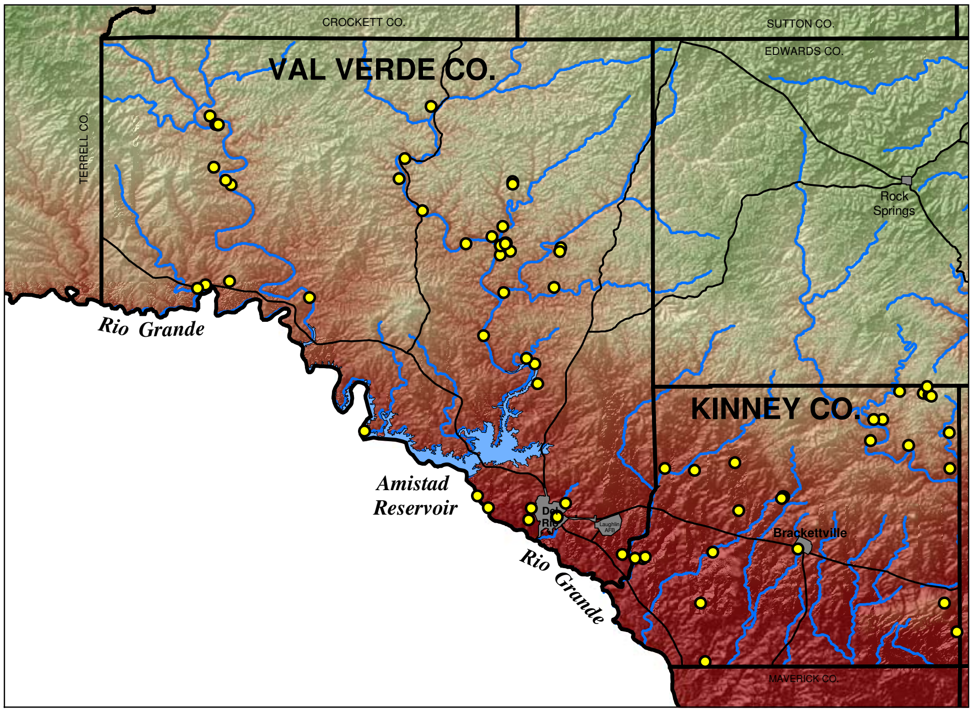
SPRINGS OF KINNEY AND VAL VERDE COUNTIES

Prepared for

Plateau Regional Water Planning Group

August 2005



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SPRINGS OF KINNEY AND VAL VERDE COUNTIES

INTRODUCTION

Water from springs has played a major role in the location of settlements throughout the history of man. In the arid region of west-central Texas (Figure 1), springs were especially significant in the establishment of early trade routes from the Texas Gulf Coast to El Paso and into Mexico. Evidence that native Indian tribes inhabited the area around Del Rio and Brackettville for many thousands of years exists in the form of pictographs found on cave walls and cliffs, and in the many artifacts found around local springs and streams.

San Felipe Springs located in the City of Del Rio was the site of a Spanish settlement founded on St. Phillip's Day in 1635. The Spaniards named the area San Felipe del Rio (St. Phillip of the River). Las Moras Springs near the City of Brackettville was the site of Fort Clark, an early U.S. Army outpost, established in the mid 1850s. Today, springs continue to be a community focal point in that they provide a drinking water supply, recreational opportunities, and irrigation use. Springs also provide a water source for livestock and wildlife, as well as habitat for threatened and endangered species.

Especially in arid regions, springs serve as a barometer for gaging the hydrologic conditions of local water-supply sources. As springflows diminish, so does flow in associated surface streams and rivers. Likewise, water levels in area aquifers are declining. The protection of springs is thus one task in the overall management of water supplies to meet long-term local water-supply needs.

The purpose of this study is to produce a more complete hydrogeologic-spring database for Kinney and Val Verde Counties that will be used to better understand the groundwater and surface water relationship that exists between the springs, their host aquifer, and the streams to which they contribute. The study also considers the potential impacts that might occur with increased pumping of local aquifers.

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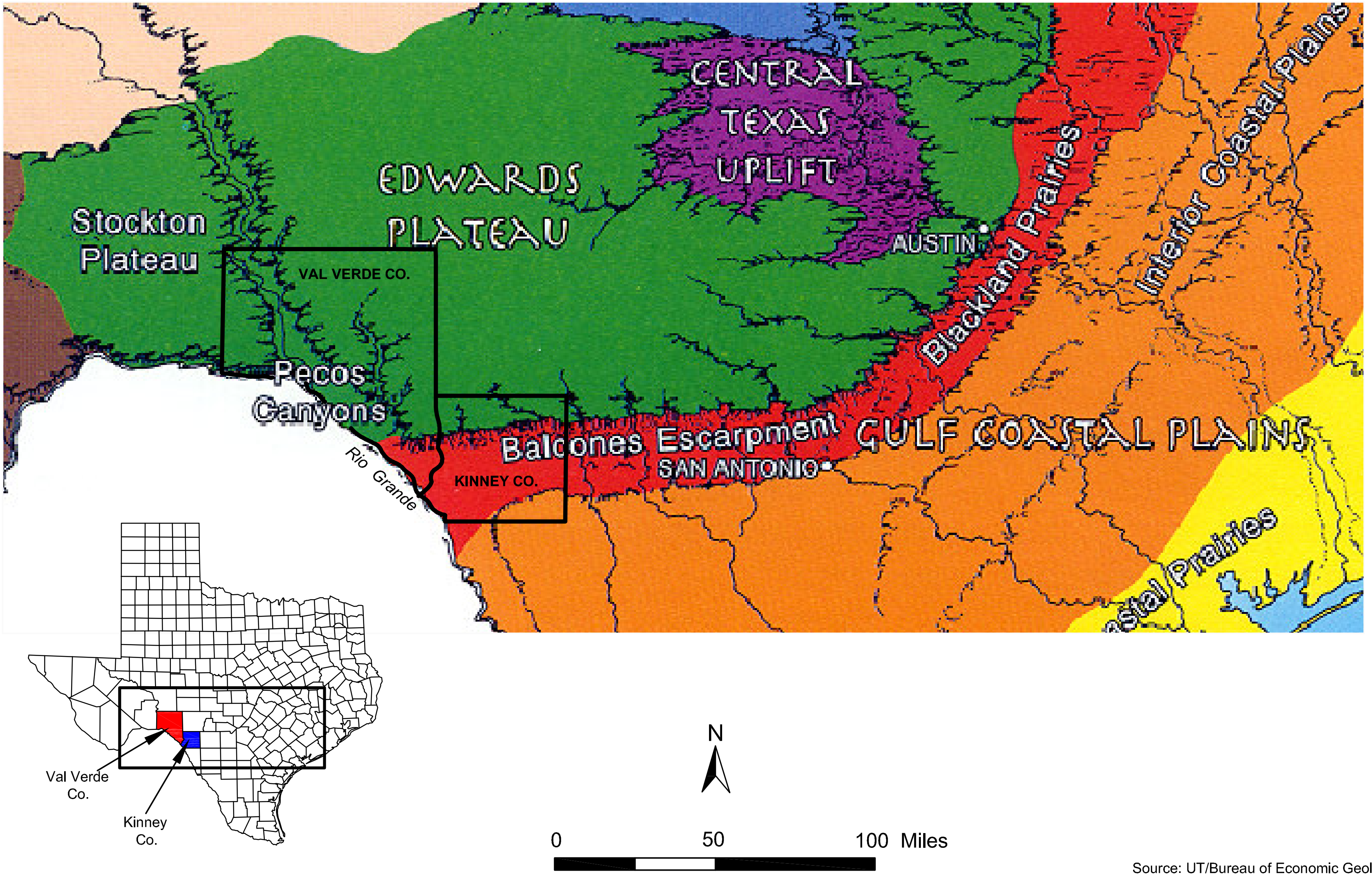


Source: UT/Bureau of Economic Geology,
Physiographic Map of Texas,1996

EDWARDS PLATEAU SHOWING LOCATION OF KINNEY AND VAL VERDE COUNTIES FIGURE 1

Spring locations and names were obtained from U.S. Geological Survey (USGS) topographic maps and spring database. Information pertaining to the springs is provided in databases and reports of the USGS, Texas Water Development Board (TWDB) and their predecessor agencies, the International Boundary and Water Commission (IBWC), and in *Springs of Texas* by Gunnar Brune. Additional field observations and measurements were performed on Mud and Pinto Springs in Kinney County. Information pertaining to wildlife, particularly threatened and endangered species, endemic to stream segments fed from and having their source of origin from springs listed in this report is from Texas Parks and Wildlife Department's (TPWD) *Ecologically Significant River and Stream Segments of Region J (Plateau), Regional Planning Area, 2001*.

ENVIRONMENTAL SIGNIFICANCE OF SPRINGS

Most of the springs found in Kinney and Val Verde Counties are at the head of or along the course of perennial streams. Altogether, these springs are responsible for all of the base flow in these streams. It is this perennial flow that has created wetland habitats in this arid environment (Figure 2) that are occupied by a number of terrestrial and aquatic species, some of which are classified as threatened or endangered (Table 1).

The U.S. Fish and Wildlife Service (USFWS) has proposed the Devils River minnow (Figure 3) for listing as an endangered species under the Endangered Species Act. The minnow has been identified in the Devils River, San Felipe, Pinto, Las Moras, and Sycamore Creeks. A voluntary Conservation Agreement for the Devils River minnow has been enacted among the TPWD, the City of Del Rio, and the USFWS. The Agreement was developed to expedite conservation measures needed to ensure the continued existence and facilitate recovery of the species.

