Terrell	1,421	1,421	1,421	1,421	1,421	1,421
Tom Green	426	426	426	426	426	426
Upton	22,381	22,381	22,381	22,381	22,381	22,381
Uvalde	1,635	1,635	1,635	1,635	1,635	1,635
Val Verde	24,988	24,988	24,988	24,988	24,988	24,988
Total	**449,411**	**449,411**	**449,411**	**449,411**	**449,411**	**449,411**

TABLE 5. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU), TRINITY, AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 BY REGIONAL WATER PLANNING AREA 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
E	1,421	1,421	1,421	1,421	1,421	1,421
F	331,684	331,684	331,684	331,684	331,684	331,684
G	1,182	1,182	1,182	1,182	1,182	1,182
J	108,493	108,493	108,493	108,493	108,493	108,493
K	4,996	4,996	4,996	4,996	4,996	4,996
L	1,635	1,635	1,635	1,635	1,635	1,635
Total	**449,411**	**449,411**	**449,411**	**449,411**	**449,411**	**449,411**

TABLE 6. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU), TRINITY, AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 BY RIVER BASIN FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

River Basin	Year					
	2010	2020	2030	2040	2050	2060
Brazos	633	633	633	633	633	633
Colorado	207,392	207,392	207,392	207,392	207,392	207,392
Guadalupe	139	139	139	139	139	139
Nueces	10,527	10,527	10,527	10,527	10,527	10,527
Rio Grande	230,720	230,720	230,720	230,720	230,720	230,720
Total	**449,411**	**449,411**	**449,411**	**449,411**	**449,411**	**449,411**

TABLE 7. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU), TRINITY, AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 BY GROUNDWATER CONSERVATION DISTRICT FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Coke County UWCD	998	998	998	998	998	998
Crockett County GCD	4,685	4,685	4,685	4,685	4,685	4,685
Glasscock GCD	106,075	106,075	106,075	106,075	106,075	106,075
Hill Country UWCD	4,996	4,996	4,996	4,996	4,996	4,996
Irion County WCD	2,435	2,435	2,435	2,435	2,435	2,435
Kimble County GCD	1,283	1,283	1,283	1,283	1,283	1,283
Kinney County GCD	70,338	70,338	70,338	70,338	70,338	70,338
Menard County UWD	2,194	2,194	2,194	2,194	2,194	2,194
Middle Pecos GCD	117,386	117,386	117,386	117,386	117,386	117,386
Plateau UWC and SD	8,050	8,050	8,050	8,050	8,050	8,050
Real-Edwards CRD	13,167	13,167	13,167	13,167	13,167	13,167
Santa Rita UWCD	27,416	27,416	27,416	27,416	27,416	27,416
Sterling County UWCD	2,497	2,497	2,497	2,497	2,497	2,497
Sutton County UWCD	6,438	6,438	6,438	6,438	6,438	6,438
Uvalde County UWCD (Edwards-Trinity Plateau)	1,635	1,635	1,635	1,635	1,635	1,635
Wes-Tex GCD	693	693	693	693	693	693

TABLE 7. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU), TRINITY, AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 BY GROUNDWATER CONSERVATION DISTRICT FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Total (areas in districts relevant for joint planning)	**370,286**	**370,286**	**370,286**	**370,286**	**370,286**	**370,286**
No District	79,125	79,125	79,125	79,125	79,125	79,125
Total (all areas)	**449,411**	**449,411**	**449,411**	**449,411**	**449,411**	**449,411**

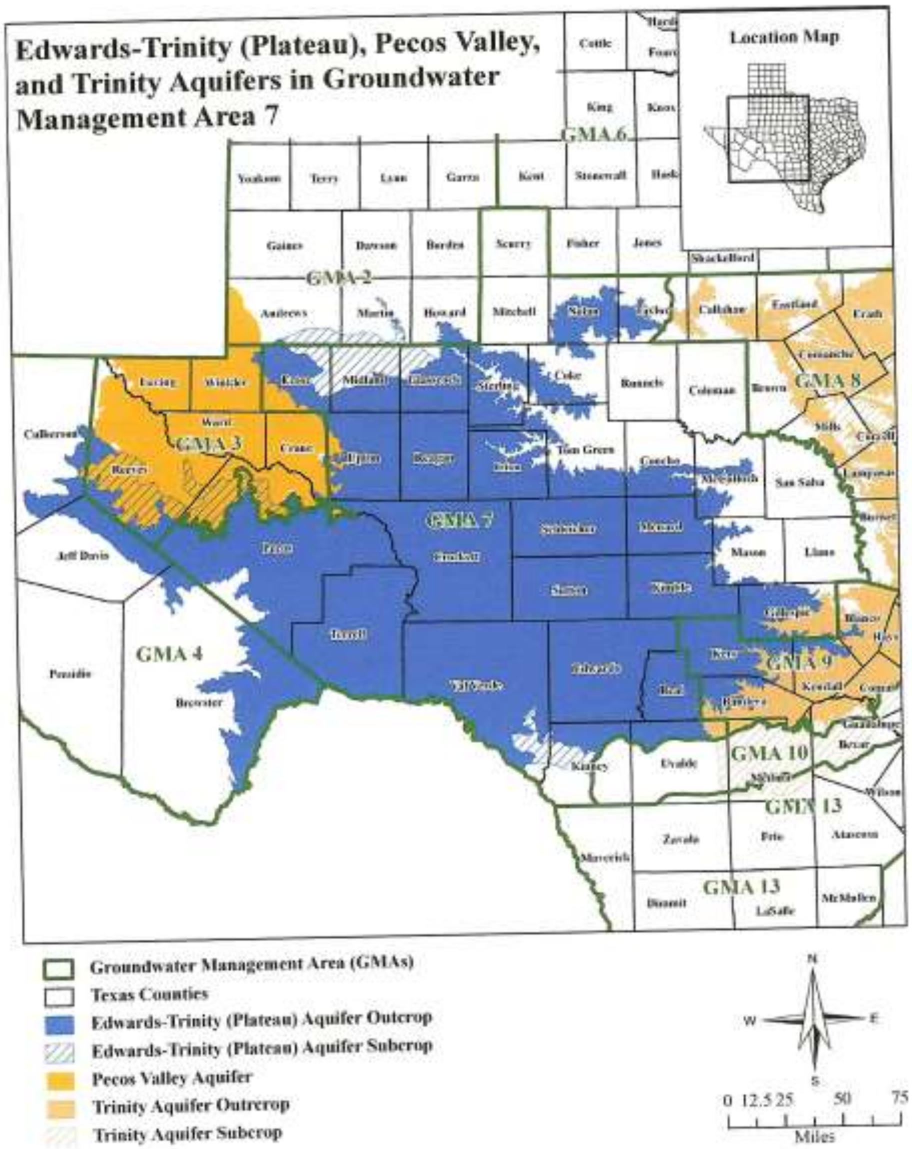


FIGURE 1. MAP SHOWING THE BOUNDARY OF THE EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS ACCORDING TO THE 2007 STATE WATER PLAN (TWDB, 2007).

