Chapter 1

Aquifers of the Edwards Plateau

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Introduction

The Edwards Plateau occupies the west-central part of Texas, extending from the Hill Country near Austin and San Antonio up to the mountains of West Texas and extending into the High Plains. Because of low rainfalls, the frequency of drought, and few major rivers, groundwater is an important source of water to the people and environmental resources of the Edwards Plateau area. The hydrogeologic centerpiece of the Edwards Plateau is the Edwards–Trinity (Plateau) aquifer, one of the major aquifers of the state. Around and in hydraulic connection with this centerpiece are a number of major and minor aquifers including the Capitan Reef, Cenozoic Pecos Alluvium, Dockum, Edwards (Balcones Fault Zone), Ellenburger-San Saba, Hickory, Lipan, Marble Falls, Ogallala, Rustler, and Trinity aquifers. Many towns and rural areas in the Edwards Plateau area rely on groundwater. Total groundwater usage in the area has ranged from about 500,000 to over 700,000 acre-ft per year over the past 20 years. A better understanding of how these aquifers behave is important for better understanding how to best manage the scarce water resources that do exist in the Edwards Plateau. The purpose of this paper is to present a general overview of the aquifers of the Edwards Plateau and recent scientific and planning activities concerning these aquifers.

Location, Physiography, and Climate

Our focus is on the Edwards Plateau area of Texas (Figure 1-1). This area comprises a large part of state and includes the following 51 counties: Andrews, Bandera, Blanco, Brewster, Brown, Burnet, Coke, Coleman, Concho, Crane, Crockett, Culberson, Ector, Edwards, Gillespie, Glasscock, Howard, Irion, Jeff Davis, Kendall, Kerr, Kimble, Kinney, Lampasas, Llano, Loving, Martin, Mason, McCulloch, Menard, Midland, Mills, Mitchell, Nolan, Pecos, Reagon, Real, Reeves, Runnels, San Saba, Schleicher, Sterling, Sutton, Taylor, Terrell, Tom Green, Upton, Uvalde, Val Verde, Ward, and Winkler. A total of 39 counties have populations of less than 20,000 people as of 2000 with four counties (Ector, Midland, Taylor, and Tom Green) with populations of more than 100,000 people (Table 1-1). The population in the area has grown by almost 80 percent since 1950, increasing by more than 440,000 people (Table 1-1). However, 19 counties

[1] Texas Water Development Board

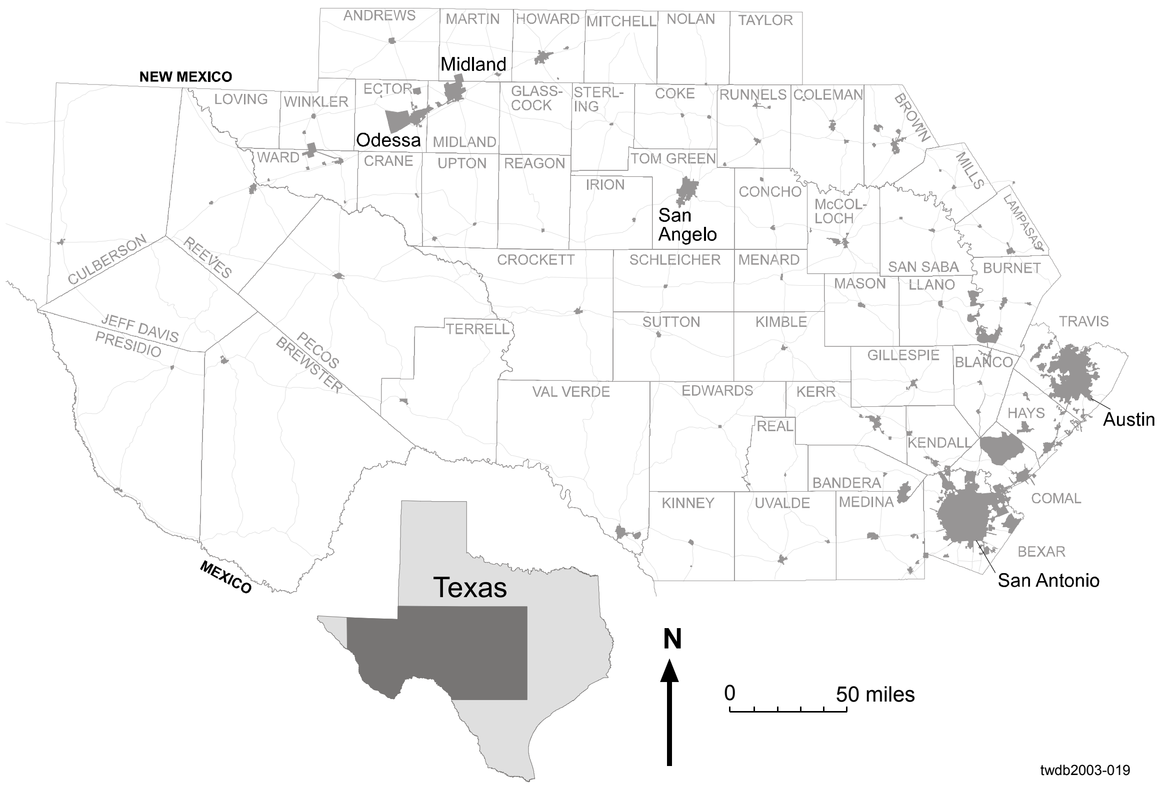

Figure 1-1: Location of the study area in the Edwards Plateau area. Bexar, Comal, Hays, Medina, Presidio, and Travis counties are shown for orientation purposes and are not considered in this paper.

have decreased in population since 1950. Total groundwater use has ranged from 443,000 to 954,000 acre-feet per year over the past twenty years (Figure 1-2). In 2000, 26 counties got more than 75 percent of their water from aquifers of the Edwards Plateau (Table 1-1).

This part of Texas is primarily located in the southern portion of Great Plains Province (Fenneman, 1931), which is characterized by asymmetric ridges or mountains and broad intervening basins (Bates and Jackson, 1984). Elevations range from 5,000 feet above sea level in the western portion of the region to 500 feet above sea level on the eastern side.

The Rio Grande and the Colorado and Pecos rivers are the major rivers than cut through the Edwards Plateau area (Figure 1-3). The headwaters of the Guadalupe, Nueces, and San Antonio rivers are also located in the Edwards Plateau area (Figure 1-3). Flow in the Rio Grande in this part of Texas is primarily controlled by inflows from the Rio Conchos near Presidio. The Pecos River is a major tributary to the Rio Grande that originates in New Mexico. The river is impounded in Red Bluff Lake in Loving County and is used for irrigation in Pecos, Reeves, and Ward counties.

Most of the study area ranges from subhumid in the eastern portion to semiarid in the western areas (Walker 1979). Average annual precipitation ranges from less than 10

Table 1-1: Population and groundwater use for counties in the Edwards Plateau area for selected years.

