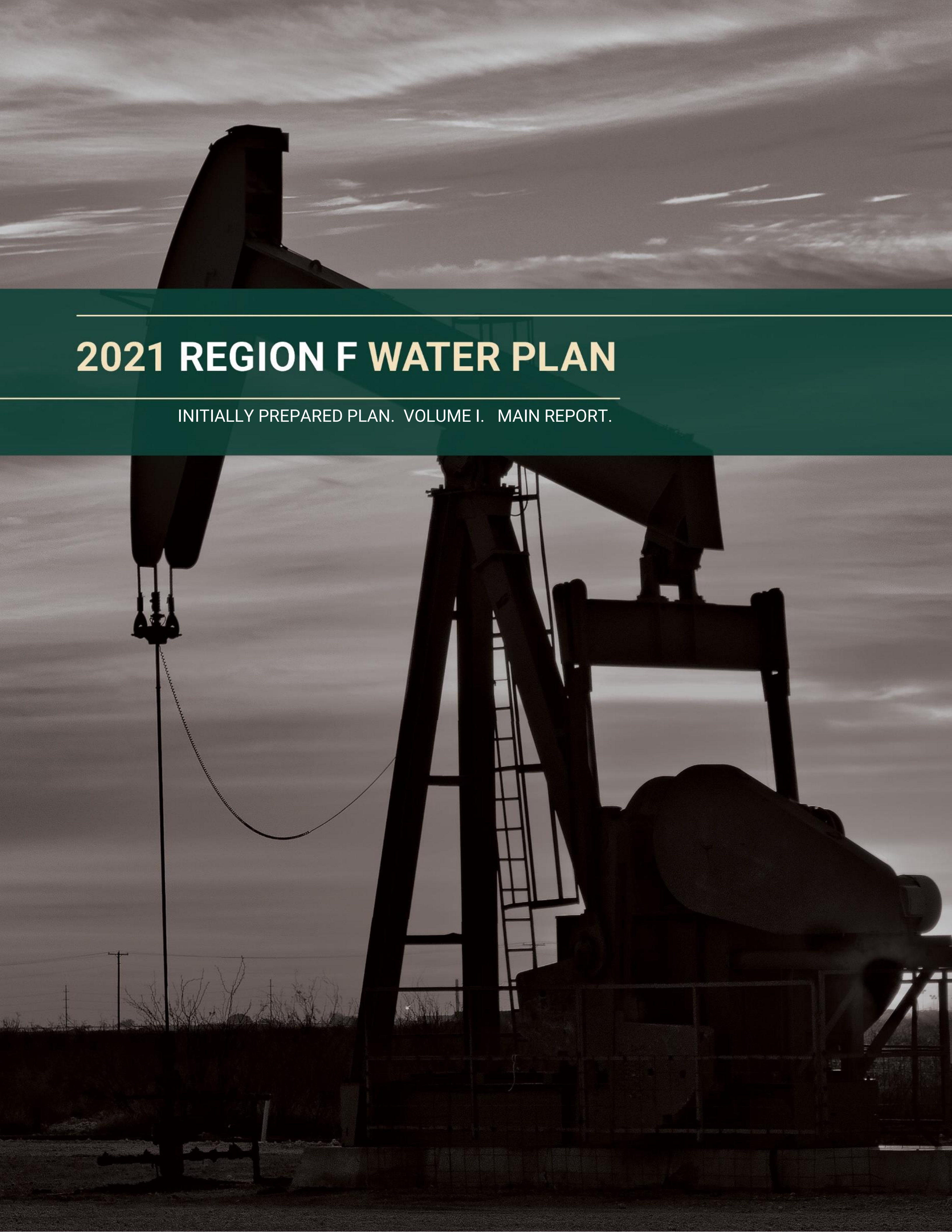
2021 REGION F WATER PLAN

INITIALLY PREPARED PLAN. VOLUME I. MAIN REPORT.



2021 REGION F WATER PLAN
INITIALLY PREPARED PLAN

MARCH 2020

Prepared for:

REGION F WATER PLANNING GROUP

DRAFT
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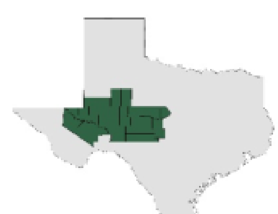

PREFACE

In 1997, the 75th Texas Legislature passed Senate Bill One, legislation designed to address Texas water issues. Senate Bill One put in place a grass-roots regional process to plan for the future water needs of all Texans. To implement this process, the Texas Water Development Board created 16 regional water planning groups across the state and established regulations governing regional planning efforts. This plan presents the results of this process for the Region F Water Planning Area that represents 32 counties in West Texas.

In accordance with the State planning guidelines, the regional water plan includes eleven specific chapters. In addition to the eleven required sections, this report also includes appendices providing more detailed information on the planning efforts. The elements contained in this plan meet Texas Water Development Board regional planning requirements and guidelines.

The *2021 Region F Water Plan* represents the culmination of five years of working together with the regional water planning group (RWPG), regional and local water providers, and the public. As you read this water plan, the RWPG would like you to keep in mind the following points:

- The *2021 Region F Water Plan* presents a comprehensive overview of the water supply issues in the region. It does not predict or forecast future droughts or floods.
- This plan is a living document that will change as new data become available that better represent the demands on our water resources, available supplies from these resources, and the water supply projects that are being pursued.
- The report presents planning level analyses of the recommended water management strategies. Additional engineering studies and design will be needed prior to the implementation of the strategies.
- The specific surpluses and needs shown in the plan should be treated with caution because their development requires certain assumptions that may or may not come to fruition.
- The RWPG has no authority to regulate water supplies or implement water management strategies. The identified water management strategies are assumed to be implemented by the respective water user.

2021 Water Plan Chapters

1. Planning Area Description
2. Current and Projected Population and Water Demand
3. Evaluation of Regional Water Supplies
4. Identification of Water Needs
5. Water Management Strategies
6. Impacts of the Regional Water Plan
7. Drought Response Information, Activities and Recommendations
8. Regulatory, Administrative and Legislative Recommendations
9. Water Infrastructure Funding Recommendations
10. Plan Adoption and Public Participation
11. Implementation and Comparison to Previous Regional Water Plan

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2021 REGION F INITIALLY PREPARED PLAN. LIST OF ACROYNMS.

Acronym	Name	Meaning
ASR	Aquifer Storage and Recovery	Aquifer storage and recovery (ASR) is the storage of water in a suitable aquifer through a well during times when water is available, and the recovery of water from the same aquifer during times when it is needed.
BCWID	Brown County Water Improvement District Number One	Owns and operates Lake Brownwood. Wholesale water provider in Brown and Coleman Counties.
CRMWD	Colorado River Municipal Water District	Water district that owns and operates 3 major reservoirs and several well fields. CRMWD is the largest water supplier in Region F and is the political subdivision for the Region F RWPG.
DFC	Desired Future Condition	Criteria for which is used to define the amount of available groundwater from an aquifer.
GAM	Groundwater Availability Model	Numerical groundwater flow model. GAMs are used to determine the aquifer response to pumping scenarios. These are the preferred models to assess groundwater availability.
GCD	Groundwater Conservation District	Generic term for all or individual state recognized Districts that oversee the groundwater resources within a specified political boundary.
GMA	Groundwater Management Area	Sixteen GMAs in Texas. Tasked by the Legislature to define the desired future conditions for major and minor aquifers within the GMA.
gpcd	Gallons per capita per day	Unit of measure that accounts for water use in the number of gallons a person uses each day.
MAG	Modeled Available Groundwater	The MAG is the amount of groundwater that can be permitted by a GCD on an annual basis. It is determined by the TWDB based on the DFC approved by the GMA. Once the MAG is established, this value must be used as the available groundwater in regional water planning.
MWP	Major Water Provider	A water user group or a wholesale water provider of particular significance to the region's water supply as determined by the regional water planning group.
PGMA	Priority Groundwater Management Area	A PGMA is an area designated and delineated by TCEQ that is experiencing or expected to experience, critical groundwater problems. If a study area is designated as a PGMA, TCEQ will make a specific recommendation on groundwater conservation district creation.
RWPG	Regional Water Planning Group	The generic term for the planning groups that oversee the regional water plan development in each respective region in the State of Texas
SB1	Senate Bill One	Legislation passed by the 75th Texas Legislature that is the basis for the current regional water planning process.
TCEQ	Texas Commission on Environmental Quality	Agency charged with oversight of Texas surface water rights and WAM program.

Acronym	Name	Meaning
TMDL	Total Maximum Daily Load	A Total Maximum Daily Load (TMDL) is a regulatory term in the U.S. Clean Water Act, describing a plan for restoring impaired waters that identifies the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.
TWDB	Texas Water Development Board	Texas Agency charged with oversight of regional water plan development and oversight of GCDs
UCRA	Upper Colorado River Authority	Owner of water rights in O.C. Fisher Reservoir and Mountain Creek Lake. Designated WWP.
WAM	Water Availability Model	Computer model of a river watershed that evaluates surface water availability based on Texas water rights.
WMS	Water Management Strategy	Strategies available to RWPG to meet water needs identified in the regional water plan.
WUG	Water User Group	A group that uses water. Six major types of WUGs: municipal, manufacturing, mining, steam electric power, irrigation and livestock.
WWP	Wholesale Water Provider	Entity that has or is expected to have contracts to sell 1,000 ac-ft./yr. or more of wholesale water.