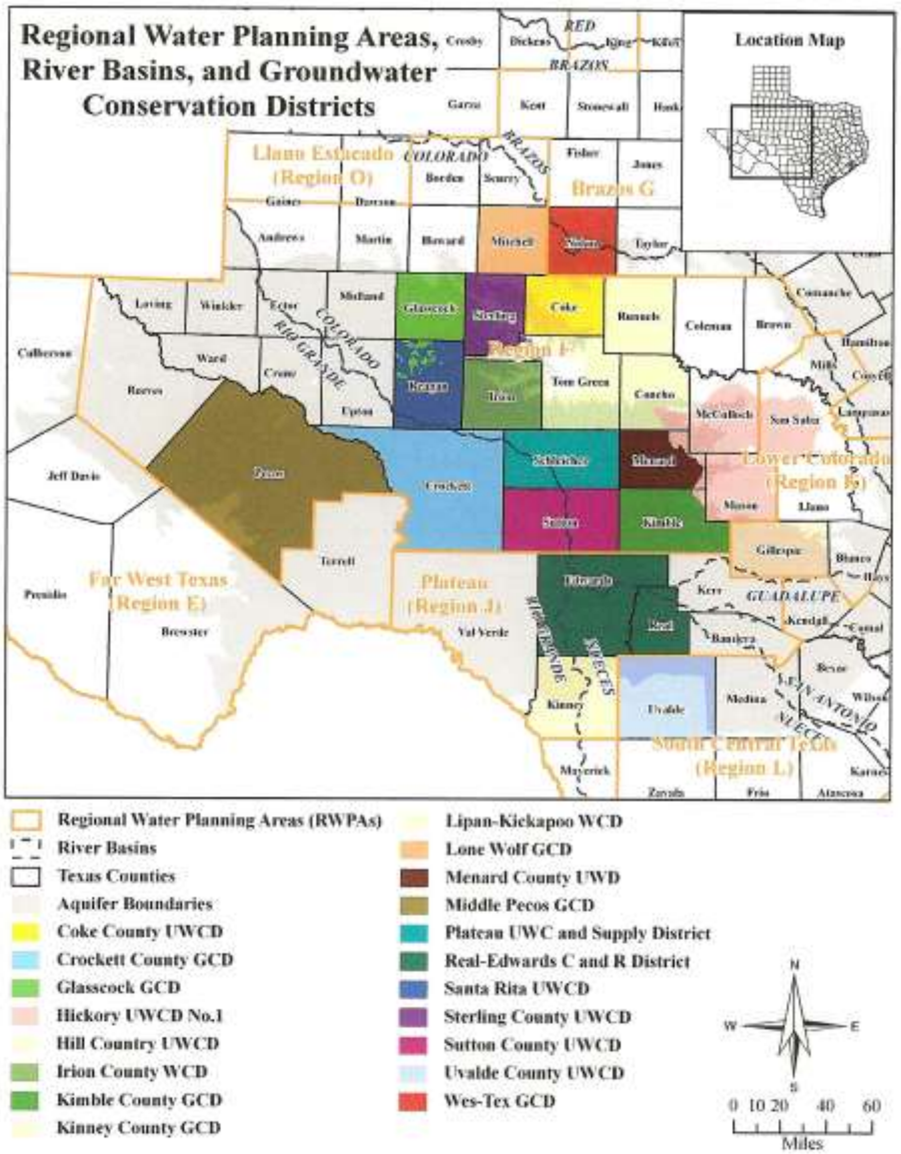


FIGURE 2. MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS, COUNTIES, AND RIVER BASINS IN AND NEIGHBORING GROUNDWATER MANAGEMENT AREA 7.

Appendix 4

Water Use by Livestock and Game Animals in the Plateau Regional Planning Area, Plateau Region Water Plan, January 2011

Water Use by Livestock and Game Animals in the Plateau Regional Water Planning Area

Jeremy Rice & Jon Albright – Freese and Nichols

April 28, 2010

Introduction

Hunting is a large part of the economy in the Plateau Region. In some cases hunting has replaced traditional livestock as the primary source of income for ranches. In addition to native species, some ranches have imported exotic game animals for their hunting clients. These exotic species are usually confined by high fencing. The high fencing limits access by both the native and non-native animals to natural sources of water, creating greater reliance on pumped groundwater to support these species. In addition, some of these exotic game animals, most notably axis deer, have escaped and established large free-roaming populations throughout the area. Feral hogs, which have originated either as escaped domestic hogs or European wild hogs imported for hunting, have large populations in the region as well.

The Plateau Regional Water Planning group is concerned that the water use for game species is not included in the regional plan. These species are similar to livestock in that they provide considerable economic benefit to the region. Ranchers develop groundwater supplies to provide water for confined exotic species as well as to attract native species. Preliminary estimates of water use by exotic animals show that these animals use about the same amount of water as more conventional livestock species.

This memorandum describes:

- Methods used by the Texas Water Development Board (TWDB) to determine water use and projected demands for traditional livestock
- Trends in water use for traditional livestock
- Available data on the population and water use by game species in the Plateau Region

Changes to the livestock demand projections for the region are not recommended at this time. However, the Plateau Regional Water Planning Group may wish to consider revisions in the next round of regional water planning. More complete data on animal populations in each county will be needed to develop these projections.

Historical and Projected Livestock Water Use in the Plateau Region

Table 1 shows the historical and projected use for livestock in the Plateau Region from the Texas Water Development Board (TWDB). The projected water demands are equal to the year 2000 historical use and remain the same throughout the planning period. Livestock water use was about 6 percent of the total historical water use in the Plateau Region in 2007. (At this time, 2007 is the last year of complete historical water use available for the Plateau Region.)

Table 1
Historical and Projected Livestock Use in the Plateau Region from the Texas Water Development Board
(Values in Acre-Feet per Year)

Historical							
Year	Bandera County	Edwards County	Kerr County	Kinney County	Real County	Val Verde County	Region Total
1974	427	1,311	1,012	780	329	1,223	5,082
1980	376	1,011	535	618	267	1,053	3,860
1984	319	510	442	482	227	471	2,451
1985	284	513	407	468	210	495	2,377
1986	265	443	306	567	226	545	2,352
1987	283	486	337	632	225	596	2,559
1988	331	552	390	680	235	687	2,875
1989	327	549	384	620	234	678	2,792
1990	325	552	382	624	232	691	2,806
1991	333	600	399	648	244	749	2,973
1992	333	615	526	675	174	663	2,986
1993	312	595	488	592	139	676	2,802
1994	361	603	492	553	182	592	2,783
1995	362	596	473	536	180	565	2,712
1996	294	426	432	465	128	534	2,279
1997	275	424	448	391	144	465	2,147
1998	288	473	428	346	143	599	2,277
1999	346	568	501	404	156	733	2,708
2000	315	562	487	445	176	767	2,752
2001	314	520	450	419	158	773	2,634
2002	278	460	415	387	160	687	2,387
2003	241	446	415	285	141	590	2,118
2004	253	439	414	309	136	533	2,084
2005	263	463	369	331	160	516	2,102
2006	263	391	385	298	127	497	1,961
2007	279	312	385	272	143	437	1,828

Projected							
Year	Bandera County	Edwards County	Kerr County	Kinney County	Real County	Val Verde County	Region Total
2000	315	562	487	445	176	767	2,752
2010	315	562	487	445	176	767	2,752
2020	315	562	487	445	176	767	2,752
2030	315	562	487	445	176	767	2,752
2040	315	562	487	445	176	767	2,752
2050	315	562	487	445	176	767	2,752
2060	315	562	487	445	176	767	2,752

TWDB calculates historical livestock water use by multiplying the number of livestock animal units by the estimated water needs for each type of animal. The Natural Resources Conservation Service *National Range and Pasture Handbook* defines an animal unit as "one mature cow of approximately 1,000 pounds and a calf up to weaning, usually 6 months of age, or their equivalent." Animal units can be used to estimate the amount of water or feed needed in livestock operations. One animal unit can represent many individual animals. For example, 1,000 hens is one animal unit.

Table 2 shows the historical animal units from 2003 to 2007, as provided by TWDB. TWDB obtains the number of animal units from the United States Department of Agriculture (USDA). Cattle, sheep, goats and horses are the dominant types of livestock in the Plateau Region. Table 3 shows the water use factors used by TWDB to develop historical water use data.

Trends in Livestock Water Use

Figure 1 compares the historical to projected livestock water use for the region. There is a significant decline in water use between 1974 and 1984, and a slight downward trend since 1984. The estimated year 2007 livestock water use is about 37 percent of the 1974 water use and about 66 percent of the projected livestock water used for planning. This trend is probably the result of the reduction of traditional ranching as a source of income in the region.

Exotic Game Animal Water Use

Numerous exotic game species have been introduced into the Plateau Region. These species were primarily introduced for hunting, which has become a significant source of income in the region. Many of these species are confined in high fenced areas. These animals are essentially equivalent to other types of livestock kept on ranches for commercial purposes. Some of these species have escaped confined operations and have become established throughout the region. Species such as axis deer can out-compete native deer for food. As a result there are now large free-roaming populations of axis deer in addition to the confined populations.

Because many of these species are kept in confined areas, access to natural sources of water may be limited. As a result, groundwater is used as a water source for the commercial herds. Other ranches that are not confined may supplement natural water sources with groundwater to attract game species and improve hunting. The Plateau Regional Water Planning Group believes that, because hunting is a major commercial activity in the area, water use by game species should be considered in regional water planning.

Although not considered a game species, feral hogs have also established significant populations in the region. These hogs originated as domestic hogs or imported European wild hogs. Because there are so many of these animals, water use by feral hogs is significant as well.

Table 2
Historical Livestock Animal Units in the Plateau Region Years 2003 to 2007