	Population				Groundwater use (acre-feet)			
County	**1950**	**1980**	**1990**	**2000**	**1980**	**1990**	**2000**	**%GW**
Andrews	5,002	13,323	14,338	13,004	21,443	15,132	24,123	99.7
Bandera	4,410	7,084	10,562	17,645	1,320	1,848	2,653	85.7
Blanco	3,780	4,681	5,972	8,418	886	1,514	1,288	74.1
Brewster	7,309	7,573	8,681	8,866	3,126	2,551	3,967	92.5
Brown	28,607	33,057	34,371	37,674	1,049	1,611	2,788	13.0
Burnet	10,356	17,803	22,677	34,147	2,123	1,946	2,957	33.2
Coke	4,045	3,196	3,424	3,864	451	678	1,070	37.6
Coleman	15,503	10,439	9,710	9,235	257	113	115	4.0
Concho	5,078	2,915	3,044	3,966	1,595	3,287	3,473	91.1
Crane	3,965	4,600	4,652	3,996	2,780	2,676	2,081	59.1
Crockett	3,981	4,608	4,078	4,099	6,606	4,561	3,376	87.4
Culberson	1,825	3,315	3,407	2,975	76,119	12,580	27,030	99.9
Ector	42,102	115,374	118,934	121,123	25,144	20,551	17,546	28.4
Edwards	2,908	2,033	2,266	2,162	1,310	854	1,041	90.3
Gillespie	10,520	13,532	17,204	20,814	4,242	5,729	6,325	89.2
Glasscock	1,089	1,304	1,447	1,406	40,443	27,491	35,788	99.9
Howard	26,722	33,142	32,343	33,627	2,682	4,141	6,103	38.8
Irion	1,590	1,386	1,629	1,771	1,030	1,458	1,542	56.6
Jeff Davis	2,090	1,647	1,946	2,207	26,872	3,767	1,084	96.4
Kendall	5,423	10,635	14,589	23,743	1,748	2,322	3,499	79.6
Kerr	14,022	28,780	36,304	43,653	5,716	3,176	3,818	43.0
Kimble	4,619	4,063	4,122	4,468	1,103	845	707	25.7
Kinney	2,668	2,279	3,119	3,379	10,834	8,394	15,833	99.4
Lampasas	9,929	12,005	13,521	17,762	1,192	993	1,872	8.0
Llano	5,377	10,144	11,631	17,044	1,958	2,122	1,824	27.4
Loving	227	91	107	67	64	44	46	11.2
Martin	5,541	4,684	4,956	4,746	21,118	13,919	15,693	97.4
Mason	4,945	3,683	3,423	3,738	16,861	18,077	11,602	97.1
Mcculloch	11,701	8,735	8,778	8,205	7,515	6,060	7,137	96.2
Menard	4,175	2,346	2,252	2,360	709	767	1,132	28.4
Midland	25,785	82,636	106,611	116,009	31,975	34,173	32,945	52.3
Mills	5,999	4,477	4,531	5,151	1,340	1,245	952	19.4
Mitchell	14,357	9,088	8,016	9,698	3,611	2,249	7,103	39.1
Nolan	19,808	17,359	16,594	15,802	3,710	3,611	6,079	59.8
Pecos	9,939	14,618	14,675	16,809	111,250	67,552	78,563	97.7
Reagan	3,127	4,135	4,514	3,326	24,378	39,919	18,724	99.8
Real	2,479	2,469	2,412	3,047	632	770	480	51.1
Reeves	11,745	15,801	15,852	13,137	120,524	40,117	68,285	85.9
Runnels	16,771	11,872	11,294	11,495	2,027	1,866	973	27.8
San Saba	8,666	6,204	5,401	6,186	3,705	1,919	2,763	45.9
Schleicher	2,852	2,820	2,990	2,935	2,350	2,113	3,364	96.9
Sterling	1,282	1,206	1,438	1,393	2,245	1,814	1,813	96.1
Sutton	3,746	5,130	4,135	4,077	3,799	2,574	3,373	96.8
Taylor	63,370	110,932	119,655	126,555	2,891	914	872	2.0
Terrell	3,189	1,595	1,410	1,081	1,379	1,139	546	85.2
Tom Green	58,929	84,784	98,458	104,010	15,268	28,246	22,609	42.3
Upton	5,307	4,619	4,447	3,404	19,516	16,310	16,098	99.7

Table 1-1 (cont): Population and groundwater use for counties in the Edwards Plateau area for selected years.

	Population				Groundwater use (acre-feet)			
County	**1950**	**1980**	**1990**	**2000**	**1980**	**1990**	**2000**	**%GW**
Uvalde	16,015	22,441	23,340	25,926	81,196	144,522	66,083	97.4
Val Verde	16,635	35,910	38,721	44,856	1,673	4,211	16,217	91.7
Ward	13,346	13,976	13,115	10,909	33,311	10,670	12,164	52.5
Winkler	10,064	9,944	8,626	7,173	8,356	3,171	5,516	99.9
Total:	255,811	549,592	660,934	754,099	621,194	310,308	447,935	63.5

% GW = percent of total water use in 1997 that was met with groundwater.
Groundwater use includes use from all aquifers, including those not discussed in this paper.

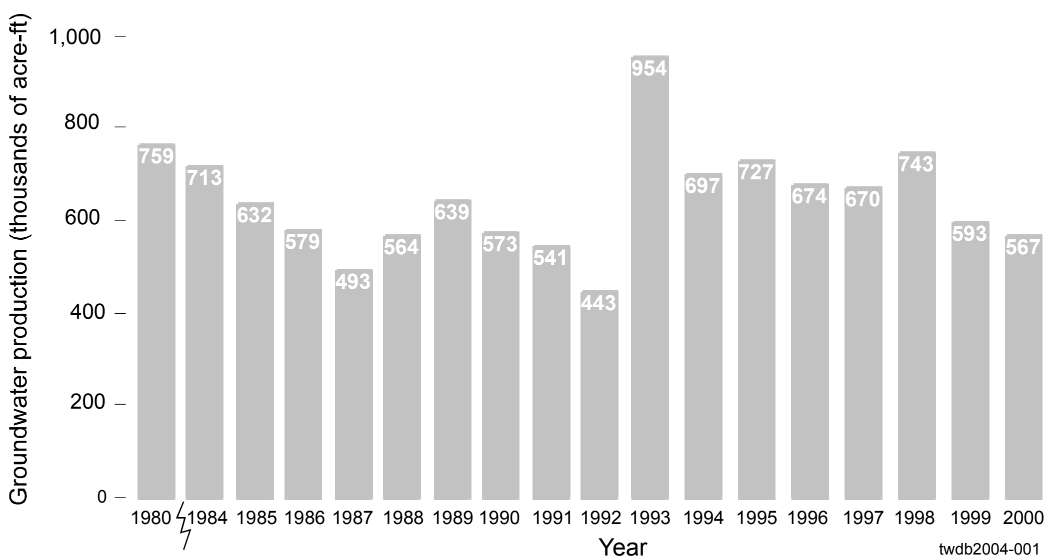

Figure 1-2: Total groundwater use for the Edwards Plateau area of Texas.

