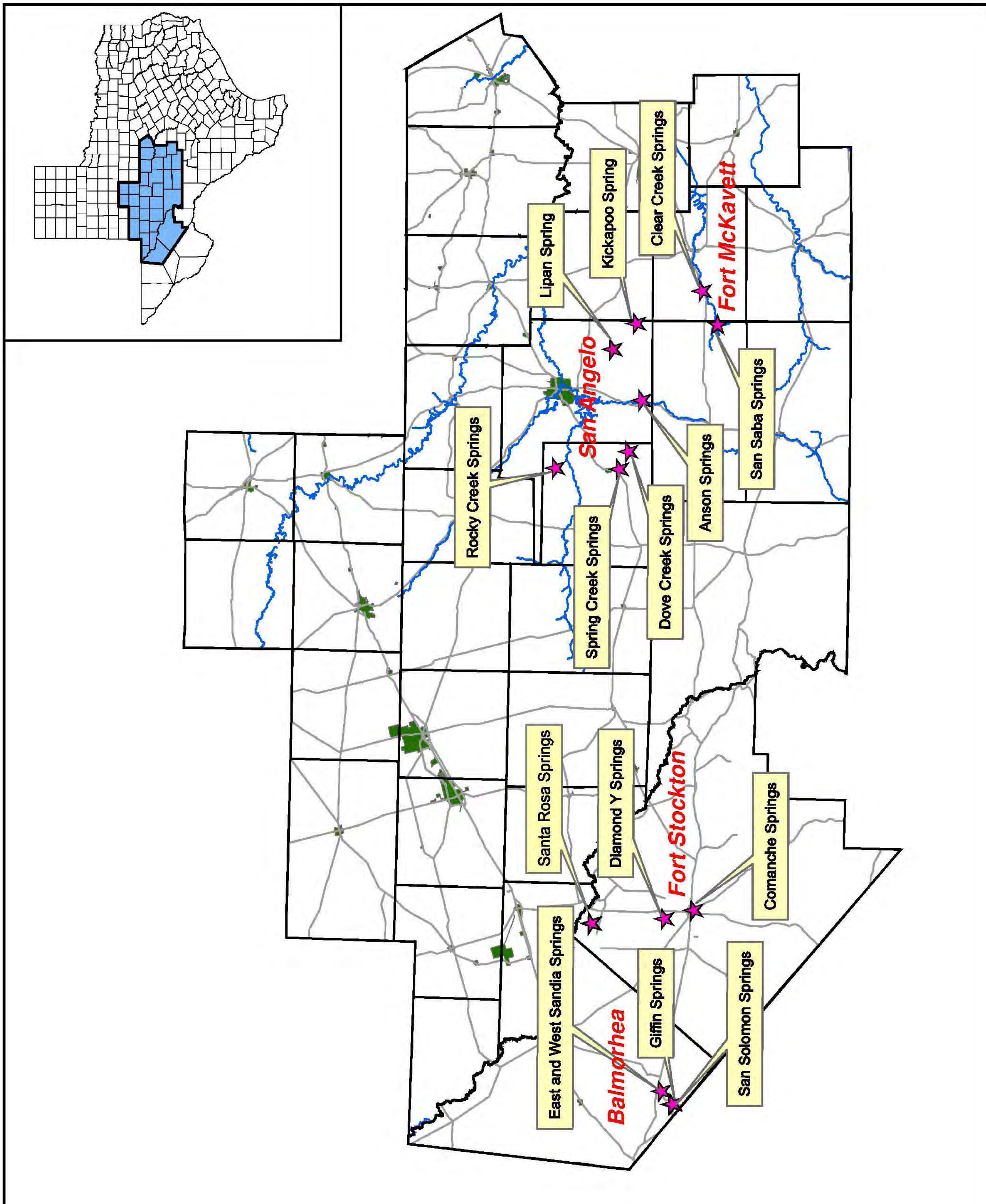
The Region F Planning Group has identified 14 major springs in the region that are important for water supply or natural resources protection (Figure 1.3-6). These major springs include: San Solomon, Giffin, and Sandia Springs in Reeves County; Comanche and Diamond Y Springs in Pecos County; Spring Creek Springs, Dove Creek Springs, and Rocky Creek Springs in Irion County; Anson Springs, Lipan Spring, and Kickapoo Spring in Tom Green County; Clear Creek Spring in Menard County; Santa Rosa in Pecos County and San Saba Spring in Schleicher County. For convenience, the following spring descriptions are grouped into related geographic areas. Discussions pertaining to the historical significance of these springs are taken from Gunner Brune.[13,14]

Balmorhea Area Springs

Springs in the Balmorhea area have supported agricultural cultures for centuries. Early native Americans dug acequias to divert spring-water to crops. In the nineteenth century several mills were powered by water from the springs. The Reeves County Water Control and Improvement District No. 1 was formed in 1915 and provides water, mostly from San Solomon Springs, to irrigated land in the area. The springs are also used for recreational purposes at the Balmorhea State Park, and are the home of rare and endangered species, including the Comanche Springs pupfish, which was transplanted here when flow in Comanche Springs at Fort Stockton became undependable. Three major springs are located in and around the community of Balmorhea: San Solomon Springs, Giffin Springs, and East and West Sandia Springs. A fourth spring, Phantom Spring, is located in Jeff Davis County (Region E) a short distance west of Balmorhea. Below average rainfall in the area over the past decade has resulted in diminishing flows from these springs.

San Solomon Springs are located in the large swimming pool in Balmorhea State Park and are the largest spring in Reeves County. The spring's importance begins with its recreational use in the pool, then its habitat for endangered species in the ditches leading from the pool,[15] and finally its irrigation use downstream, where water from these springs is used to irrigate approximately 10,000 acres of farmland. These springs, which were once known as Mescalero or Head Springs, issue from lower Cretaceous limestones that underlie surface gravels in the area. Spring flow is maintained by precipitation recharge in the nearby Davis Mountains to the south. Discharge from San Solomon Springs is typically between 25 cubic feet per second (cfs)



LBG-Guyton Associates
1101 S. Capital of Tx. Hwy. B-220
Austin, Texas 78746
Phone - (512) 327 - 9640

Region F Water Plan

Identified Major Springs in Region F

FN JOB NO	
FILE	
DATE	July 18, 2005
SCALE	1" = 35 miles
DESIGNED	ACAD
DRAFTED	BJS

1.3-6
FIGURE

and 30 cfs. After strong rains, the springflow often increases rapidly and becomes somewhat turbid. These bursts in springflow are typically short-lived.

Giffin Springs are located across the highway from Balmorhea State Park, and are at the same elevation as San Solomon Springs. Giffin Springs are smaller than, but very similar to, San Solomon Springs. Water discharging from these springs is used for irrigation, and typically averages between three and four cubic feet per second. Discharge from Giffin Springs responds much more closely to precipitation than the other Balmorhea-area springs.

East and West Sandia Springs are located about one mile east of Balmorhea at an elevation slightly lower than San Solomon and Giffin Springs. Flow from this spring system was classified as a “stream segment with significant natural resources” in the first regional plan. They are ecologically significant due to the presence of the Pecos Gambusia and the Pecos Sunflower, and the only known naturally occurring populations of the Comanche Springs pupfish.[16] East Sandia Springs are about twice as large as the West Sandia Springs located approximately one mile farther up the valley. Together these two springs were called the Patterson Springs in 1915 by the U.S. Army Corps of Engineers. East and West Sandia Springs flow from alluvial sand and gravel, but the water is probably derived from the underlying Cretaceous Comanchean limestone. Discharge is typically between one and three cfs.

Fort Stockton Area Springs

Comanche Springs flows from a fault fracture in the Comanchean limestone. This complex of springs includes as many as five larger springs and eight smaller springs in and around Rooney Park. These springs were historically very important, serving as a major crossroads on early southwestern travel routes. It is because of their historical significance and their continued ecotourism importance to the city of Fort Stockton, that this spring system is considered a major spring. The development of irrigated farming in the Belding area 12 miles to the southwest has intercepted natural groundwater flow, and by the early 1960s Comanche Springs had ceased to flow continuously. However, since 1987, Comanche Springs has sporadically flowed, primarily during winter months.

Diamond Y Springs (or Deep Springs) is the largest spring system in Pecos County, and provides aquatic habitat for rare and endangered species. The springs are one of the largest and last remaining cienega (desert marshland) systems in West Texas. These springs are located north of Fort Stockton, and issue from a deep hole in Comanchean limestone, approximately sixty feet in diameter. The chemical quality of the spring water suggests that its origin may be from the deeper Rustler aquifer. This spring is one of the last places the Leon Springs pupfish can be found, and is also home for the Pecos Gambusia. The Texas Nature Conservancy maintains conservation management of the Diamond Y Springs.

Santa Rosa Spring is located in a cavern southwest of the City of Grandfalls. At one time this spring provided irrigation water. Spring flow ceased in the 1950s.

San Angelo Area Springs

Six springs/spring-fed creeks located within approximately twenty miles of San Angelo are identified as major springs. Four of these springs, including Dove Creek Springs, Spring Creek Springs, Rocky Creek Springs, and Anson Springs, form the primary tributaries that feed into Twin Buttes Reservoir, which is a water supply source for the City of San Angelo. Two other springs, Lipan Spring and Kickapoo Spring, do not feed into Twin Buttes, but instead flow into the Concho River downstream from San Angelo.

Dove Creek Springs are located at the head of Dove Creek in Irion County about eight miles southwest of Knickerbocker. The perennial springs flow an average of 9 cfs and contribute to surface flow destined for Twin Buttes Reservoir. The landowners of these springs have placed the river corridor surrounding the springs into a Conservation Reserve Program so as to protect aquatic and other wildlife as well as vegetation species.

Anson Springs, also known as the Head of the River Springs, are located on ranchland approximately five miles south of Christoval in Tom Green County. Perennial spring flow in the bed and banks of the South Concho River results in an average discharge of more than 20 cfs. This springflow sustains the South Concho River, which has major irrigation diversion permits dating back to the early 1900s. The environment surrounding the springs is a sensitive eco-system with diverse flora and fauna found only in this specific location. The landowners of the springs have placed the river corridor of their property where the springs are located into a Conservation Reserve Program to protect vegetation and aquatic life as well as other wildlife.