Year	County	Cattle	Hogs	Sheep	Goats	Broilers	Horses	*County Total*
2003	Bandera	11,000	0	8,100	11,000	0	2,465	*32,565*
	Edwards	16,000	438	37,000	67,000	0	3,797	*124,235*
	Kerr	20,000	0	13,000	21,000	0	2,828	*56,828*
	Kinney	11,000	0	23,000	22,000	249	2,491	*58,740*
	Real	7,000	0	4,200	10,000	0	534	*21,734*
	Val Verde	15,000	0	108,000	42,000	0	5,396	*170,396*
	Category Total	*80,000*	*438*	*193,300*	*173,000*	*249*	*17,511*	*464,498*
2004	Bandera	12,000	0	5,500	11,000	0	2,465	*30,965*
	Edwards	16,000	0	35,000	73,000	0	3,797	*127,797*
	Kerr	20,000	0	12,000	21,000	0	2,828	*55,828*
	Kinney	13,000	0	18,000	21,000	257	2,491	*54,748*
	Real	7,000	0	2,100	9,000	0	534	*18,634*
	Val Verde	14,000	0	90,000	41,000	0	5,396	*150,396*
	Category Total	*82,000*	*0*	*162,600*	*176,000*	*257*	*17,511*	*438,368*
2005	Bandera	12,000	0	5,000	11,000	0	3,252	*31,252*
	Edwards	17,000	0	36,000	77,000	0	4,022	*134,022*
	Kerr	18,000	0	12,000	22,000	0	2,054	*54,054*
	Kinney	15,000	0	17,000	24,000	0	2,054	*58,054*
	Real	7,000	0	2,300	8,000	3	2,396	*19,699*
	Val Verde	11,000	0	91,000	43,000	0	7,702	*152,702*
	Category Total	*80,000*	*0*	*163,300*	*185,000*	*3*	*21,480*	*449,783*
2006	Bandera	12,000	0	4,900	12,000	0	3,252	*32,152*
	Edwards	13,000	0	34,000	75,000	0	4,022	*126,022*
	Kerr	19,000	0	12,000	21,000	0	2,054	*54,054*
	Kinney	13,000	0	17,000	24,000	0	2,054	*56,054*
	Real	5,000	0	2,500	8,500	3	2,396	*18,399*
	Val Verde	10,000	0	89,000	46,000	0	7,702	*152,702*
	Category Total	*72,000*	*0*	*159,400*	*186,500*	*3*	*21,480*	*439,383*
2007	*Bandera*	*13,000*	*0*	*4,600*	*11,000*	*0*	*3,252*	*31,852*
	Edwards	9,000	0	30,000	70,000	0	4,022	*113,022*
	Kerr	19,000	0	12,000	20,000	0	2,054	*53,054*
	Kinney	12,000	0	13,000	24,000	0	2,054	*51,054*
	Real	6,000	0	2,200	8,500	14	2,396	*19,110*
	Val Verde	7,000	0	85,000	45,000	0	7,702	*144,702*
	Category Total	66,000	0	146,800	178,500	14	21,480	*412,794*

* Data are from the Texas Water Development Board

Table 3
TWDB Livestock Water Use Factors

Livestock Type	Water Needs (gallons per animal unit)
Dairy Cattle	75
Fed Cattle	15
Other Cattle	15
Hogs & Pigs	11
Sheep	2
Goats	0.5
Hens (thousand)*	90
Broilers (thousand)*	15
Horses	12

* For poultry 1 animal unit equals 1,000 birds

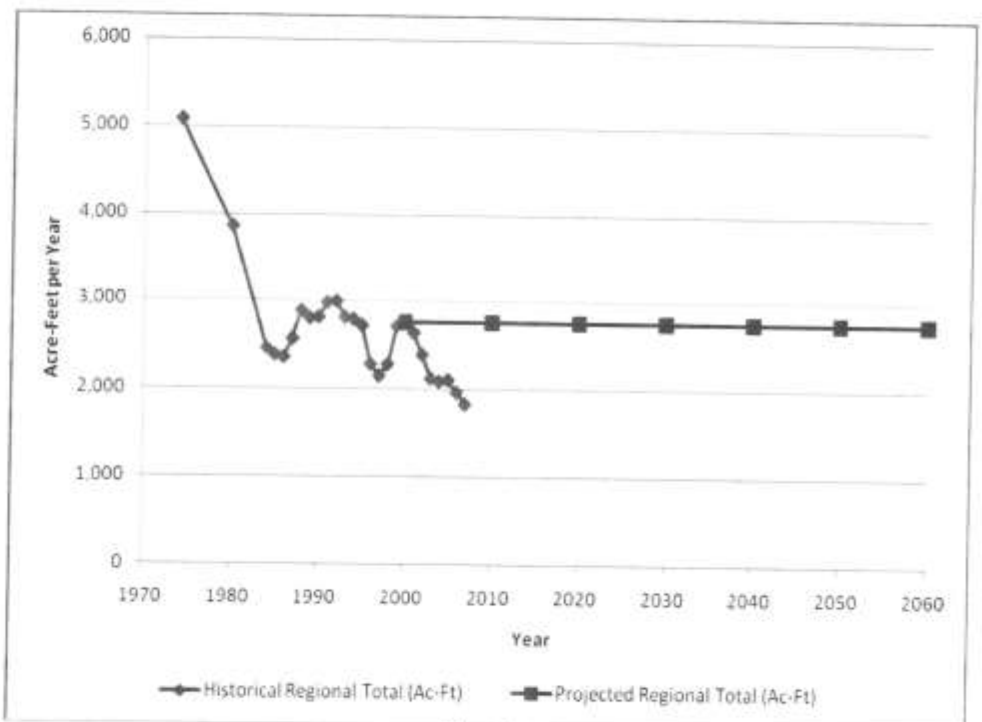


Figure 1
Historical and Projected Livestock Water Use for the Plateau Region

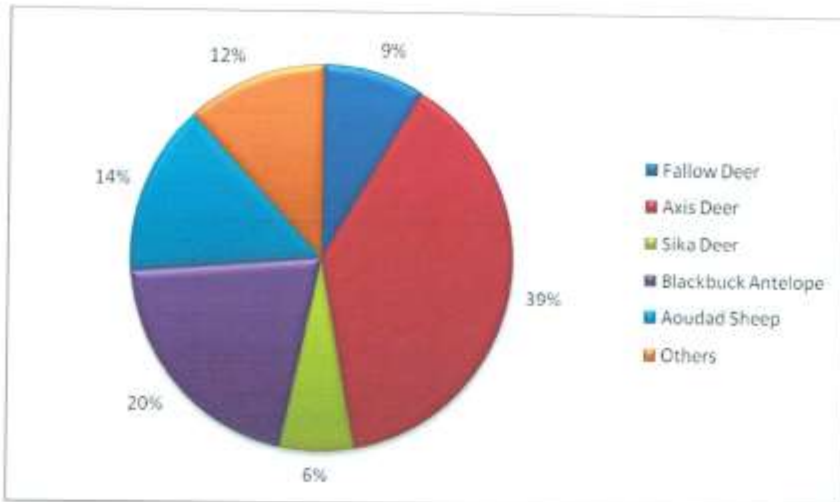
A four-step methodology was developed to determine the water used by game species and feral hogs:

1. Select dominant species
2. Determine water use per animal
3. Estimate population
4. Multiply population by water use per animal.

In the mid 1990s two surveys were conducted on the populations of exotic game animals in Texas. In 1995 the Texas Parks and Wildlife Department (TPWD) conducted a statewide census of exotic big game animals. TPWD reported these data for each county. The second survey was conducted in 1996 by the Texas Agricultural Statistics Service and the Exotic Wildlife Association. In this survey the state was divided into four regions. Figure 2 shows that the Plateau Regional Planning Area falls in Region 3 in this survey. Since Region 3 is a large area it is difficult to apply the results to the Plateau Region. FNI was unable to locate more recent surveys of exotic game species.

Figure 2
Texas Agricultural Statistics Service and the Exotic Wildlife Associations Survey Regions

According to the 1995 TPWD survey, the dominant species in the Plateau Region were axis deer, aoudad sheep, blackbuck antelope, fallow deer, and sika deer. Figure 3 shows the percentage of these animals compared to the overall population of exotic game species in the Plateau Region.



Data are from the 1995 TPWD Statewide Census of Exotic Big Game Animals.

Figure 3
Percentage of Exotic Game Species in the Plateau Region from 1995 TPWD Survey

Data on water use by these exotic game animals are not readily available. According to Dr. Fred Bryant of Texas A&M – Kingsville and Dr. Urs Kreuter of Texas A&M - College Station, water use by exotic game is proportional to the weight of the animal. Dr. Bryant recommends using 0.005 gal/day/lb and Dr. Kreuter recommends using 0.008 gal/day/lb. These water use factors can be multiplied by the average weight of exotic species to estimate gallons per animal per day. Average weights for exotic species were determined from the *Mammals of Texas Online Edition*. Table 4 shows the estimated average weight and water needs for exotic game using both factors.

Table 4
Exotic Game Average Adult Weight and Range of Estimated Water Needs

Species	Average Adult Weight (lbs)	Estimated Water Needs (gallons per animal per day)	
		@ 0.005 gal/day/animal	@ 0.008 gal/day/animal
Fallow Deer	132	0.7	1.1
Axis Deer	173	0.9	1.4
Sika Deer	175	0.9	1.4
Blackbuck Antelope	72	0.4	0.6
Aoudad Sheep	231	1.2	1.8

The only comprehensive sources of exotic species population data are the two surveys conducted in the mid 1990s. TPWD and other agencies no longer collect data on exotic game species, so more recent data are not readily available. Mr. Ray Aguirre, a TPWD biologist in Kerr County, estimates that there are 8,000-10,000 axis deer in Kerr County and 6,000 axis deer in Bandera and Real Counties. Ryan Schmidt, a TPWD biologist in Edwards County, estimates that in Edwards County there is one white tail deer for every 11 to 15 acres, one axis deer for every 20 acres, and 1 feral hog for every 10 acres. Lee Sweeten of the Real Edwards Conservation and Reclamation District (RECRD) provided both population and water use estimates for game species and feral hogs in Edwards and Real Counties (Tables 5 and 6). Mr. Sweeten estimates 602 acre-feet of water use by exotics in Edwards County and 233 acre-feet in Real County. The projected demands for traditional livestock in these counties are 562 and 176 acre-feet per year, respectively. These estimates show that including exotic species could more than double livestock water use projections in these counties.