Pecos River

Dolan Creek

San Felipe Creek

Sycamore Creek

WETLAND HABITATS ASSOCIATED WITH SPRING-FED RIVERS AND CREEKS **FIGURE 2**

(Photos Compliments of Texas Parks & Wildlife Department)

Las Moras Creek

Pinto Creek

Mud Creek

West Nueces River

WETLAND HABITATS ASSOCIATED WITH SPRING-FED RIVERS AND CREEKS

(Photos Compliments of Texas Parks & Wildlife Department)

FIGURE 2
(continued)

Figure 3 - Devils River Minnow

TABLE 1. THREATENED AND ENDANGERED SPECIES ENDEMIC TO RIVER SEGMENTS

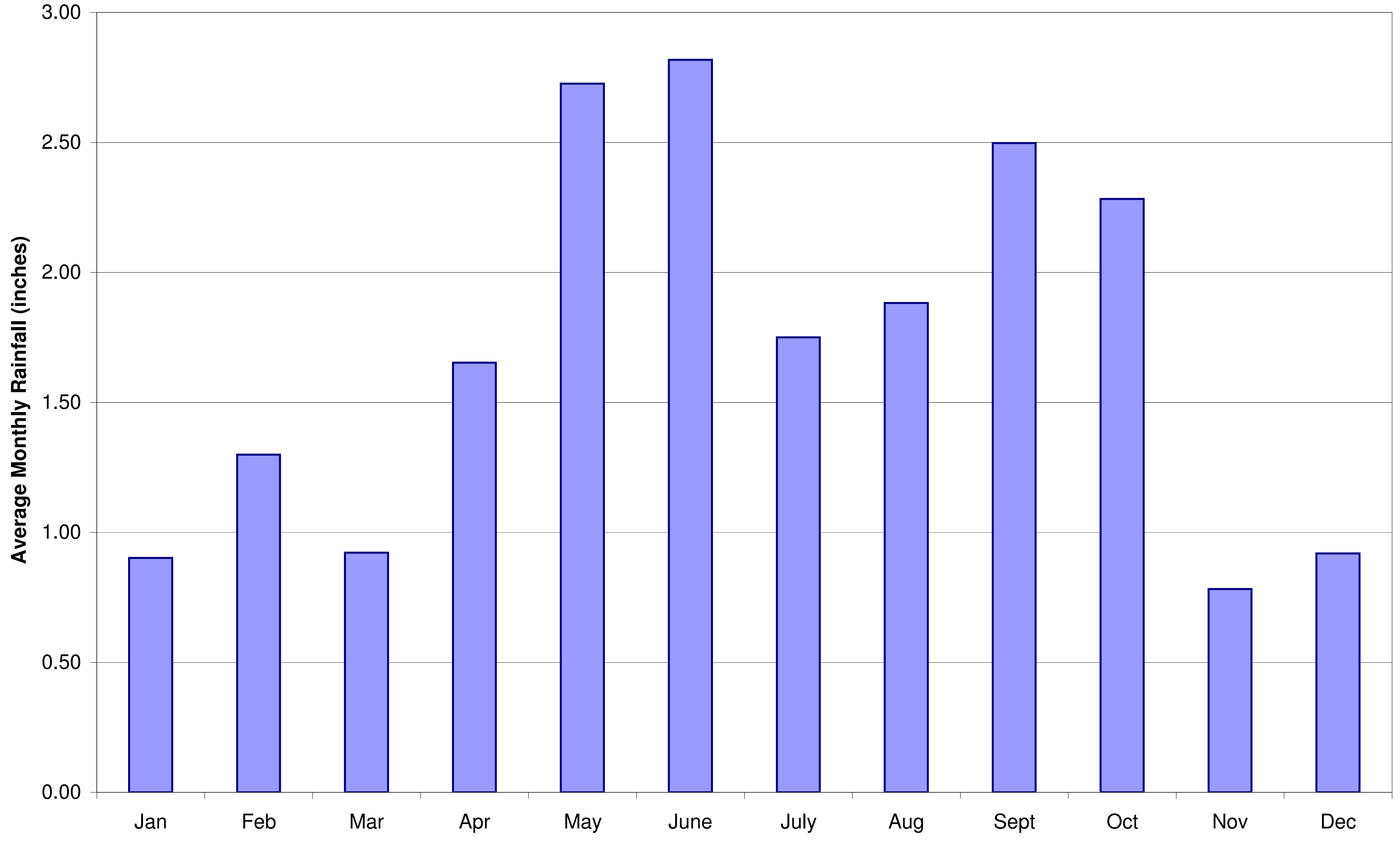
River Segments	Birds					Fish				Reptiles		Plants	
	Black-capped vireo	Golden-cheeked warbler	Interior least tern	Zone-tailed hawk	Common black hawk	Rio Grande darter	Proserpine shiner	Devils River minnow	Concho pupfish	Indigo snake	Big Bend blackhead snake	Texas snowbells	Tobusch fishhook cactus
Pecos River	X		X	X		X	X			X	X		
Devils River	X		X	X		X	X	X	X	X	X	X	X
San Felipe Creek						X	X	X		X	X		
Sycamore Creek	X	X			X	X	X	X		X			X
Mud Creek	X	X			X					X			X
Pinto Creek	X	X			X		X	*X		X			X
Las Moras Creek	X	X			X		X			X			X
West Nueces River	X	X	X		X					X		X	X

Sources: El-Hage and Moulton, 2001
* Garrett and others, 2004

CLIMATE IMPACT ON SPRINGFLOW

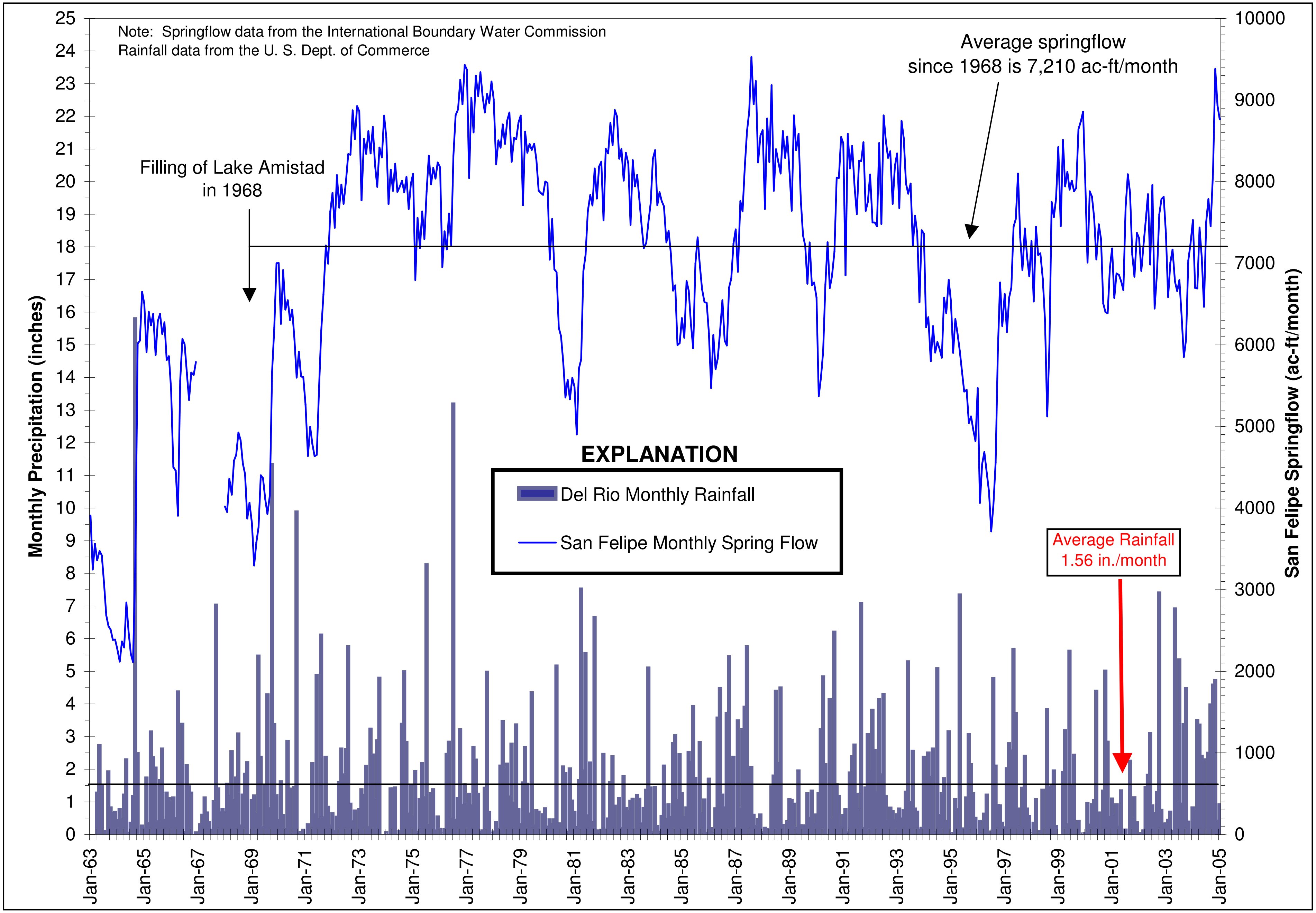
The combination of high temperatures, high evapotranspiration and relatively low rainfall in Val Verde and Kinney Counties combine to produce a semiarid climate with drought conditions during all or parts of some years (Bomar, 1995). The rate of flow from springs is directly related to the occurrence, intensity, and timing of rainfall events. The rainfall in Val Verde and Kinney Counties decreases from about 25 inches per year in the northeastern Kinney County to about 12 inches per year near Del Rio. Most of the rainfall occurs as thunderstorms during the months of April through October, with the highest amounts falling in May through June and September through October (Figure 4). The average annual rainfall over the period of record at the Del Rio International Airport is 17.6 inches and has ranged from 4.3 inches in 1956 to 33.2 inches in 1969. Over a 100-year recorded period at the Brackettville gage, rainfall has averaged 20.3 inches. Net lake evaporation, which is about 60 inches in western Val Verde County, is the difference between total evaporation from a lake's surface and total precipitation.

Generally, the drought during the mid-1950s is considered the most severe drought of record. Miscellaneous measurements by the USGS during the drought of the 1950s indicate an instantaneous low flow of about 25 to 30 cfs for San Felipe Springs (Reeves and Small, 1973). The direct linkage between precipitation and springflow from San Felipe Springs is indicated by dramatic increases in spring discharge following major rainfall events. Likewise, long dry spells can also be correlated to declines in springflow (Figure 5).