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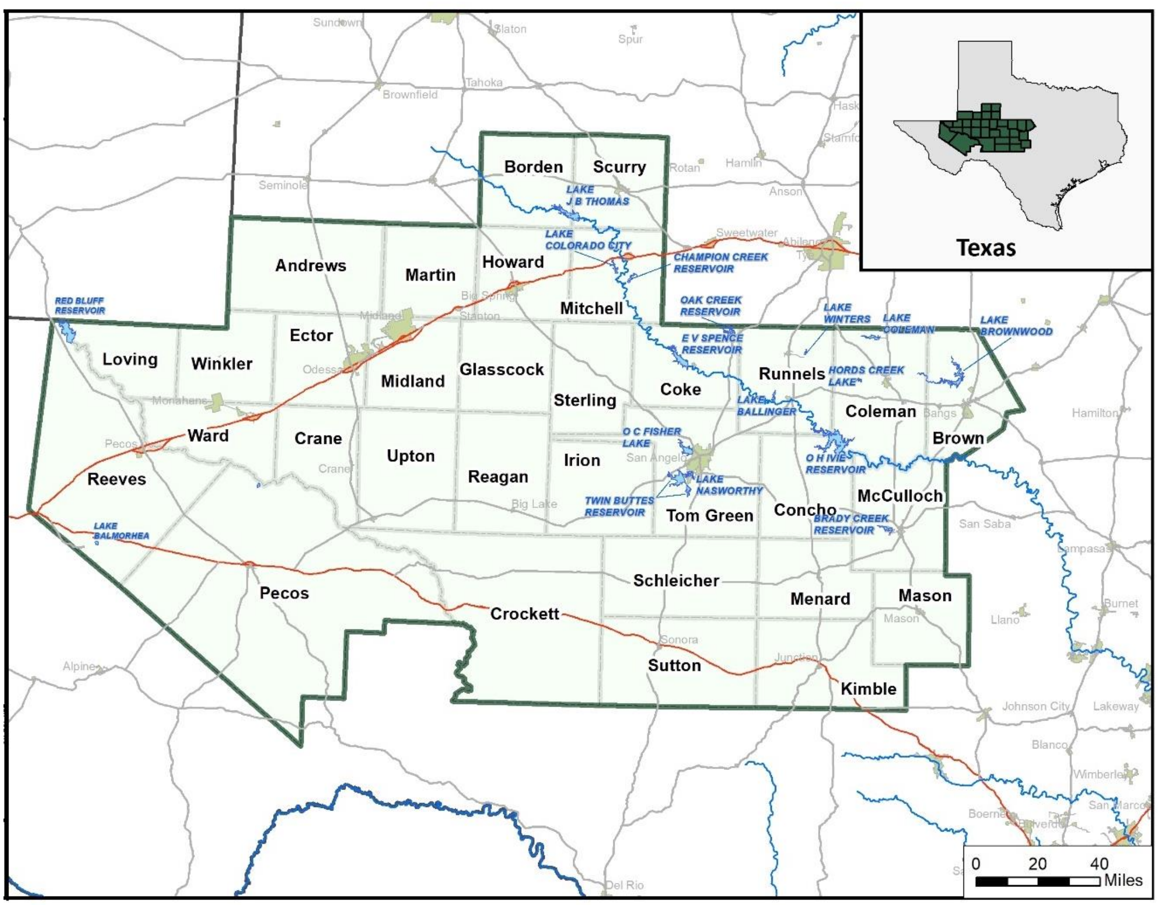
EXECUTIVE SUMMARY

In 1997, the state of Texas began a comprehensive water planning and management effort using a “bottom up” approach to ensure that the water needs of all Texans are met. This process results in 16 unique regional water plans that are compiled into the State Water Plan. Since this planning effort began there have been four State Water Plans developed. This report presents the *Region F Water Plan* developed in the fifth round of the regional water planning process. Region F includes all of 32 counties in West Texas, as show in Figure ES- 1.

The 2021 Region F Water Plan consists of 11 chapters that identify the water needs in the region and then maps out a path to conserve water supplies, meet future water supply needs, and respond to future droughts. Associated data necessary in developing the plan is included in several appendices. All of the TWDB rules, guidance, and regulations were followed and compliance with them is documented in Appendix A. The plan’s required database reports are in Appendix I.

The 2021 Region F Initially Prepared Water Plan was developed under the direction of the Region F Water Planning Group and adopted by the planning group on February 20, 2020. This report presents the results of a five-year planning effort to develop a plan for water supply for the region through 2070.

Figure ES- 1
Region F Area Map



ES.1 Key Findings

The Region F Water Plan projects population and water demands over a fifty-year planning horizon and seeks to identify possible strategies to avoid potential water shortages in the region. Due to drought in the Colorado River Basin, the estimated surface water availability has declined from previous estimates. This has resulted in the development of other supplies and reduced reliance on surface water in the region. For some areas, the only source of water is groundwater. Continued and increased demands on groundwater affect the long-term availability of many Region F aquifers. Groundwater availability in the region has increased overall from the 2016 Water Plan, but there continues to be areas with insufficient surface water and groundwater. Also, water quality is significant concern in the region for both surface water and groundwater sources. As entities continue to stress existing water sources, the impacts to quality will increase and the usability of the water will decline. To address this concern, there are several advanced treatment strategies recommended in the region. Irrigation continues to be largest user of water in Region F, but the ability to fully meet this demand during drought is limited. Irrigation conservation is estimated to provide up to 35 percent of the projected water need, but there remains a regional unmet need of 24,739 acre-feet pear year by 2070. The increased mining activities in the region has had multiple impacts to water demands, including spurring population growth and economic activities in both rural and urban communities, which increase associated water demands. As the region looks to meet its projected needs, conservation, additional groundwater development, and advanced treatment will become greater integral components of the region's water supplies.

Key Findings

- Continued interest in oil and gas development has increased the demand for water, directly for mining operations and for communities experiencing increased population growth.
- Conservation (municipal, irrigation, and mining) accounts for one quarter to one third of the future water supply in Region F.
- Additional groundwater development is a major water supply strategy, accounting for 20 to 30 percent of new supplies for the region.

ES.2 Current Water Needs and Supplies in Region F

As of the 2010 census, the population of Region F was 623,354. The three most populous counties in Region F, Ector, Midland, and Tom Green, have 62 percent of the region's population. Seven cities in Region F had a population of more than 10,000 people as of year 2010. These seven cities include 60 percent of the population in Region F. Since 2010 some communities have experienced substantial growth, mostly due to the increased activities in the oil and gas industry in the Permian Basin. Some of these increases are not accurately reflected in the population projection for the 2021 Region F Water Plan. As a result, the plan recognizes the additional water demands on these communities by including water management strategies to meet the anticipated needs.

2.1.1 Physical Setting

Most of Region F is located in the upper portion of the Colorado Basin and in the Pecos portion of the Rio Grande Basin. A small portion of the region is in the Brazos Basin. Figure ES- 1. shows the major streams in Region F. Precipitation increases from west to east across the region, as does the average runoff. Evaporation increases from southeast to northwest. The patterns of rainfall, runoff, and evaporation result in more abundant water supplies in the eastern portion of the region.

Region F includes 17 major water supply reservoirs that provide most of the region's surface water supply. Four major aquifers and ten minor aquifers provide groundwater supplies to Region F. Springs have historically played an important role in water supply; however, over time most of the springs have greatly diminished and only contribute to water supply in specific locations.

ES.2.1 Current Sources of Water

The Region F surface water supplies are associated primarily with major reservoirs. Region F does not import a significant amount of surface water from outside the region. However, Region F exports surface water to the cities of Sweetwater and Abilene, both in the Brazos G Region. The City of Sweetwater owns and operates Oak Creek Reservoir in Region F. The City of Abilene has a contract to purchase water out of O.H. Ivie Reservoir in Region F. Surface water supplies have historically been an important source of water for municipal use and is the primary source for many communities.

Based on historic groundwater estimates (2012-2016), approximately 60 percent of the water used in Region F is supplied by groundwater. Region F has 16 Underground Water Conservation Districts (GCDs) that oversee the use of water from the aquifers in the region. Twelve of these GCDs formed an alliance known as the West Texas Regional Groundwater Alliance that promotes conservation, preservation, and beneficial use of water in Region F.

ES.2.2 Water Providers in Region F

Water providers in Region F are classified by use type and can be grouped into municipal and non-municipal water users. Non-municipal water users are aggregated by county and include irrigation, livestock, manufacturing, mining, and steam electric power. Municipal water user groups are defined by water utilities that provide 100 acre-feet per year or more to retail customers. A major water provider is an entity that provides a significant amount of water in the region. In Region F, there are 95 municipal water user groups and five major water providers. The major water providers include the Colorado River Municipal Water District, Brown County Water Improvement District Number 1, Midland, Odessa, and San Angelo.

ES.3 Projected Need for Water

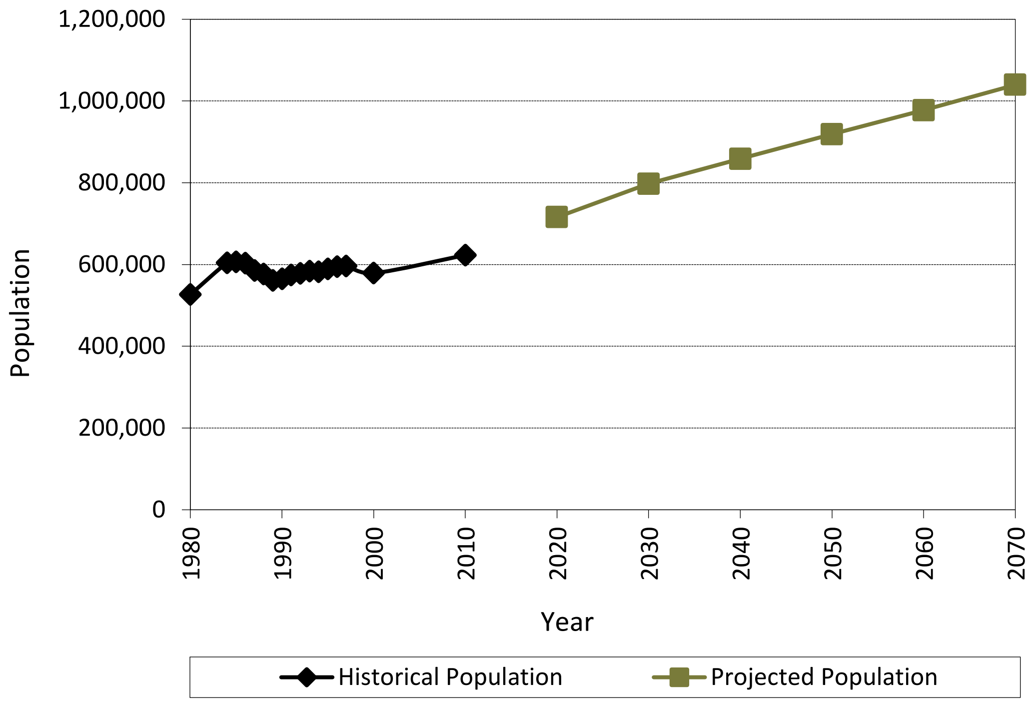
ES.3.1 Population Projections

The population of Region F as shown on Table ES- 1 is projected to grow from 715,773 in the year 2020 to 1,039,502 in 2070, which equates to an average growth rate of 0.90 percent per year. The population projections were developed by the Texas Water Development Board (TWDB). The relative distribution of population in Region F is expected to remain stable throughout the planning period. All but three of the counties are generally rural counties and are expected to remain so into the future. The distribution of the projected population by county and city is discussed in Chapter 2. Figure ES- 2 shows the historical and projected population for Region F.