Spring Creek Springs (also known as Seven, Headwaters, or Good Springs) are located on Spring Creek in eastern Irion County approximately three miles south of the town of Mertzon.

Besides evidence of significant occupation by early American Indians, the U.S. Cavalry also used the springs in the late 1840s. This was the last fresh water spring on the route westward.

Rocky Creek Springs are located on West Rocky Creek in northeastern Irion County, four to five miles northwest of the town of Arden.

Lipan Spring is located approximately 15 miles southeast of San Angelo and was a stop on the old Chihuahua Road. This spring, which issues from Edwards limestone, has historically flowed at less than one cfs.

Kickapoo Spring also discharges from Edwards limestone, and is located approximately twelve miles south of Vancourt. This spring was used for irrigation in the early days of settlement and historically has flowed between 1 and 4 cfs.

Fort McKavett Area Springs

San Saba Springs (Government or Main Springs), located at the headwaters of the San Saba River, were on the Chihuahua Road from the Port of Indianola to Mexico and were the water supply for Fort McKavett, established in 1852.

Clear Creek Springs (Wilkinson Springs) forms the headwaters of Clear Creek, which contributes significant flow to the upper reaches of the San Saba River in Menard County. The old San Saba Mission was located near these springs from 1756 to 1758. The springs were also a stop on the Chihuahua Road.

1.4 Agricultural and Natural Resources in Region F

1.4.1 Endangered or Threatened Species

Table 1.4-1 is a compilation of federal and state threatened and endangered species found in Region F counties. Section 7 of the Federal Endangered Species Act requires federal agencies to consult with the U.S. Fish and Wildlife Services (USFWS) to ensure that action they authorize, fund, or carry out will not jeopardize listed species. Under Section 9 of the same act, it is unlawful for a person to "take" a listed species. Under the federal definition "take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect or attempt to engage in any such conduct." Included in the definition of harm are habitat modifications or degradation that actually kills or injures a species or impairs essential behavioral patterns such as breeding, feeding or sheltering.[17]

Table 1.4-1
Endangered and Threatened Species in Region F

Species		Status		County																															
Common Name	**Scientific Name**	**Federal**	**State**	**Andrews**	**Borden**	**Brown**	**Coke**	**Coleman**	**Concho**	**Crane**	**Crockett**	**Ector**	**Glasscock**	**Howard**	**Irion**	**Kimble**	**Loving**	**Martin**	**Mason**	**McCulloch**	**Menard**	**Midland**	**Mitchell**	**Pecos**	**Reagan**	**Reeves**	**Runnels**	**Schleicher**	**Scurry**	**Sterling**	**Sutton**	**Tom Green**	**Upton**	**Ward**	**Winkler**
Birds																																			
American Peregrine Falcon	*Falco peregrinus anatum*		T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Bald Eagle	*Haliaeetus leucocephalus*		T	S	S	S	S	S	S	S		S	S	S	S	S	S	S	S	S	S	S	S		S		S	S	S	S		S	S	S	S
Black-capped Vireo	*Vireo atricapilla*	E	E			B	B	B	B		B				B	B			B	B	B	F		B	B		B	B		B	B	B	F		
Common Black-hawk	*Buteogallus anthracinus*		T																													S			
Golden-Cheeked Warbler	*Dendroica chrysoparia*	E	E			S		S	S							B			B	S	B														
Interior Least Tern	*Sterna antillarum*	E	E		S	S	S	S	S	S	S						S			S			S	S		S	S		S			B		S	
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	E	E																					S		B									
Peregrine Falcon	*Falco peregrinus*		T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Reddish Egret	*Egretta rufuscens*		T																					S		S									
Whooping Crane	*Grus americana*	E	E	S	S	B	S	B	S				S	S	S	S		B	B	B	S	S	S		S		S	S	S	S	S	S			
Zone-Tailed Hawk	*Buteo albonotatus*		T								S					S			S	S	S			S		S									
Fish																																			
Clear Creek Gambusia	*Gambusia hetochir*	E	E																		B														
Comanche Springs Pupfish	*Cyprinodon elegans*	E	E																					S		B									
Leon Springs Pupfish	*Cyprinodon bovinus*	E	E																					B											
Pecos Gambusia	*Gambusia nobilis*	E	E																					B		B									
Pecos Pupfish	*Cyprinodon pecosensis*		T							S	S						S							S		S								S	
Proserpine Shiner	*Cyprinella proserpina*		T								S													S											
Rio Grande Darter	*Etheostoma grahami*		T								S																								
Mammals																																			
Black Bear	*Ursus americanus*		T							S	S					S	S		S					S	S	S		S			S		S	S	
Gray Wolf	*Canis lupus*		E	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ocelot	*Leopardus pardalis*		E								S																				S				
Palo Duro Mouse	*Peromyscus truei comanche*		T		S																														
Red Wolf	*Canis rufus*		E			S		S	S							S			S	S	S						S	S			S	S			
Reptiles																																			
Concho Water Snake	*Nerodia paucimaculata*	T				F	F	F	F						F					F			F				F					F			
Texas Horned Lizard	*Phrynosoma cornutum*		T		S		S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Trans-Pecos Black-headed Snake	*Tantilla cucullata*		T	S		S					S													S											
Texas Tortoise	*Gopherus berlandiere*		T																												S				

Table 1.4-1 (Cont.)
Endangered and Threatened Species in Region F

Species		Status		County																															
Common Name	Scientific Name	Federal	State	Andrews	Borden	Brown	Coke	Coleman	Concho	Crane	Crockett	Ector	Glasscock	Howard	Irion	Kimble	Loving	Martin	Mason	McCulloch	Menard	Midland	Mitchell	Pecos	Reagan	Reeves	Runnels	Schleicher	Scurry	Sterling	Sutton	Tom Green	Upton	Ward	Winkler
Flowering Plants																																			
Texas Poppy-mallow	*Callirhoe scabriuscula*	E	E				B																B				B								
Texas Snowbells	*Styrax texanus*	E														F																			
Tobusch Fishhook Cactus	*Ancistrocactus tobuschii*	E	E													B																			
Pecos/Puzzle Sunflower	*Helianthus paradoxus*	T	T																					B		B									
Snails																																			
Pecos Assiminea Snail	*Assiminea pecos*	E	E																					B		B									
Mussels																																			
False Spike	*Quadrula mitchelli*		T			S		S	S	S	S					S	S		S	S	S			S		S						S		S	
Smooth Pimpleback	*Quadrula houstonensis*		T			S		S	S										S	S	S						S								
Texas Fatmucket	*Lampsilis bracteata*		T			S		S	S						S	S			S	S	S						S					S			
Texas Fawnsfoot	*Truncilla macrodon*		T			S		S	S							S			S	S	S						S					S			
Texas Hornshell	*Popenaias popeii*		T							S	S						S							S		S		S			S			S	

Status:
T - Threatened
E - Endangered

Key:
F - Federal listings only (US Fish and Wildlife Service. 2009. Ecological Services. Endangered Species List. http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm)
S - State listings only (Texas parks and Wildlife Department. 2009. Annotated County Lists of Rare Species. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx)
B - Both Federal and State listings

The Texas Endangered Species Act gives the Texas Parks and Wildlife Department (TPWD) the authority to establish a list of fish and wildlife that are endangered or threatened with statewide extinction. As defined by the statute, “fish and wildlife” excludes all invertebrates except mollusks and crustaceans. No person may capture, trap, take, or kill or attempt to capture, trap, take, or kill listed fish and wildlife species without a permit. Plants are not protected by these provisions. Endangered, threatened or protected plants may not be taken from public land for commercial sale or taken from private land for commercial purposes without a permit. Laws and regulations pertaining to endangered or threatened animal species are contained in Chapters 67 and 68 of the Texas Parks and Wildlife (TPW) Code and Sections 65.171 - 65.184 of Title 31 of the Texas Administrative Code (T.A.C.). Laws and regulations pertaining to endangered or threatened plant species are contained in Chapter 88 of the TPW Code and Sections 69.01 - 69.14 of the T.A.C.

The Texas Endangered Species Act does not protect wildlife species from indirect take (e.g., destruction of habitat or unfavorable management practices). The TPWD has a Memorandum of Understanding with every state agency to conduct a thorough environmental review of state initiated and funded projects, such as highways, reservoirs, land acquisition, and building construction, to determine their potential impact on state endangered or threatened species.

1.4.2 Agriculture and Prime Farmland

Agriculture plays a significant role the economy of Region F. Table 1.4-2 provides basic data regarding agricultural production in Region F.[18] Region F includes approximately 22,300,000 acres in farms and over 2,800,000 acres of potential cropland. In 2007 the market value of agriculture products (crops and livestock) for Region F was over $738,000,000, with livestock and crops each accounting for approximately 50 percent of the total.

Figure 1.4-1 shows the distribution of prime farmland in Region F.[19] The National Resources Conservation Service (NRCS) defines prime farmland as “land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses”. As part of the National Resources Inventory, the NRCS has identified prime farmland throughout the country. Each color in Figure 1.4-1 represents the percentage of the total acreage that is considered prime farmland of any kind.

Table 1.4-2
2007 U.S. Department of Agriculture County Census Data for Region F

Category	Andrews	Borden	Brown	Coke	Coleman	Concho	Crane	Crockett
Farms	175	116	1,726	430	1,003	418	37	183
Land in Farms (acres)								
- Crop Land[a]	62,247	93,814	95,342	45,927	188,432	105,973	15,252	18,637
- Pasture Land	(D)	(D)	384,656	427,659	458,635	430,504	(D)	1,573,739
- Other	(D)	(D)	80,067	17,625	52,385	14,894	(D)	10,109
- Total	808,474	435,166	560,065	491,211	699,452	551,371	375,177	1,602,485
Market Value ($1,000)								
- Crops	$11,362	$8,038	$5,896	$605	$5,444	$10,212	$7	(D)
- Livestock	$4,556	$5,196	$29,989	$13,034	$14,591	$10,980	$1,667	(D)
- Total	$15,919	$13,233	$35,885	$13,639	$20,035	$21,192	$1,674	$13,636

Category	Ector	Glasscock	Howard	Irion	Kimble	Loving	Martin	Mason
Farms	301	185	519	156	639	9	464	647
Land in Farms (acres)								
- Crop Land[a]	6,993	126,695	227,974	7,500	35,921	(D)	275,982	57,098
- Pasture Land	416,233	343,089	279,802	612,144	544,997	(D)	175,589	431,562
- Other	693	10,001	15,015	4,982	39,043	(D)	6,419	47,742
- Total	423,919	479,785	522,791	624,626	619,961	426,792	457,990	536,402
Market Value ($1,000)								
Crops	$979	$44,099	$33,274	$705	$1,346	-	$51,231	$1,837
Livestock	$2,580	$2,158	$7,578	$5,373	$7,086	$497	$1,669	$46,206
Total	$3,559	$46,258	$40,853	$6,078	$8,432	$497	$52,900	$48,044

a. Crop land is the land that is currently or recently cultivated for farming. Acreages in active farms may be less.