AVERAGE MONTHLY RAINFALL AT BRACKETTVILLE, TEXAS
(1897-1998)

FIGURE 4



MONTHLY RAINFALL AT DEL RIO AND SAN FELIPE SPRINGFLOW

FIGURE 5

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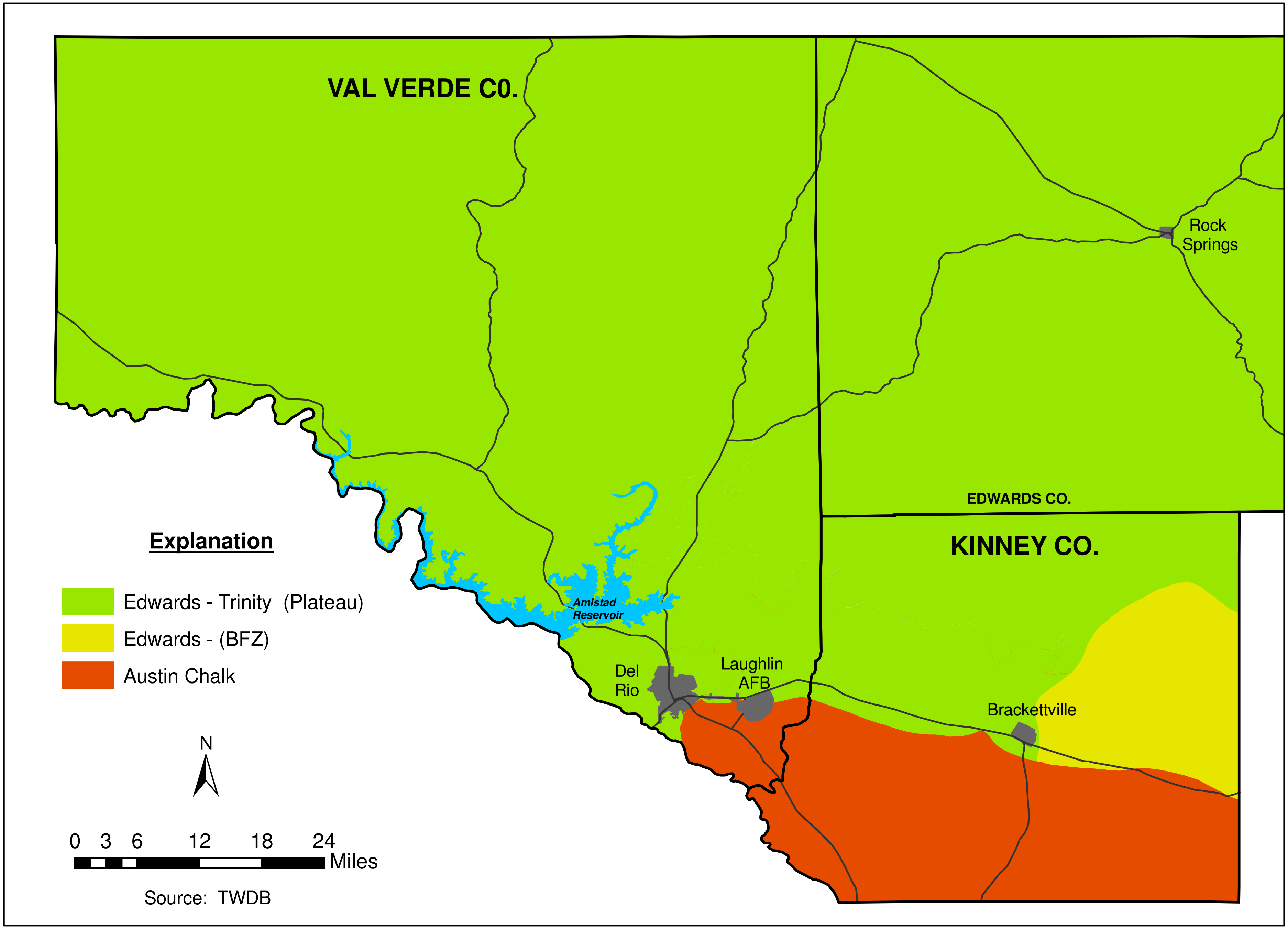
GROUNDWATER OCCURRENCE AND RECHARGE

Kinney and Val Verde Counties lie along the southern boundary of the Edwards/Stockton Plateau (Figure 1). Most of the water, in the form of precipitation falling on the Plateau, either runs off into streams and lakes or is evaporated or transpired by plants. Only a small percentage of total rainfall percolates downward into the underlying rock formations that form the Edwards-Trinity (Plateau) aquifer. Most of the groundwater in the aquifer system is retained within the more porous and permeable Edwards limestone; however, a lesser amount moves downward into the underlying Trinity formations. Groundwater in the Edwards-Trinity (Plateau) aquifer moving downgradient into eastern Kinney County remains within the Edwards Formation but becomes the Edwards - Balcones Fault Zone (BFZ) aquifer (Figure 6).

Most of the streamflow available for recharge originates from drainage off the uplands and flows in streams and rivers generally in a southerly direction. Runoff from this catchment area is channeled downstream to areas of greater recharge potential. The West Nueces River in northeast Kinney County provides substantial recharge and has a mean discharge of about 40 cfs (Figure 7). Stream losses in this stretch of the West Nueces are currently included in recharge calculations in the San Antonio region of the Edwards aquifer. Additional recharge occurs from direct infiltration of precipitation on the land surface where water infiltrates through fractures, faults and solution openings into the subsurface.



Source: TWDB

EDWARDS-TRINITY (PLATEAU) - EDWARDS (BFZ) - AUSTIN CHALK AQUIFERS

FIGURE 6

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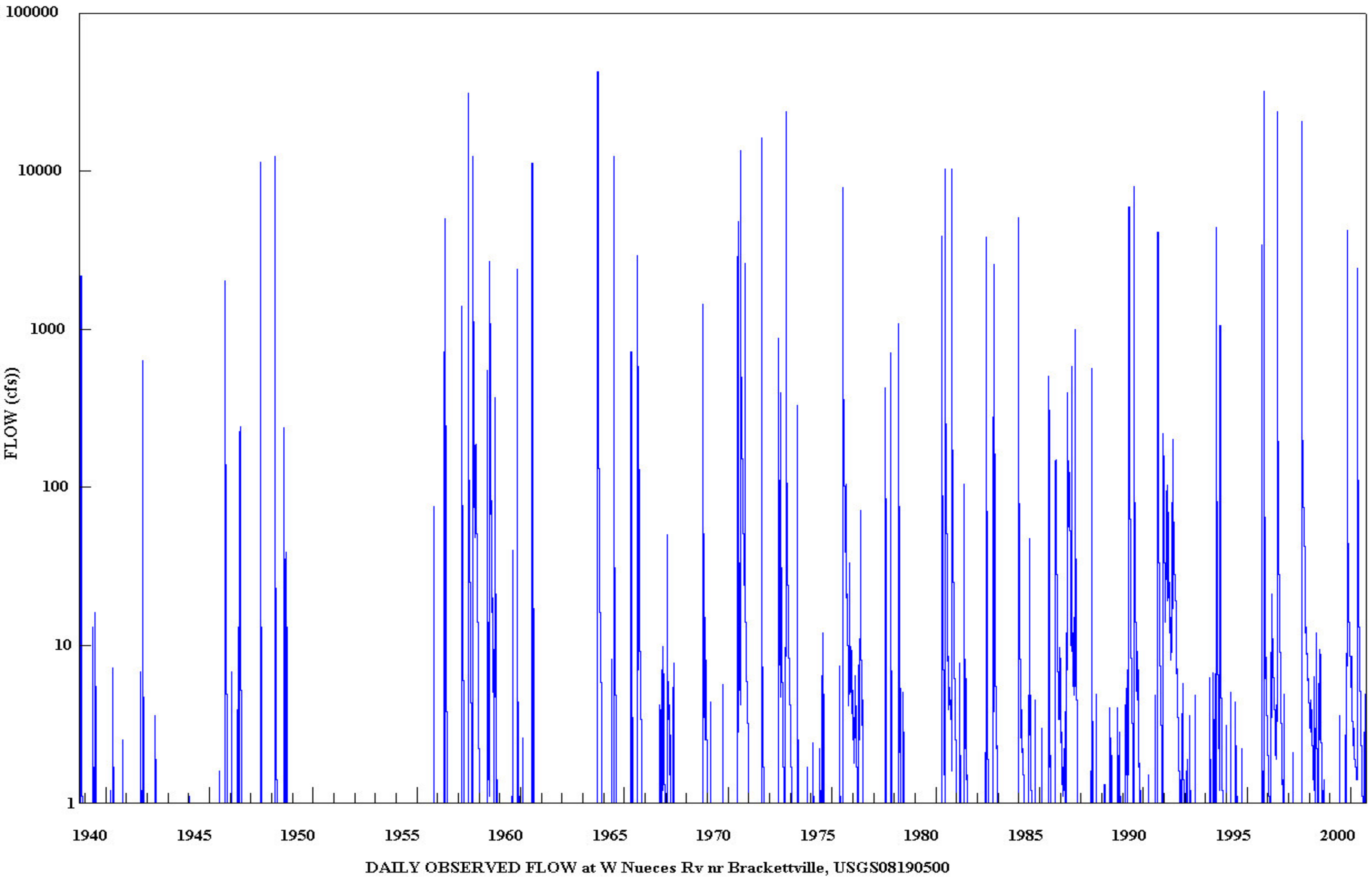

WEST NUECES STREAM GAGE HYDROGRAPH

FIGURE 7

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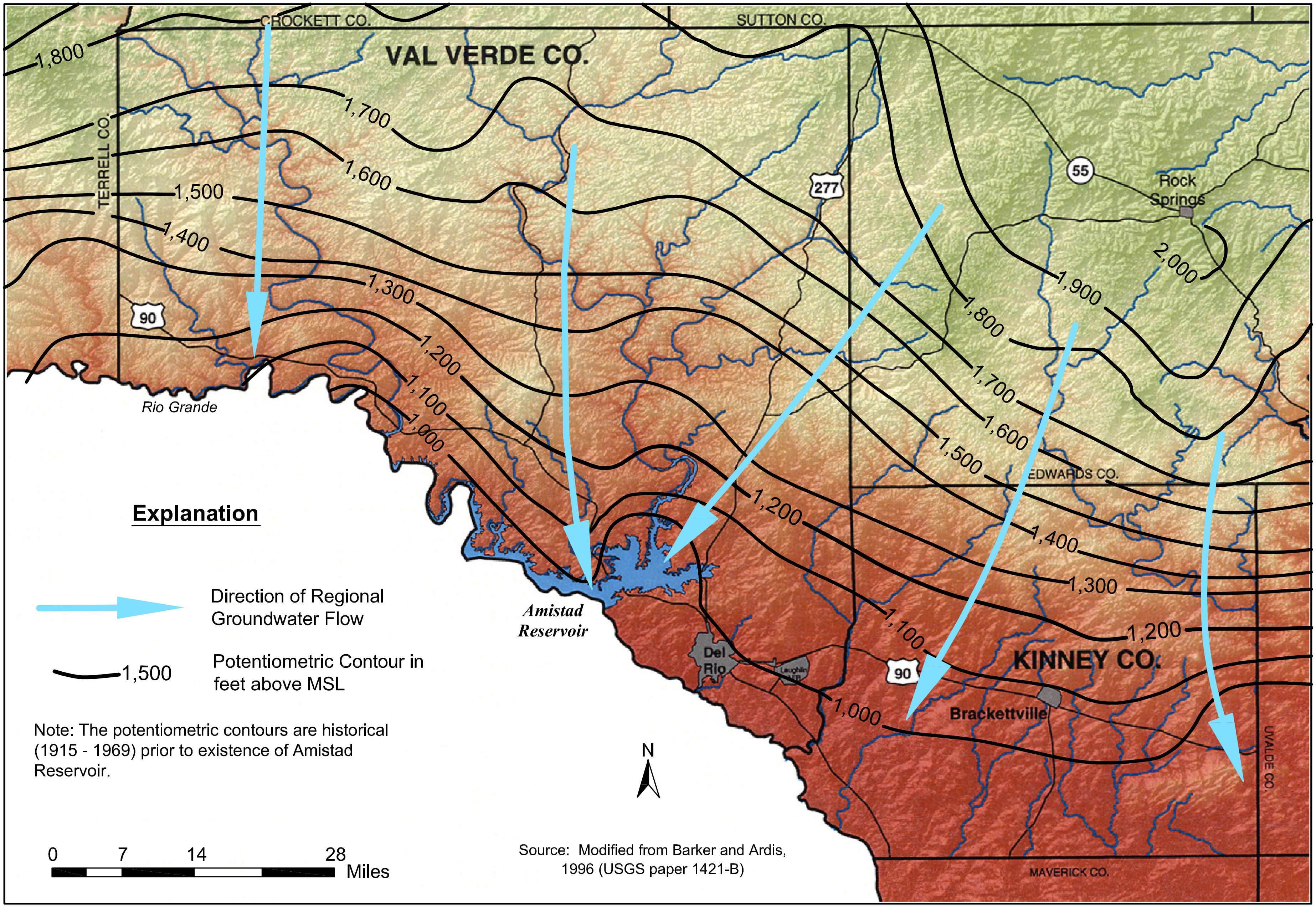
GROUNDWATER MOVEMENT