Table ES- 1
Region F Population Projections

Population Projections	2020	2030	2040	2050	2060	2070
Region F Total	715,773	797,589	858,726	918,597	977,543	1,039,502

Figure ES- 2
Historical and Projected Population in Region F



ES.3.2 Demand Projections

Table ES-2 shows the projected demands for water by category of use in Region F. The total historical water use was about 625,000 acre-feet in the year 2010 and is projected to be as much as 765,150 acre-feet in 2020. The significant increase in water use between the historical year 2010 data and the year 2020 projections is primarily due to increases in mining demands. While the increased mining activity is anticipated to continue over an extended period, the projected demands begin to decline in 2040 and return to near historical levels by 2070.

The largest water user in Region F is irrigated agriculture. This use type accounts for over 62 percent of the projected water use in 2020. While the demand projections do not decline over the planning period, it is possible that some irrigation water use will be converted to other use types as the need for water increases. Other non-municipal water demands are expected to remain steady over the planning period. Municipal water use increases as population increases.

Figure ES- 3
Projected Water Demand in Region F by Use Category

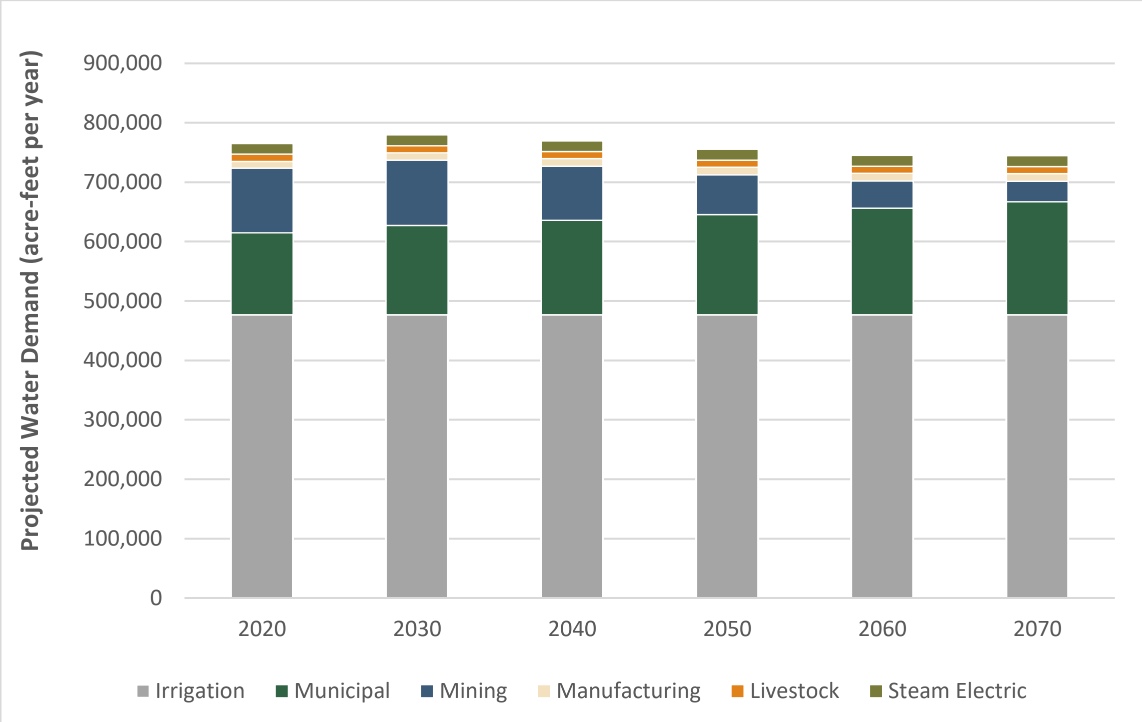


Table ES- 2
Water Demands by Use Type (acre-feet per year)

Demands	2020	2030	2040	2050	2060	2070
Municipal	137,727	150,060	158,957	168,702	179,098	190,290
Manufacturing	11,591	12,607	12,607	12,607	12,607	12,607
Irrigation	476,941	476,941	476,941	476,941	476,941	476,941
Steam Electric	18,092	18,092	18,092	18,092	18,092	18,092
Mining	108,841	109,847	90,970	66,812	46,251	34,478
Livestock	11,958	11,958	11,958	11,958	11,958	11,958
Region F Total	**765,150**	**779,505**	**769,525**	**755,112**	**744,947**	**744,366**

ES.3.3 Water Supply Analysis

As required by TWDB rules, the available surface water supplies are derived from Water Availability Models (WAMs), Full Authorization Run (Run 3). The WAMs were developed by the Texas Commission on Environmental Quality (TCEQ). Three WAMs are available in Region F: (a) the Colorado WAM, which covers most of the central and eastern portions of the region, (b) the Rio Grande WAM, which covers the Pecos Basin, and (c) the Brazos WAM. The WAMs allocate water based on priority without regard to geographic location, agreements between water right holders, or type of use. As a result, the Colorado WAM significantly underestimates the total surface water supply in Region F as currently operated.

Groundwater provides most of the irrigation water used in the region, as well as a significant portion of the water used for municipal and other purposes. Groundwater is primarily found in four major and ten minor aquifers that vary in quantity and quality (Figure ES- 4 and Figure ES- 5). Total groundwater supply is determined using the Modeled Available Groundwater (MAG) value as determined by the TWDB.

Figure ES- 4
Major Aquifer Map

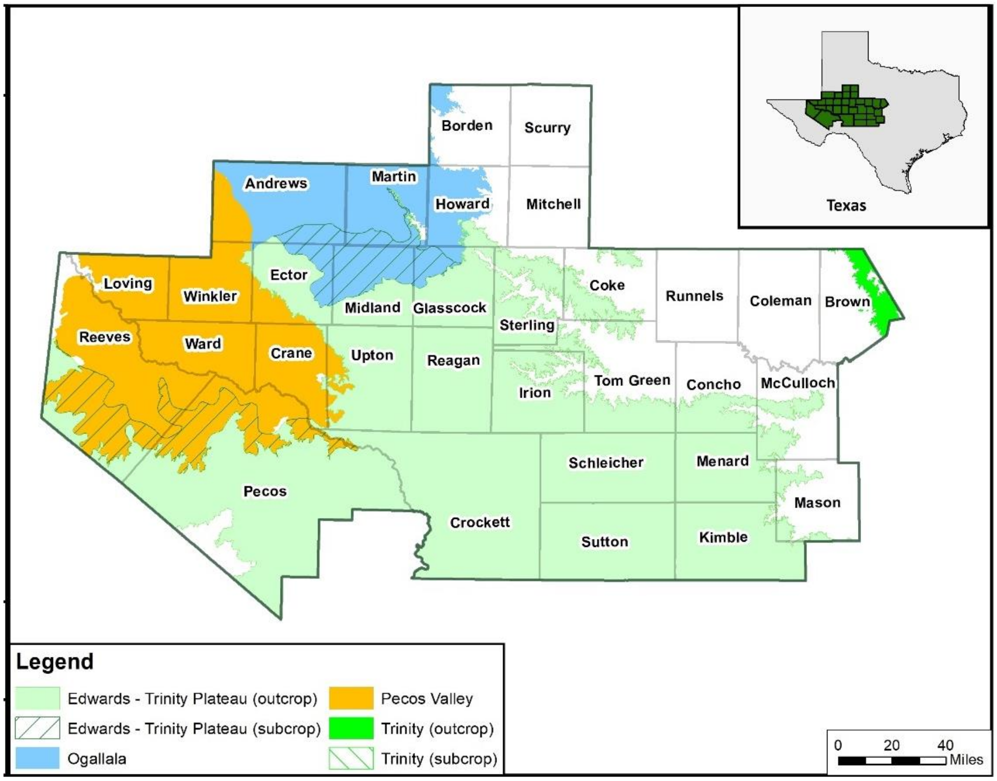
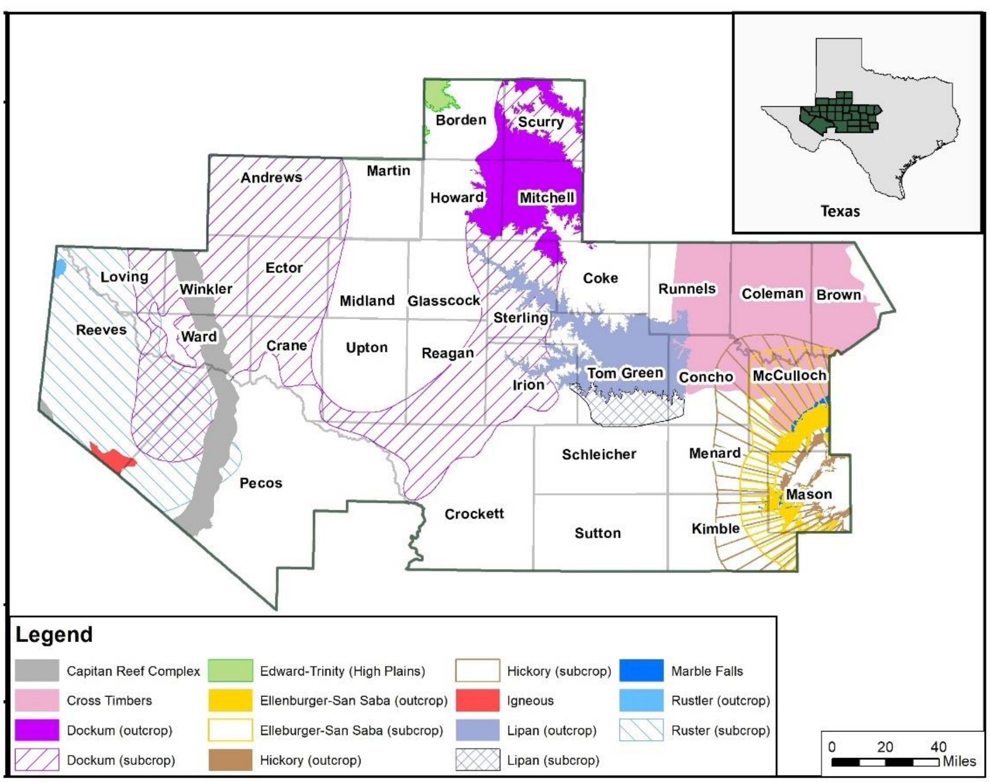


Figure ES- 5
Minor Aquifer Map



The total amount of water available in Region F is approximately 1.3 million acre-feet per year as shown on Figure ES- 6. This includes over 1.1 million acre-feet of groundwater. However, not all the water supplies in the region are currently available and connected to users. Water supply may be limited by the yield of reservoirs, well field capacity, aquifer characteristics, water quality, water rights, permits, contracts, regulatory restrictions, raw water delivery infrastructure or water treatment capacity.

Table ES- 3 shows the supplies available to water users by use type. The total amount of water currently available to users in Region F is less than 730,000 acre-feet per year in 2020 and less than 670,000 acre-feet per year by 2070.