Table 1.4-2 (Cont'd)
2007 U.S. Department of Agriculture County Census Data for Region F

Category	McCulloch	Menard	Midland	Mitchell	Pecos	Reagan	Reeves	Runnels
Farms	694	356	601	519	287	137	221	953
Land in Farms (acres)								
- Crop Land[a]	108,473	22,731	90,046	163,760	101,383	57,947	136,698	264,780
- Pasture Land	473,422	450,964	353,336	398,577	2,778,691	590,941	890,289	355,293
- Other	30,732	17,598	13,251	12,658	27,891	34,926	13,357	36,131
- Total	612,627	491,293	456,633	574,995	2,907,965	683,814	1,040,344	656,204
Market Value ($1,000)								
Crops	$5,541	$611	$11,962	$17,400	$11,763	$12,393	$4,275	$30,814
Livestock	$12,559	$7,319	$3,436	$9,884	$15,781	$4,078	$12,904	$23,026
Total	$18,100	$7,930	$15,398	$27,284	$27,545	$16,471	$17,179	$53,840

Category	Schleicher	Scurry	Sterling	Sutton	Tom Green	Upton	Ward	Winkler	Total
Farms	332	681	74	234	1180	110	119	53	13,559
Land in Farms (acres)									
- Crop Land[a]	49,920	214,315	9,524	21,603	227,958	31,974	22,899	(D)	2,887,798
- Pasture Land	739,448	280,910	567,156	851,160	670,856	600,924	408,676	(D)	16,489,252
- Other	11,228	24,325	1,636	21,752	24,695	1,618	1,345	(D)	572,118
- Total	800,596	519,550	578,316	894,515	923,509	634,516	432,920	532,883	22,356,347
Market Value ($1,000)									
Crops	$3,270	$28,211	(D)	$333	$49,986	$6,231	$479	(D)	358,304
Livestock	$10,336	$15,223	(D)	$9,280	$83,005	$2,342	$1,050	(D)	363,383
Total	$13,606	$43,434	(D)	$9,613	$132,990	$8,573	$1,529	$3,262	738,588

a. Crop land is the land that is currently or recently cultivated for farming. Acreages in active farms may be less.

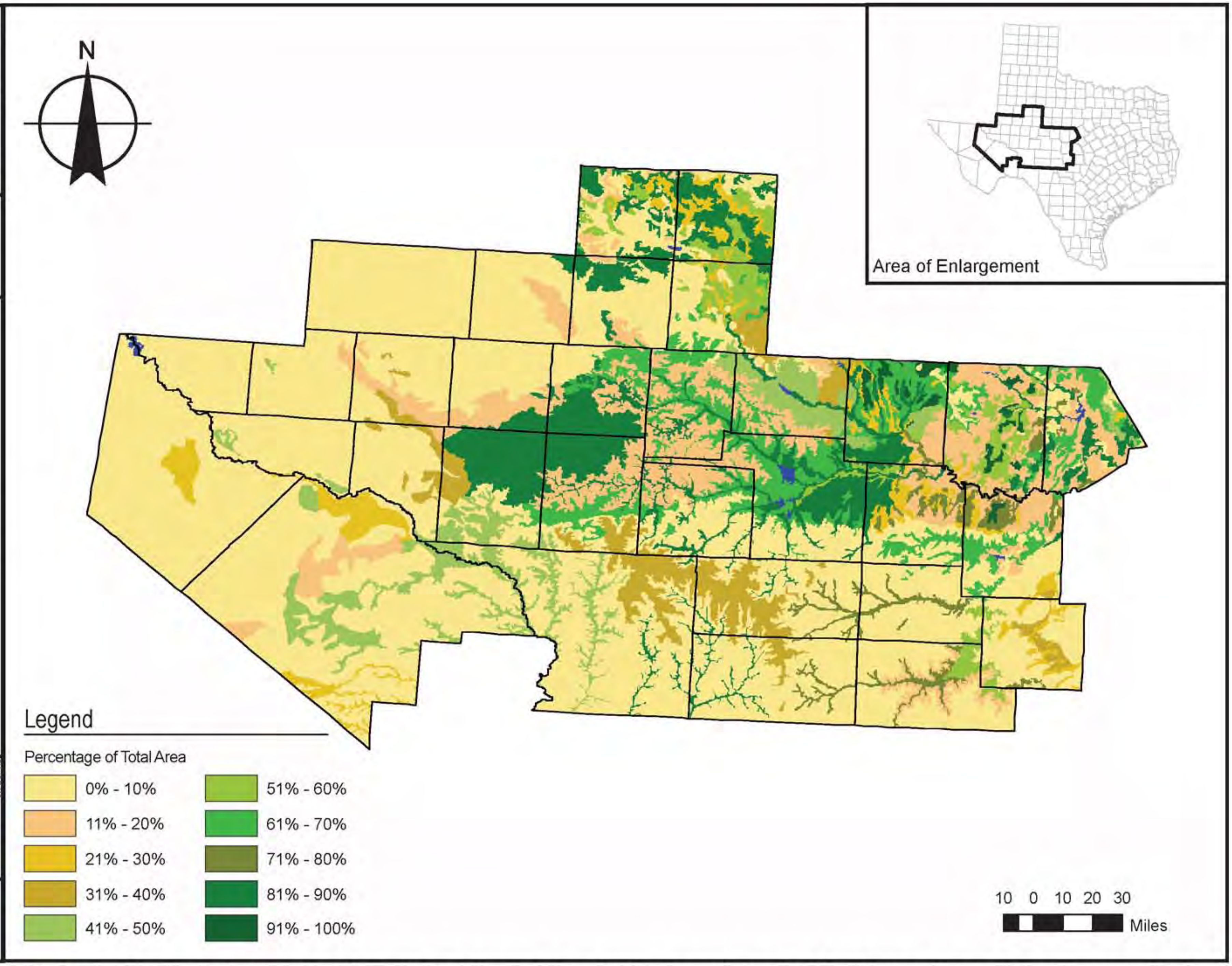
NOTES: (D) – Data withheld to avoid disclosing data for individual farms.
Total Market Value amounts include value of crops and livestock listed as (D) (data withheld). .
Source: Data are from the U.S. Department of Agriculture (USDA, 2007)

Freese and Nichols
4055 International Plaza, Suite 200
Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

Region F
Prime Farmland Percentage of Total Area

FN JOB NO: CMD01311
FILE: RegionF_Farm.mxd
DATE: January 17, 2005
SCALE: 1:2,795,000
DESIGNED: BME
DRAFTED: BME

FIGURE 1.4-1



Prime farmland has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses.

A number of counties in Region F have significant prime farmland acreage. Those with the largest acreage include Runnels, Glasscock, Upton, Tom Green, Scurry, and Reagan Counties. These six counties accounted for about 17 percent of the total land in farms and 41 percent of the total crop value for Region F in 2007.

It is interesting to note that major agricultural production also occurs in some counties with a relatively small amount of prime farmland. For example, Andrews, Martin, Pecos, and Reeves Counties have 10 percent or less acreage identified as prime farmland. However, these four counties combined accounted for approximately 23 percent of the total land in farms and 15 percent of the crop value for the region in 2007.

Shrimp farming is a relatively new business in West Texas. In 2008, 4 acres of ponds were located in Pecos County. Because the water used in this industry has a TDS range of 3,000 to 20,000 parts per million, it is not in direct competition with most other water uses.

1.4.3 Mineral Resources

Oil and natural gas fields are significant natural resources throughout Region F. Eleven of the top-producing oil fields and seven of the top-producing gas fields are located in Region F.[20] Other significant mineral resources in Region F include lignite resources in Brown and Coleman Counties, and stone, sand and gravel in various parts of the region.

1.5 Water Providers in Region F

Water providers in Region F include regional providers and retail suppliers. Regional water providers include river authorities and water districts. Retail water suppliers include cities and towns, water supply corporations, special utility districts, and private water companies.

1.5.1 Wholesale Water Providers

The TWDB defined the term wholesale water provider (WWP) as “any person or entity, including river authorities and irrigation districts, that has contracts to sell more than 1,000 acre-feet of water wholesale in any one year during the five years immediately preceding the adoption of the last Regional Water Plan. The Planning Groups shall include as wholesale water providers other persons and entities that enter or that the Planning Group expects to enter contracts to sell more than 1,000 acre-feet of water wholesale during the period covered by the plan."[21] Region F has identified seven entities that qualify as wholesale water providers:

- Colorado River Municipal Water District
- Brown County Water Improvement District Number One
- Upper Colorado River Authority
- Great Plains Water System, Inc.
- City of Odessa
- City of San Angelo
- University Lands

There are no implications of designation as a "wholesale water provider" except for the additional data required by TWDB. The wholesale water provider designation provides a different way of grouping water supply information.

Colorado River Municipal Water District (CRMWD). CRMWD is the largest water supplier in Region F. CRMWD member cities include Big Spring, Odessa and Snyder. CRMWD also supplies water to Midland, San Angelo and Abilene, as well as several smaller cities in Ward, Martin, Howard and Coke Counties. CRMWD owns and operates Lake J.B. Thomas, E.V. Spence Reservoir, and O.H. Ivie Reservoir, as well as several chloride control reservoirs. The district's water supply system also includes well fields in Ward, Scurry, Ector and Martin Counties. Table 1.5-1 is a list of fiscal year 2006 sales by the CRMWD, which totaled 78,069 acre-feet.

Brown County Water Improvement District Number One (BCWID). The 2006 sales by the BCWID totaled 13,230 acre-feet and are listed in Table 1.5-2. BCWID supplies raw water and treated water from Lake Brownwood to the Cities of Brownwood, Early, Bangs and Santa Anna, and rural areas of Brown and Coleman Counties, as well as irrigation water in Brown County.