Groundwater in the aquifer underlying the Edwards Plateau moves laterally generally in a southerly. Transmission of water through the Edwards aquifer is dependent mostly on size, shape and connection of the pore spaces (effective porosity) in the form of fractures and solution openings. Thus, the southern terminus of this regional flow is a logical place to find the aquifer system naturally discharging back to the land surface in the form of springs. In general, Edwards-Trinity groundwater flow paths in Kinney and Val Verde Counties tend to parallel surface drainages (Figure 8). However, groundwater movement is also locally influenced, particularly in Kinney County, by geologic structures and faulting. Significant groundwater withdrawals in the form of pumping can also influence groundwater flow direction.

Probably the most prominent structural control on groundwater flow direction in the two counties occurs in what is termed the Edwards groundwater divide in Kinney County. West of this divide near Brackettville, groundwater tends to flow in a direction that ultimately takes it toward the Rio Grande. While east of the divide, groundwater in the Edwards-Trinity aquifer is diverted to the east and becomes part of the Edwards - Balcones Fault Zone (BFZ) aquifer with flow toward San Antonio. This groundwater divide may be the result of a geologic structure that is recognizable as a northwest-trending lineament that runs from Anacacho Mountain south of Brackettville through the Las Moras Mountain and Pinto Mountain area and along an escarpment to the northwest of Pinto Mountain. The unnamed escarpment located northwest of Pinto Mountain in the Edwards aquifer recharge zone may allow groundwater to flow southwest off the escarpment but would not likely allow flow to move to the east back across the escarpment.

Structural folding of the otherwise gently dipping formations likely influences groundwater movement. Bennett and Sayre (1962) describe folded geologic structures along Road 334 between Brackettville and Laguna. The axis of the down-folded structure (syncline) dips toward the southwest. The syncline structure forms a pie-shaped area that likely funnels water in the aquifer toward Las Moras Springs (LBG-Guyton Associates, 1994). A similar synclinal structure exists between Las Moras Mountain and Pinto Mountain that funnels groundwater toward Pinto Springs.



Note: The potentiometric contours are historical (1915 - 1969) prior to existence of Amistad Reservoir.

Source: Modified from Barker and Ardis, 1996 (USGS paper 1421-B)

REGIONAL GROUNDWATER FLOW

FIGURE 8

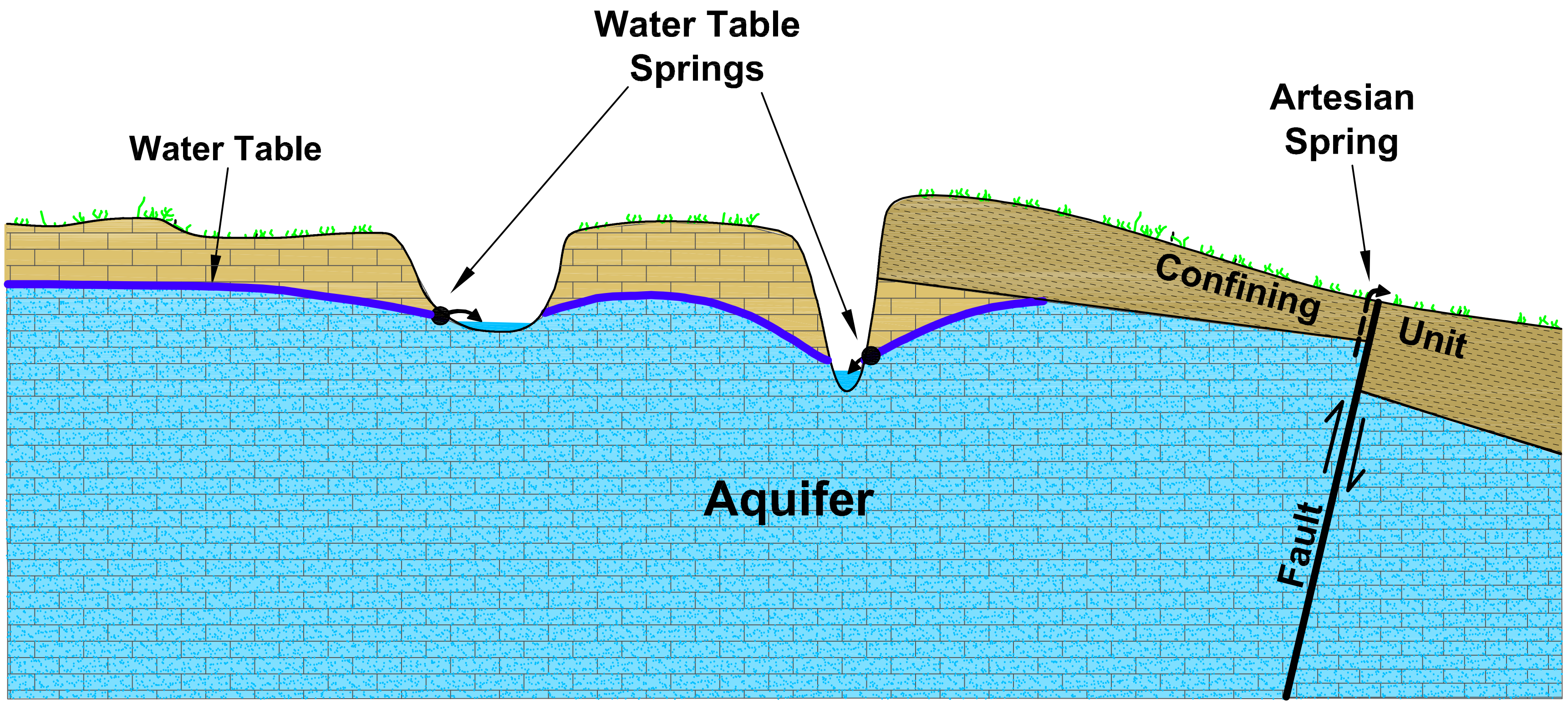
LBG-GUYTON ASSOCIATES

The synclines also structurally help concentrate surface-water runoff generally along their low axes, and as a result increase recharge to the aquifer in these areas within the synclines. The northeast/southwest-trending faults in the area also help to direct flow toward both of these springs from the northeast from their respective synclines (LBG-Guyton Associates, 1994).

Kinney County is on the western end of the Balcones Fault Zone with fault trends predominantly in a northeast/southwest direction. Faulting decreases from east to west in the County, and most of the fault extents and displacements are much less than the displacements found in faults further east within the Balcones Fault Zone. As a result, the faults likely do not form barriers to flow, but because of the broken nature of rocks within the fault zones, these areas have enhanced porosities and permeabilities, especially parallel to the faults.

SPRINGS

Springs in Kinney and Val Verde Counties are generally the result of one or both of two processes (Figure 9). Spring discharge occurs where surface water streams have dissected the land surface to a depth that intersects the underlying water table. This is common in the deep canyons formed by the Devils River and the Pecos River in northern Val Verde County. The other spring process occurs where groundwater under artesian pressure finds a conduit to the land surface. Las Moras Springs near Brackettville in Kinney County is an example of this process. Tables 2 and 3 list springs in Kinney and Val Verde Counties. Numerous other springs likely occur in the area, especially during wetter periods.



SPRING TYPES

FIGURE 9

Kinney County Springs

Twenty-eight springs are identified in Kinney County (Figure 10) (Table 2). Springs discharging from the Edwards aquifer in Kinney County occur primarily from three main sets of springs, Las Moras, Pinto, and Mud Springs (Figure 11). Las Moras discharge measurements recorded by the IBWC and USGS are shown on the graphs in Figure 12. IBWC discharge measurements for Mud and Pinto Springs are shown in Figure 13. The IBWC discontinued measurements at Pinto and Mud Springs in 1996.