Figure ES- 6
Water Availability by Source Type

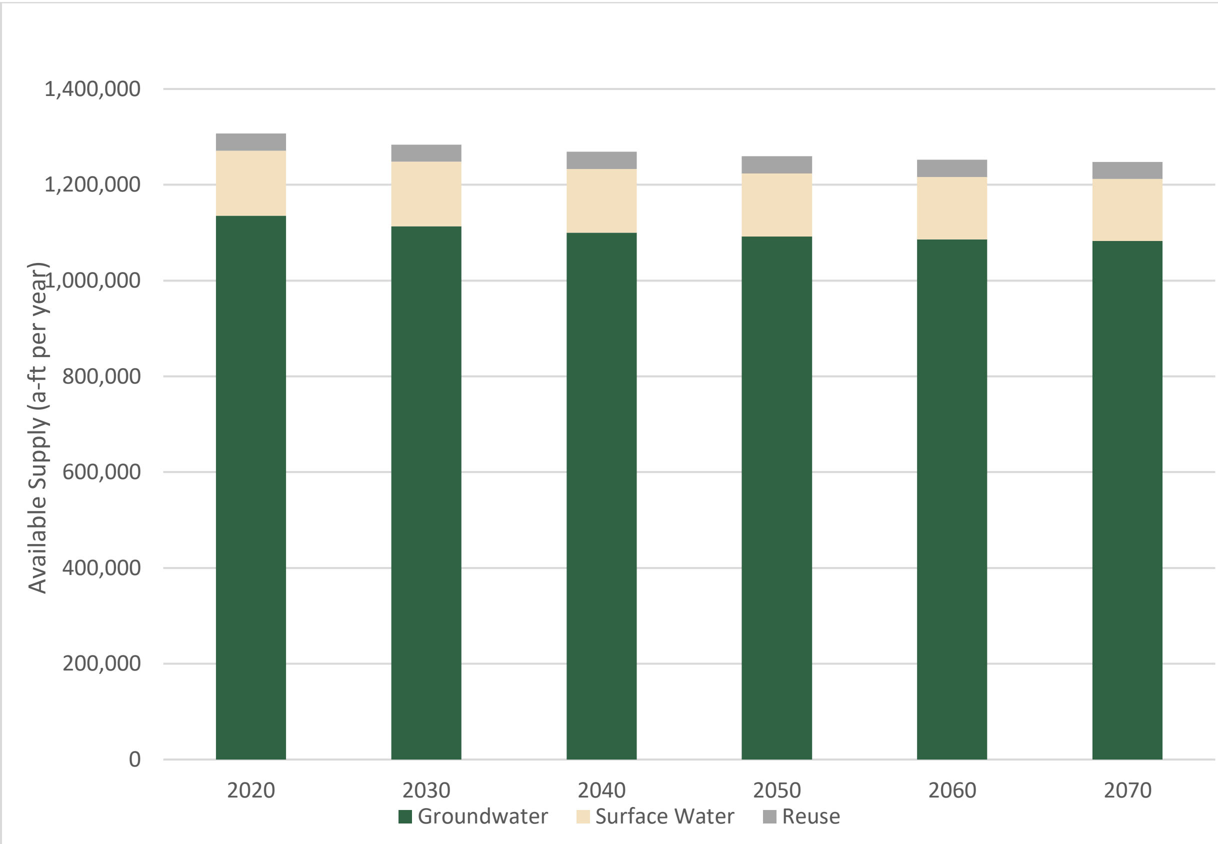


Table ES- 3
Existing Supplies by Use Type (acre-feet per year)

Existing Supplies	2020	2030	2040	2050	2060	2070
Irrigation	467,747	463,419	461,774	459,907	456,369	453,708
Manufacturing	11,705	12,603	12,549	12,111	11,080	10,897
Mining	89,083	89,809	76,117	60,694	50,724	45,852
Municipal	143,377	135,008	138,702	138,560	138,362	138,114
Steam Electric	5,298	5,428	5,428	5,292	5,169	5,053
Livestock	12,053	12,045	12,037	12,023	12,012	12,002
Region F Total	**729,263**	**718,312**	**706,607**	**688,587**	**673,716**	**665,626**

ES.3.4 Comparison of Supply and Demand

Figure ES- 7 illustrates a comparison of the available water supply to Region F and projected demands. Table ES- 4 shows the needs by water use type. With a projected 2070 demand of 744,366 acre-feet per year and declining water supplies, Region F has a projected regional shortage of nearly 103,00 acre-feet per year by 2070. Most of this need is associated with municipal water use, which some users rely heavily on surface water supplies. The subordination strategy that better reflects current operations in the Colorado River Basin will meet some of the municipal water need but not all of it.

Irrigation, mining, and steam electric power are the other use categories with needs greater than 10,000 acre-feet per year. Irrigation and mining needs are mainly due to limitations in groundwater availability; while the projected steam electric power needs are associated with demands that may no longer be needed due to changes in cooling processes or facilities that may not be constructed.

Figure ES- 7
Comparison of Supply and Demand (acre-feet per year)

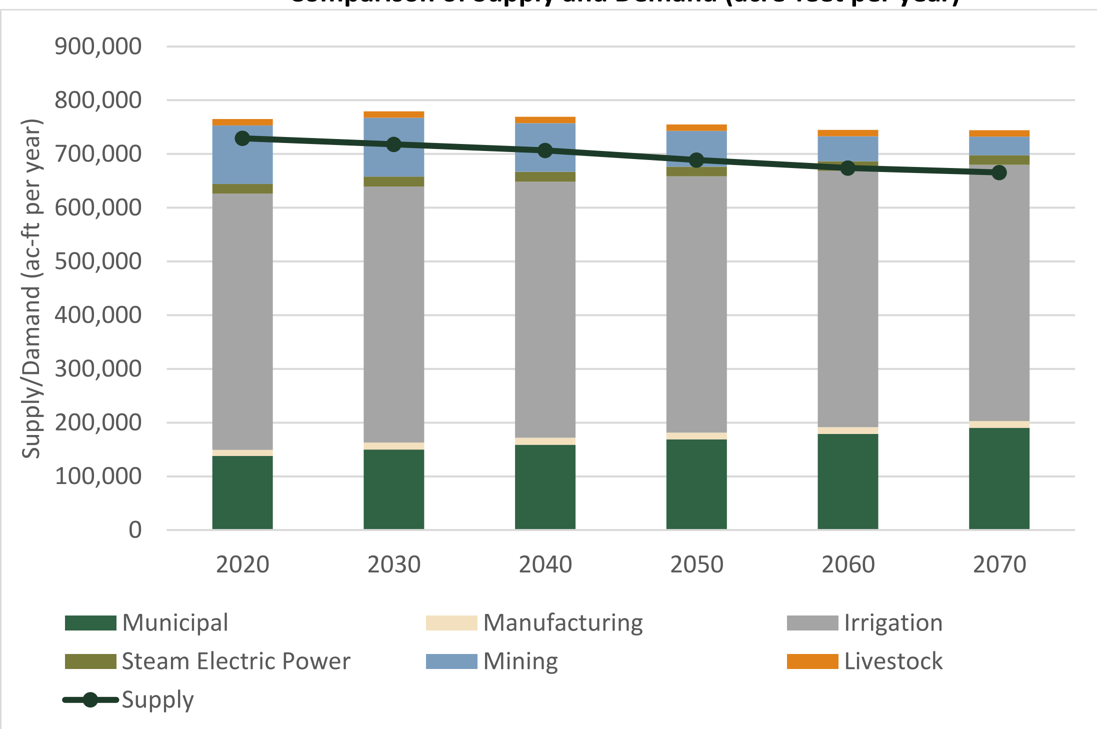


Table ES- 4
Needs by Use Type (acre-feet per year)

Need	2020	2030	2040	2050	2060	2070
Municipal	14,048	18,792	23,899	33,706	44,212	55,510
Manufacturing	951	1,065	1,108	1,327	1,527	1,710
Irrigation	13,529	17,957	19,544	21,240	24,585	27,060
Livestock	9	17	25	39	50	60
Mining	21,261	21,357	17,834	12,088	7,677	5,407
Steam Electric Power	12,794	12,678	12,678	12,800	12,923	13,039
Region F Total	**62,592**	**71,866**	**75,088**	**81,200**	**90,974**	**102,786**

ES.3.5 Socio-Economic Impact of Not Meeting Projected Water Needs

According to the comparison of supply and demand, Region F could face significant shortages in water supply over the planning period for some water users. To assess the potential socio-economic impacts of these shortages, the TWDB conducted an evaluation of failing to meet the projected water needs in Region F. The TWDB's analysis calculated the impacts of a severe drought occurring in a single year at each decadal period in Region F. The findings of this study are summarized below:

- With the projected shortages, the region's projected 2020 population would be reduced by approximately 2.6 percent.
- The region may experience 23 percent reduction in employment in 2020. The mining sector accounts for 96 percent of these jobs losses in 2020.
- The region's projected annual income in 2020 would be reduced by $19.6 billion, approximately 95 percent of which is within the mining industry. This represents nearly 40 percent of the region's current income.
- Economic impacts decline over time as the projected needs decrease.

ES.4 Identification and Selection of Water Management Strategies

The Region F Water Planning Group identified and evaluated a wide variety of potentially feasible water management strategies in developing this plan. Water supply availability, costs and environmental impacts were determined for conservation and reuse efforts, the connection of existing supplies, and the development of new supplies.

As required by the TWDB regulations, the evaluation of water management strategies was an equitable comparison of all feasible strategies and considered the following factors:

- Evaluation of quantity, reliability, and cost of water diverted and treated
- Environmental factors
- Impacts on other water resources and on threats to agricultural and natural resources
- Significant issues affecting feasibility
- Consideration of other water management strategies affected

ES.4.1 Water Conservation

The Region F Water Planning Group considered three major categories of water conservation: municipal, mining, and irrigation. Overall, it is estimated that nearly 66,000 acre-feet of water could be conserved annually by 2070 in Region F.

Municipal water conservation is recommended for all individual municipal water user groups and county-other groups that have a shortage. The total water savings from municipal conservation is estimated to be over 2,800 acre-feet per year in 2020 and is projected to grow to over 4,200 acre-feet per year by 2070. This reduces the projected municipal water needs by 11 and 6 percent, respectively, for those with needs. It also places less demand on limited water sources for municipal water users with enough supplies.

The recommended water conservation activities for municipal water users in Region F are:

- Education and outreach programs,
- Reduction of unaccounted for water through water audits and leak repair,
- Water rate structures that discourage water waste,
- Ordinances prohibiting the waste of water
- Landscape ordinances (for entities >20,000), and
- Time of day watering limits (for entities >20,000).