Upper Colorado River Authority (UCRA). The UCRA is the owner of water rights in O.C. Fisher Reservoir in Tom Green County and Mountain Creek Lake in Coke County. O.C. Fisher supplies are used by the Cities of San Angelo and Miles. The City of Robert Lee uses water from Mountain Creek Lake. Table 1.5-3 is a list of year 2006 diversions from UCRA sources, which totaled 130 acre-feet.

Table 1.5-1
Fiscal Year 2006 Sales by the Colorado River Municipal Water District
(Values in Acre-Feet per Year)

Customer	Total Water Sales
Odessa	22,028
Big Spring	6,862
Snyder	2,326
Midland	24,382
Stanton	285
San Angelo	14,992
Robert Lee	178
Grandfalls	169
Pyote/West Tx State School	151
Ballinger	0
MDWSC	339
West Central Texas MWD	4,258
Non-Municipal Customers	2,099
Total	*78,069*

Data are from the Colorado River Municipal Water District[22]

Table 1.5-2
2006 Sales by the Brown County Water Improvement District Number One
(Values in Acre-Feet)

Customer	2006 Total Water Sales[a]
Bangs	330
Early	1,040
Brownwood	4,525
Brookesmith WSC	1,100
Santa Anna	(b)
Thunderbird Bay	90
Other	1,687
Irrigation	4,458
Total	13,230

a. Data are from the Brown County Water Improvement District No. 1 [23]

b. Santa Anna Served by Brookesmith WSC

Table 1.5-3
2006 Diversions from Upper Colorado River Authority Sources
(Values in Acre-Feet per Year)

Customer	2006 Diversions
San Angelo	0
Miles	90
Robert Lee	40
Total	130

Data are from UCRA. [24]

Great Plains Water System, Inc. The Great Plains Water System was initially developed to provide water to oil field operations in the Permian Basin. The System's source of water is the Ogallala aquifer in Andrews County in Region F and Gaines County in Region O. The System's largest customer is the recently established steam electric operation in Ector County. Great Plains has contracts to supply 6,096 acre-feet per year. The 2010 projected demand for steam electric operation in Ector County is 6,375 acre-feet, increasing to 17,637 acre-feet by 2060. The System also provides water to the City of Goldsmith (64 acre-feet in 2006).

City of Odessa. The City of Odessa is a CRMWD member city. The City of Odessa sells treated water to the Ector County Utility District and the Odessa County Club. In the year 2006, Odessa purchased 22,028 acre-feet from CRMWD.

City of San Angelo. The City of San Angelo's sources of supply are Lake O.C. Fisher (purchased from Upper Colorado River Authority), Twin Buttes Reservoir, Lake Nasworthy, local surface water rights, O.H. Ivie Reservoir (purchased from CRMWD), and E.V. Spence Reservoir (purchased from CRMWD). San Angelo supplies water to the power plant located on Lake Nasworthy. San Angelo also treats and delivers O.C. Fisher water to the City of Miles.

University Lands. University Lands manages property owned by the University of Texas System in West Texas. Although University Lands does not actively provide water, several major water well fields are located on property leased from University Lands, including fields operated by CRMWD, the City of Midland and the City of Andrews.

1.5.2 Retail Water Sales

Cities and towns provide most of the retail water service in Region F, and some cities also serve as retail water providers to connections outside of their city limits or as wholesale water suppliers by selling treated water to other water suppliers. Table 1.5-4 lists the cities in Region F that had outside sales in 2006.

Table 1.5-4
Water Supplied by Selected Cities in Region F

Supplier	County	Year 2006 Sales in Acre-Feet		
		Municipal Sales within City	Outside Sales	Total
Odessa	Ector	20,639	704	21,343
San Angelo	Tom Green	14,682	2,116	16,798
Big Spring	Howard	4,409	903	5,312
Brownwood	Brown	3,885	415	4,300
Snyder	Scurry	1,898	526	2,424
Pecos	Reeves	2,608	282	2,890
Andrews	Andrews	2,523	352	2,875
Coleman	Coleman	1,126	618	1,744
Colorado City	Mitchell	823	251	1,074
Crane	Crane	937	27	964
Ballinger	Runnels	494	183	677
Early	Brown	678	368	1,046
Winters	Runnels	457	9	466
Balmorhea	Reeves	52	29	81

Data are from the TWDB [9]

1.6 Existing Plans for Water Supply Development

Prior to SB1 regional water plans and water availability models, the most comprehensive study of water availability in the basin was published in 1978 by the Texas Department of Water Resources (TDWR). This study, titled *Present and Future Water Availability in the Colorado River Basin, Texas, Report LP-60*, was a detailed analysis of water availability and needs for the years 1980 and 2030.[25] According to this report, in 1980 there would be sufficient supplies in the basin to meet demands. By 2030, there would only be minor shortages in the upper basin provided that Ivie Reservoir was constructed. In the same period the middle and lower basins could experience significant shortages. The report recommended the construction of new reservoirs to meet needs in the lower basin.

In 2007, the Texas Water Development Board released the State Water Plan, *Water for Texas – 2007*, which was a compilation of the 16 regional water plans developed under SB1.[26] The Region F Water Planning Group published the *Region F Regional Water Plan* in January 2006. Some of the findings of the 2006 Region F plan included:

- Approximately 60 water user groups had projected water shortages over the planning period (through 2060). Many of these shortages were associated with WAM priority analysis of surface water supplies. Water management strategies were developed to address these needs.
- Sixteen counties had a collective irrigation need of over 167,000 acre-feet per year. No water supply is readily available to meet this need. Advanced water conservation irrigation technologies were recommended to reduce the irrigation demands. This strategy would significantly reduce the demands and eliminate projected shortages in several counties. However, some counties in Region F still had significant irrigation water needs.
- Major municipal needs occur with water user groups that rely on the Hickory aquifer. Needs are the result of water quality standards for radionuclides imposed by USEPA and TCEQ. Four water management strategies were developed for the users of Hickory aquifer:
  - Brady Creek Reservoir water treatment plant
  - Lake Ivie water treatment plant
  - New Ellenberger well field
  - New Hickory well field (in area with low radionuclides)
  - Advanced Treatment (Reverse Osmosis)
- General water management strategies recommended in the plan included: subordination, water conservation and drought response, brush control, weather modification, wastewater reuse, recharge enhancement, and desalination and chloride control.

The City of San Angelo completed their *Long-Range Water Supply Plan* in November of 2000.[27] Major recommendations from the plan include:

- *Improve delivery system from Fisher, Ivie and Spence.* At that time, the City was unable to receive water from both Lake Spence and Lake Ivie concurrently and was limited to a maximum delivery capacity of 18 mgd. The proposed improvements included a parallel pipeline and a new pump station, increasing the delivery capacity to 50 mgd. The new pipeline has been constructed.

- *Increase water treatment capacity*. The City's water treatment plant should have adequate capacity through about 2031. Expansion may be delayed by using water from the McCulloch County Well Field even during times when the local reservoirs are full (Groundwater from McCulloch County requires different level of treatment from surface water supplies, pending water quality).
- *Pursue trade of treated effluent for irrigation supplies.* The City can gain additional supply and reduce pumping costs by trading irrigation supply from Twin Buttes and Nasworthy for treated effluent from the City's wastewater plant. Effluent is available even during droughts and increases over time as municipal demands increase. To implement this option, additional wastewater storage ponds will be needed. Construction is recommended in the years 2002, 2015 and 2032 at a cost of $7 million per pond or expansion.
- *Add the McCulloch County well field to the system.* Two options were considered to bring McCulloch County water to the City:
  - Constructing a pipeline directly from the well field to San Angelo or
  - Constructing a pipeline to Ivie Reservoir and using CRMWD facilities to transport the water the remaining distance (San Angelo already has such a right by its contract with CRMWD to do so under specific circumstances).

Although the capital costs of the Ivie option are much lower, the direct option was recommended because:

- The operational savings of the direct pipeline offset most of the increased capital costs, and
- The Ivie option impacts other users of the CRMWD system by adding radionuclides to the Ivie pipeline.

The City of San Angelo is currently studying several water supply options, including desalination of brackish groundwater, reuse, alternative sources of groundwater and other options. Identified goals for the city include:

- Development of groundwater resources in the Edwards-Trinity south of San Angelo,
- Acquisition of additional surface water rights in the Concho watershed, and
- Continuation of brush control efforts on O.C. Fisher Reservoir and Twin Buttes Reservoir.

Several groundwater districts in Region F (including those located in Crockett, Schleicher, Sutton, Menard, and Kimble Counties) as well as the Real-Edwards district, Val Verde County, and the City of Del Rio collectively funded an independent water budget analysis to determine their respective Desired Future Conditions. Ronald Green, Ph.D., P.G. and Paul Bertelli, P.G. of the Southwest Research Institute are the primary investigators for the study, which is currently ongoing. Preliminary findings are presented in the following discussion. The study is in progress and therefore these finding are subject to revision.

The saturated thickness of the Edwards-Trinity across the eight county study area ranges from 200 to 300 feet in the northern counties and thickens up to 500 to 1000 feet in the southern counties. The potentiometric surface across the eight counties indicates that flow is predominantly toward the south and southwest.

Numerous springs occur in the western Edwards-Trinity (Plateau) where the base of the lower Edwards intersects topographic lows and discharge near streams. Major springs utilized in the water balance analysis for Val Verde County include Goodenough and San Felipe Springs.

The project study area encompasses seven river sub watersheds within three river basins: the Lower Pecos, Devils, Rio Grande Amistad, and Rio Grande Falcon watersheds within the Rio Grande River Basin; the Concho and Llano watersheds within the Colorado River Basin, and the Nueces River Basin (undivided). The watershed divide between the Colorado and Rio Grande/Nueces basins defines the primary surface water flow. In the Colorado River basin, flow is primarily to the north and east, whereas in the Rio Grande and Nueces basin, flow is typically to the east, south, and southwest. Green emphasizes that the groundwater catchment area is not the same as the surface water catchment.

For Schleicher, Menard, Kimble and Sutton counties, Green used a watershed analysis to calculate recharge. Green's results (including Val Verde County and historical estimates for comparison) are summarized in Table 1.6-1.