Table 5
RECRD Exotic Species Estimates for Edwards County

Edwards County	Estimated Number	Gallons per Day	Gallons per Year	Acre Feet per Year
White Tail	106,899	106,899	39,045,004	120
Axis	67,840	138,723	50,668,559	156
Feral Hog	135,680	281,282	102,738,093	315
Black Buck	4,500	3,681	1,344,390	4
Elk	500	4,499	1,643,143	5
Other	1,500	1,840	672,195	2
Totals	*316,919*	*536,924*	*196,111,384*	*602*

Table 6
RECRD Exotic Species Estimates for Real County

Real County	Estimated Number	Gallons per Day	Gallons per Year	Acre Feet per Year
White Tail	44,800	44,800	16,363,200	50
Axis	29,867	61,073	22,306,913	68
Feral Hog	44,800	92,876	33,922,955	104
Black Buck	2,500	2,045	746,883	2
Elk	500	4,499	1,643,143	5
Other	2,000	2,454	896,260	3
Totals	*124,467*	*207,746*	*75,879,354*	*233*

Conclusions

- The water use projections for traditional livestock may be higher than the actual livestock needs in the region. The Plateau Region may wish to monitor livestock population data to see if the downward trend in livestock populations continues.
- Water use by game species can be estimated using techniques similar to those employed by TWDB in estimating traditional livestock water use. However, at this time there are insufficient data on the number of animals in the region to make these estimates. Additional information on exotic game populations will be required if the Plateau Region wishes to include this water use in regional planning.

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Appendix 5

Occurrence of Significant River Alluvium Aquifers in the Plateau Region, Plateau Region Water Plan, January 2011

Occurrence of Significant River Alluvium Aquifers in the Plateau Region

Prepared for:

Plateau Region Water Planning Group
and
Texas Water Development Board

January 2010

LBG-Guyton Associates

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1.0 Occurrence of River Alluvium in the Plateau Region

1.1 Introduction

The Plateau Region contains five river basins, four of which represent the headwaters of these rivers or their tributaries. Variable widths and thicknesses of floodplain deposits, or alluvium, are characteristic of these stream courses. Figure 1 illustrates the extent of all river alluvium in the Plateau Region. The Plateau Region Water Planning Group recognizes that river alluvium aquifers have not been adequately documented in the Plateau Regional Water Plan. The previous Plan published in 2006 recognized only the Frio River Alluvium Aquifer in Real County and estimated its water supply availability as a factor of recharge over a limited portion of the alluvial outcrop area.

This current study evaluates all river alluviums throughout the Region except in Val Verde County. River alluviums that were found to contain a viable aquifer were further analyzed to estimate reasonable and quantifiable annual water supply availability. Availability volumes that are considered relevant by the residing groundwater conservation district will be provided in the appropriate Chapter 3 tables of the 2011 Plateau Region Water Plan.

1.2 Origin and Hydrologic Characteristics

Precipitation runoff moves rapidly down gradient from the highlands of the Edwards Plateau. As the surface water gravity flows to the east and south, the various riverbeds continuously erode deeper into the Edwards limestone formations creating along the way spectacular canyons and relatively narrow floodplains. Once the streambed has incised through the Edwards and exposed the underlying Trinity - Glen Rose Limestone, the gradient of the river lessens. With a slower rate of flow, the active riverbed may meander from side to side, thus creating an ever-widening floodplain relative to the upstream canyons. Periods of intense rainfall often cause the rivers to overspill their banks with sediment-laden floodwaters that continuously contribute to the thickness of the developing floodplain. These floodplain deposits ranging in size from silt to gravel are collectively referred to as river alluvium.

Water in the form of rainfall, surface runoff from adjacent highlands, and occasional flood overflows percolate downward into the alluvial sediments where it generally moves slowly through the floodplain system, eventually draining to the river where it contributes to the base flow of the river. This captured groundwater may accumulate in sufficient volumes to be considered a viable aquifer capable of supplying water to wells. However, due to the relatively thin nature of the water-bearing thickness, alluvial aquifers generally produce only low to moderate yields to wells.

1.3 Methodology

The evaluation of river alluviums entailed two phases, the consideration of the existence of groundwater in all river alluviums and the quantification of groundwater availability in those river alluviums that were considered to contain a viable aquifer. The potential for the existence of groundwater in sufficient quantities to allow flow to wells was evaluated based on the compilation and evaluation of recorded well data from: 1) wells listed in the TWDB groundwater database and retrieval through the Board's WIID system; 2) drillers logs also retrievable from the TWDB WIID system; and 3) well data housed with local groundwater conservation districts. All identified wells located within a mile of the river channels were placed on surface geologic maps (GAT sheets). The wells were then evaluated based on location in reference to a floodplain area, on well depth, and on driller's lithologic descriptions. The number of wells considered to be producing from alluvial aquifers in each river basin are listed in Table 1. Driller's lithologic log descriptions were also used to compute the average depth to the base of alluvial sediments.

Table 1. Alluvial Wells Used for Analysis per Basin

Basin	Well Count
Guadalupe	7
Medina	0
Sabinal	2
South Llano	0
West Nueces	4
Nueces	29
Frio	55 with locations
	158 RECRD database

In addition, managers of the Bandera County River Authority and Groundwater District, the Headwaters Groundwater Conservation District, and the Real-Edwards Conservation and Reclamation District were interviewed in regard to their knowledge of existing wells completed in the alluvial systems within their respective districts. Based on the above evaluation, only the Guadalupe, Nueces, and Frio River Alluviums were considered to contain viable aquifers.

Phase Two provided the quantification of annual groundwater availability from the three alluvial aquifers. The quantification process required certain assumptions. Due to the potential variable nature of these assumptions, other researchers could reach different conclusions. Two basic assessments are made for each aquifer, water in storage and recharge.

Water in storage within the aquifer is based on area of significant alluvial outcrop times the average saturated thickness times a specific yield of 15 percent. The area of significant alluvial outcrop is arbitrarily set at 70 percent of the total area of alluvial outcrop for the Guadalupe and Nueces Alluviums and 90 percent for the Frio Alluvium. Average saturated thickness is the average depth to the base of the lowest gravel layer in the alluvium minus the average depth to groundwater.

To test the assumption that only a portion (70-90 percent) of the total outcrop area contains sufficient volumes of water such that leakage to the river occurs, gain-loss study data were reviewed to determine stretches of the Frio River that appear to be receiving inflow from the adjacent alluvium. As can be seen in Figure 8, the data illustrates that the river is losing flow to the underlying bedrock in the upper two branches above Leakey where the alluvium coverage is narrow. From the confluence of the two upper branches downstream to the southern county line, the data shows that the river is gaining as groundwater in the alluvium and bedrock springs discharge to the river course.

Recharge is computed as total area of alluvial outcrop times the average annual rainfall times a recharge factor of 0.04 percent. Average annual rainfall in the Guadalupe, Nueces, and Frio basins is 29, 25 and 27 inches respectively.

The final computation of total (annual) groundwater availability is calculated as annual average recharge plus a portion of water in storage. To avoid over estimating availability, an assumption is made that only one-tenth of the volume of water in storage is available to be depleted in any one year. It is further assumed that any storage depletion would be replenished by recharge in years when rainfall was above average. Summaries of these computations are provided for the three alluvial aquifers in Tables 2, 3 and 4.