The two other conservation strategies, irrigation and mining conservation, provide approximately 28,400 acre-feet of water savings in 2020 and is projected to increase to 60,200 acre-feet by 2070. The irrigation conservation activities evaluated as part of this plan focus on efficient irrigation practices. Mining conservation focuses on the treatment and reuse of flowback water from fracking operations.

ES.4.2 Water Management Strategies

In addition to conservation, subordination of surface water in the Colorado River Basin and groundwater development are two of the major strategies in Region F. The subordination strategy, which was developed in conjunction with the Lower Colorado Region (Region K), reserves nearly 44,000 acre-feet of surface water for use in Region F in 2070. New groundwater development projects planned in Region F will provide approximately 19,000 acre-feet of additional reliable supply in 2020, increasing to nearly 64,000 acre-feet of supply in 2070. This strategy is recommended for both smaller users as well as major water providers.

Figure ES- 8 shows the supplies from water management strategies by type for 2020 and 2070.

Table ES- 5 lists recommended water management strategies for Region F. In total, the Region F plan includes recommended water management strategies to develop or preserve over 200,000 acre-feet per year of additional supplies by 2070, including new well fields, reuse, new or additional treatment, and voluntary redistribution. Alternative water management strategies are included in summary Table ES- 6.

Figure ES- 8
Distribution of Supplies from Recommended Water Management Strategies

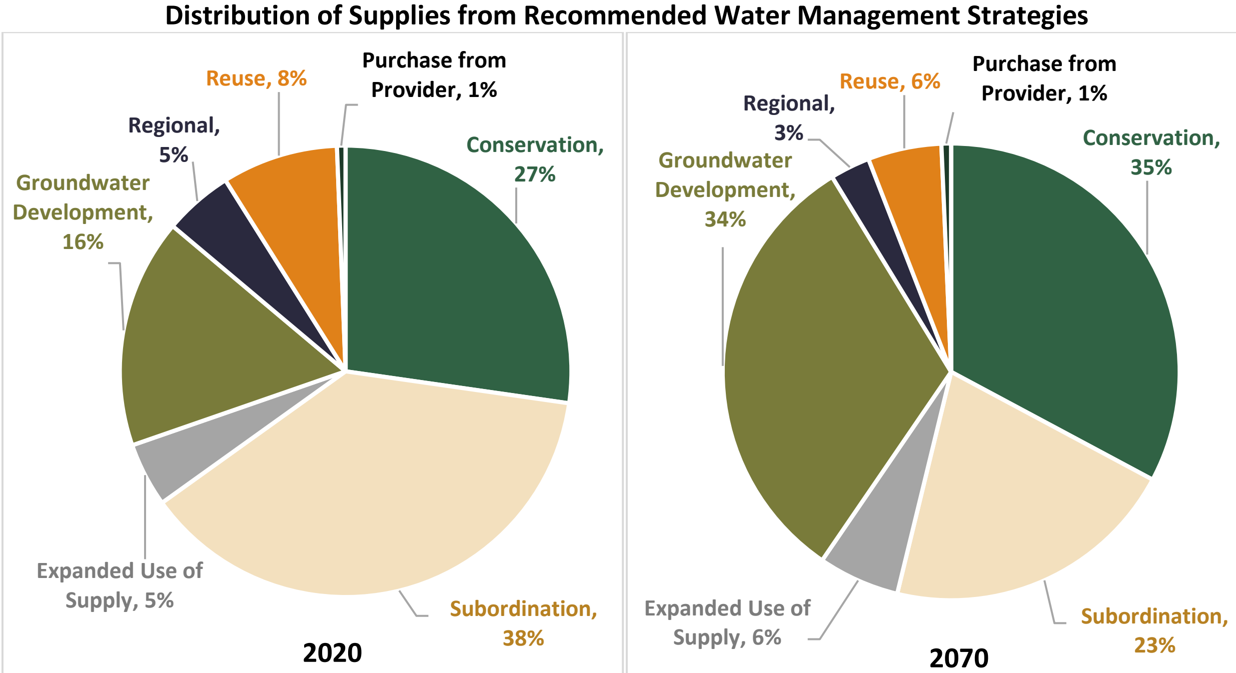


Table ES- 5
Recommended Water Management Strategies

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield 2020	2030	2040	2050	2060	2070	Last Decade Unit Cost ($/ac-ft/yr)
Brush Control											
BCWID	Multiple	2020	$0	$390	400	400	400	400	400	400	$390
San Angelo	Multiple	2020	$0	$489	60	60	60	60	60	60	$489
UCRA	Multiple	2020	$0	$850	90	90	90	90	90	90	$850
Develop Cross Timbers Aquifer Supplies											
Mining	Brown	2020	$2,440,000	$948	210	210	210	210	210	210	$129
Develop Edwards-Trinity Plateau Aquifer Supplies											
Junction	Kimble	2020	$3,634,000	$822	370	370	370	370	370	370	$130
Pecos County WCID #1	Pecos	2020	$3,630,000	$1,224	250	250	250	250	250	250	$204
Balmorhea	Reeves	2020	$1,948,000	$1,053	150	150	150	150	150	150	$140
Develop Ellenburger San Saba Aquifer Supplies											
Manufacturing	Kimble	2020	$1,621,000	$274	500	500	500	500	500	500	$46
Develop Hickory Aquifer Supplies											
San Angelo	Ector	2030	$55,491,000	$2,321	0	1,040	3,040	3,040	3,040	3,040	$1,037
Menard	Menard	2020	$3,287,000	$3,820	200	200	200	200	200	200	$160
Develop Other Aquifer Supplies											
Bronte	Coke	2020	$23,694,000	$2,424	800	800	800	800	800	800	$340
Manufacturing	Scurry	2020	$677,000	$356	160	160	160	160	160	160	$56
Develop Pecos Valley Aquifer Supplies											
CRMWD	Multiple	2050	$168,324,000	$849	0	0	0	22,400	22,400	22,400	$321
County-Other	Midland	2020	$24,557,000	$738	2,800	2,800	2,800	2,800	2,800	2,800	$121
Mining	Pecos	2020	$492,000	$164	3,000	3,000	3,000	3,000	3,000	3,000	$55
Mining	Reeves	2020	$17,465,000	$173	10,400	10,400	10,400	10,400	10,400	10,400	$54
Grandfalls	Ward	2050	$2,410,000	$1,245	0	0	0	155	155	155	$148
Dredging River Intake											
Junction	*Kimble*	*2020*	*$7,505,000*	*$2,112*	*250*	*250*	*250*	*250*	*250*	*250*	*$0*

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield						Last Decade Unit Cost ($/ac-ft/yr)
					2020	2030	2040	2050	2060	2070	
Groundwater Strategies											
CRMWD	Multiple	2030	$10,440,000	$102	0	755	2,650	6,295	8,361	10,343	$76
Pecos	Reeves	2020	$43,107,000	$427	0	8,960	8,960	8,960	8,960	8,960	$89
Sonora	Sutton	2020	$437,000	$1,000	35	35	35	35	35	35	$114
Irrigation Conservation											
Irrigation	Andrews	2020	$1,548,000	$21	1,018	2,037	2,037	2,037	2,037	2,037	$0
Irrigation	Borden	2020	$224,000	$21	147	295	295	295	295	295	$0
Irrigation	Brown	2020	$494,000	$21	406	650	650	650	650	650	$0
Irrigation	Coke	2020	$63,000	$21	34	69	83	83	83	83	$0
Irrigation	Coleman	2020	$35,000	$21	23	47	47	47	47	47	$0
Irrigation	Concho	2020	$410,000	$21	245	490	539	539	539	539	$0
Irrigation	Crockett	2020	$15,000	$21	7	14	20	20	20	20	$0
Irrigation	Ector	2020	$86,000	$21	38	76	113	113	113	113	$0
Irrigation	Glasscock	2020	$1,558,000	$21	2,050	2,050	2,050	2,050	2,050	2,050	$0
Irrigation	Howard	2020	$575,000	$21	344	688	757	757	757	757	$0
Irrigation	Irion	2020	$120,000	$21	53	105	158	158	158	158	$0
Irrigation	Kimble	2020	$242,000	$21	133	266	319	319	319	319	$0
Irrigation	Martin	2020	$4,160,000	$21	1,825	3,649	5,474	5,474	5,474	5,474	$0
Irrigation	Mason	2020	$566,000	$21	248	497	745	745	745	745	$0
Irrigation	McCulloch	2020	$265,000	$21	116	232	349	349	349	349	$0
Irrigation	Menard	2020	$418,000	$21	183	366	549	549	549	549	$0
Irrigation	Midland	2020	$2,064,000	$21	905	1,811	2,716	2,716	2,716	2,716	$0
Irrigation	Mitchell	2020	$194,000	$21	256	256	256	256	256	256	$0
Irrigation	Pecos	2020	$16,341,000	$21	7,167	14,335	21,502	21,502	21,502	21,502	$0
Irrigation	Reagan	2020	$2,512,000	$21	1,102	2,203	3,305	3,305	3,305	3,305	$0
Irrigation	Reeves	2020	$6,719,000	$21	2,947	5,894	8,841	8,841	8,841	8,841	$0
Irrigation	Runnels	2020	$283,000	$21	155	311	373	373	373	373	$0
Irrigation	Schleicher	2020	$83,000	$21	91	109	109	109	109	109	$0
Irrigation	Scurry	2020	$747,000	$21	378	756	983	983	983	983	$0
Irrigation	Sterling	2020	$102,000	$21	45	90	135	135	135	135	$0