Table 1.6-1
Recharge Rates from Green's Water Budget Analysis

County	Recharge Rate (in/yr)	Recharge Rate (ac-ft/yr)
Estimates from Water Budget Analysis		
Schleicher	0.98 to 1.15	68,520 to 80,400
Menard	0.73	35,100
Kimble	1.45	96,700
Sutton	1.0	78,200
Val Verde (groundwater basin)	0.76	634,200
Val Verde (Devils River basin)	1.25	263,536
Historical Estimates from other Sources		
Edwards	1.3	150,000
Real	2.0	70,000

Key findings of the study include:

- Groundwater basins and surface water basins do not align and are not equivalent in area of catchment nor do they align with geopolitical entity boundaries
- Groundwater flow rates have less certainty that surface water flow rates
- The recharge rates derived by this water budget analysis are somewhat greater than previous investigations
- Downstream users are impacted significantly by upstream users

This is an ongoing project with preliminary results subject to revision. The primary remaining tasks include:

- Completion of technical literature review,
- Refinement of the conceptual model,
- Completion of surface water data review,
- Refinement of drought discharge/recharge estimates,
- Correction of Rio Grande budget gauging data for storm flow,
- Identification and assessment of additional factors impacting the water budget analysis,
- Comparison of recharge estimates to published values, and
- Presentation of a final comprehensive interpretation.

Several projects that have been envisioned by Dr. Green in order to complete a more precise evaluation in the future are as follows:

- Establishment of a controlled monitor well network,
- Refinement of exempt and non-exempt water well inventory,
- Installation of flow meters on select wells,
- Evaluation of water chemistry signatures and sources,
- Refinement of the water balance,
- Determination of baseline conditions,
- Performance of tracer tests to determine extent of groundwater basin, and
- Refinement of the Edwards-Trinity Aquifer GAM.

1.6.1 Conservation Planning in Region F

The Texas Water Code requires that certain entities develop, submit, and implement a water conservation plan (Texas Water Code § 11.1271). Those entities include holders of an existing permit, certified filing, or certificate of adjudication for the appropriation of surface water in the amount of 1,000 acre-feet per year or more for municipal, industrial, and other uses, as well as 10,000 acre-feet per year or more for irrigation uses. These plans must be consistent with the appropriate approved regional water plan(s). Water conservation plans must include specific, quantified 5-year and 10-year targets for water savings. Goals must be set for water loss programs and for municipal per capita water use. In 2007, § 13.146 of the Texas Water Code was amended requiring retail public suppliers with more than 3,300 connections to submit a water conservation plan by May 1, 2009 to the TWDB.

Many entities around the state have already developed conservation plans and/or drought contingency plans. These plans have improved the awareness of the need for water conservation in Texas. In its projections of water use the Texas Water Development Board has assumed reductions in per capita municipal use due to the implementation of the plumbing code requiring the use of low flow plumbing fixtures in all new development and renovation.

Many cities in Region F have developed water conservation plans. Water conservation education is stressed in most cities. These cities plan to provide educational brochures to new and existing customers. Other measures to conserve water include retrofit programs, leak detection and repair, recycling of wastewater, water conservation landscaping, and adoption of the plumbing code. As part this plan, model water conservation plans are included in Appendix 6A. These models can serve as templates for entities to develop or update their water conservation plan.

1.6.2 Assessment of Current Preparations for Drought in Region F

Drought is a fact of life in Region F. Periods of low rainfall are frequent and can extend for a long period of time. Most of the area has been in drought-of-record conditions since the mid 1990s. Many Region F water suppliers have already made or are currently making improvements to increase their capacity to deliver raw and treated water under drought conditions. Some smaller suppliers in Region F have faced a shortage of supplies within the last few years and have had to restrict water use.[28]

The Texas Water Code requires that wholesale and retail public water suppliers and irrigation districts develop drought contingency plans (Texas Water Code § 11.1272). These plans must also be consistent with the appropriate approved regional water plan(s). In addition, all drought contingency plans must include specific, quantified targets for water use reductions to be achieved during periods of water shortages and drought.

Most of the conservation plans that have been developed in response to state requirements also include a drought contingency plan. The purpose of the drought contingency plan is to address circumstances that could affect a water supplier's ability to supply water to the customer due to transmission line failures, water treatment plant failures, prolonged emergency demand, or acts of God. The drought contingency plans for each area have established trigger conditions that indicate when to take demand management measures. These trigger conditions range from mild to emergency. Model drought contingency plans are included in Appendix 6B. These models can serve as templates for entities to develop or update their drought contingency plan.

1.6.3 Other Water-Related Programs

In addition to the SB1 regional planning efforts, there are a number of other significant water-related programs that affect water supply in Region F. Perhaps the most significant are Texas Commission on Environmental Quality's water rights permitting, the Clean Rivers Program, the Clean Water Act, the Safe Drinking Water Act, the Texas Brush Control Plan, and precipitation enhancement programs.

Texas Commission on Environmental Quality (TCEQ) Water Rights Permitting. Surface water in Texas is a public resource, and the TCEQ is empowered to grant water rights that allow beneficial use of that resource. Any major new surface water supply source will require a water right permit. In recent years, TCEQ has increased its scrutiny of the environmental impacts of water supply projects, and permitting has become more difficult and complex. Among its many other provisions, SB1 set out formal criteria for the permitting of interbasin transfers for water supply.

Clean Rivers Program. The Texas Clean Rivers Program (CRP) is a state-fee funded water quality monitoring, assessment, and public outreach program. The CRP is a collaboration of 15 partner agencies and the TCEQ. The CRP provides the opportunity to approach water quality issues within a watershed or river basin at the local and regional level through coordinated efforts among diverse organizations. In Region F, the program is carried out by the Lower

Colorado River Authority, with assistance from CRMWD and UCRA, in the Colorado Basin, and by the International Boundary and Water Commission in the Rio Grande Basin.[29]

Clean Water Act. The Clean Water Act is a federal law designed to protect water quality. The Act does not directly address groundwater nor water quantity issues. The statute employs a variety of regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water." [30]

The parts of the act which have the greatest impact on water supplies are the NPDES permitting process, which affects water quality, and the Section 404 permitting process for dredging and filling in the waters of the United States, which affects reservoir construction. In Texas, the state oversees the NPDES permitting system, which sets the operating requirements for wastewater treatment plants. The Section 404 permitting process is facilitated by the Corps of Engineers and is an important step in the development of a new reservoir.

The TCEQ administers a Total Maximum Daily Load (TMDL) Program for surface water bodies in the state of Texas. TMDL programs are a result of the Clean Water Act. In this program, water quality analyses are performed for water bodies to determine the maximum load of pollutants the water body can handle and still support its designated uses. The load is then allocated to potential sources of pollution in the watershed and implementation plans are developed which contain measures to reduce the pollutant loads. The Implementation Plan for Sulfate and Total Dissolved Solids (TDS) TMDLs in the E.V. Spence Reservoir (Segment 1411) was established in August 2001. The TCEQ has completed analyzing the Colorado River below E.V. Spence Reservoir (Segment 1426) for chloride, sulfate, and TDS concentrations.

Safe Drinking Water Act. The Safe Drinking Water Act (SDWA) was originally passed by Congress to protect public health by regulating the nation's public drinking water supply. The law requires many actions to protect drinking water and its sources – rivers, lakes, reservoirs, springs, and groundwater wells. To ensure that drinking water is safe, SDWA sets up multiple barriers against pollution including source water protection, treatment, distribution system integrity, and public information.[31] Some of the initiatives that will most likely have significant impacts in Region F are the reduction in allowable levels of trihalomethanes in treated water, the requirement for reduction of total organic carbon levels in raw water, and the reduction in the allowable level of arsenic and radionuclides in drinking water. The allowable limit on arsenic has been reduced from 50 micrograms per liter to 10 micrograms per liter.

Texas Brush Control Plan. The Texas Brush Control Plan was developed pursuant to Chapter 203 of the Texas Agricultural Code. There are seven Brush Control Projects currently underway in Region F, including the O.C. Fisher Project, Twin Buttes Reservoir/Lake Nasworthy Brush Control Projects, and the Lake Brownwood Project. These projects are discussed further in Chapter 4. In these programs, cost share funds are administered at the local level by soil and water conservation districts based on allocations made by the State Board. Acreages of land are treated to eliminate the amount of water being used by brush.

Precipitation Enhancement Programs. In Region F, there are several ongoing weather modification programs, including the West Texas Weather Modification Association (WTWMA) project, and the Trans Pecos Weather Modification Association (TPWMA) program. Another weather modification program, conducted by the West Central Texas Weather Modification Association (WCTWMA), was started in 2001, but due to budgetary issues, stopped cloud seeding after the 2003 season. The Southern Ogallala Aquifer Rain (SOAR) program is being conducted in Region O counties bordering Region F to the north. Precipitation enhancement is discussed in more detail in Chapter 4.

1.7 Summary of First Biennium Special Studies

As part of the 2011 regional water planning effort the Region F Water Planning Group conducted six special studies. The purpose of these special studies was to evaluate in greater detail important aspects of the *2006 Region F Water Plan*. An overview of each special study is provided including how the study is incorporated into the *2011 Region F Water Plan*. The complete studies were previously published and submitted to the TWDB.

1.7.1 Ground Water Study

Future water supplies for Region F will likely be developed from groundwater or wastewater reuse. This study identified several new sites that have groundwater development potential and focused on refining the groundwater quantity and quality estimates for Region F. The objective of this study was to refine groundwater supply estimates in selected areas and identify potential projects that may use fresh and brackish groundwater. As appropriate, the findings of this study are incorporated in the recommended water management strategies discussed in Chapter 4 of this plan.

Three potential groundwater areas were identified for further study. The three areas selected for further study were:

1. The Ogallala aquifer in the southeast portion of Andrews County,
2. Potential local groundwater sources for the City of Robert Lee in Coke County,
3. Region wide assessment using the TWDB database to assess areas containing multiple productive wells that might sustain long-term pumping.

Ogallala Aquifer – Andrews County

Based on the data obtained for this study and the methods employed, there are a few areas that may yield small volumes of fresh and brackish groundwater for municipal use in southeast Andrews County. However, the data indicate that there may be less groundwater available than previously estimated, depending on the assumptions used for the calculations. This results in greater uncertainty of the available supply from the Ogallala aquifer in Andrews County. More field investigations are required to confirm the quantity and quality of groundwater for development. At this time, it is not recommended to develop additional Ogallala supplies for the City of Andrews.