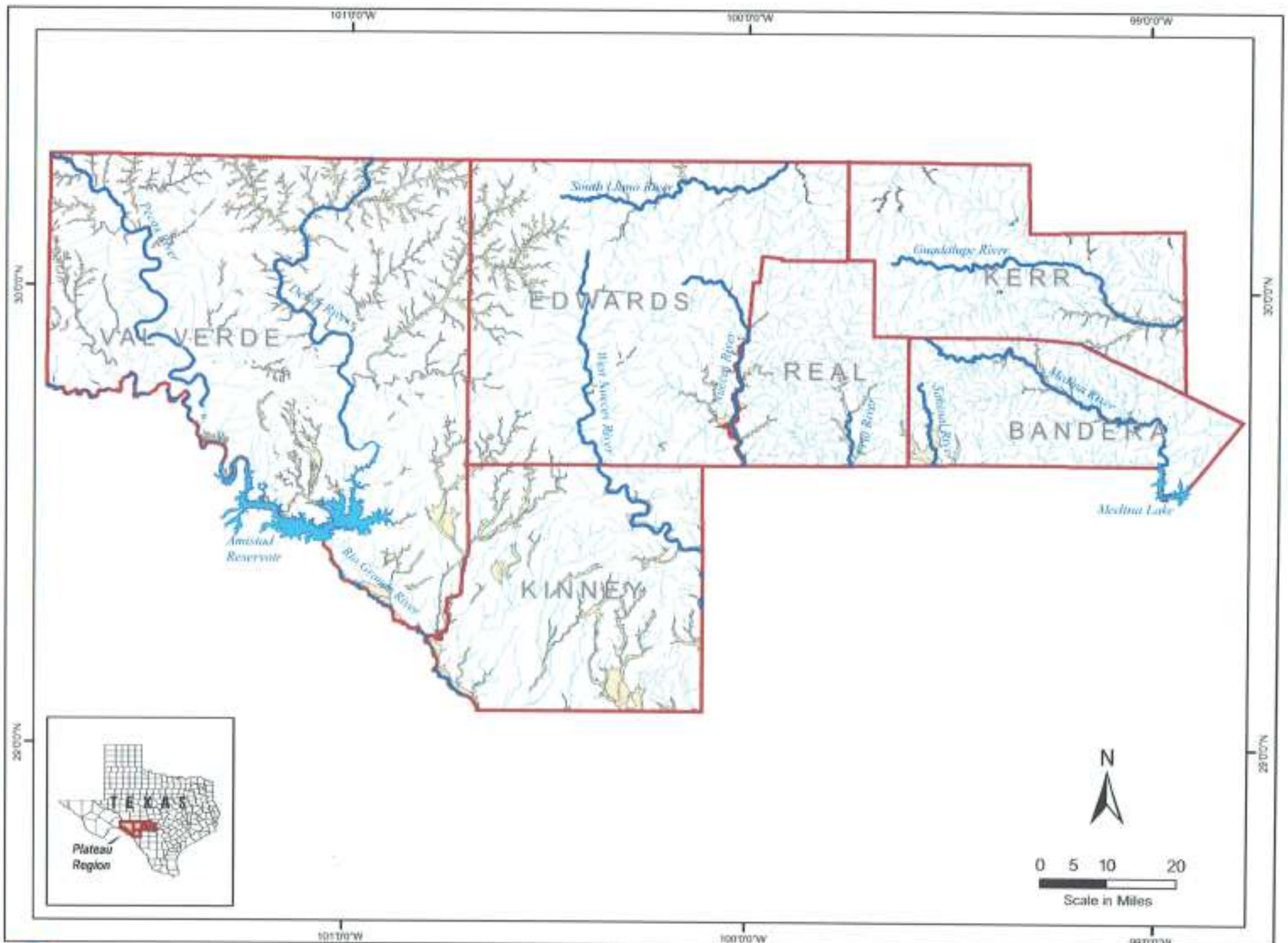

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FIGURE 1
EXTENT OF ALL RIVER ALLUVIUM IN THE PLATEAU REGION

2.0 River Basins

2.1 Guadalupe River Alluvium

Seven alluvial wells identified in the Guadalupe River Alluvium are shown on Figure 2. Note that these locations do not coincide with irrigation pivots that are visible along the river from SH 27 downstream from Kerrville; these pivots utilize surface water taken directly from the Guadalupe River. Many alluvial wells in Kerr County are not registered with Headwaters Groundwater Conservation District, therefore there are likely to be numerous unrecognized additional wells. Due to the minimal number of wells on file that are available to characterize the formation, only a limited analysis was performed on the main alluvial segment from Kerrville downstream to the county line. After consultation with the Headwaters Groundwater Conservation District, the groundwater availability estimated from this analysis is not included in the Plateau Region Water Plan Chapter 3 listing of water-supply sources.

Table 2. Guadalupe River Alluvium Aquifer

Parameter	Estimated Value
Total Area of Alluvium Outcrop	8,928 ac
Area of Significant Alluvium Outcrop *(70%)*	6,250 ac
Average Depth to Base of Alluvium	30 ft
Average Depth to Water	20 ft
Average Saturated Thickness	10 ft
Saturated Volume of Alluvium *(Significant Area x Saturated Thickness)*	62,500 ac-ft
Volume of Water in Storage *(Sat. Vol. of Alluv. x Specific Yield [15%])*	9,375 ac-ft
Average Annual Recharge *(Total Outcrop Area x 29 in/yr x .04)*	857 ac-ft/yr
Total Groundwater Availability *(Recharge + 0.1 Vol. Water in Storage)*	1,795 ac-ft/yr

2.2 Medina and Sabinal River Alluviums

No alluvial wells are listed in the TWDB groundwater database in the Medina River Alluvium, and only two wells are identified in the upper reaches of the Sabinal River basin are shown on Figure 3. Due to the minimal number of alluvial wells identified in these basins and after consultation with the Bandera County River Authority and Groundwater District, no further analyses of groundwater availability from these particular alluviums were considered necessary.

2.3 South Llano River Alluvium

As no alluvial wells are listed in the TWDB groundwater database in the South Llano River Alluvium (Figure 4) and the indication that the existing alluvium is very thin, no further analyses of groundwater availability from this particular alluvium was considered necessary.

2.4 West Nueces River Alluvium

Only four alluvial wells identified in the West Nueces River Alluvium are shown on Figure 5. Due to the minimal number of alluvial wells identified in this basin and the indication that the existing alluvium is very thin, no further analysis of groundwater availability from this alluvium was considered necessary.

2.5 Nueces River Alluvium

Twenty-nine alluvial wells identified in the Nueces River Alluvium are shown on Figure 6. The Real-Edwards Conservation and Reclamation District is scheduled to collect additional well data for this aquifer system in the near future. As a result of a significantly larger outcrop area, the availability volume calculated for the Nueces Alluvium is greater than the volume reported for the Frio Alluvium. However, due to thinner average saturated thickness, average well yields may be less in the Nueces Alluvium. The Community of Barksdale pumps groundwater from this aquifer for public supply use. Analysis of potential groundwater availability in the Nueces River Alluvium is as follows:

Table 3. Nueces River Alluvium Aquifer

Parameter	Estimated Value
Total Area of Alluvium Outcrop	24,450 ac
Area of Significant Alluvium Outcrop *(70%)*	17,115 ac
Range in Depth to Base of Alluvium	17-35 ft
Average Depth to Base of Alluvium	25 ft
Range in Depth to Water	10-35 ft
Average Depth to Water	19 ft
Average Saturated Thickness	6 ft
Saturated Volume of Alluvium *(Significant Area x Saturated Thickness)*	102,690 ac-ft
Volume of Water in Storage *(Sat. Vol. of Alluv. x Specific Yield [15%])*	15,404 ac-ft
Average Annual Recharge *(Total Outcrop Area x 25 in/yr x .04)*	2,034 ac-ft/yr
Total Groundwater Availability *(Recharge + 0.1 Vol. Water in Storage)*	3,574 ac-ft/yr

2.6 Frio River Alluvium

The 32 alluvial wells identified in the Frio River Alluvium are shown on Figure 7. The Real-Edwards Conservation and Reclamation District has a total of 158 wells listed as being completed in the Frio River Alluvium; however, only 55 of these wells have location coordinates for display on Figure 7, some of which are duplicates of TWDB database wells. Of the 158 wells, 144 wells have sufficient well log data to calculate a saturated thickness (10 feet average) and average well yield of 31 GPM. The district feels that there may be several hundred additional undocumented wells in the Frio Alluvium. The City of Leakey, along with several other small public water supply corporations, pumps groundwater from this aquifer for public supply use. Analysis of potential groundwater availability in the Frio River Alluvium is as follows:

Table 4. Frio River Alluvium Aquifer

Parameter	Estimated Value
Total Area of Alluvium Outcrop	9,530 ac
Area of Significant Alluvium Outcrop *(90%)*	8,577 ac
Range in Depth to Base of Alluvium	15-42 ft
Average Depth to Base Alluvium*	32 ft
Range in Depth to Water	5-35 ft
Average Depth to Water*	22 ft
Average Saturated Thickness*	10 ft
Saturated Volume of Alluvium *(Significant Area x Saturated Thickness)*	85,770 ac-ft
Volume of Water in Storage *(Sat. Vol. of Alluv. x Specific Yield [15%])*	12,866 ac-ft
Average Annual Recharge *(Total Outcrop Area x 27 in/yr x .04)*	858 ac-ft/yr
Total Groundwater Availability *(Recharge + 0.1 Vol. Water in Storage)*	2,145 ac-ft/yr