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield						Last Decade Unit Cost ($/ac-ft/yr)
					2020	2030	2040	2050	2060	2070	
Irrigation	Sutton	2020	$128,000	$21	56	112	168	168	168	168	$0
Irrigation	Tom Green	2020	$3,875,000	$21	2,125	4,249	5,099	5,099	5,099	5,099	$0
Irrigation	Upton	2020	$1,186,000	$21	520	1,040	1,560	1,560	1,560	1,560	$0
Irrigation	Ward	2020	$360,000	$21	158	316	474	474	474	474	$0
Irrigation	Winkler	2020	$400,000	$21	175	351	526	526	526	526	$0
Mining Conservation (Recycling)											
Mining	Andrews	2020	$5,540,000	$632	277	260	222	176	135	104	$0
Mining	Borden	2020	$780,000	$1,117	29	39	33	21	10	5	$0
Mining	Brown	2020	$1,340,000	$654	66	66	67	67	66	66	$0
Mining	Coke	2020	$400,000	$632	20	20	18	16	14	12	$0
Mining	Coleman	2020	$100,000	$632	5	4	4	4	3	3	$0
Mining	Concho	2020	$400,000	$632	20	20	18	15	13	12	$0
Mining	Crane	2020	$720,000	$1,173	26	35	36	29	22	17	$0
Mining	Crockett	2020	$6,300,000	$632	315	315	43	24	7	3	$0
Mining	Ector	2020	$600,000	$733	28	30	27	22	18	15	$0
Mining	Glasscock	2020	$4,960,000	$632	248	248	189	134	88	63	$0
Mining	Howard	2020	$2,860,000	$632	143	143	101	59	25	13	$0
Mining	Irion	2020	$6,440,000	$632	322	322	231	28	14	7	$0
Mining	Kimble	2020	$20,000	$632	1	1	1	1	1	1	$0
Mining	Loving	2020	$10,500,000	$632	525	525	462	378	301	238	$0
Mining	Martin	2020	$6,040,000	$632	302	302	227	49	27	14	$0
Mining	Mason	2020	$860,000	$632	43	40	30	24	19	16	$0
Mining	McCulloch	2020	$7,500,000	$632	375	351	279	236	203	176	$0
Mining	Menard	2020	$920,000	$632	46	45	40	35	30	26	$0
Mining	Midland	2020	$8,900,000	$632	445	445	344	231	46	32	$0
Mining	Mitchell	2020	$620,000	$970	25	31	27	21	16	12	$0
Mining	Pecos	2020	$10,780,000	$632	539	539	539	434	67	52	$0
Mining	Reagan	2020	$8,900,000	$632	445	445	323	62	24	8	$0
Mining	Reeves	2020	$17,640,000	$632	882	882	847	693	546	434	$0
Mining	Runnels	2020	$220,000	$632	11	11	10	9	8	7	$0

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield						Last Decade Unit Cost ($/ac-ft/yr)
					2020	2030	2040	2050	2060	2070	
Mining	Schleicher	2020	$620,000	$903	26	31	24	16	10	6	$0
Mining	Scurry	2020	$680,000	$1,617	20	32	34	25	17	12	$0
Mining	Sterling	2020	$800,000	$931	33	40	34	22	11	6	$0
Mining	Sutton	2020	$640,000	$1,595	19	30	32	24	16	11	$0
Mining	Tom Green	2020	$980,000	$792	44	45	47	47	48	49	$0
Mining	Upton	2020	$2,020,000	$632	101	101	80	53	32	22	$0
Mining	Ward	2020	$1,600,000	$632	80	80	71	55	38	25	$0
Mining	Winkler	2020	$980,000	$1,315	33	49	42	32	22	16	$0
Municipal Conservation											
Airline Mobile Home Park	Midland	2020	$0	$1,263	7	7	8	9	10	10	$1,134
Andrews	Andrews	2020	$0	$952	45	55	96	111	129	150	$592
County-Other	Andrews	2020	$0	$1,080	14	15	17	18	20	21	$821
Ballinger	Runnels	2020	$0	$1,107	12	12	12	12	12	12	$1,101
Bangs	Brown	2020	$0	$1,221	8	8	8	8	8	8	$2,189
Balmorhea	Reeves	2020	$0	$2,472	2	2	2	2	2	2	$1,214
Barstow	Ward	2020	$0	$3,068	1	1	1	1	1	1	$2,731
Big Lake	Reagan	2020	$0	$1,139	10	12	12	13	13	14	$1,079
Big Spring	Howard	2020	$0	$557	131	138	140	139	139	139	$620
Brady	McCulloch	2020	$0	$988	18	18	19	19	19	19	$930
Bronte	Coke	2020	$0	$1,647	3	3	3	3	3	3	$1,647
Brookesmith SUD	Brown	2020	$0	$705	25	25	25	25	25	25	$688
Brownwood	Brown	2020	$0	$937	61	91	91	91	91	91	$735
Coahoma	Howard	2020	$0	$1,222	8	8	8	8	8	8	$1,203
Coleman	Coleman	2020	$0	$1,065	15	15	15	15	15	15	$1,061
County-Other	Coleman	2020	$0	$5,095	1	1	1	1	1	1	$1,138
Coleman County SUD	Coleman	2020	$0	$1,144	10	10	10	10	10	10	$5,161
Colorado City	Mitchell	2020	$0	$1,054	16	18	18	18	18	19	$938
Concho Rural WSC	Tom Green	2020	$0	$894	20	21	22	23	24	24	$1,821
County-Other	Concho	2020	$0	$1,836	3	3	3	3	3	3	$714

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield						Last Decade Unit Cost ($/ac-ft/yr)
					2020	2030	2040	2050	2060	2070	
Crockett County WCID	Crockett	2020	$0	$1,106	12	13	13	13	13	13	$1,070
Crane	Crane	2020	$0	$1,120	11	12	13	13	14	14	$1,083
DADS SLC	Tom Green	2020	$0	$4,116	1	1	1	1	1	1	$4,116
Early	Brown	2020	$0	$1,176	9	9	9	9	9	9	$1,170
Ector County Utility District	Ector	2020	$0	$292	60	84	94	125	137	149	$598
Eden	Concho	2020	$0	$1,541	4	4	4	4	4	4	$1,518
El Dorado	Schleicher	2020	$0	$1,283	6	6	6	6	6	6	$1,283
Fort Stockton	Pecos	2020	$0	$484	36	39	42	44	46	48	$363
Goodfellow AFB	Tom Green	2020	$0	$1,222	8	9	9	10	10	11	$1,123
Grandfalls	Ward	2020	$0	$2,804	1	1	1	1	2	2	$2,509
Greater Gardendale WSC	Ector	2020	$0	$1,108	12	13	15	17	19	20	$859
Greenwood Water	Midland	2020	$0	$1,716	3	3	4	4	4	5	$1,430
Iraan	Pecos	2020	$0	$1,501	4	4	5	5	5	5	$1,351
Junction	Kimble	2020	$0	$1,206	8	8	8	8	8	8	$1,203
Kermit	Winkler	2020	$0	$964	18	18	19	19	19	19	$916
Loraine	Mitchell	2020	$0	$2,138	2	2	2	2	2	2	$2,039
Madera Valley WSC	Reeves	2020	$0	$1,425	5	5	5	6	6	6	$1,330
Mason	Mason	2020	$0	$1,278	7	7	7	7	7	7	$1,278
McCamey	Upton	2020	$0	$1,264	7	7	8	8	8	8	$1,203
Menard	Menard	2020	$0	$1,442	5	5	5	5	5	5	$1,442
Mertzon	Irion	2020	$0	$1,886	3	3	3	3	3	3	$1,875
Midland	Midland	2020	$0	$436	631	755	816	882	944	1012	$428
Miles	Runnels	2020	$0	$1,730	3	3	3	3	3	3	$1,614
Mitchell County Utility	Mitchell	2020	$0	$1,407	5	5	5	5	5	6	$1,068
Millersview-Doole WSC	Tom Green	2020	$0	$1,088	13	14	14	14	14	15	$1,347
Monahans	Ward	2020	$0	$763	23	24	25	26	27	27	$645

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield						Last Decade Unit Cost ($/ac-ft/yr)
					2020	2030	2040	2050	2060	2070	
North Runnels WSC	Runnels	2020	$0	$1,407	5	5	5	5	5	5	$1,375
Odessa	Ector	2020	$0	$440	568	680	752	829	905	990	$427
Pecos	Reeves	2020	$0	$607	29	31	33	34	35	35	$498
Pecos WCID	Pecos	2020	$0	$1,166	9	10	11	11	12	12	$1,716
Pecos County Fresh Water	Pecos	2020	$0	$1,985	2	2	3	3	3	3	$1,099
Rankin	Upton	2020	$0	$1,848	3	3	3	3	3	3	$1,690
Richland SUD	McCulloch	2020	$0	$1,712	3	3	3	3	3	3	$1,665
Robert Lee	Coke	2020	$0	$1,672	3	3	3	3	3	3	$1,672
County-Other	Runnels	2020	$0	$1,953	2	2	2	2	2	2	$1,988
San Angelo	Tom Green	2020	$0	$448	459	532	558	592	629	668	$444
Snyder	Scurry	2020	$0	$957	41	47	51	55	59	93	$1,606
Santa Anna	Coleman	2020	$0	$1,623	3	4	4	4	4	4	$589
County-Other	Scurry	2020	$0	$863	20	22	24	26	28	30	$720
Sonora	Sutton	2020	$0	$1,187	9	9	9	10	10	10	$1,152
Southwest Sandhills WSC	Ward	2020	$0	$863	20	22	24	26	28	30	$589
Stanton	Martin	2020	$0	$1,199	8	9	10	10	11	11	$1,124
Sterling City	Sterling	2020	$0	$1,759	3	3	3	3	3	3	$1,718
Tom Green County FWSD 3	Tom Green	2020	$0	$1,616	3	4	4	4	5	5	$1,409
Wickett	Ward	2020	$0	$2,487	2	2	2	2	2	2	$2,240
Wink	Winkler	2020	$0	$1,665	3	4	4	4	4	5	$1,449
Winters	Runnels	2020	$0	$1,191	17	12	9	9	9	9	$1,183
Zephyr WSC	Brown	2020	$0	$1,091	13	13	13	13	13	13	$1,087
New or Additional Treatment											
Bronte	*Coke*	*2020*	*$10,270,000*	*$1,720*	*800*	*800*	*800*	*800*	*800*	*800*	*$816*
Odessa	*Ector*	*2020*	*$83,062,000*	*$1,111*	*15,700*	*15,700*	*15,700*	*15,700*	*15,700*	*15,700*	*$738*
Big Spring	*Howard*	*2020*	*$104,651,000*	*$1,128*	*830*	*0*	*0*	*878*	*1,671*	*2,420*	*$471*
Brady	McCulloch	2020	$29,719,000	$2,069	1,200	1,200	1,200	1,200	1,200	1,200	$327