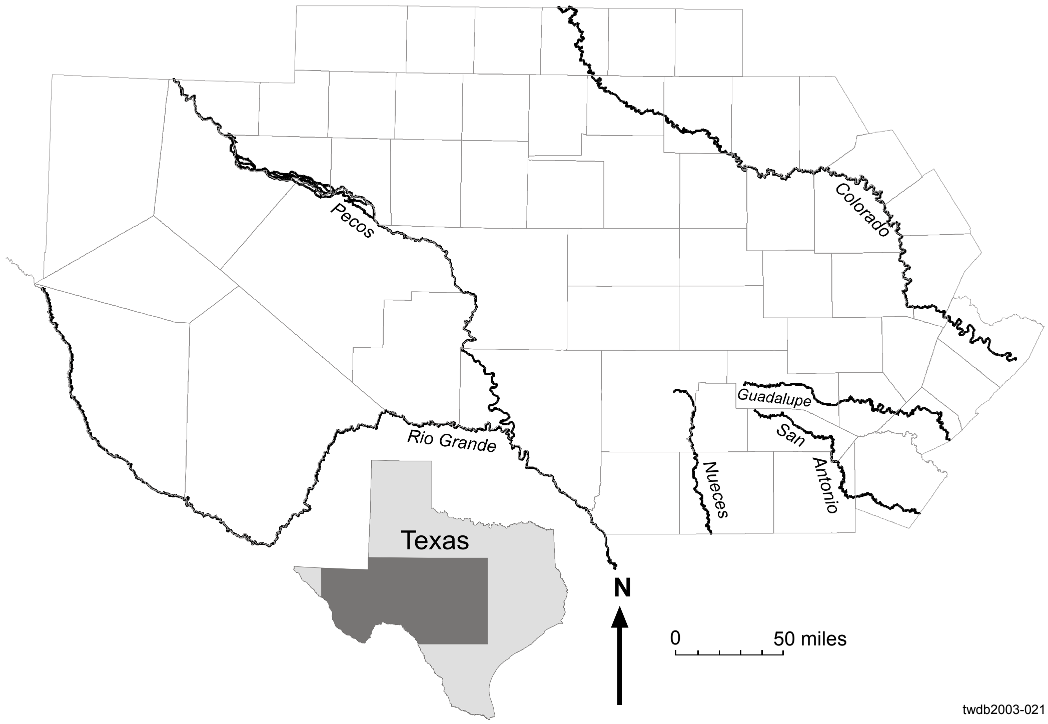

Figure 1-3: Location of major rivers in the Edwards Plateau area.

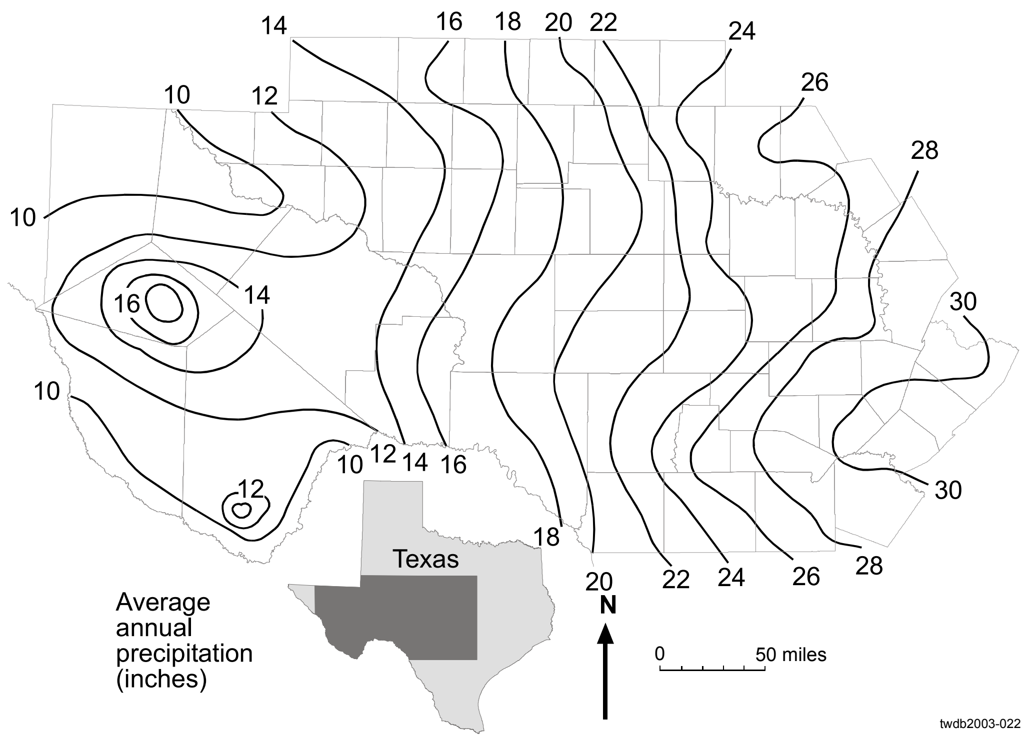

Figure 1-4: Amount of average annual precipitation in the Edwards Plateau area (after Larkin and Bomar, 1983).