**Averages based on data from 144 wells in RECRD database.*

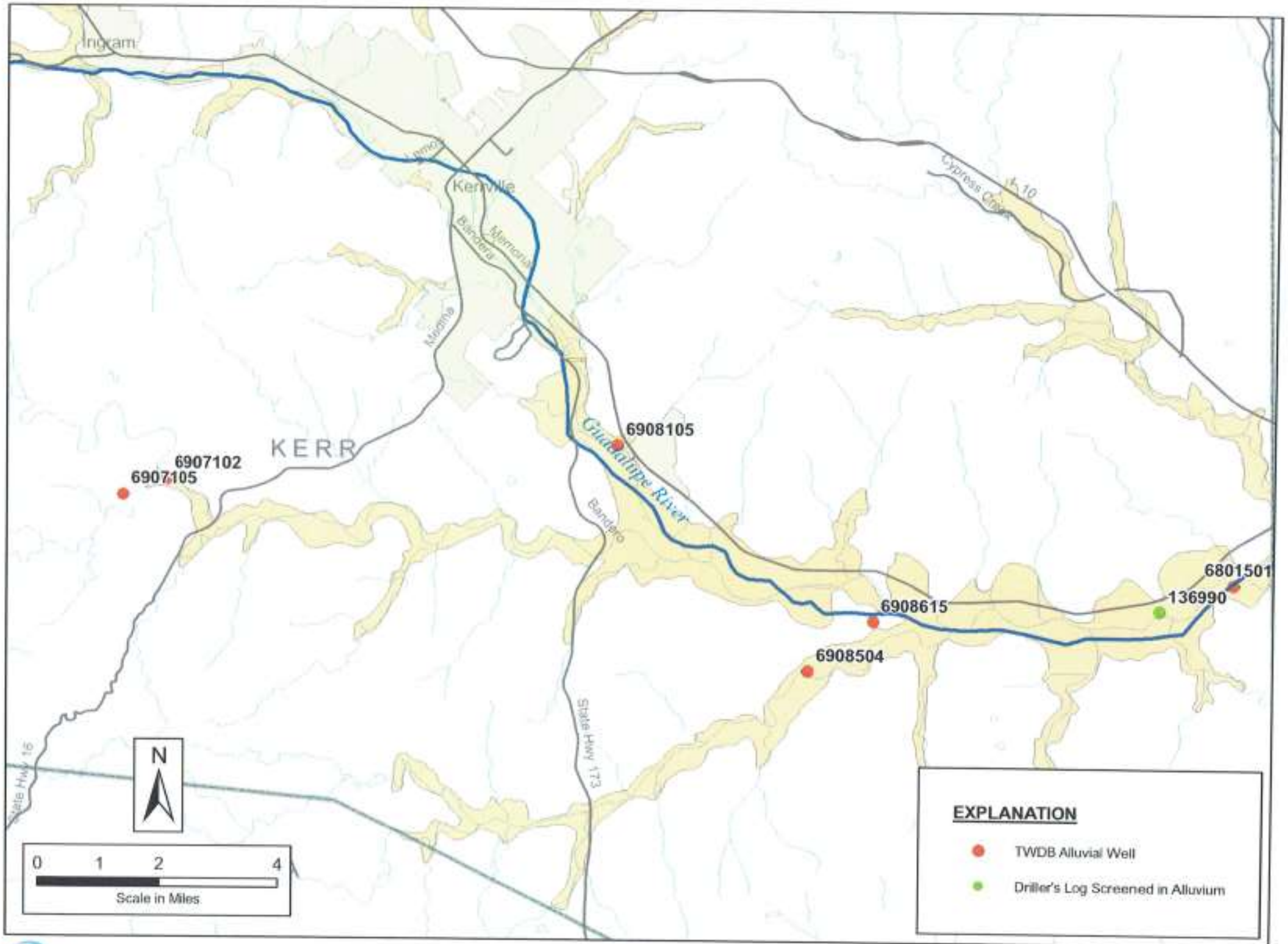

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FIGURE 2
RIVER ALLUVIUM IN THE GUADALUPE RIVER
EASTERN KERR COUNTY, TEXAS

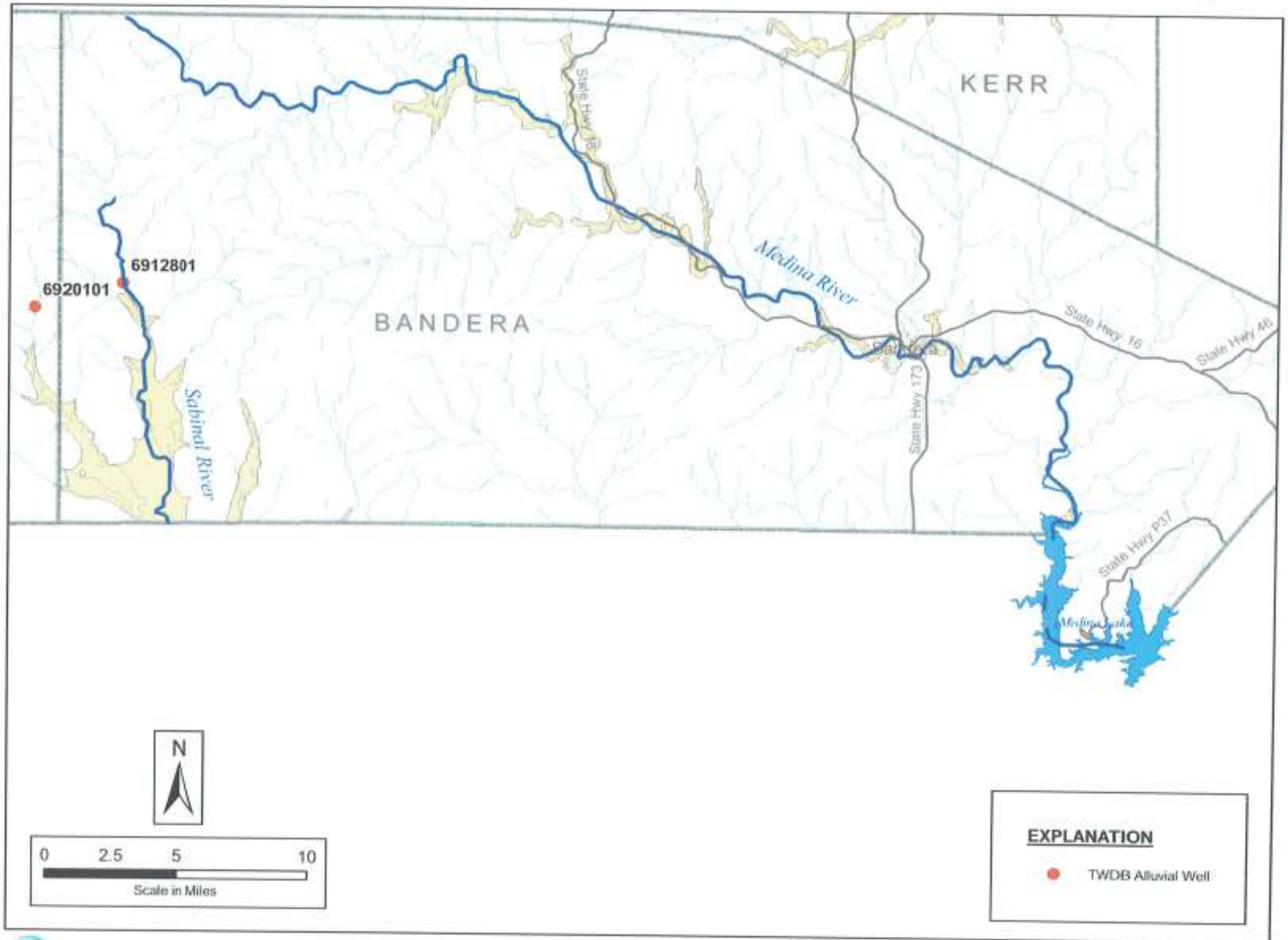

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FIGURE 3
RIVER ALLUVIUM IN THE MEDINA AND SABINAL RIVERS
BANDERA COUNTY, TEXAS