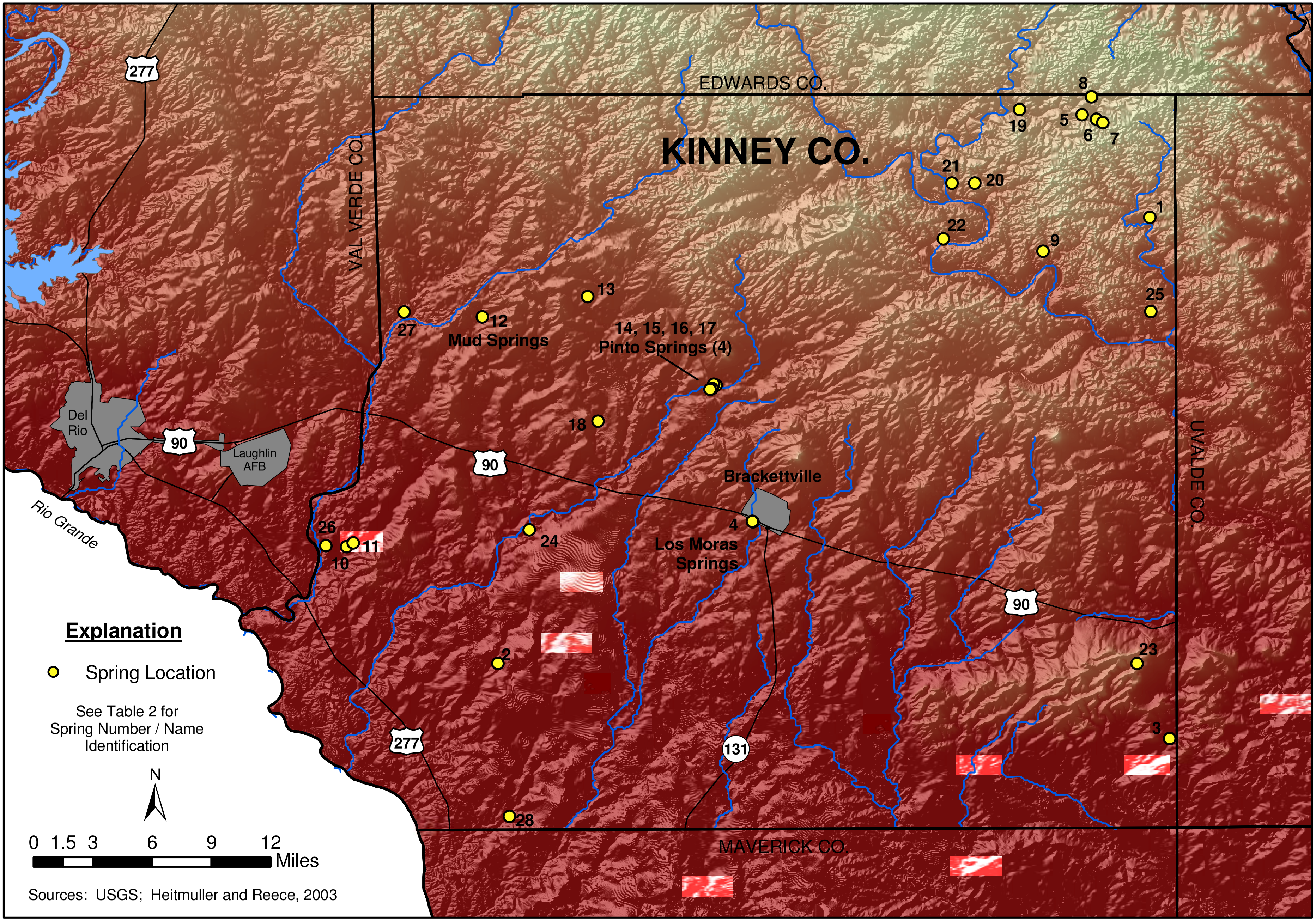
Las Moras Springs issue through a small displacement fault located in the City of Brackettville (Bennett and Sayre, 1962). No effects from the filling of Lake Amistad have been detected in the vicinity of the groundwater divide in Kinney County (LBG-Guyton, 1994). In addition to direct recharge from precipitation over the Edwards aquifer recharge zone, stream losses from the West Nueces River north-northeast of the study area are the source of recharge to the groundwater system in north central and northeast Kinney County.

In October of 1993, the IBWC performed a gain/loss study on Las Moras Creek from the springs downstream to just above the confluence with the Rio Grande (Figure 14). The measurements at the springs start at 9.5 cfs and increase to 11 cfs at the second measurement location, then decline to 5.1 cfs and then to 0 cfs. Las Moras Creek finally regains some flow near the south end of the measurement locations.

Prior to August 1981, the IBWC measurements on Pinto Creek were made downstream of the four spring locations on what was the Belcher Ranch. The IBWC then moved the measurement location on to the Shahan Ranch upstream about ¼-mile. The spring measurement location on the Shahan Ranch was between the upper two and downstream two spring locations shown on the topographic maps.

As part of this study, LBG-Guyton made flow measurements at Mud Springs and on selected locations along Pinto Creek in February and March 2005 during relatively wet conditions with higher flows. The measured flow observed downstream of Mud Springs was 26 cfs on February 25, 2005 (Figure 14).

Stream-flow measurements were made at four locations along Pinto Creek on March 2, 2005 to determine stream gains and losses (Figure 14). The first measurement (19 cfs) was made at approximately the same location as the last measurements made by the IBWC. The second measurement (29.2 cfs) was made at the upstream side of the intersection of Pinto Creek and County Road 2804. The third measurement (41.2 cfs) was made on the upstream side of the intersection of Pinto Creek and Highway 90, which was downstream of the confluence of West Pinto Creek and Pecan Springs. The fourth and last measurement (36.2 cfs) was made just upstream of where the Southern Pacific Railroad crosses Pinto Creek, and is located downstream of Stricklin Springs that issues from the Austin Chalk. The stream measurements indicate a gaining flow from station 1 to 3, but then the stream loses flow by the last station as the stream traverses the Austin Chalk.



Sources: USGS; Heitmuller and Reece, 2003

KINNEY COUNTY SPRING LOCATIONS

FIGURE 10

LBG-GUYTON ASSOCIATES

TABLE 2

Kinney County Springs

ID No.	State Well Number	Spring Name	Location		Land Elevation (Ft.)
			Latitude (dd)	Longitude (dd)	
1		Boiling Springs	29.5333	-100.1302	1,513
2		Cow Creek Spring	29.1513	-100.6078	1,009
3		Indian Springs	29.1511	-100.1161	947
4	7045501 & 506	Las Moras Springs	29.3099	-100.4211	1,100
5		Lost Creek Spring (1)	29.6086	-100.1803	1,751
6		Lost Creek Spring (2)	29.6054	-100.1697	1,789
7		Lost Creek Spring (3)	29.6029	-100.1651	1,836
8		Spring N of Lost Creek	29.6217	-100.1733	1,811
9	7031703	Moran Springs	29.5083	-100.2083	1,536
10		Mud Creek (1)	29.2918	-100.7186	945
11		Mud Creek (2)	29.2946	-100.7137	967
12	7036102	Mud Springs	29.4604	-100.6183	1,189
13	7036204	Pecan Springs	29.4752	-100.5421	1,294
14		Pinto Springs (NE)	29.4104	-100.4478	1,197
15		Pinto Springs (NW)	29.411	-100.4498	1,199
16	7037801	Pinto Springs (SE)	29.4067	-100.4509	1,190
17		Pinto Springs (SW)	29.4073	-100.4524	1,194
18		W Pinto Creek Spring	29.3841	-100.5345	1,138
19		Riddle Spring	29.6122	-100.2255	1,679
20	7030601	Schwander Springs	29.5583	-100.2583	1,688
21	7030602	Silver Springs	29.5586	-100.2754	1,567
22		Silver Lake Spring	29.5176	-100.2816	1,403
23		Sleeping Spring	29.2069	-100.14	1,359
24		Stricklin Spring	29.4719	-100.5847	1,023
25		Sycamore Springs	29.465	-100.13	1,360
26		East Sycamore Creek Spring	29.2926	-100.7337	961
27		East Fork of Sycamore Creek Spring	29.4641	-100.6765	1,141
28		Tequesquite Spring	29.0941	-100.6	893