Local Groundwater – Coke County

Several potential areas/units were identified in Coke County that may merit further field investigation. These are (1) dual completion wells in the San Angelo Formation, Choza Formation, (2) Choza Formation/Merkel Dolomite Member in southeast Coke County, (3) Choza Formation/Merkel Dolomite Member/Alluvium in Runnels County, and (4) River Alluvium. Water quantity and quality were identified as a concern in some areas. The study recommended further investigations, including test well drilling north and east of Bronte in the San Angelo and Choza formations, structural and well capacity assessment of Merkel Dolomite in southeast Coke County, and water sampling of alluvial wells to determine water quality trends in alluvium. Development of groundwater is a considered strategy for the City of Robert Lee.

Regional Groundwater Supplies

The Regional Supply project evaluated the TWDB groundwater database to assess areas containing multiple productive wells that might sustain long-term pumping. The goal was to use the data to discern the long-term availability of groundwater from areas that have had high volume wells in the past. The assessment indicates that there are some areas with moderate to high production capacity. With the exception of the Pecos Valley Alluvium, most of the available groundwater in these areas is already being utilized. In most areas, groundwater would need to be transferred from an existing use to a new use.

The study also assessed the cost of co-developing groundwater from separate wellfields in the Pecos Valley Alluvium (Ward and Winkler County area) and transporting it to the Midland/Odessa area. The results indicate that unit costs of the joint project are slightly less than individual projects, but the initial capital costs are higher. This is because the joint project is developing and moving more water than the sum of the individual projects. Pending the timing of increased demands, it may not be cost effective to develop the joint project. At this time, a joint project is not recommended.

1.7.2 Irrigation Survey

Irrigation water use represents the largest demand category in Region F, and in the *2006 Region F Water Plan* there were significant unmet irrigation needs. Conservation was identified as the primary means to meet these needs but more information is needed to accurately quantify the projected water savings. The Irrigation Survey was conducted to better define historical irrigation data, identify data gaps in irrigation data that are needed to reasonably project future irrigation water use and identify means to collect the information needed to close those gaps. Six counties were selected for this survey: Glasscock, Midland, Reagan, Reeves, Pecos and Tom Green. These counties represent over 70 percent of the irrigation demand in the 32-county region, and 76 percent of the irrigation shortage.

Region F planning group members and interested members of the public actively participated in providing and reviewing the available data. Four sources provided quantifiable data on historical water use and crop types: Texas Water Development Board (TWDB), Farm Service Agency, National Agricultural Statistical Services and members of the Irrigation Work Group (these members also represent groundwater conservation districts). The Environmental Quality Incentives Program (EQIP) and the TWDB also provided some data on irrigation equipment.

Irrigation data reported by the different sources are generally consistent with a few notable exceptions. The largest differences are based on the reporting categories (variety and types of crops reported as irrigated). Counties with few major crops, such as Glasscock and Reagan Counties, have relatively small differences while counties with wide varieties of crops or non-major crops, have greater differences. The TWDB provides the most comprehensive data on irrigation. While these data represent the best available information it is at best an estimate of the irrigation water used in the study area. The data reported by these agencies are based on application practices and crop types rather than metered water use. Actual water use may differ significantly from one irrigator to the next.

The percentage of irrigated acres using high-efficiency irrigation methods are increasing in the six counties. The data indicate over 90 percent of the irrigated acres in Glasscock County currently use either sprinkler or drip irrigation, which is up from 45 percent in 2000. In Reagan County 75 percent of the crops are irrigated using either sprinkler or drip. These percentages are considerably higher than the assumed adoption rate in the *2006 Region F Water Plan*. However, there were limited data on type of equipment in other counties.

Based on the findings of this study the Region F Planning Group chose not to change the irrigation water use projections for the *2011 Region F Water Plan*, but rather continue to collect and monitor historical irrigation water use data to adequately plan for agricultural water needs in subsequent plans. As appropriate, conservation savings for irrigation were refined for the *2011 Region F Water Plan* to reflect current conservation equipment adoption rates.

1.7.3 Municipal Conservation Survey

Water conservation has been identified throughout the state's regional water planning process as an important strategy for meeting future water needs. While important, the methods to achieve water conservation and the costs and effectiveness of conservation strategies remain uncertain. In an effort to gain more information regarding those uncertainties, Region F authorized a study to document current conservation practices used by municipalities in Region

F and the costs and water savings associated with them. This study was also intended to identify municipal conservation practices that may be appropriate for Region F.

Thirteen cities were surveyed regarding their conservation efforts, and selected cities were interviewed to obtain further information on their conservation practices. The results from the surveys were compiled and analyzed along with rainfall data and TWDB historical water use data. Costs of implementing conservation strategies were also collected and analyzed.

The results of this survey and analysis show that most cities are implementing one or more conservation strategies, but funding is key to continued and increased conservation efforts in the region. Several cities expressed interest in wastewater reuse for municipal or industrial purposes. Cities have great difficulty in tracking water savings from conservation practices. Only specific projects, such as pipe replacement programs and reuse, had quantified savings. Reuse and System Water Audit and Water Loss are two practices that show the greatest overall savings. (System Water Audit and Water Loss include repair and replacement of pipelines.) These findings were incorporated in the recommended conservation strategies for the respective entities.

1.7.4 Evaluation of Supplies in the Pecan Bayou Watershed

This study presents the results the analyses of potential operating scenarios for four reservoirs in the Pecan Bayou watershed: Lake Brownwood, Lake Coleman, Hords Creek Reservoir and Lake Clyde. The *2006 Region F Water Plan* assumed that Lake Brownwood, which is the senior water rights holder in the watershed, would not make priority calls on Lake Coleman, Hords Creek Reservoir and Lake Clyde. This assumption is consistent with the operations of other major reservoirs in the region, but may not be appropriate for the Pecan Bayou watershed during times of drought. If Lake Brownwood fully exercises its senior priority right, the three upstream reservoirs have no reliable supply. However, under drought conditions it is possible that Lake Brownwood would call on inflows from the three upstream junior reservoirs. This study examined six different operational scenarios for regional water planning purposes, varying assumptions for when water is passed through the upper reservoirs to meet priority calls from Lake Brownwood.

The modeling indicated that passing only high flows or flows when Lake Brownwood was below 50 percent of its capacity would result in sufficient supply to meet projected demands from the three upstream reservoirs. Lake Brownwood has sufficient supplies to meet its projected demands in all scenarios.

Scenario 3, *Priority call when Lake Brownwood storage is below 50%,* was the preferred strategy for regional water planning, and is incorporated in the *2011 Region F Water Plan* Subordination Strategy for the water users in Pecan Bayou watershed. This assumption is for planning purposes only and does not imply any restrictions on the ability of Brown County WID No. 1 to exercise its full permitted water rights.

1.7.5 Economics of Rural Water Distribution and Integrated Water Supply Study

The *Economics of Rural Water Distribution and Integrated Water Supply Study* addresses several concerns for rural water providers that were raised during the development of the *2006 Region F Water Plan*:

- Reliability problems
- Water quality problems, and
- High costs of strategies to address problems.

The study concentrated on rural water providers in a seven-county area in the eastern portion of Region F (Brown, Coke, Coleman, Concho, Runnels, Tom Green and McCulloch Counties). The objective of this study was to examine the factors that impact costs of rural water systems and how those factors might affect the ability of these systems to function as part of regional solutions.

Key findings of the study include:

- The primary factors that affect the economics of rural water systems in the study area are a limited economic base, lack of water supply alternatives, extensive infrastructure for small populations, and difficulties in meeting regulatory requirements.
- If regionalization or integration strategies are pursued, water providers in the study area will most likely need to rely on volunteer construction of water lines to reduce costs.

- Attractive alternatives to regionalization or integration strategies include rainwater harvesting, point-of-use or point-of-entry treatment, and bottled water programs.

One of the most important factors in the capability of rural systems to initiate new strategies appears to be population density and the expectation for growth. Systems such as the Brookesmith Special Utility District were designed with larger water lines that anticipate additional water use. The near term water quality problems associated with oversized lines is expected to be offset by future growth and flexibility in operation. On the other hand, systems in areas with lower population densities and less expectation of growth were, by necessity, built with smaller lines. Although appropriate for these systems, the smaller lines mean that additional growth may require new infrastructure. These systems may not have the flexibility to add new sources of water or add emergency connections without construction of new infrastructure. Therefore regionalization or other integration strategies are unlikely to be cost-effective for these systems.

1.7.6 Region K Coordination

The coordination with Region K included attending meetings with the Region K water Planning Group and evaluating the differences between the adopted Region K "cutoff" model and the model currently used by the Region F for the Subordination Strategy (discussed in Chapter 4).

- The Region K cutoff model shows that less water is passed from Region F to Region K than the Region F model used in the 2006 plan.
- The Region K model does not include Brady Creek Lake or the City of Junction water right. However the total amount of flow retained in Region F is more than the impact of these two rights. Therefore the overall water balance between the two regions should not be impacted.
- Region F does not intend to change its water availability analysis for the *2011 Region F Water Plan*, and intends to retain the Subordination Strategy initially developed in the *2006 Region F Water Plan*, including water provider agreements and system operations. This approach should not have an impact to the supplies in Region K as determined by the new Region K "cutoff" model.

- While there are some differences between the models, the use of the two models in this round of planning should not impact the overall balance of water between the two regions. However future water availability analyses should address the Brady Creek Lake and the City of Junction water rights. This is further discussed in Chapter 4 under the Subordination Strategy.

1.8 Summary of Threats and Constraints to Water Supply in Region F

1.8.1 Threats to Water Supply

Threats to water supply in Region F include:

- Use of the TCEQ Water Availability Model (WAM) Run 3 for regional water planning;
- Water quality concerns in several areas of the region; and
- The impact of drought.

Surface water quality concerns identified by the TWDB, TCEQ, TPWD, EPA and others (River Authorities, etc.) within Region F are summarized in Table 1.8-1.