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield 2020	2030	2040	2050	2060	2070	Last Decade Unit Cost ($/ac-ft/yr)
Mason	Mason	2020	$2,605,000	$856	700	700	700	700	700	700	$594
Midland	Multiple	2040	$60,804,000	$1,656			5,899	6,101	6,235	6,327	$998
Pecos	Reeves	2030	$27,680,000	$754	3,360	3,360	3,360	3,360	3,360	3,360	$319
Rehabilitation/Replacement of Pipeline											
Bronte	*Coke*	*2020*	*$9,896,000*	*$1,748*	*450*	*450*	*450*	*450*	*450*	*450*	*$202*
Pecos County WCID #1	*Pecos*	*2020*	*$26,102,000*	*$2,767*	*750*	*750*	*750*	*750*	*750*	*750*	*$317*
Reuse											
Bangs	Brown	2020	$581,000	$1,816	25	25	25	25	25	25	$176
Menard	Menard	2020	$696,500	$820	67	67	67	67	67	67	$88
Steam Electric Power	Mitchell	2020	$8,642,000	$1,428	500	500	500	500	500	500	$212
San Angelo	Multiple	2020	$116,861,000	$1,250	8,400	8,400	8,400	8,400	8,400	8,400	$269
Pecos	Reeves	2030	$29,541,000	$4,961		925	925	925	925	925	$2,443
Pecos	Reeves	2020	$8,707,000	$1,286	560	560	560	560	560	560	$191
Subordination											
Ballinger	Runnels	2020	$0	$0	794	751	750	748	753	791	$0
County-Other	Runnels	2020	$0	$0	23	21	19	18	18	19	$0
North Runnels WSC	Runnels	2020	$0	$0	86	86	87	87	87	89	$0
Brady	McCulloch	2020	$0	$0	841	841	841	841	841	841	$0
Steam Electric Power	Mitchell	2020	$0	$0	1,170	1,156	1,142	1,128	1,114	1,100	$0
Junction	Kimble	2020	$0	$0	250	250	250	250	250	250	$0
Manufacturing	Kimble	2020	$0	$0	228	228	228	228	228	228	$0
Abilene	Taylor, Jones	2020	$0	$0	329	359	391	421	453	483	$0
Midland	Midland	2020	$0	$0	2,173	359	391	421	453	483	$0
Millersview-Doole WSC	Tom Green	2020	$0	$0	52	0	0	0	9	62	$0
Odessa	Ector	2020	$0	$0	2,451	0	0	3,492	7,263	11,493	$0
Ector County Utility District	Ector	2020	$0	$0	234	0	0	332	694	1,097	$0
Irrigation	Ector	2020	$0	$0	157	0	0	162	312	449	$0

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield						Last Decade Unit Cost ($/ac-ft/yr)
					2020	2030	2040	2050	2060	2070	
Irrigation	Midland	2020	$0	$0	3	0	0	2	6	8	$0
Manufacturing	Ector	2020	$0	$0	186	0	0	199	381	551	$0
Steam Electric Power	Ector	2020	$0	$0	109	0	0	114	219	316	$0
Big Spring	Howard	2020	$0	$0	611	0	0	647	1,233	1,785	$0
Coahoma	Howard	2020	$0	$0	51	0	0	56	105	152	$0
Manufacturing	Howard	2020	$0	$0	147	0	0	153	293	424	$0
Steam Electric Power	Howard	2020	$0	$0	21	0	0	22	40	59	$0
Snyder	Scurry	2020	$0	$0	194	0	0	256	524	814	$0
County-Other	Scurry	2020	$0	$0	29	0	0	31	59	85	$0
Rotan	Fisher	2020	$0	$0	18	0	0	17	32	46	$0
Stanton	Martin	2020	$0	$0	31	0	0	33	62	90	$0
Irrigation	Coleman	2020	$0	$0	400	400	400	400	400	400	$0
Coleman	Coleman	2020	$0	$0	1,319	1,296	1,276	1,255	1,227	1,200	$0
Coleman County SUD	Coleman	2020	$0	$0	227	225	218	214	215	215	$0
County-Other	Coleman	2020	$0	$0	24	22	22	21	21	21	$0
Manufacturing	Coleman	2020	$0	$0	2	2	2	2	2	2	$0
County-Other	Tom Green	2020	$0	$0	70	70	70	70	70	70	$0
Bronte	Coke	2020	$0	$0	212	210	209	207	207	207	$0
Robert Lee	Coke	2020	$0	$0	237	239	240	240	240	240	$0
San Angelo	Tom Green	2020	$0	$0	1,875	1,819	1,766	1,709	1,656	1,600	$0
Upper Colorado River Authority	Tom Green	2020	$0	$0	42	37	33	30	26	23	$0
Goodfellow Air Force Base	Tom Green	2020	$0	$0	44	42	40	38	35	33	$0
Manufacturing	Tom Green	2020	$0	$0	37	36	32	29	26	22	$0
Winters	Runnels	2020	$0	$0	100	99	98	98	98	97	$0
Brady Creek (non-allocated)	McCulloch	2020	$0	$0	1,109	1,069	1,029	989	949	909	$0
BCWID (non-allocated)	Brown	2020	$0	$0	5,440	5,466	5,492	5,518	5,544	5,570	$0

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield 2020	2030	2040	2050	2060	2070	Last Decade Unit Cost ($/ac-ft/yr)
CRMWD (non-allocated)	Tom Green	2020	$0	$0	15,819	19,911	18,533	13,002	7,245	972	$0
Oak Creek (non-allocated)	Coke	2020	$0	$0	577	540	503	468	431	394	$0
Lake Colorado City (non-allocated)	Mitchell	2020	$0	$0	1,800	1,750	1,700	1,650	1,600	1,550	$0
Odessa (Future Sales)	Ector, Midland	2020	$0	$0	3,930	3,930	3,930	3,930	3,930	3,930	$0
Manufacturing, Howard (Future Sales)	Howard	2030	$0	$0	0	500	500	500	500	500	$0
Greater Gardendale WSC (Future Sales)	Ector	2030	$0	$0	0	375	445	445	445	445	$0
County-Other (Future Sales)	Ector	2030	$0	$0	0	1,200	2,500	2,500	2,500	2,500	$0
County-Other (Future Sales)	Scurry	2020	$0	$0	373	414	447	491	547	607	$0
Voluntary Transfer (Purchase)											
Robert Lee	Coke	2020	$0	$0	80	80	80	80	80	80	$0
Concho Rural WSC	Ector	2020	$0	$0	50	50	50	50	50	50	$0
Greater Gardendale WSC	Ector	2020	$6,078,000	$3,730	0	375	445	445	445	445	$2,769
Winters	Runnels	2020	$974,000	$668	220	220	220	220	220	220	$355
County-Other	Scurry	2020	$0	$0	373	414	447	491	547	607	$0
Water Audits and Leak Repairs											
Brookesmith SUD	Brown	2020	$1,737,000	$1,509	81	81	79	78	78	78	$1,584
Coleman	Coleman	2020	$1,074,800	$1,282	59	58	57	57	57	57	$1,340
Millersview-Doole WSC	Tom Green	2020	$965,800	$1,045	65	66	65	66	67	68	$1,076
Sonora	Sutton	2020	$679,900	$451	106	112	114	116	117	118	$438
Zephyr WSC	Brown	2020	$944,700	$3,498	19	19	18	18	18	18	$3,732

Entity	County Used	Expected Online	Capital Cost	First Decade Unit Cost ($/ac-ft/yr)	Total Yield 2020	2030	2040	2050	2060	2070	Last Decade Unit Cost ($/ac-ft/yr)
Weather Modification											
Irrigation	Crocket	2020	$0	$0.47	1	1	1	1	1	1	$0.47
Irrigation	Irion	2020	$0	$0.21	202	202	202	202	202	202	$0.21
Irrigation	Pecos	2020	$0	$5.45	106	106	106	106	106	106	$5.45
Irrigation	Reagan	2020	$0	$0.19	1,869	1,869	1,869	1,869	1,869	1,869	$0.19
Irrigation	Reeves	2020	$0	$1.13	326	326	326	326	326	326	$1.13
Irrigation	Schleicher	2020	$0	$0.23	275	275	275	275	275	275	$0.23
Irrigation	Sterling	2020	$0	$0.39	48	48	48	48	48	48	$0.39
Irrigation	Sutton	2020	$0	$0.45	34	34	34	34	34	34	$0.45
Irrigation	Tom Green	2020	$0	$0.44	2,007	2,007	2,007	2,007	2,007	2,007	$0.44
Irrigation	Ward	2020	$0	$0.57	259	259	259	259	259	259	$0.57

Note: Grey italics indicates projects that are needed to access supplies from other strategies and are not included in the total to avoid double counting.

Table ES- 6
Alternative Water Management Strategies

Entity	County Used	Capital Cost	First Decade Unit Cost ($ per ac-ft per yr)	Total Yield						Last Decade Unit Cost ($ per ac-ft/per yr)
				2020	2030	2040	2050	2060	2070	
Desalination										
San Angelo	*Tom Green*	*$70,709,000*	*$1,062*	*11,210*	*11,210*	*11,210*	*11,210*	*11,210*	*11,210*	*$615*
Develop Capitan Reef Complex Aquifer Supplies										
Odessa	Ector	$154,165,000	$2,168	8,400	8,400	8,400	8,400	8,400	8,400	$884
Develop Dockum Aquifer Supplies										
Colorado City	Mitchell	$3,744,000	$1,824	170	170	170	170	170	170	$276
Develop Edwards-Trinity Plateau Aquifer Supplies										
Andrews	Andrews	$24,927,000	$891	2,600	2,600	2,600	2,600	2,600	2,600	$217
County-Other	Andrews	$751,000	$252	250	250	250	250	250	250	$40
Livestock	Andrews	$327,000	$433	60	60	60	60	60	60	$50
Manufacturing	Andrews	$349,000	$243	210	210	210	210	210	210	$43
Robert Lee	Coke	$4,154,000	$4,293	75	75	75	75	75	75	$400
Robert Lee	Coke	$7,272,000	$3,756	75	75	75	75	75	75	$556
San Angelo	Tom Green	$102,100,000	$1,800	4,500	4,500	4,500	4,500	4,500	4,500	$209
Develop Ellenburger-San Saba Aquifer Supplies										
BCWID #1	Brown	$13,947,000	$12,553	806	806	806	806	806	806	$1,336
Develop Ogallala Aquifer Supplies										
Andrews	Andrews	$15,663,000	$496	2,810	2,810	2,810	2,810	2,810	2,810	$104
Great Plains	Andrews, Gaines	$676,000	$190	200	200	200	200	200	200	$55
Develop Other Aquifer Supplies										
Bronte	Coke	$2,666,000	$2,787	75	75	75	75	75	75	$280
Develop Additional Groundwater Supplies										
CRMWD	Western Region F Counties	$147,558,000	$1,348	10,000	10,000	10,000	10,000	10,000	10,000	$310
Odessa	Ector	$826,808,000	$3,249	28,000	28,000	28,000	28,000	28,000	28,000	$1,172
San Angelo	Tom Green	$327,576,000	$2,604	10,800	10,800	10,800	10,800	10,800	10,800	$470
New or Additional Water Treatment										

Entity	County Used	Capital Cost	First Decade Unit Cost ($ per ac-ft per yr)	Total Yield						Last Decade Unit Cost ($ per ac-ft/per yr)
				2020	2030	2040	2050	2060	2070	
Robert Lee	Coke	$6,541,000	$2,657	335	335	335	335	335	335	$1,284
Potable Reuse with Aquifer Storage and Recovery										
Pecos	Reeves	$34,456,000	$6,790	0	695	695	695	695	695	$3,301
Regional Water Management Strategies										
Bronte, Ballinger, Winters, Robert Lee (Lake Brownwood)	Coke, Runnels	$115,443,000	$3,904	2,802	2,802	2,802	2,802	2,802	2,802	$1,005
Bronte, Ballinger, Winters, Robert Lee (Lake Fort Phantom Hill)	Coke, Runnels	$103,328,000	$7,606	1,155	1,155	1,155	1,155	1,155	1,155	$1,312
Voluntary Transfer (Purchase)										
Greater Gardendale WSC	Ector	$2,946,000	$2,355	0	375	445	445	445	445	$1,890
Midland	Midland	$0	$0	4000	4000	4000	4000	4000	4000	$0
Grandfalls	Ector	$0	$0	0	0	0	155	155	155	$0

Note: Grey italics indicates projects that are needed to access supplies from other strategies and are not included in the total to avoid double counting.