Las Moras Springs

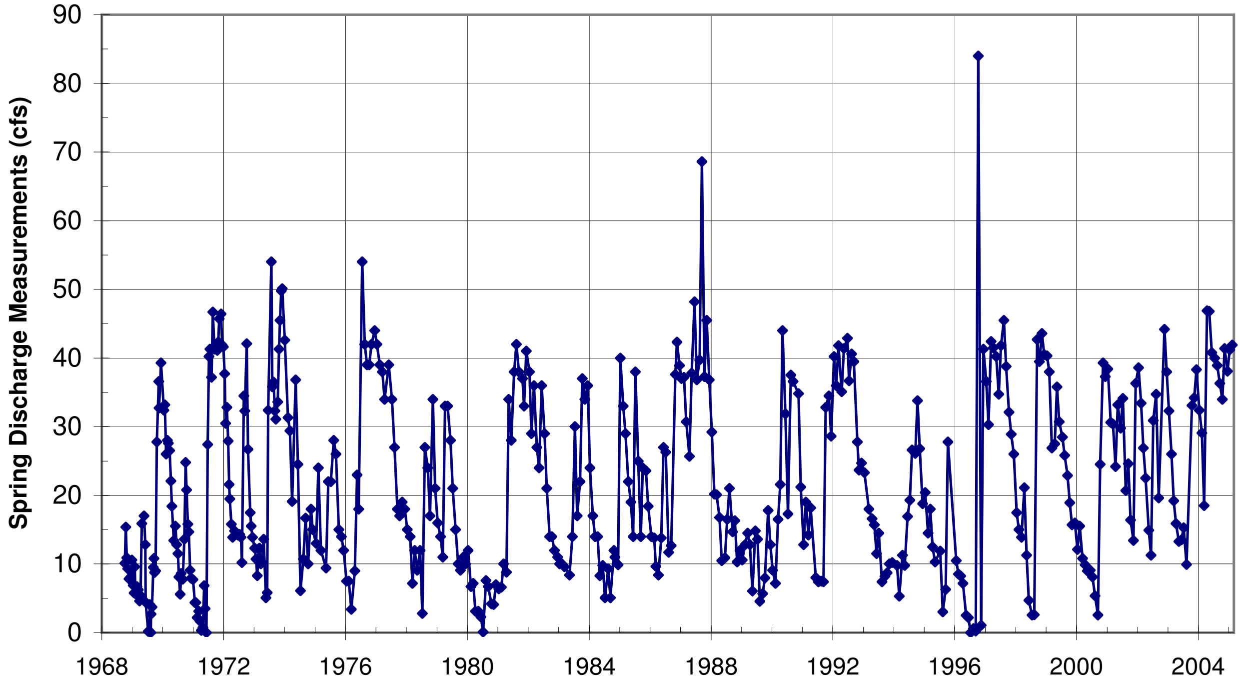
Pinto Springs

Mud Springs

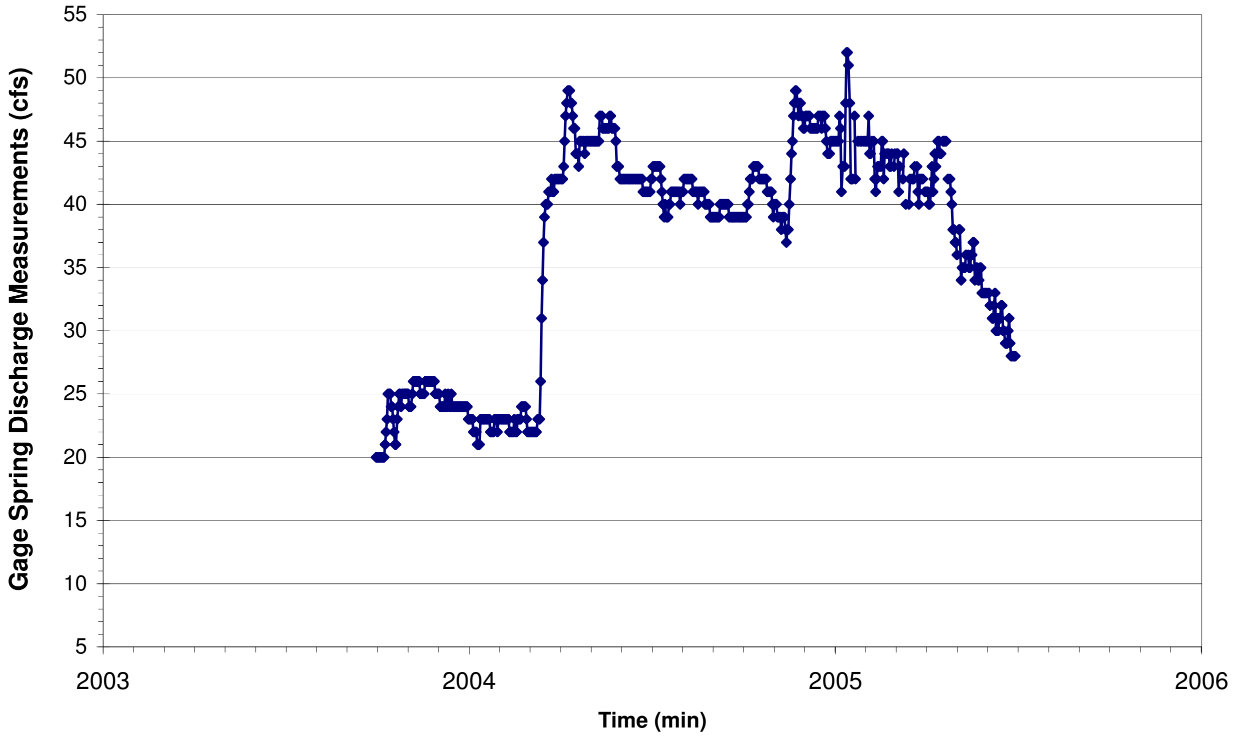
LAS MORAS, PINTO AND MUD SPRINGS

FIGURE 11

LBG-GUYTON ASSOCIATES

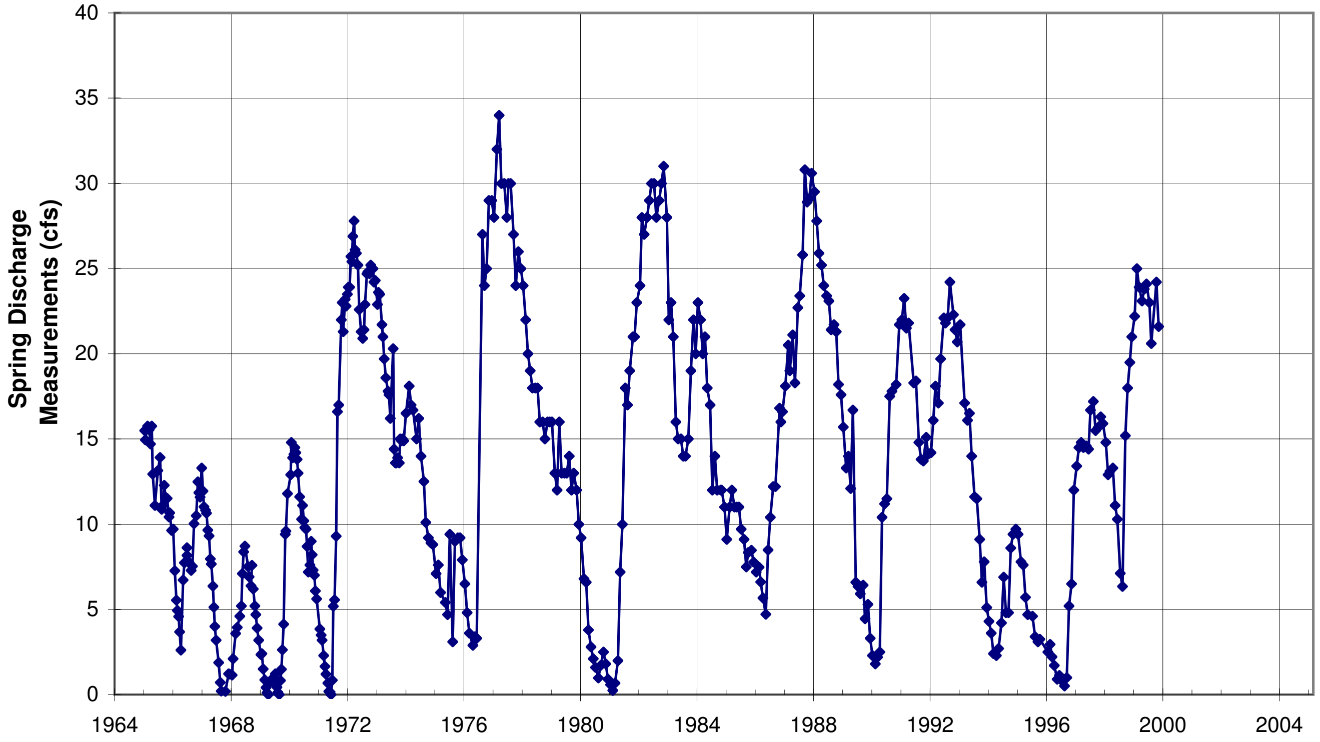


LAS MORAS SPRINGS DISCHARGE
Measurements by IBWC

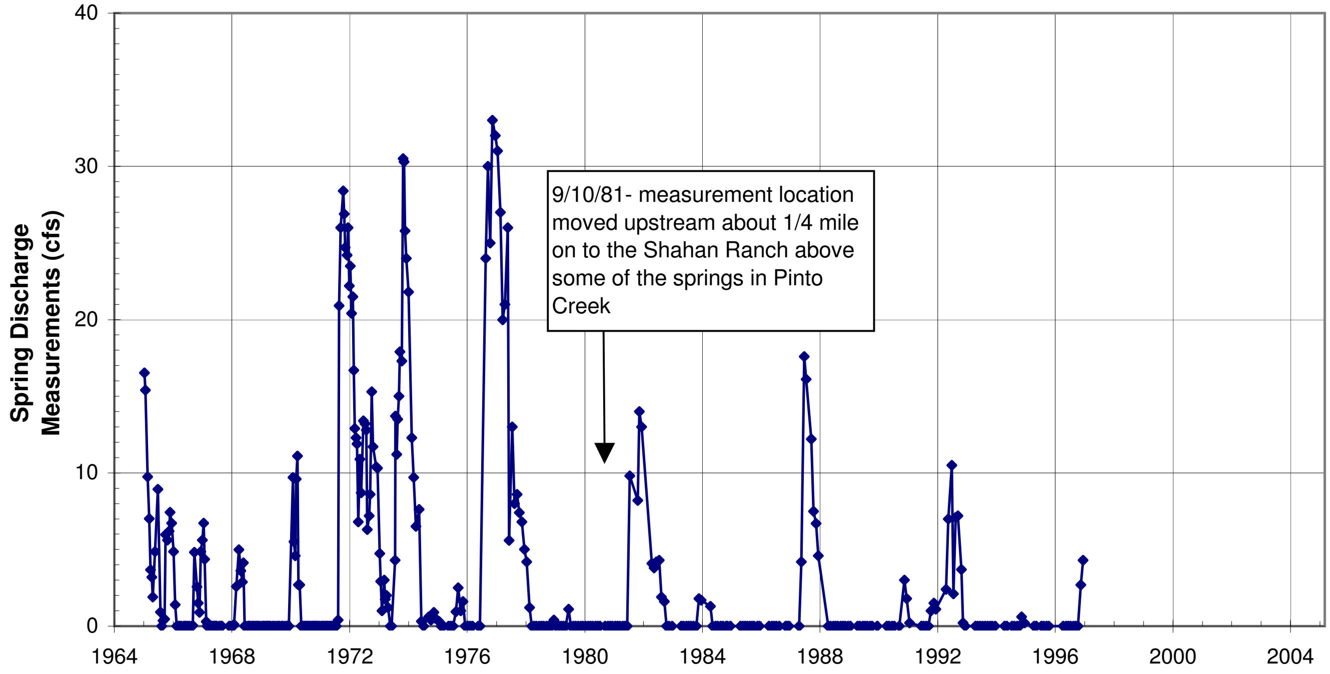


LAS MORAS SPRINGS DISCHARGE
(Data from USGS)

LAS MORAS SPRINGS DISCHARGE **FIGURE 12**



MUD SPRINGS



9/10/81- measurement location moved upstream about 1/4 mile on to the Shahan Ranch above some of the springs in Pinto Creek

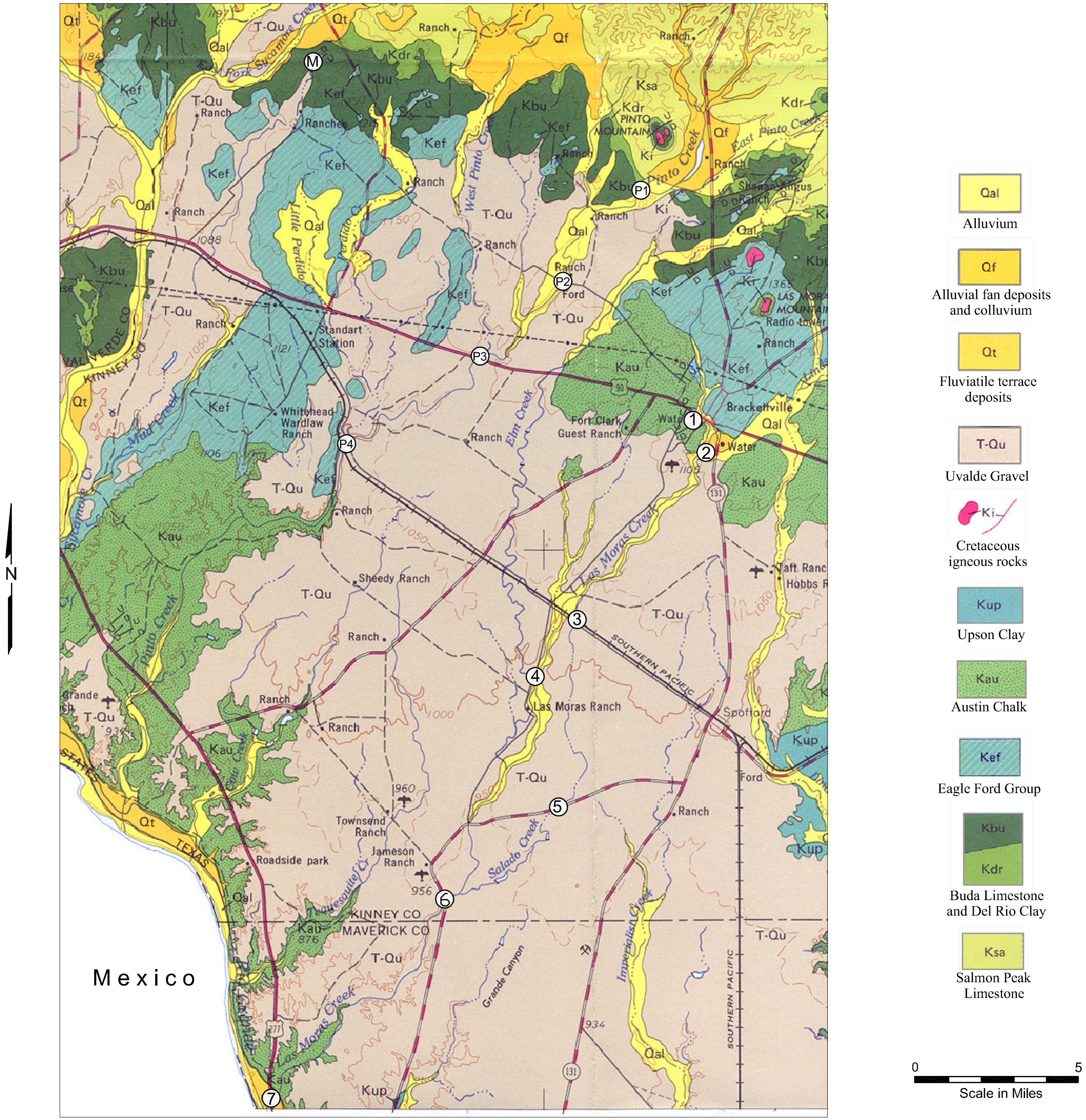
PINTO SPRINGS

MUD SPRINGS AND PINTO SPRINGS DISCHARGE

(Measured by IBWC)