Use of TCEQ WAM Run 3 for Regional Water Planning

The TWDB requires the use of the TCEQ Water Availability Models (WAM) Run 3 as the definition of water availability for regional water planning. WAM Run 3 has the following major assumptions:

- Full use of permitted diversion and storage
- 100 percent reuse of return flows (except return flows specified within the water right permit)
- Allocation of water according to priority date regardless of geographic location or type of use

The Colorado WAM Run 3 has significantly different results than previous assessments of water availability in the basin. Previous studies by the State of Texas and others showed sufficient reliable supplies from reservoirs in Region F to meet current and projected demands, including the 1978 Report LP-60, the 1990 state water plan,[32] the 1997 state water plan,[33] and the 2002 state water plan. Recent experience of critical drought conditions in the upper basin show that supplies are available from the region’s reservoirs under drought-of-record conditions.

Table 1.8-1
Summary of Identified Surface Water Quality Problems in Region F

Segment ID	Segment Name	Concern Location	Water Quality Concern	Status
1412	Colorado River Below J.B Thomas	From the confluence of Beals Creek upstream to the dam below Barber Reservoir pump station	bacteria	Additional data and information will be collected before a TMDL is scheduled.
1413	Lake J. B. Thomas	Entire water body	chloride	Additional data and information will be collected before a TMDL is scheduled.
1416	San Saba River	From the confluence with the Colorado River in San Saba County upstream to the US 190	bacteria	Additional data and information will be collected before a TMDL is scheduled.
1416 A	Brady Creek (unclassified water body)	From FM 714 upstream to Brady Lake dam	depressed dissolved oxygen	Additional data and information will be collected before a TMDL is scheduled.
1421	Concho River	From the dam near Vines Road upstream to the confluence of the North Concho River and the South Concho River	impaired macrobenthic community	Additional data and information will be collected before a TMDL is scheduled.
		North Concho River, from the confluence with the South Concho River upstream to O.C. Fisher dam	bacteria	Additional data and information will be collected before a TMDL is scheduled.
			depressed dissolved oxygen	Additional data and information will be collected before a TMDL is scheduled.
1425	O.C. Fisher	Entire reservoir	chloride	Additional data and information will be collected before a TMDL is scheduled.
1431	Mid Pecan Bayou	Entire water body	bacteria	Additional data and information will be collected before a TMDL is scheduled.
2311	Upper Pecos River	US 80 (Bus 20) to FM 1776	depressed dissolved oxygen	Additional data and information will be collected before a TMDL is scheduled.
		FM 1776 to US 67	depressed dissolved oxygen	Additional data and information will be collected before a TMDL is scheduled.

Source: Data from 2008 Draft 303(d) list (March 19, 2008) [34]

However, the Colorado WAM indicates that almost all of the major reservoirs in Region F have little or no reliable supply. This result is contrary to previous water plans and recent historical experience.

The WAM was developed by TCEQ to process new water rights and amendments to existing water rights. The WAM operates in a theoretical legal space that is different from the way that the Colorado Basin has historically been operated. The WAM generally does not include return flows, which can be a significant source of water in many areas. Many run-of-the-river irrigation rights depend on these return flows for reliable supplies. Until such time as return flows are claimed for reuse, water rights holders can legally make use of these return flows. The WAM also assumes that storage in a reservoir has the same weight as diversion. A downstream reservoir with a senior priority date can appropriate all of the available water just to fill storage, often leaving upstream junior water rights with no available water for use.

WAMs are a relatively new tool available to state agencies for planning, permitting and making policy decisions. Care must be used when using these models without modifications to set state water policies for existing and future water users. In some cases, modifications to the assumptions used in TCEQ WAM Run 3 would make these models more appropriate for other purposes. As presently used, the WAM adversely impacts water availability in Region F.

The development of water supplies in the Colorado Basin has a long history of conflict and resolution over the impact upstream development may have on downstream water rights. Requiring the use of the WAM for planning purposes without modification has reopened these issues and thus poses a policy threat to existing water rights in Region F. It also forces an overestimation of water needs within Region F, and a corresponding underestimation of the future water needs downstream in Region K.

Rio Grande Basin Water Quality

The high levels of chlorides, sulfates and TDS present in the Pecos River below Red Bluff Reservoir appear to originate from geologic formations and oil and gas production activities. The cause of the toxic algae blooms is unknown. However, their occurrence has been linked to salinity and nutrient concentrations. The elevated levels of arsenic have been attributed to agricultural activities. Red Bluff Reservoir contains elevated levels of mercury. The heavy metals present in the surface water in this region represent the most serious public health concern. The high chloride and TDS levels in the surface water preclude most agricultural uses. Instead, agricultural water users rely heavily on the groundwater supply.

Colorado River Basin Water Quality

The high levels of chlorides, sulfates and TDS present in the Upper Colorado River above O.H. Ivie Reservoir (including E.V. Spence Reservoir) are thought to originate from geologic formations and oil and gas production.[35] In August 2000, a Total Maximum Daily Load (TMDL) study was completed at E.V. Spence Reservoir. This TMDL study was approved by the Environmental Protection Agency (EPA) in May 2003. As a result of the TMDL study, a Watershed Action Plan was developed which provides a comprehensive strategy for restoring and maintaining water quality in the area. Continued monitoring of the area should show improving water quality as the Action Plan is implemented.

Infrequent low dissolved oxygen levels have been reported by the TCEQ within the lower 25 miles of Pecan Bayou above Lake Brownwood. There are no known point sources of water pollution within the segment that could be responsible for the problem. Low oxygen levels may be due to natural conditions and/or agricultural non-point source pollution. The TCEQ has not given this a priority ranking on the 303(d) list, instead stating that more data will be collected before a TMDL is scheduled. No impairment to water use as a result of the water quality has been reported.

The high nitrate levels present in the Concho River east of San Angelo and the groundwater water in Runnels, Concho and Tom Green Counties appear to be from a combination of natural conditions, general agricultural activities (particularly as related to wide spread and intense crop production), and locally from confined animal feeding operations and/or industrial activities. Surface waters in the Concho River near Paint Rock have consistently demonstrated nitrate levels above drinking water limits during winter months. This condition has caused compliance problems for the city of Paint Rock, which uses water from the Concho River. It has been determined through studies funded by the Texas Clean Rivers Program that the elevated nitrates in the Concho River result from dewatering of the Lipan aquifer through springs and seeps to the river.[36]

The North Fork of the Concho River from O.C. Fisher Reservoir Dam to Bell Street in San Angelo is heavily impacted with non-point source urban runoff, which leads to oxygen depletion and a general water quality deterioration. Numerous fish kills have occurred along this 4.75 mile stretch of the Concho River since the late 1960's. In addition, toxics have been reported by the TCEQ within the same stream segment. Both of these problems are believed to result from non-point source water pollution. Since 1994, the Upper Colorado River Authority and the City of San Angelo have been involved in a comprehensive effort to mitigate these problems through the Federal Clean Water Act (CWA) 319(h) program. This program provides grant funds to implement Best Management Practices (BMPs) designed to mitigate non-point source water quality problems. The EPA 319(h) program is administered in Texas through the TCEQ.

Hickory Aquifer

Radionuclides present in the Hickory aquifer originate from geologic formations. Several of the public water systems that rely on this aquifer sometimes exceed the TCEQ's radionuclide limits, including limits on radon. Some users are blending water from other sources with Hickory supplies to reduce radionuclide concentrations. According to local representatives of Hickory aquifer users on the Region F Water Planning Group, water from the Hickory aquifer has been used for decades with no known or identified health risk or problems. Since the radioactive contaminants are similar chemically to water hardness minerals (with the exception of radon), removal techniques are well known within the water industry. Problems that have yet to be resolved in utilizing these techniques are the storage and disposal of the removed radioactive materials left over from the water treatment process, and the funding of treatment improvements for small, rural communities. Removal techniques for radon are well known and should not present any major problems to suppliers in implementation. Generally, agricultural use is not impaired by the presence of the radionuclides.

Other Groundwater Quality Issues

Other groundwater quality issues in Region F include elevated levels of fluoride, nitrate, arsenic and perchlorate. Table 1.8-2 shows the percentage of water wells sampled by the TWDB that exceed drinking water standards for fluoride, nitrate and arsenic. The largest percentage of wells with excessive fluoride can be found in Andrews and Martin Counties. Elevated nitrate levels can be found throughout Region F, with a high percentage of wells exceeding standards in Ector, Midland, Runnels and Upton Counties. The highest percentages of wells exceeding arsenic standards are found in Borden, Midland and Martin Counties. Perchlorate is a growing water quality concern for water from the Ogallala aquifer in west Texas. Preliminary research found perchlorate levels exceeding drinking water standards in 35 percent of the public drinking water wells.[37]

Table 1.8-2
Percentage of Sampled Water Wells Exceeding Drinking Water Standards for Fluoride, Nitrate and Arsenic (2008)

County	Fluoride	Nitrate	Arsenic
Andrews	27%	54%	36%
Borden	13%	44%	40%
Brown	2%	36%	0%
Coke	1%	39%	0%
Coleman	1%	41%	0%
Concho	1%	56%	0%
Crane	7%	38%	30%
Crockett	0%	15%	0%
Ector	2%	81%	26%
Glasscock	3%	72%	11%
Howard	20%	61%	28%
Irion	0%	22%	0%
Kimble	0%	26%	0%
Loving	0%	41%	5%
Martin	46%	76%	72%
Mason	0%	52%	0%
McCulloch	1%	26%	0%
Menard	0%	19%	0%
Midland	11%	85%	42%
Mitchell	6%	37%	0%
Pecos	2%	31%	5%
Reagan	3%	67%	10%
Reeves	1%	30%	1%
Runnels	10%	94%	0%
Schleicher	0%	22%	0%
Scurry	3%	34%	6%
Sterling	0%	29%	0%
Sutton	0%	18%	0%
Tom Green	0%	52%	0%
Upton	0%	80%	3%
Ward	1%	25%	8%
Winkler	2%	13%	14%

Data are from the Texas Water Development Board 12-2008[38]

Current and Proposed TMDL Studies in Region F

The TCEQ publishes *The State of Texas Water Quality Inventory* every two years. The Water Quality inventories indicate whether public water supply use is supported in the stream segments designated for public water supply in Region F. The TCEQ has also established a list of stream segments for which it intends to develop Total Maximum Daily Load (TMDL) evaluations to address water quality concerns.[39] Two TMDLs exist in Region F: one for E.V. Spence Reservoir and one for the Colorado River downstream of E.V. Spence Reservoir. Monitoring of these reaches is conducted by TCEQ.