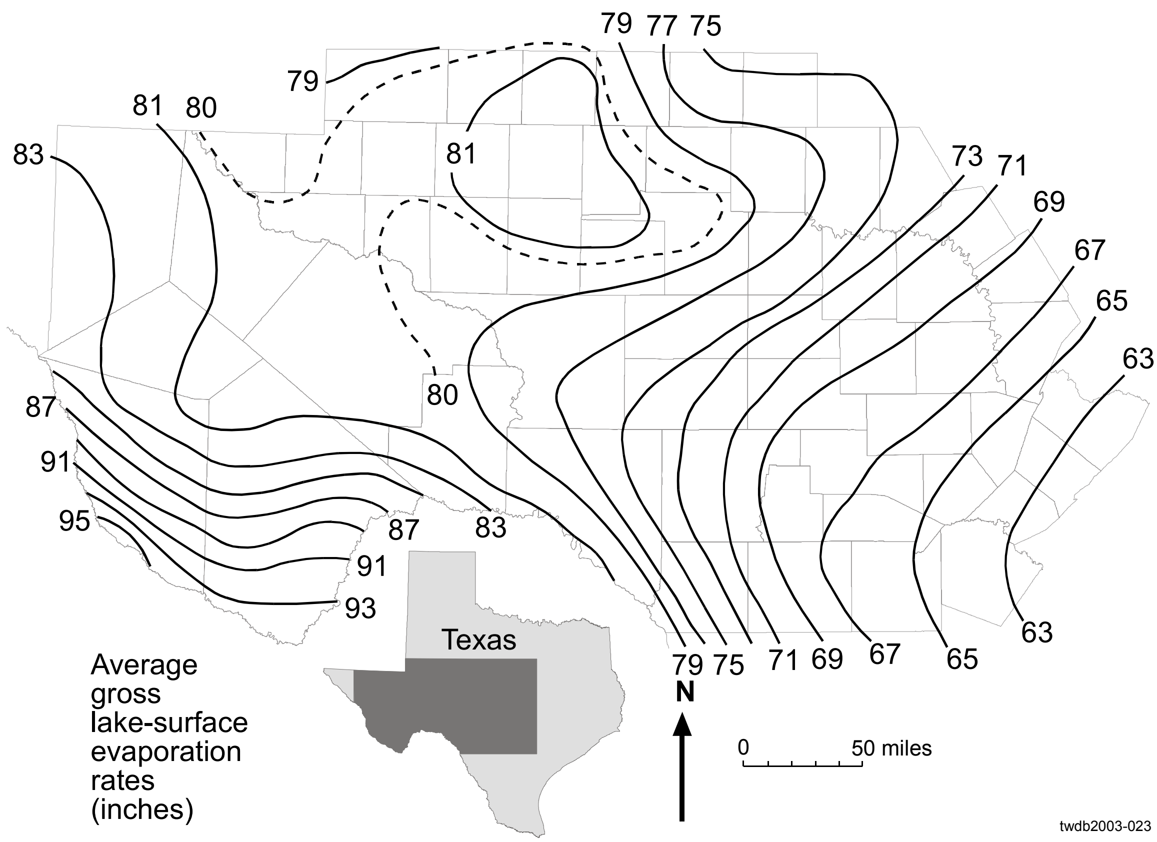

Figure 1-5: Amount of average gross lake-surface evaporation rates in the Edwards Plateau area (after Larkin and Bomar, 1983).

inches in the west to more than 30 inches in east (Figure 1-4). Late spring and early summer bring the greatest rainfalls to the eastern portion of the plateau while late summer results in the heaviest rainfall in the western areas. Average annual gross lake-surface evaporation rates range from less than 65 inches in east to more than 90 inches in west (Figure 1-5).

Aquifers of the Edwards Plateau

The Edwards Plateau area includes all or part of 12 aquifers recognized by the Texas Water Development Board (Figure 1-6). Five major aquifers, the Edwards (Balcones Fault Zone), the Edwards–Trinity (Plateau), the Cenozoic Pecos Alluvium, the Ogallala, and the Trinity are found in the area. Seven minor aquifers are also located in the area including the Capitan Reef, Dockum, Ellenburger-San Saba, Hickory, Lipan, Marble Falls, and Rustler aquifers. The Texas Water Development Board (TWDB) has assigned a major and minor status to the State's aquifers based on the quantity of water supplied by each aquifer (Ashworth and Hopkins, 1995). In addition to the aquifer recognized by the TWDB, there are several other geologic formations that locally produce water.

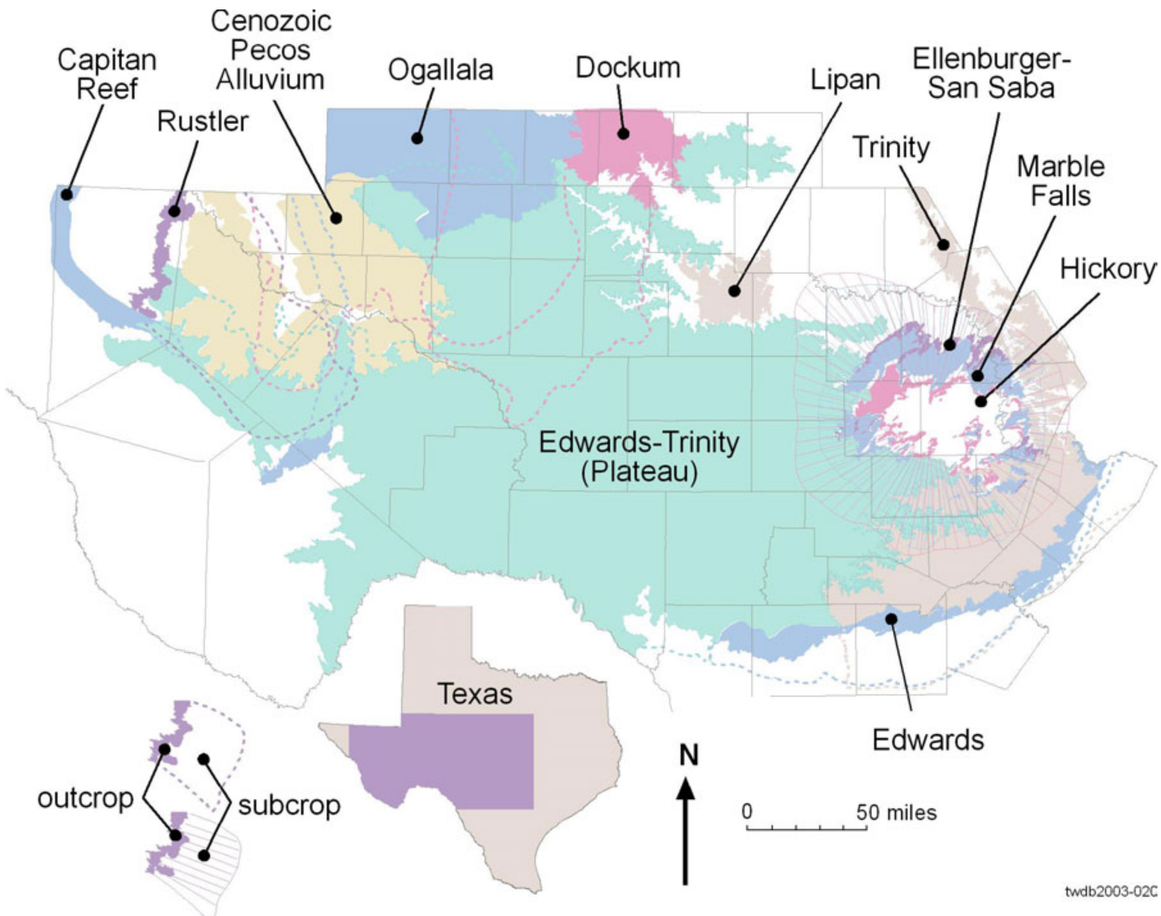

Figure 1-6: Location of recognized major and minor aquifers in Far West Texas (delineations from TWDB, map does not include the Igneous, West Texas Bolsons, and Marathon aquifers).

The major aquifers have had a number of scientific studies done on them. However, with a few exceptions in some local areas, the minor aquifers have had little to almost no groundwater studies done on them.

The general information presented below is from "Aquifers of Texas" by Ashworth and Hopkins (1995); "Aquifers of West Texas" by Mace and others (2001); the regional water plans of the Region F, Lower Colorado, South Central Texas, Plateau, and Far West Texas regions; and water-use information from TWDB surveys and estimates. Bradley and Malstaff (2004, Chapter 10 of this volume) discuss drought in the area. Paine (2004, Chapter 12 of this volume) discusses natural and oil-field contamination in an area of the Edwards Plateau, and Standen and Opdyke (2004; Chapter 11 of this volume) discuss aquifer susceptibility to contaminants. Edwards and others (2004, Chapter 13 of this volume) discuss the aquifer-dependant fishes of the Edwards Plateau. Keese and others (2004, Chapter 14 of this volume) evaluate climate, vegetation, and soil controls on groundwater recharge in Texas, including the Edwards Plateau. Arroyo and Mullican

(2004, Chapter 15 of this volume) discuss desalination, and Hart (2004, Chapter 16 of this volume) discuss brush control. Chowdhury and others (2004, Chapter 17 of this volume) discuss the origin of flow to the San Solomon Spring system.