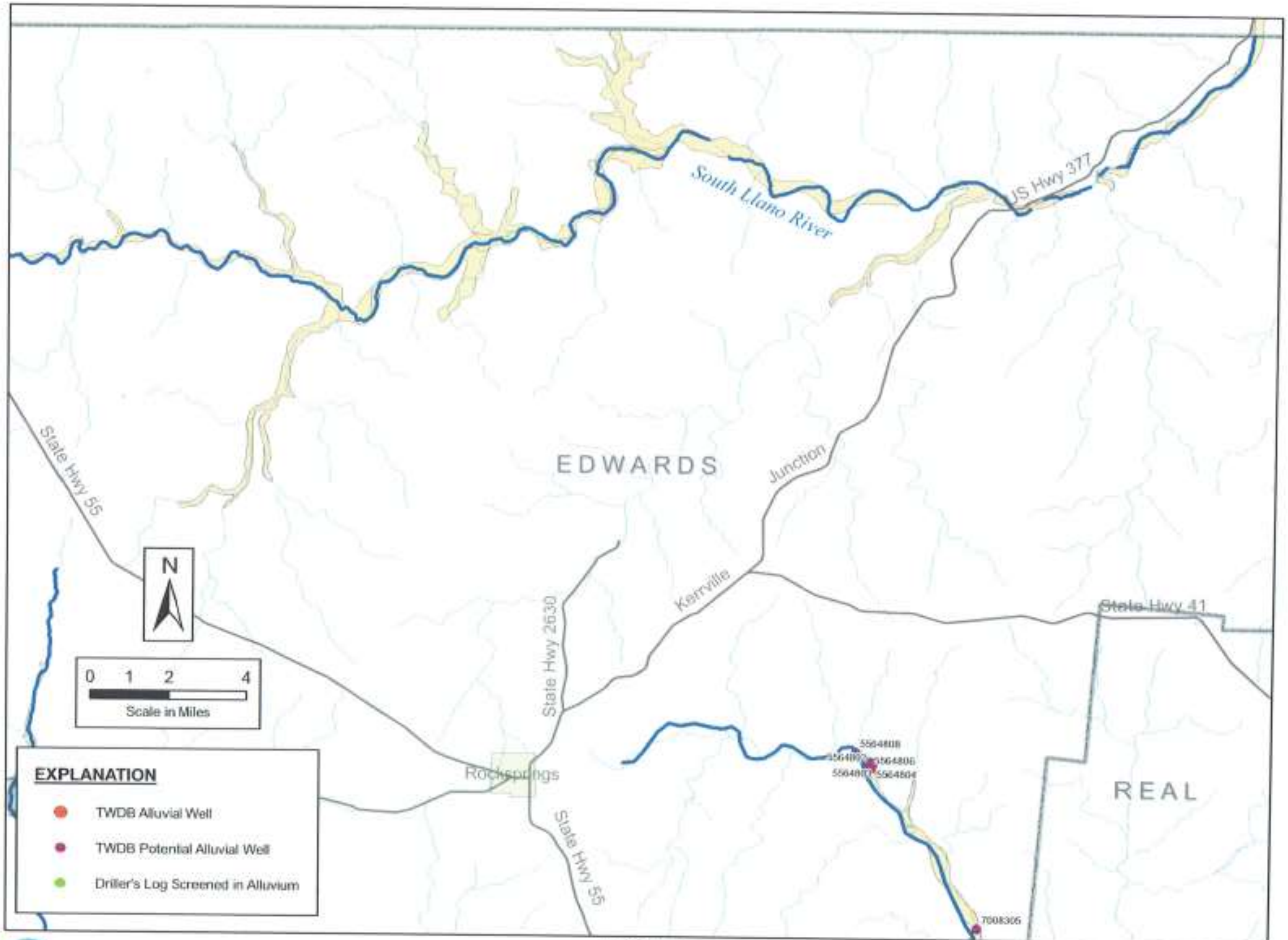

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FIGURE 4
RIVER ALLUVIUM IN THE SOUTH LLANO RIVER
EDWARDS COUNTY, TEXAS

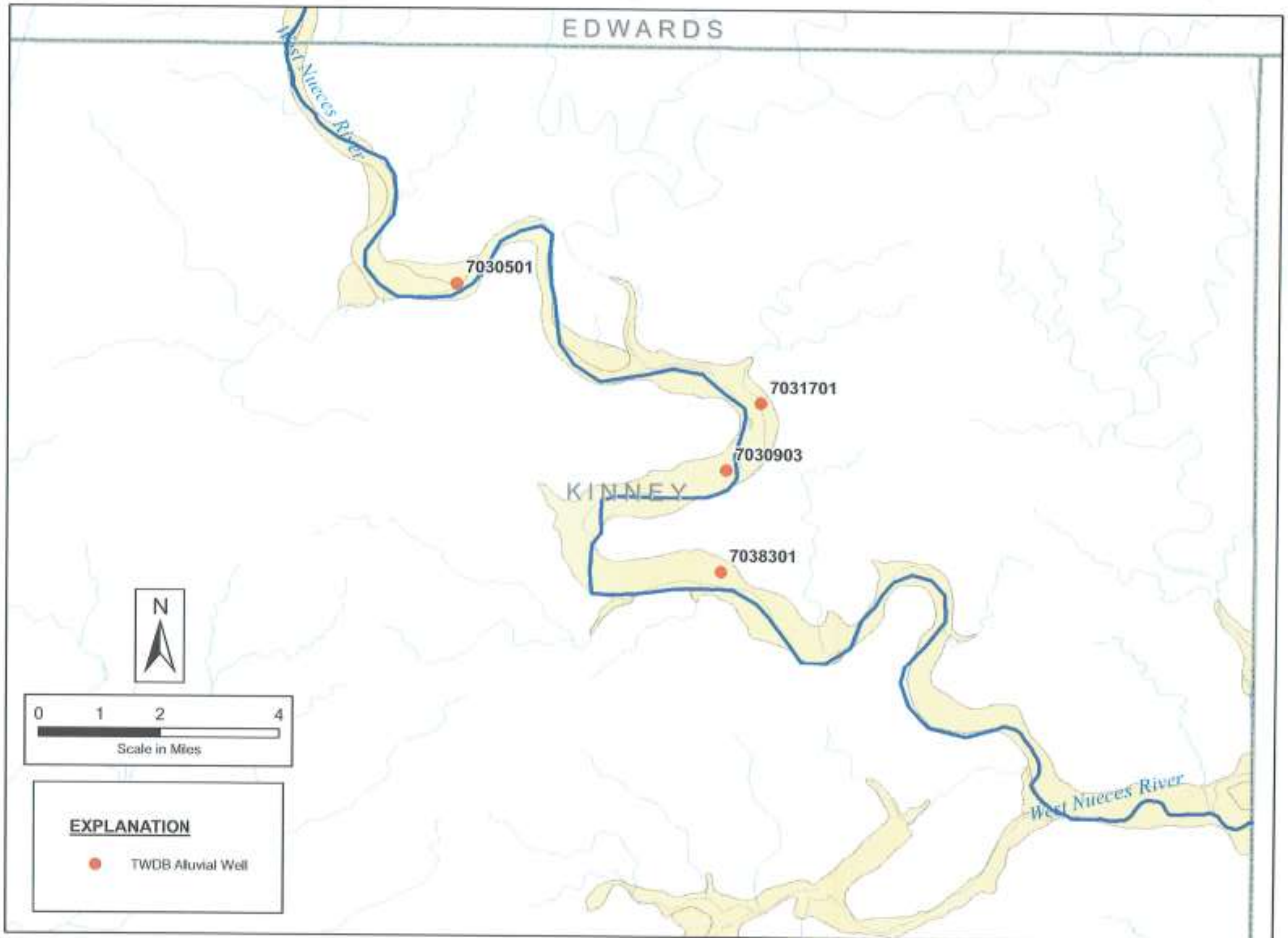

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FIGURE 5
RIVER ALLUVIUM IN THE WEST NUECES RIVER
NORTHEASTERN KINNEY COUNTY, TEXAS