Regional Drought

Most of Region F has experience drought-of-record conditions since the mid 1990s. Although extensive rains in 2004 and 2007 brought some relief to the drought conditions, there remains a large volume of empty reservoir storage in the region. Over the last few years, reservoir storage has generally continued to remain low. In March 2010, the capacities of Lake J.B. Thomas, E.V. Spence Reservoir, and O.C. Fisher Lake were less than 10 percent. Twin Buttes, Champion Creek, Hords Creek Lake and Red Bluff reservoirs reported storage amounts at less than or equal to 25 percent of capacity. O.H. Ivie was at 43 percent of capacity. Aquifers generally respond more slowly to drought conditions than surface water supplies. However, without significant rainfall, little recharge will be available to replace water currently being pumped from these aquifers.

Drought conditions also have a negative impact on water quality. As water levels decline, reservoirs tend to concentrate dissolved materials. Without significant fresh water inflows the water quality in a reservoir degrades. The lack of recharge to aquifers has a similar effect on groundwater.

1.8.2 Constraints

A major constraint to enhancing water supply in Region F is a lack of appropriate locations for new surface water supply development and lack of available water for new surface water supply projects. There are few sites in the region that have sufficient runoff to justify the cost of developing a new reservoir without having a major impact on downstream water supplies. Generally, the few locations that do have promise are located far from the areas with the greatest needs for additional water. In addition, the Colorado and Rio Grande WAMs show very little available surface water for new appropriations in Region F. There is very little water available that has not already been allocated to existing water rights.

Much of the surface water and groundwater in the region contains high concentrations of dissolved solids, originating from natural and man-made sources. It is possible to make use of these resources, but the cost to treat this water can be high. Much of the region is economically distressed due to downturns in the petroleum industry and agriculture. Therefore, advanced treatment, system improvements or long distance transportation of water may not be economically feasible. Also, many of these smaller communities have experienced declining populations in recent years. More than one-half of the counties in the region have a population less than 5,000 people. These smaller counties lost 2.2 percent of their population between 1990 and 2000. Thus they are ill equipped to afford the high cost of advanced water treatment techniques, given their declining revenue base.

Finally, many of the municipal water supply needs in Region F are relatively small and are in locations that are far away from reliable water supplies of good quality. Transporting small quantities of water over large distances is seldom cost-effective. Desalination and reuse are good options for these communities. However, the high cost of developing and permitting these types of supplies is a significant constraint on water development. Also, finding a suitable means of disposing the reject concentrate from a desalination project may limit the feasibility of such projects in many locations.

1.9 Water-Related Threats to Agricultural and Natural Resources in Region F

Water-related threats to agricultural resources in Region F include water quality concerns and insufficient groundwater supplies. Water-related threats to natural resources include changes to natural flow conditions and water quality concerns.

1.9.1 Water Related Threats to Agriculture

Water quality concerns for agriculture are largely limited to salt water pollution, both from natural and man-made sources. In some cases, improperly abandoned oil and gas wells have served as a conduit for brines originating deep within the earth to contaminate the shallow groundwater supplies. Prior to 1977, the brines associated with oil and gas production were commonly disposed in open, unlined pits. In some cases these disposal pits have not been remediated and remain as sources of salt contamination. Current brine disposal practices involve repressurizing hydrocarbon-producing formations or disposing through deep well injection. These practices lead to the possibility of leaks into water supply aquifers since the hydraulic pressure of the injected water routinely exceeds the pressure needed to raise the water to the ground's surface. In other aquifers, excessive pumping may cause naturally occurring poor quality water to migrate into fresh water zones.

Most of Region F depends on groundwater for irrigation. According to the *2006 Region F Water Plan,*[40] agricultural demand exceeds the available groundwater supply in several counties. Parts of three counties (Midland, Reagan and Upton) have already been declared a Priority Groundwater Management Area by the TCEQ in response to excessive drawdown in the aquifer.

1.9.2 Water Related Threats to Natural Resources

Reservoir development and invasion by brush have altered natural stream flow patterns in Region F. Spring flows in Region F have greatly diminished. Many springs have dried up because of groundwater development, the spread of high water use plant species such as mesquite and salt cedar, or the loss of native grasses and other plant cover. High water use plant species have reduced reliable flows for many tributary streams. Reservoir development also changes natural hydrology by diminishing flood flows and capturing low flows. It is unlikely that future changes to flow conditions in Region F will be as dramatic as those that have already occurred. If additional reservoirs are developed, they will be required to make low flow releases to maintain downstream stream conditions.

1.10 Water Loss Audit

Retail public water utilities are required to complete and submit a water loss audit form to the Texas Water Development Board every five years. The first water loss audit reports were submitted to the TWDB by March 31, 2006. The data from these reports were compiled by Alan Plummer Associates Inc. through a research and planning fund grant from TWDB.[41] The water audit reporting requirements follow the International Water Association (IWA) and American Water Works Association (AWWA) Water Loss Control Committee methodology.[42]

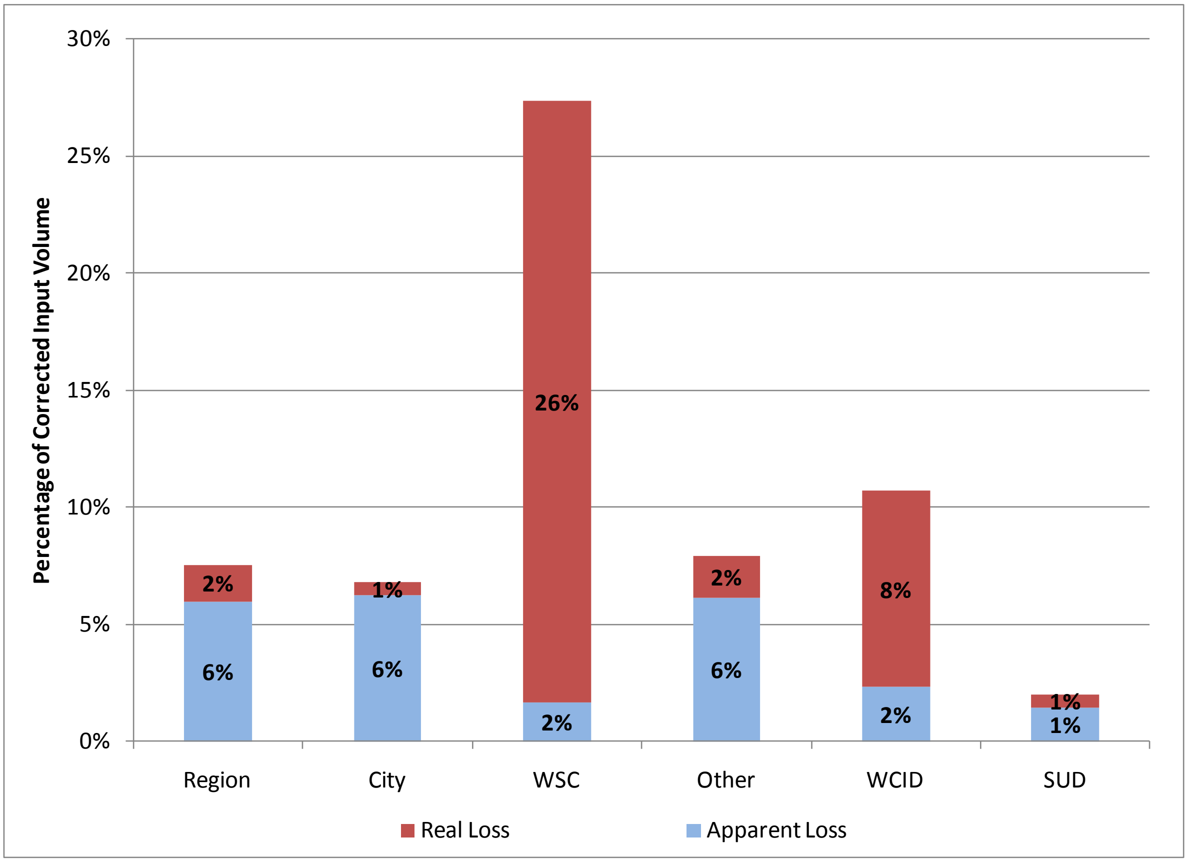
The primary purposes of a water loss audit are to account for all of the water being used and to identify potential areas where water can be saved. Water losses are classified as either as apparent loss or real loss. Apparent loss is the water that has been used but has not been tracked. It includes losses associated with inaccurate meters, billing adjustment and waivers, and unauthorized consumption. Real loss is the actual water loss of water from the system, and includes main breaks and leaks, customer service line breaks and leaks, and storage overflows. The sum of the apparent loss and the real loss make up the total water loss for a utility.

In the Region F planning area, 56 public water suppliers submitted a water loss audit to TWDB. These suppliers include 31 cities, 16 water supply corporations, five other water suppliers, three water conservation and improvement districts and one special utility district. Figure 1.10-1 shows the percentage of total water loss for the region, cities, water supply corporations, other utilities, water conservation and improvement districts and the special utility district.

The average total water loss for Region F is 8 percent. The percentage of total water loss for cities, other suppliers, water conservation and improvement districts and the special utility district are within the range of acceptable water loss (less than or equal to 12 percent). The water loss for water supply corporations is much higher. One explanation for this may be the large areas with low population densities served by rural water suppliers. This makes it difficult for these entities to identify and repair leaks.

The amount of real losses in Region F from the 56 public water suppliers totaled 454 million gallons in 2006. This represents 1.1 percent of the total estimated municipal water demand for the region. Based on these findings, the region is adequately addressing municipal water loss. Measures that are currently in place to control water loss should continue. For the water suppliers that fall under WSC category, there may be few cost effective options in reducing water loss. However, these providers may consider more efficient leak detection and reducing the time required to repair a leak after it is identified.

Figure 1.10-1: Water Loss in Region F



1.11 Navigation in Region F

The U.S. Army Corps of Engineers has published a list of the navigable portions of the rivers in Texas.[43] The Colorado River is considered navigable from the Bastrop-Fayette County line to Longhorn Dam in Travis County. The Rio Grande is considered navigable from the Zapata-Webb County line to the point of intersection of the Texas-New Mexico state line and Mexico. All of these areas are outside of the boundaries of Region F. The Pecos River segment is not specifically included.

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