Capitan Reef aquifer

The Capitan Reef aquifer consists of two strips located in Brewster, Culberson, Hudspeth, Jeff Davis, Pecos, Reeves, Ward, and Winkler counties (Figure 1-6) and extends northward into New Mexico. The aquifer is an ancient reef consisting of 2,360 ft of dolomite and limestone, and, in Texas, generally has poor water quality except in the exposed areas of the aquifer. Most of the water pumped from the aquifer is in Ward and Winkler counties for water-flooding operations in oil-producing areas. A small amount water is used for irrigation in Pecos and Culberson counties. Carlsbad, New Mexico, relies on the aquifer for municipal use. Pumping from the aquifer in the Edwards Plateau area over the past twenty years has ranged from less than 30 to about 12,500 acre-ft per year (Table 1-2). Recent pumping has been less than 50 acre-ft per year. The Capitan Reef aquifer is discussed in more detail by Uliana (2001) in "Aquifers of West Texas" (Mace and others, 2001).

Cenozoic Pecos Alluvium aquifer

The Cenozoic Pecos Alluvium aquifer is located in Andrews, Crane, Crockett, Culberson, Ector, Jeff Davis, Loving, Pecos, Reeves, Upton, Ward, and Winkler counties (Figure 1-6) and extends to the north into New Mexico. The aquifer consists of sands, gravels, and clays of ancient river deposits of up to 1,500 ft thick. The aquifer is connected to the Dockum and Edwards–Trinity (Plateau) aquifers where they exist underneath the alluvium. Water quality is naturally highly variable and has also been locally impacted by past activities of the petroleum industry. Water levels have declined more than 200 ft in south-central Reeves and northwest Pecos counties but have remained somewhat steady since the 1970s with a decrease in irrigation. Lowered water levels have decreased baseflow to the Pecos River and, in some cases, now cause the river to lose water to the aquifer. Pumping from the aquifer in the Edwards Plateau area over the past twenty years has ranged from about 64,000 to about 200,000 acre-ft per year (Table 1-2). Reeves County has been the largest user of groundwater from the aquifer, using 67 percent of the total water pumped in 1997. The Cenozoic Pecos Alluvium aquifer is discussed in more detail by Jones (2004; Chapter 6 of this volume).

Dockum aquifer

The Dockum aquifer is located in Andrews, Coke, Crane, Crockett, Ector, Glasscock, Howard, Irion, Loving, Martin, Midland, Mitchell, Nolan, Pecos, Reagon, Reeves, Sterling, Tom Green, Upton, Ward, and Winkler counties in the Edwards Plateau area (Figure 1-6) and extends to the north beneath the Ogallala aquifer and to the northwest

Table 1-2: Groundwater use for the different aquifers in the Edwards Plateau area (acre-feet). This table only includes groundwater use in the counties listed in the Location section of this paper.

	Year						
	1980	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Aquifer	**1997**	**1998**	**1999**	**2000**			
Capitan Reef Complex	12,450	826	645	95	62	62	582
	181	583	156	724	642	510	398
	41	26	26	28			
Cenozoic Pecos Alluvium	199,327	127,460	102,719	93,947	75,260	79,109	106,541
	71,377	70,348	64,220	388,502	152,290	159,427	150,621
	151,371	165,084	143,806	132,456			
Dockum	12,715	12,894	14,813	10,860	10,004	10,210	9,808
	8,301	8,841	8,734	11,024	10,638	7,981	9,277
	8,432	9,196	10,019	8,260			
Edward (BFZ)	81,265	157,365	156,567	126,656	105,155	139,328	159,878
	145,346	119,805	47,592	113,493	99,221	71,447	91,970
	66,464	72,485	84,861	72,369			
Edwards–Trinity (Plateau)	184,129	205,845	163,347	171,741	149,924	153,225	168,308
	153,441	164,327	151,280	212,185	181,165	201,393	184,180
	176,708	192,717	156,151	153,371			
Ellenburger-San Saba	4,948	6,293	6,293	5,447	6,238	5,222	4,638
	6,659	6,413	6,473	6,737	7,498	5,518	5,854
	6,172	5,919	6,455	5,853			
Hickory	28,348	16,728	28,250	26,764	24,595	27,616	28,130
	26,402	26,638	20,857	24,000	23,523	22,094	20,658
	19,603	21,379	19,099	17,634			
Igneous	5,135	2,465	2,613	2,677	2,185	2,623	2,118
	2,217	2,727	2,646	2,594	2,762	2,697	2,629
	2,968	3,237	3,239	2,635			
Lipan	10,121	22,794	19,653	17,333	14,534	22,672	24,383
	24,588	20,512	13,850	63,867	60,581	76,180	35,230
	66,292	72,298	25,781	37,560			
Marble Falls	1,350	1,278	1,141	987	718	772	814
	790	749	693	702	1,524	1,601	1,647
	1,644	1,793	1,646	1,468			
Ogallala	73,283	58,124	57,240	49,075	36,434	45,606	51,249
	60,217	50,770	62,013	61,609	88,476	92,930	86,018
	76,134	83,031	83,625	73,097			
Rustler	371	539	327	297	301	251	268
	246	302	310	681	1,486	1,605	1,515
	1,584	1,728	1,542	1,380			
Trinity	14,693	12,385	13,640	13,326	12,181	13,074	14,465
	13,505	13,234	14,250	16,296	17,093	18,120	19,427
	18,765	20,465	19,940	17,296			
West Texas Bolsons	75,582	21,548	24,098	19,890	20,238	21,697	15,584
	12,752	11,788	13,987	7,936	8,818	8,968	9,387
	9,860	10,753	15,240	10,338			
Other aquifers	25,308	24,208	23,509	20,697	19,002	24,226	23,813
	15,989	18,581	16,203	23,943	18,678	20,351	16,899
	20,014	21,827	15,534	15,560			
Total	729,025	664,606	614,855	559,792	476,831	545,693	610,579
	542,011	515,618	423,264	934,293	674,395	690,822	635,710
	626,052	681,938	586,965	549,305			

into New Mexico. The Dockum aquifer consists of up to 700 ft of sand and conglomerate with layers of silt and shale of the Dockum Group. Water quality is variable and is used for water-flooding operations in oil-producing areas of the southern High Plains. Pumping from the aquifer in the counties in the study area over the past twenty years has ranged from about 8,000 to about 15,000 acre-ft per year (Table 1-2). The Dockum aquifer is discussed in more detail by Kalaswad and Bradley (2004; Chapter 7 of this volume).