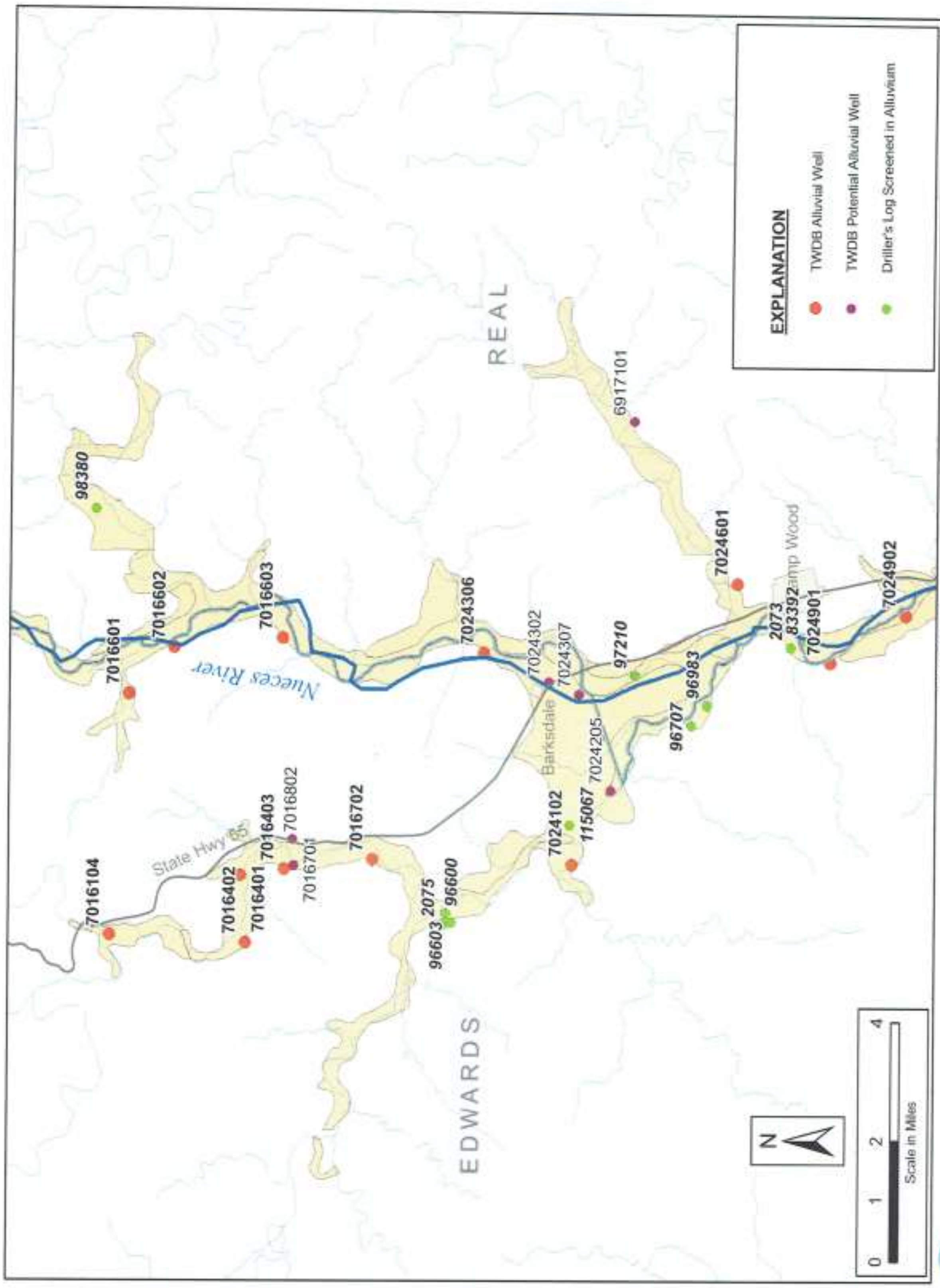

FIGURE 6
RIVER ALLUVIUM IN THE NUECES RIVER
EDWARDS AND R[illegible]L COUNTIES, TEXAS

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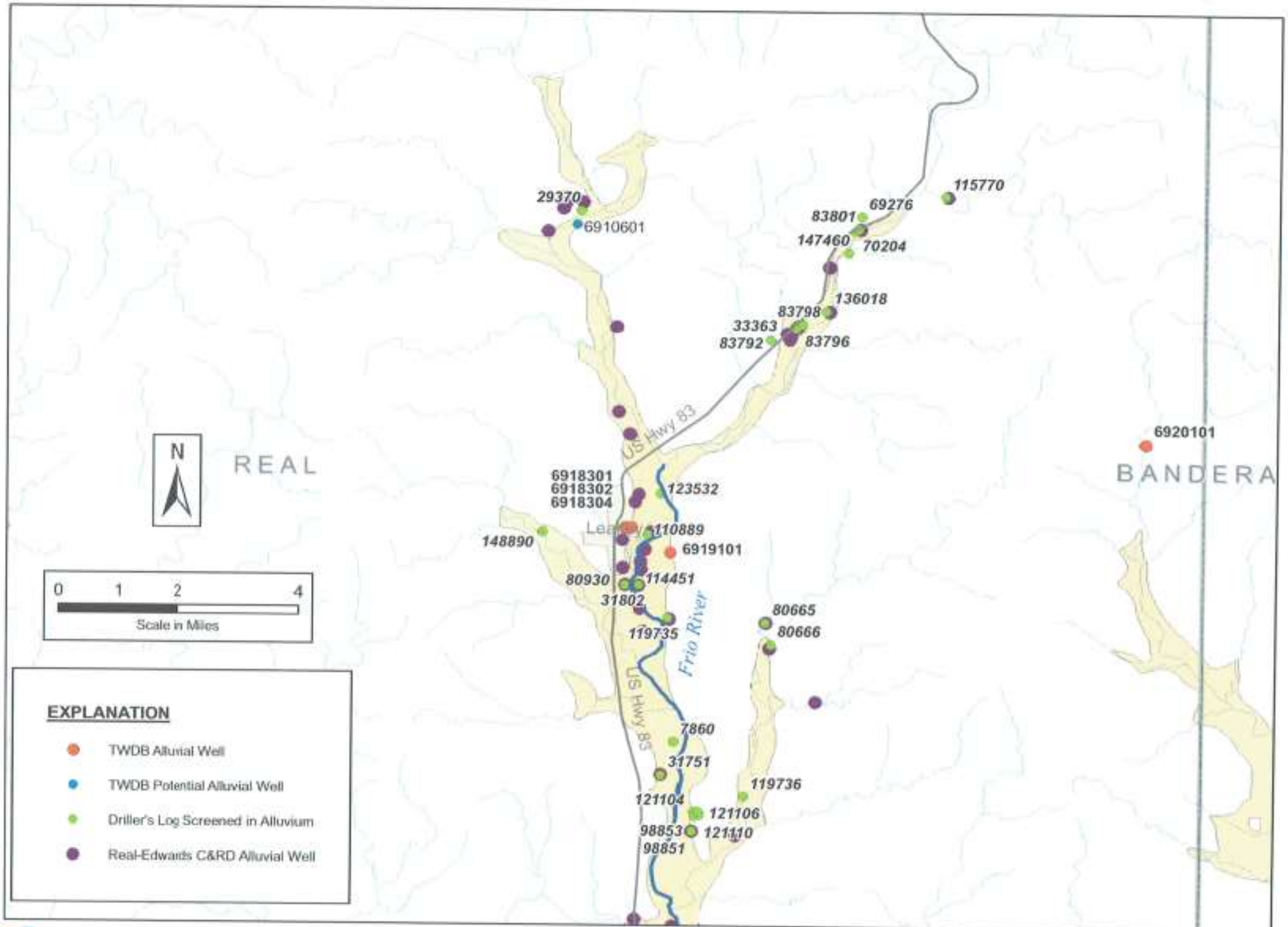

FIGURE 7
RIVER ALLUVIUM IN THE FRIO RIVER
REAL COUNTY, TEXAS

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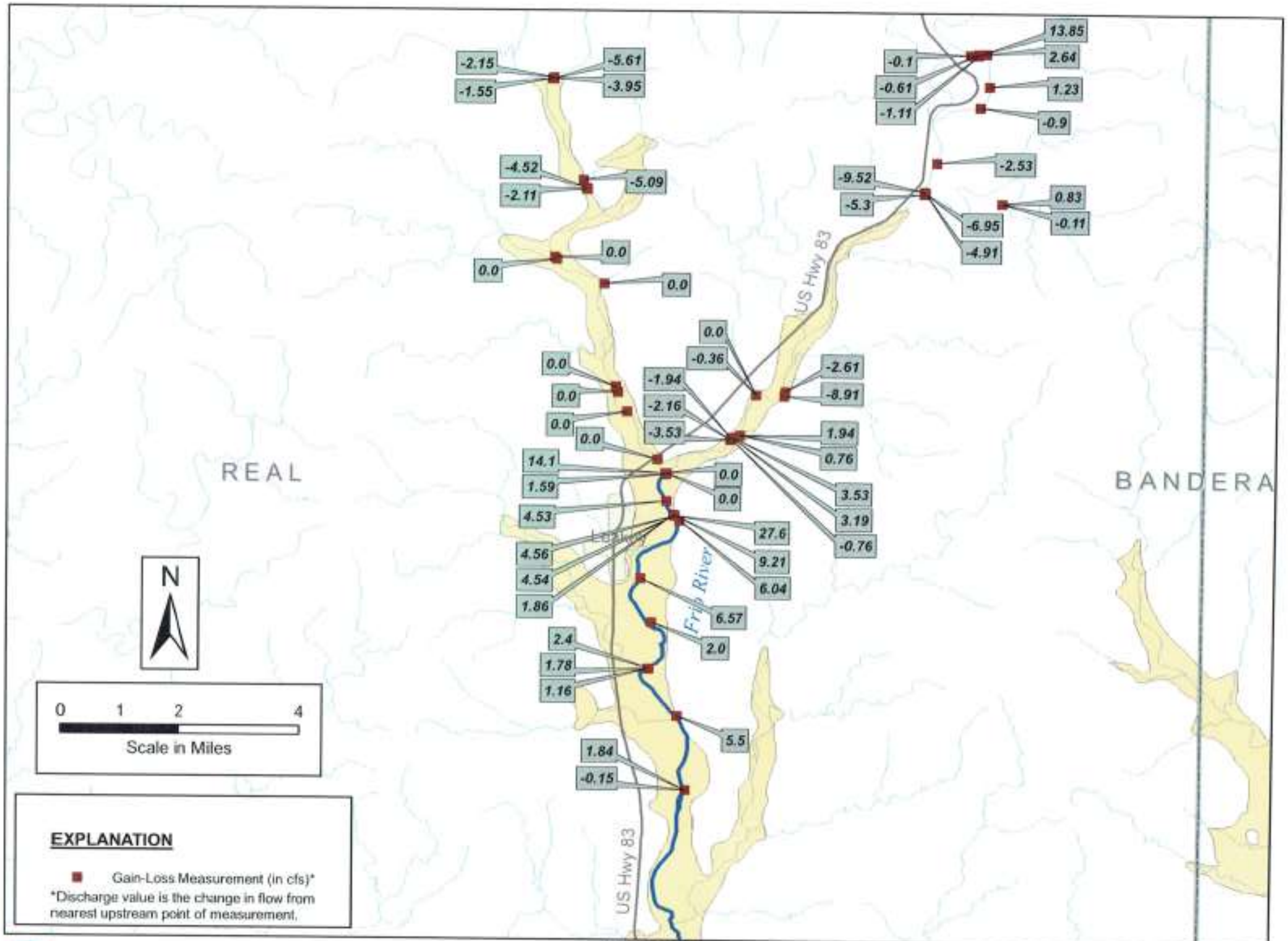

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FIGURE 8
GAIN-LOSS DATA IN THE FRIO RIVER
REAL CC `'TY, TEXAS