FIGURE 13

LBG-GUYTON ASSOCIATES



Explanation

Location of Stream Measurements on Las Moras Creek by IBWC on 10/18/1993

①	9.5 cfs	Las Moras Creek at springs
②	11.0 cfs	Las Moras Creek Fort Clark Springs at road entrance
③	5.1 cfs	Las Moras Creek at first crossing below S.T.P.
④	0 cfs (Dry)	Las Moras Creek at county road by railroad crossing
⑤	0 cfs (Dry)	Salado Creek at F.M. 1908
⑥	2.7 cfs	Las Moras Creek at lower F.M. 1908
⑦	4.5 cfs	Las Moras Creek at Hwy. 277

Location of Stream Measurements at Mud Springs and on Pinto Creek by LBG-Guyton Associates

(M)	26.0 cfs	Mud Springs, measured on 2/25/2005

Pinto Creek, measured on 3/02/2005

(P1)	19.1 cfs	Pinto Springs
(P2)	29.2 cfs	Pinto Creek at County Rd. 2804
(P3)	41.2 cfs	Pinto Creek at I-90
(P4)	36.2 cfs	Pinto Creek at railroad crossing

BASE MAP COMPILED FROM B.E.G. GEOLOGIC ATLAS OF TEXAS, DEL RIO SHEET, 1977
ROBERT THOMAS HILL MEMORIAL EDITION.

LAS MORAS CREEK GAIN/LOSS - MUD SPRINGS DISCHARGE - PINTO CREEK GAIN/LOSS

FIGURE 14

Val Verde County Springs

Forty-five springs issuing from the Edwards-Trinity (Plateau) aquifer are identified in Val Verde County (Figure 15) (Table 3) ranging from seeps to mostly medium to very large springs (2.8 to 2,800 cfs). Several of the springs are very large, including the third and fourth largest springs in Texas, Goodenough and San Felipe, respectively (Brune, 1981).

Figure 16 shows three views of Goodenough Springs in the early 1960s before Amistad Reservoir inundated the site in 1968. Goodenough Springs, the largest spring in the County, is now submerged below about 150 feet of lake water when the reservoir is at conservation pool level, but still discharges significant volumes of water under the lake surface. In August of 2004, cave divers explored to a depth of approximately 400 feet below the lake surface http://www.goodenoughsprings.org/index.htm.

San Felipe Springs, the fourth largest spring in Texas is actually a combination of about 10 springs located along San Felipe Creek. Two of these 10 springs, referred to as the East Spring and West Spring, supply all the water currently used by the City of Del Rio by means of pumps installed in the springs. Cumulatively, San Felipe Springs has never ceased flowing throughout recorded history.

Discharge records from USGS Gage 084528.00, maintained by the IBWC at San Felipe Springs, for the period of record from February 1961 to present are shown in Figure 17. The IBWC reported springflow includes gaged flow downstream plus amounts withdrawn by the City's pumpage and additional irrigation via canal. The minimum monthly amount of flow from San Felipe Springs occurred during 1963 at about 2,000 acre-feet (ac-ft) per month, which equates to about 32 cfs or 15,000 gpm. The yearly total flow for 1963 was 36,580 ac-ft.

Since the filling of Lake Amistad, measurements have been on a daily basis for San Felipe Springs and periodically measured at McKee Springs on the Rio Grande, Cienegas and Cantu Springs down gradient from Amistad Dam. Hydrographs of these springs are also shown in Figure 17. Obvious increases can be seen in San Felipe Springs' flow after the lake filled. The average discharge of San Felipe Springs is about 110 cfs or about 80,000 ac-ft/yr. The lowest flow at San Felipe since the lake filled occurred in 1996 at a little less than 4,000 ac-ft per month.

The City of Del Rio relies on San Felipe Springs for all of its water supply. The water is collected through a number of pumps set in the orifices of East Spring and West Spring where water is issuing from the Edwards aquifer (Figure 18). The water is then treated in a new microfiltration plant, chlorinated and distributed to the City and to Laughlin Air Force Base. The pumps in West Spring are installed in boreholes drilled just upstream of the spring outlet. The pumps in East Spring are set in a reservoir formed by the concrete enclosure surrounding the spring orifices.

In consideration of drought impacts on springflow, recent droughts are more appropriate to view compared to the 1950s drought because the filling of Amistad Lake has generally increased the springflow since 1968. A minimum flow has not been determined to sustain the endangered species living downstream from San Felipe Springs.

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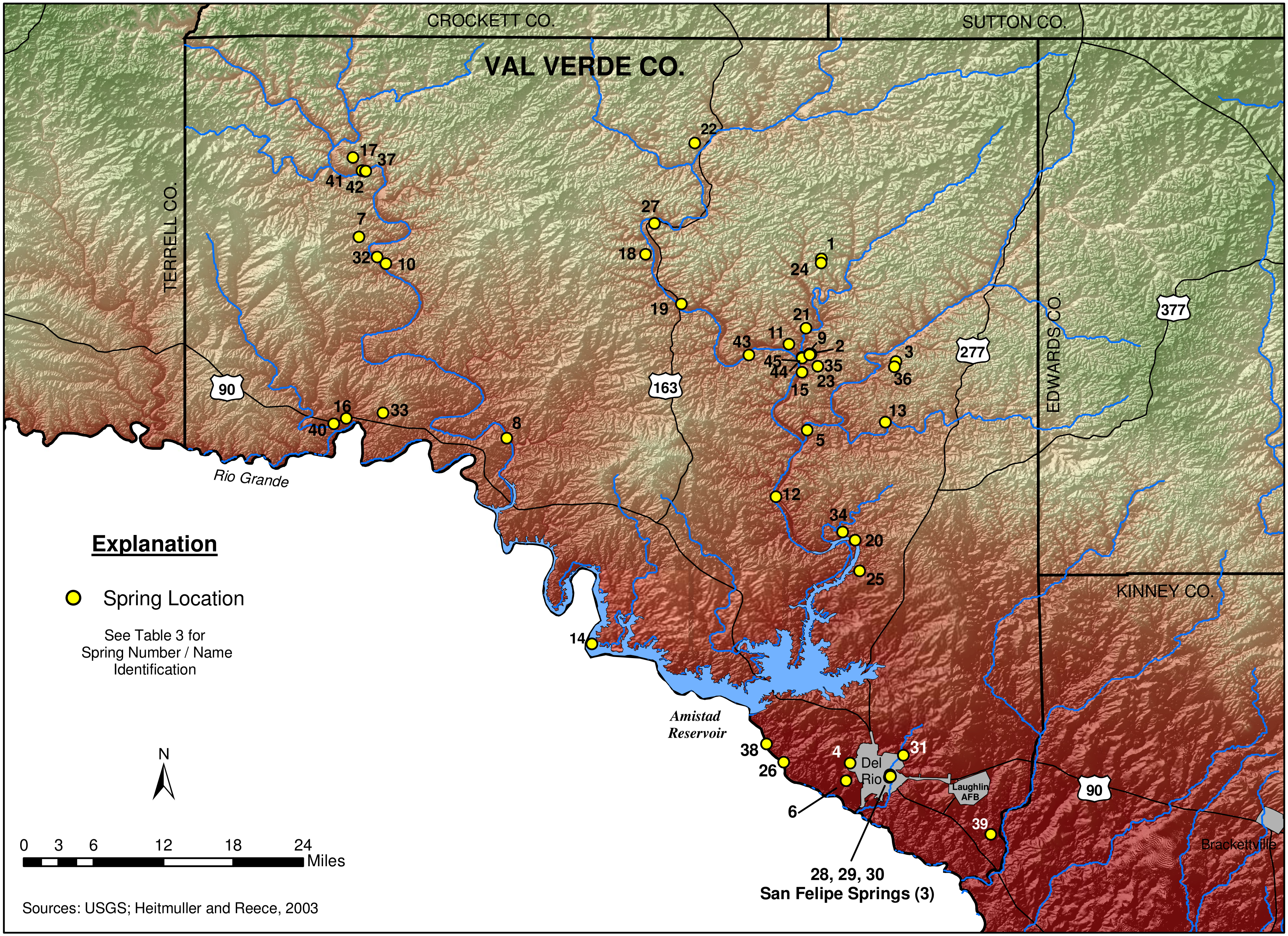