Edwards (Balcones Fault Zone) aquifer

The Edwards (Balcones Fault Zone) aquifer is located in Bexar, Comal, Hays, Kinney, Medina, Travis, and Uvalde counties in the Edwards Plateau area (Figure 1-6) and extends north into Bell and Williamson counties. The Edwards (Balcones Fault Zone) aquifer consists of the Georgetown Limestone, formations of the Edwards Group and its equivalents, and the Comanche Peak limestone where it exists. The thickness of the aquifer ranges from 200 to 400 feet. Water quality and quantity are excellent. Much of the water is used for agricultural and municipal purposes. Pumping from the aquifer in Kinney and Uvalde counties in the study area over the past twenty years has ranged from about 50,000 to about 160,000 acre-ft per year (Table 1-2). Mace and Anaya (Chapter 18 of this volume) discuss the Edwards (Balcones Fault Zone) aquifer in Kinney County in more detail. The reader is directed to Maclay and Land (1988) and Klemt and others (1979) for more detailed overviews of the aquifer. The Edwards (Balcones Fault Zone) aquifer is expected to be the focus of an upcoming Aquifers of Texas conference.

Edwards–Trinity (Plateau) aquifer

The Edwards–Trinity (Plateau) aquifer is the hydrogeologic centerpiece of the Edwards Plateau and is hydraulically connected, in one way or the other, to every other aquifer discussed in this paper. The Edwards–Trinity (Plateau) aquifer underlies Bandera, Blanco, Brewster, Coke, Concho, Crane, Crockett, Culberson, Ector, Edwards, Gillespie, Glasscock, Irion, Jeff Davis, Kerr, Kendall, Kimble, Kinney, Mason, McCulloch, Menard, Midland, Nolan, Pecos, Reagon, Real, Reeves, Schleicher, Sterling, Sutton, Taylor, Terrell, Tom Green, Upton, Uvalde, Val Verde, Ward, and Winkler counties (Figure 1-6) and extends southward into Mexico. Equivalent rocks of the Edwards-Trinity (Plateau) aquifer extend north of the Plateau area under the Ogallala aquifer are recognized as the Edwards–Trinity (High Plains) aquifer (Ashworth and Hopkins, 1995).

The Edwards–Trinity (Plateau) aquifer consists of rocks of the Comanche Peak, Edwards, and Georgetown Formations and the Trinity Group. The Trinity Group consists primarily of sands (Antlers and Maxim sands) and limestones. The Comanche Peak, Edwards, and Georgetown Formations consist primarily of limestones and dolomites. Pumping from the aquifer over the past twenty years has ranged from about 150,000 to about 200,000 acre-ft per yr (Table 1-2). The Edwards–Trinity (Plateau) aquifer is discussed in more detail by Anaya (2004) for the aquifer in Texas (Chapter 2 of this volume), by Boghici (2004) for the aquifer in Mexico (Chapter 4 of this volume), and by Nance (2004) on the groundwater chemistry (Chapter 3 of this volume). Mace and Anaya (2004; Chapter 18 of this volume) discuss recharge in Kinney County in greater detail.

Ellenburger-San Saba aquifer

The Ellenburger-San Saba aquifer is located in Blanco, Brown, Burnet, Coleman, Concho, Gillespie, Kendall, Kerr, Kimble, Lampasas, Llano, Mason, McCulloch, Menard, Mills, and San Saba counties (Figure 1-6). The aquifer consists of limestone and dolomite facies of Cambrian and early Ordovician age (Ashworth and Hopkins, 1995). The outcrop of the aquifer encircles the core of the Llano Uplift. The down-dip portions of the aquifer are as deep as 3,000 feet. The majority of water pumped from this aquifer is use for municipal supplies (Ashworth and Hopkins, 1995). Pumping from the aquifer over the past twenty years has ranged from about 5,000 to about 7,500 acre-ft per yr (Table 1-2). The Ellenburger-San Saba aquifer is discussed in more detail by Smith (2004; Chapter 9 of this volume).

Hickory aquifer

This Hickory aquifer is located in Blanco, Brown, Burnet, Coleman, Concho, Gillespie, Hays, Kendall, Kerr, Kimble, Lampasas, Llano, Mason, McCulloch, Menard, Mills, San Saba, Travis, and Williamson and counties (Figure 1-6). The aquifer consists primarily of sands and occurs in some of the oldest Cambrian sedimentary rocks in Texas (Ashworth and Hopkins, 1995). The outcrop areas encircle and overlie directly on the Precambrian metamorphic rocks that make up the Llano uplift. The down dip portions are as deep as 4,500 feet below land surface. Most of the water pumped from this aquifer is used for irrigation, although some high capacity wells are used for municipal supplies as well (Ashworth and Hopkins, 1995). Pumping from the aquifer over the past twenty years has ranged from about 17,000 to about 28,000 acre-ft per yr (Table 1-2). The Hickory aquifer is discussed in more detail by Smith (2004; Chapter 9 of this volume).

Lipan aquifer

The Lipan aquifer is located in Coke, Concho, Runnels, and Tom Green counties (Figure 1-6). It consists of 125 feet of alluvial sediments of the Quaternary Leona Formation (Ashworth and Hopkins, 1995). The groundwater from the Lipan usually does not meet drinking water standards but is suitable for irrigation. Pumping from the aquifer over the past twenty years has ranged from about 10,000 to about 76,000 acre-ft per yr (Table 1-2). The Lipan aquifer is discussed in more detail by Beach and Burton (2004; Chapter 8 of this volume).

Marble Falls aquifer

The Marble Falls aquifer is located in Blanco, Burnet, Kimble, Lampasas, Llano, Mason, McCulloch, Menard, and San Saba counties (Figure 1-6). The aquifer consists of Pennsylvanian-age limestones and occurs as a series of discontinuous outcrops that surround the Llano Uplift area (Ashworth and Hopkins, 1995). Water occurs in fractures and solution cavities in the formation. Pumping from the aquifer over the past twenty years has ranged from about 700 to about 1,800 acre-ft per yr (Table 1-2). The Marble Falls aquifer is discuss in detail by Smith (2004; Chapter 8 of this volume).

Ogallala aquifer

The Ogallala aquifer is located in Andrews, Ector, Glasscock, Howard, Martin, and Midland counties in the Edwards Plateau area (Figure 1-6). The Ogallala aquifer is composed primarily of sand, gravel, clay, and silt and generally has a saturated thickness of less than 100 ft in the Edwards Plateau area. The quality of water tends to be mixed in this part of the aquifer. The Ogallala aquifer partially overlies the Edwards–Trinity (Plateau) aquifer in the Edwards Plateau area. Pumping from the aquifer in the counties in the study area over the past twenty years has ranged from about 36,000 to about 93,000 acre-ft per year (Table 1-2). The Ogallala aquifer and its interaction with the Edwards–Trinity (Plateau) aquifer is discussed in more detail by Blandford and Blazer (2004) (Chapter 18 of this volume).

Rustler aquifer

The Rustler aquifer is located in Brewster, Culberson, Jeff Davis, Loving, Pecos, Reeves, and Ward counties (Figure 1-6). Groundwater occurs in the partially dissolved dolomite, limestone, and gypsum beds of the Rustler Formation. The water is of poor quality and is used primarily for irrigation, livestock, and for water-flooding operations in oil-producing areas. Pumping from the aquifer in the counties in the study area over the past twenty years has ranged from less than 300 to about 1,700 acre-ft per year (Table 1-2). The Rustler aquifer is discussed in more detail by Boghici and van Broekhoven (2001) in "Aquifers of West Texas" (Mace and others, 2001).

Other aquifers

There are areas along the fringes of the Edward Plateau that do not have a TWDB recognized major or minor aquifer beneath them (see white areas in Figure 1-6). This does not mean that there are no groundwater resources in these areas. These areas may have small, local aquifers that can supply water for limited purposes. According to the TWDB information, about 700 to as much as 11,000 acre-ft per year has been pumped from other aquifers in the area (Table 1-2). Further study and evaluation will increase our knowledge of water resources in these areas.

Groundwater Conservation Districts

Groundwater in Texas is governed by the rule of capture. Rule of capture allows a landowner to produce as much groundwater as the landowner chooses, absent malice or willful waste, without liability to neighbors who may claim that pumping has depleted their wells. The Legislature enabled the regulation of groundwater through the creation of groundwater conservation districts the first of which, the High Plains Groundwater Conservation District No. 1, was created in 1949. Groundwater conservation districts are recognized by the Legislature as the state's preferred method of managing groundwater resources. Depending on the rules and regulations of each district, absolute rule of capture does not necessarily apply within the boundary of a groundwater conservation district.

The Edwards Plateau area is home to 35 confirmed groundwater conservation districts (Figure 1-7):

1. Bandera County River Authority/Ground Water District
2. Barton Springs/Edwards Aquifer Conservation District
3. Blanco-Pedernales Groundwater Conservation District
4. Brewster County Groundwater Conservation District
5. Coke County Underground Water Conservation District
6. Cow Creek Groundwater Conservation District
7. Culberson County Groundwater Conservation District
8. Edwards Aquifer Authority
9. Emerald Underground Water Conservation District
10. Fox Crossing Water District
11. Glasscock Groundwater Conservation District
12. Hays Trinity Groundwater Conservation District
13. Headwaters Groundwater Conservation District
14. Hickory Underground Water Conservation District No. 1
15. Hill Country Groundwater Conservation District
16. Irion County Water Conservation District
17. Jeff Davis County Underground Water Conservation District
18. Kimble County Groundwater Conservation District
19. Kinney County Groundwater Conservation District
20. Lipan Kickapoo Groundwater Conservation District
21. Lone Wolf Groundwater Conservation District
22. Medina County Groundwater Conservation District
23. Menard County Underground Water Conservation District
24. Middle Pecos Groundwater Conservation District
25. Permian Basin Underground Water Conservation District
26. Plateau Underground Water Conservation and Supply District
27. Presidio County Underground Water Conservation District
28. Real and Edwards Conservation and Reclamation District
29. Santa Rita Underground Water Conservation District
30. Saratosa Underground Water Conservation District
31. Sterling County Underground Water Conservation District
32. Sutton County Underground Water Conservation District
33. Trinity Glen Rose Groundwater Conservation District
34. Uvalde Underground Water Conservation District
35. Wes-Tex Groundwater Conservation District

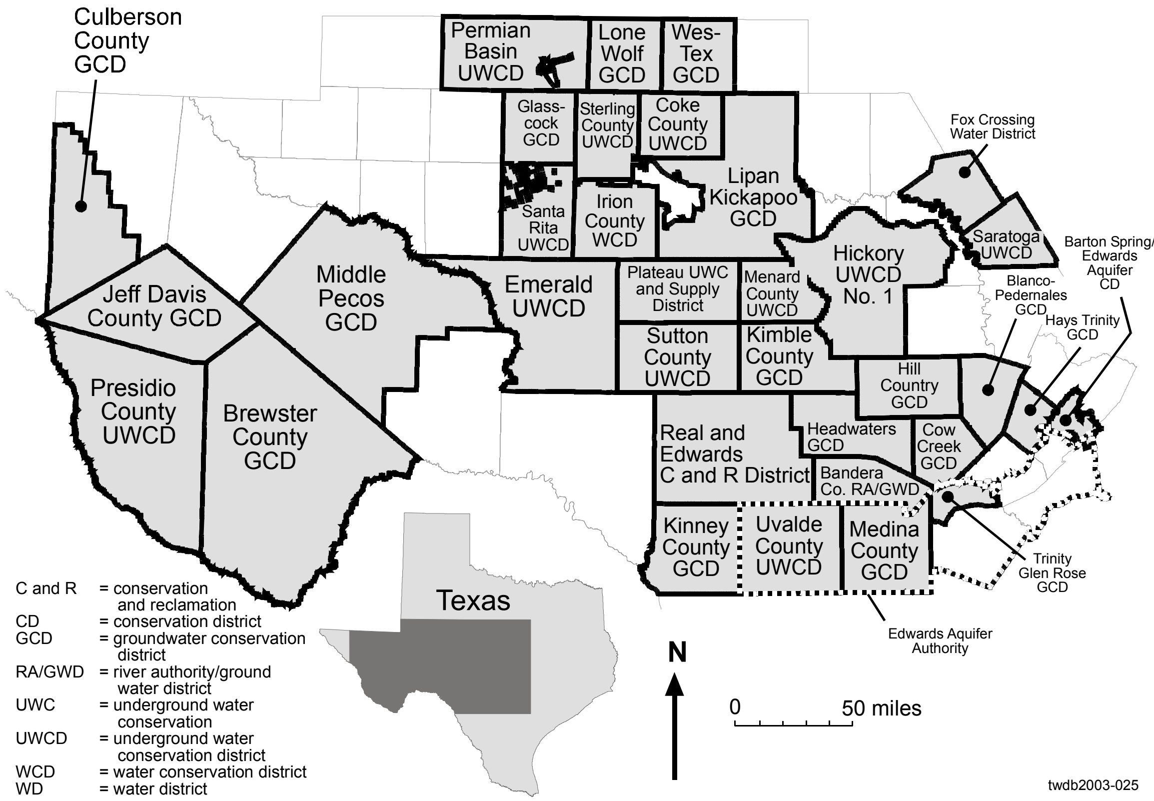

Figure 1-7: Location of confirmed groundwater conservation districts in the Edwards Plateau area.

Regional Water Planning

Through Senate Bill 1, the 1997 Legislature enacted comprehensive water management to plan for drought and meet increasing demands as population grows (Hubert, 1999). Senate Bill 1 is a “bottom up” water planning process that allows individuals representing different interest groups to serve as members of Regional Water Planning Groups. The interest groups include the public, counties, municipalities, industries, agriculture, environmental, small business, steam-electric generating utilities, river authorities, water districts, water utilities, and others selected by the Planning Groups. A total of 16 Regional Planning Areas cover the State. The Planning Groups are charged with preparing regional water plans for their respective planning areas. These plans will show, for each planning area, how to conserve water, meet future water needs, and respond to future droughts.