Sources: USGS; Heitmuller and Reece, 2003

VAL VERDE COUNTY SPRING LOCATIONS

FIGURE 15

LBG-GUYTON ASSOCIATES

TABLE 3

Val Verde County Springs

ID No.	State Well Number	Spring Name	Location		Land Elevation (Ft.)
			Latitude (dd)	Longitude (dd)	
1		Big Norris Spring	30.0141	-100.968	1,959
2	7001704	Blue Spring	29.8936	-100.9938	1,480
3		Camp Spring	29.8869	-100.8755	1,667
4	7033801	Cantu Springs	29.3875	-100.9322	979
5		Carlos Camp Spring	29.8016	-100.9583	1,373
6		Cienegas Creek Spring	29.3662	-100.9379	938
7	5460804	Cox Springs	30.0416	-101.5416	1,763
8		Dead Man Springs	29.7916	-101.3583	1,378
9	7001702	Dolan Springs	29.8969	-100.9836	1,340
10		Everett Springs	30.0083	-101.5083	1,683
11	7108901	Finegan Springs	29.9083	-101.0083	1,607
12	7124301	Gillis Springs	29.752	-101.0416	1,180
13		Glenn Spring	29.8116	-100.8886	1,449
14	7130901	Goodenough Springs	29.5363	-101.2531	1,122
15		Grass Patch Springs	29.8736	-100.9922	1,331
16	7112504	Guy Skiles Springs	29.8166	-101.5579	1,320
17	5452801	Howard Springs	30.1583	-101.5417	1,661
18	5463801	Hudspeth Springs	30.025	-101.175	1,618
19	7107603	Huffstutler Springs	29.9583	-101.1416	1,506
20		Indian Springs	29.665	-101.9263	1,220
21		Jose Maria Spring	29.9283	-100.9872	1,451
22	5455905	Juno Springs	30.1583	-101.1254	2,007
23		Leon Spring	29.8811	-100.9725	1,492
24		Little Norris Spring	30.0091	-100.9683	2,010
25		Lowry Springs	29.6269	-100.9208	1,196
26	7140903	McKee Springs	29.425	-101.0416	970
27		Pecan Springs	30.0583	-101.1751	1,844
28	7041301	San Felipe Spring E	29.3725	-100.883	975
29	7041302	San Felipe Spring W	29.3728	-100.8847	960
30	7041303	San Felipe Spring S	29.373	-100.8825	975
31		San Felipe Creek Spring	29.3981	-100.8666	1,015
32		Scott Spring	30.0166	-101.5189	1,447
33		Seep Springs	29.8233	-101.5116	1,422
34	7017501	Slaughter Bend Springs	29.6751	-100.9416	1,345
35		Snake Springs	29.8961	-100.9808	1,385
36		Spotted Oak Spring	29.8802	-100.8775	1,671
37		Tardy Spring	30.1239	-101.5378	1,563
38	7140905	US No. 3 Spring	29.4122	-101.0365	921
39	7042601	Yoas Springs	29.3083	-100.7751	980
40	7112501		29.8099	-101.5732	1,260
41	5460301		30.1233	-101.534	1,537
42	5460302		30.1235	-101.5335	1,537
43	7108801		29.8952	-101.0582	1,472
44	7001703		29.8913	-100.9923	1,520
45	7001701		29.8955	-100.9829	1,360

Aerial Photo - 1965

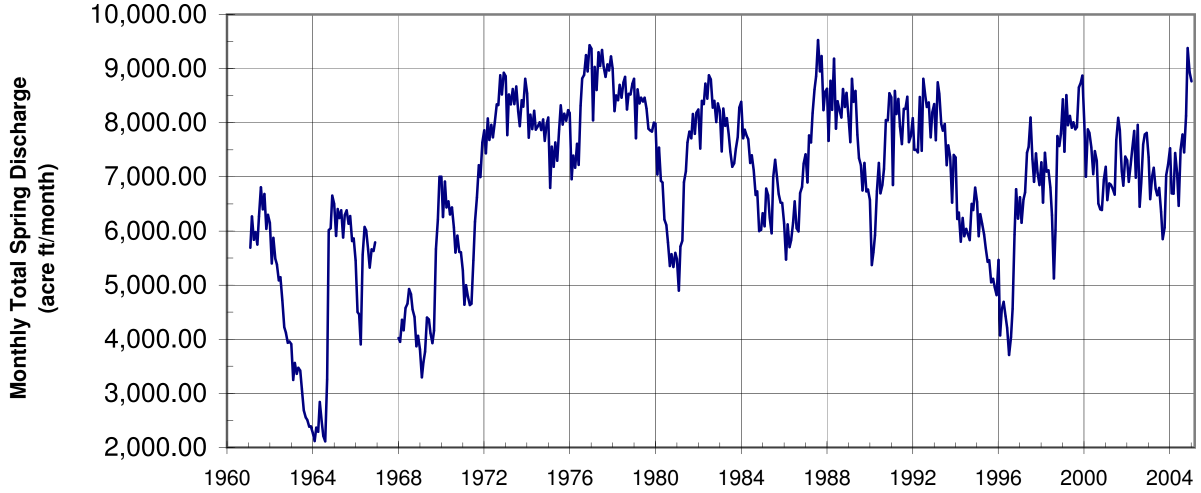
1965

1964

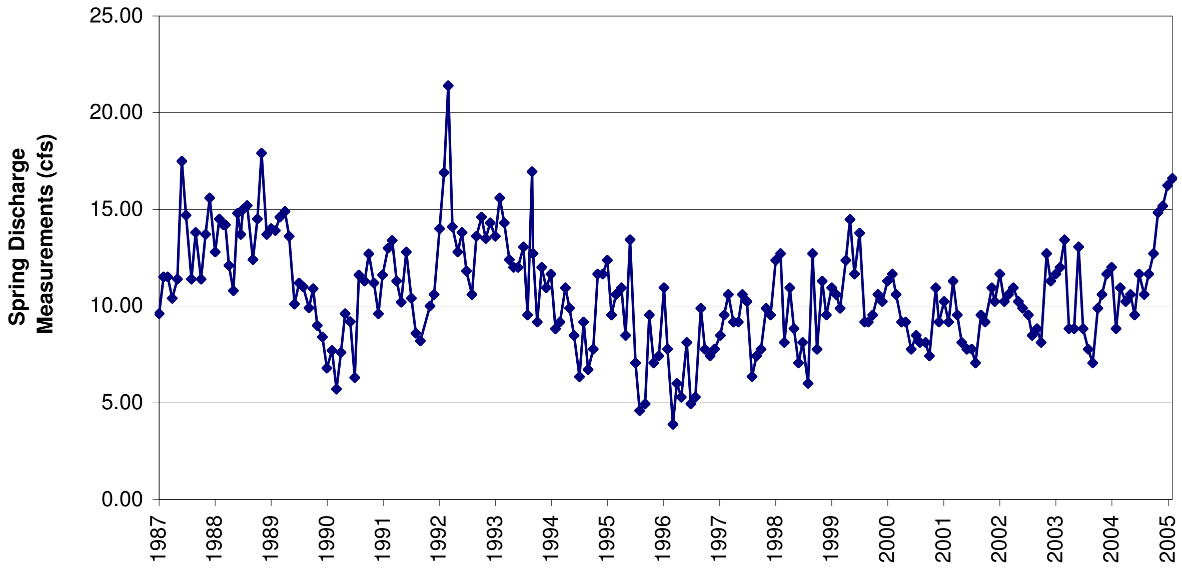
Photos provided by
Ted Small, retired USGS

GOODENOUGH SPRINGS
Prior to being inundated by Amistad Reservoir

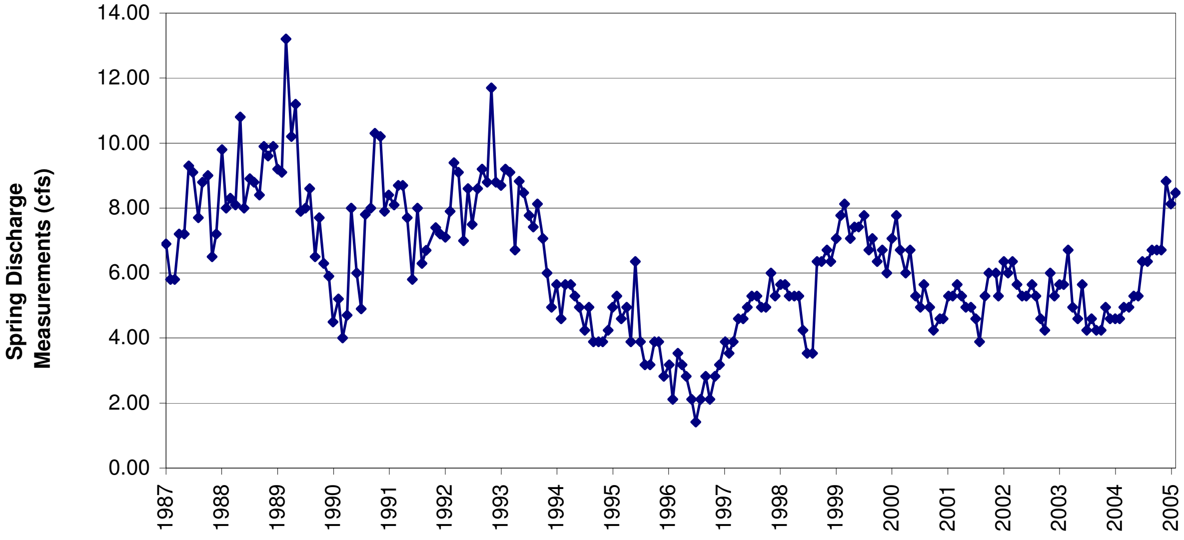
FIGURE 16



SAN FELIPE SPRINGS TOTAL DISCHARGE



CIENEGAS SPRINGS DISCHARGE MEASUREMENTS BY IBWC



CANTU SPRINGS DISCHARGE MEASUREMENTS BY IBWC

SAN FELIPE - CIENEGAS - CANTU SPRINGS DISCHARGE **FIGURE 17**

LBG-GUYTON ASSOCIATES

East San Felipe Springs

West San Felipe Springs

EAST AND WEST SAN FELIPE SPRINGS

FIGURE 18

POTENTIAL IMPACT TO SPRINGS DUE TO PUMPING

Base flows of the rivers and streams that flow through Kinney and Val Verde Counties is principally generated from the numerous springs that occur in the headwaters of these surface drainages. Sustaining flow in these important rivers and streams is highly dependent on maintaining an appropriate water level in the aquifer systems that feed the supporting springs. Spring discharge rates can be negatively impacted by nearby wells if the pumping withdrawals lower the water table in the aquifer that contributes to the spring. If the water-level elevation drops below the elevation of the land surface at the point of spring discharge the spring will cease to flow.

With the sustainability of local water supplies and the economic welfare of the region in mind, the Plateau Regional Water Planning Group defines groundwater availability as <u>a maximum level of aquifer withdrawal that results in an acceptable level of long-term aquifer impact such that the base flow in rivers and streams is not significantly affected beyond a level that would be anticipated due to naturally occurring conditions</u>.

To evaluate the potential effect that pumping might have on springs and subsequent base flow to rivers and streams, several pumping scenarios were run using the TWDB Edwards-Trinity (Plateau) aquifer groundwater availability model (GAM). The aquifer simulation model was run by increasing pumping withdrawals at set intervals until reasonably acceptable levels of impact to surface water drains (non-specified springs) were observed. For regional planning purposes, this exercise resulted in a maximum pumping level from the Edwards-Trinity (Plateau) aquifer in Kinney County of 22,432 ac-ft per year, and in Val Verde County of 49,607 ac-ft per year. However, it is important to recognize that this amount of pumping is assumed to be evenly spaced over the extent of the aquifer. Concentrating pumping in smaller areas would increase the impact potential on springs in the general vicinity. Also, these model runs assumed average rainfall/recharge conditions. Less then normal recharge would intensify the pumping impact.

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