Each Planning Group submitted their first regional water plans in January of 2001. The TWDB integrated their individual plans into a comprehensive State Water Plan which was released on January 5, 2002. The TWDB will only provide financial assistance to those projects that are consistent with the regional water plans, and the Texas Commission on Environmental Quality will only issue water right permits for

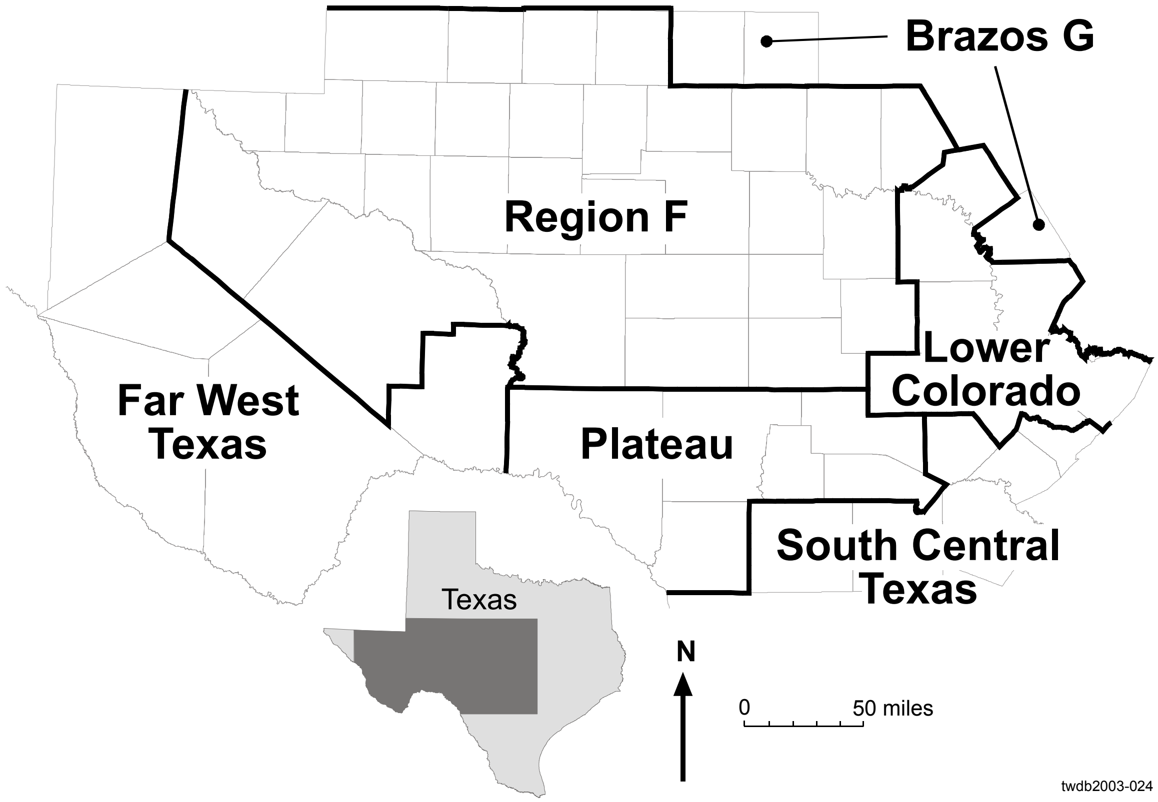

Figure 1-8: Location of regional water planning areas in the Edwards Plateau area.

municipal purposes consistent with the plan. These water plans are updated every five years.

The Edwards Plateau area includes all of Region F and parts of the Brazos G, Far West Texas, Lower Colorado, Plateau, and South Central Texas regions (Figure 1-8). All of the regions except the Far West Texas region have cities with needs by 2050. The Plateau region showed that projected water supplies exceeds projected demands, although there are specific water user groups with needs. They also noted that they need more groundwater information and that endangered and threatened species could limit future water development options. Region F showed that projected water supplies do not meet projected water demands. Over the regions, the Brazos G, Lower Colorado, and South Central Texas regions showed that projected water supplies do not meet projected water demands.

The regional water planning groups recommended a number of strategies to meet future needs for water, including:

- new groundwater,
- expanded use of existing groundwater,
- new surface water,
- expanded use of surface water,
- conservation, and
- water reuse.

The water plans for these regions can be found on the TWDB Web page (www.twdb.state.tx.us). A statewide summary of the regional water plans is available in the 2002 State Water Plan (TWDB, 2002).

Groundwater Availability Modeling

Texas is developing new, state-of-the-art computer models of groundwater resources. In 1999, the Legislature provided initial funding for development of groundwater availability models (GAMs) for the major aquifers and in Senate Bill 2, enacted by the 77th Texas Legislature (2001), directed the TWDB to develop groundwater availability models for the minor aquifers.

There are several completed and ongoing modeling projects in the Edward Plateau area. A GAM for the Hill Country part of the Trinity aquifer that includes part of the Edwards–Trinity (Plateau) aquifer was completed in 2000 (Mace and others, 2000). A GAM for the southern part of the Ogallala aquifer was completed in early 2003 (Blandford and others, 2003). GAMs for the Cenozoic Pecos Alluvium, Edwards (Balcones Fault Zone), Edwards–Trinity (Plateau), Lipan, and northern part of the Trinity aquifers are expected to be completed in 2004. TWDB plans to develop GAMs for the Capitan Reef, Dockum, Ellenburger-San Saba, Hickory, Marble Falls, and Rustler aquifers, but development of these GAMs has not yet been scheduled.

Planning Groups and groundwater conservation districts will use the models to assess availability of groundwater in the areas or regions. These assessments will be based on the socio-economic needs of their areas and may be guided by groundwater management standards that describe the desired future condition of the aquifer, such as the quantity and quality of groundwater and the amount of springflow, baseflow, and subsidence (Mace and others, 2001, 2002).

Final reports, models, and aquifer information will be posted on the TWDB GAM Web page (www.twdb.state.tx.us/gam).

Summary

The Edwards Plateau of Texas is blessed with many aquifers but faces many challenges to meet current and future water needs. The Edwards Plateau is dry and is susceptible to drought. Because of limited surface-water resources, groundwater is often the only choice of water supply. Because of its size and ownership of the rocks that form the plateau, the centerpiece of the Edwards Plateau is the Edwards–Trinity (Plateau) aquifer. However, bordering aquifers are no less important to those that rely on them for water. In addition, the Edwards-Trinity (Plateau) aquifer is in hydraulic connection with many of its bordering aquifers.

Groundwater conservation districts, regional water planning groups, and groundwater availability models are helping to further the understanding of the aquifers and the options for meeting future water needs. However, additional study is needed, particularly on the less studied minor aquifers in the area and on the less studied areas of the major aquifers.

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