ES.4.3 Unmet Needs

No sources were over allocated as a part of this plan. The source balance report that demonstrates this is included in Appendix I.

Despite the best efforts to meet all projected water needs, there are several unmet needs in Region F. Most of these unmet needs are due to limitations of groundwater availability supplies and the lack of cost-effective alternative sources of water, especially in Andrews, Loving, and Scurry Counties. For Andrews County, which does not have a GCD to manage groundwater, water users intend to meet their needs with groundwater. Some irrigation needs may be met in non-drought years or producers will implement changes, such as drought tolerant crops or dryland farming. Unmet water needs for Region F are summarized in Table ES-7.

Table ES- 7
Unmet Needs Summary (acre-feet per year)

Water User	2020	2030	2040	2050	2060	2070
Municipal	163	519	819	1,457	2,192	3,068
Manufacturing	31	59	87	134	174	209
Livestock	9	17	25	39	50	60
Irrigation	10,686	13,151	16,733	18,660	22,157	24,739
Mining	5,956	6,052	3,219	1,717	895	894
Steam Electric Power	11,008	11,022	11,036	11,050	11,064	11,078
Total	**27,853**	**30,820**	**31,919**	**33,057**	**36,532**	**40,048**

1 DESCRIPTION OF THE REGION

In 1997, the 75th Texas Legislature passed Senate Bill One (SB1), legislation designed to address Texas water issues. With the passage of SB1, the legislature put in place a grass-roots regional planning process to plan for the future water needs of all Texans. To implement this planning process, the Texas Water Development Board (TWDB) created 16 regional water planning areas across the state and established regulations governing regional planning efforts. The first 16 Regional Water Plans developed as part of the SB1 planning process were submitted to the TWDB in 2001. The TWDB combined these regional plans into one statewide plan. SB1 calls for these plans to be updated every five years. Since 2001, the regional water plans have been updated three times, in 2006, 2011, and 2016, and then consolidated into the state water plans, Water for Texas 2007, 2012, and 2017, respectively.

The TWDB refers to the current round of regional planning as SB1, Fifth Round. This report is the update to the 2016 Region F Water Plan and will become part of the basis for the next state water plan.

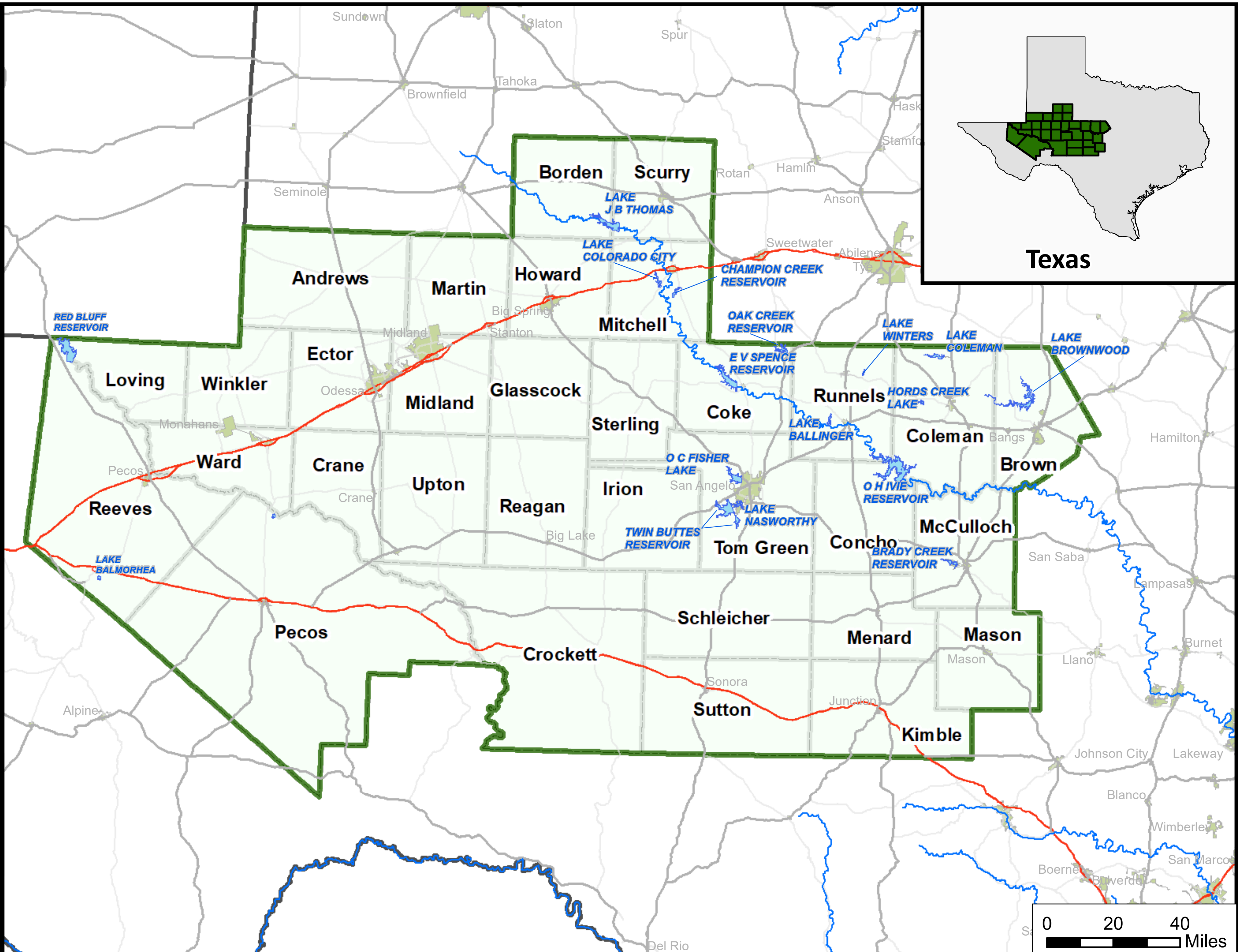
This chapter presents a description of Region F, one of the 16 regions created to implement SB1. Figure 1-1 is a map of Region F, which includes 32 counties in West Texas. The data presented in this regional water plan is a compilation of information from previous planning reports, on-going planning efforts and new data. A list of references is found at the end of each chapter.

1.1 INTRODUCTION TO REGION F

Region F includes all of Borden, Scurry, Andrews, Martin, Howard, Mitchell, Loving, Winkler, Ector, Midland, Glasscock, Sterling, Coke, Runnels, Coleman, Brown, Reeves, Ward, Crane, Upton, Reagan, Irion, Tom Green, Concho, McCulloch, Pecos, Crockett, Schleicher, Menard, Sutton, Kimble and Mason Counties. Table 1-1 shows historical populations for these counties from 1900 through 2010 and estimated populations for 2017[1].

Region F at a Glance:

- 32 Counties
- Mostly rural
- Major cities include Midland, Odessa, and San Angelo
- Heart of Permian Basin development of oil & gas
- Major economic drivers include agriculture, oil & gas, and service industries
- 76 % of total regional water use came from groundwater in 2016
- 49 % of municipal water supply is from surface water
- 17 major reservoirs in Region F
- 14 named aquifers
- Wide range of climate variability across region
- Area is subject to frequent droughts



Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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Regional Water Planning Area

Region F

FN JOB NO	FILE	DATE	SCALE	DESIGNED	DRAFTED
CMD17216	Figure 1-1.mxd	APRIL 2019	1:2,500,000	JLA	JJS

FIGURE 1-1

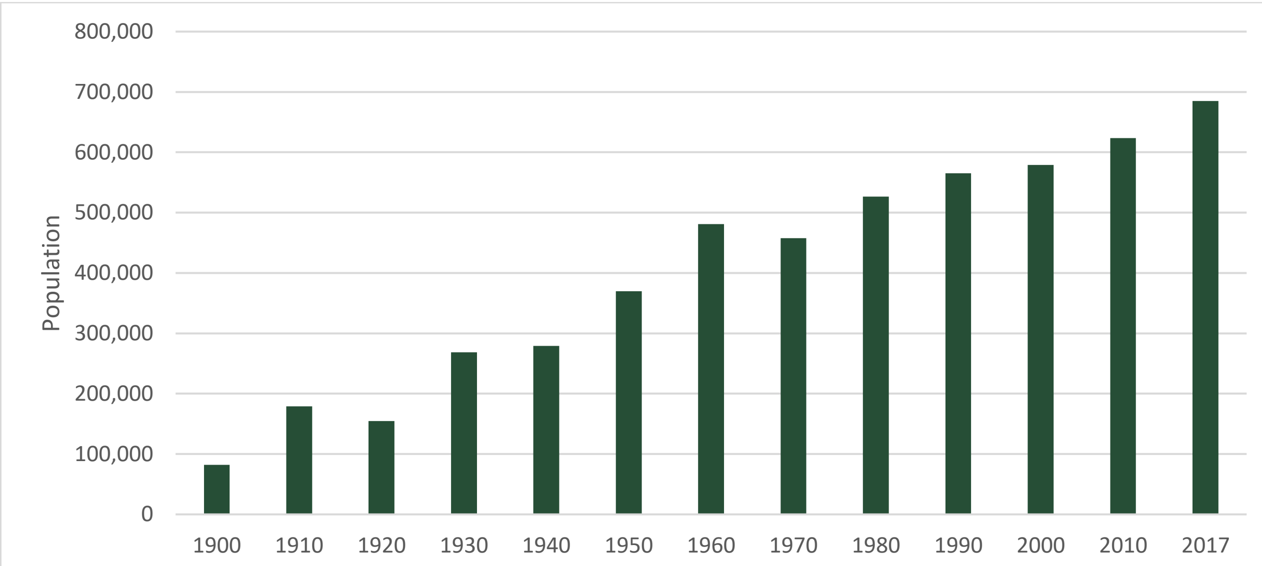
Table 1-1
Historical Population of Region F Counties[a]

County	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2017
Andrews	87	975	350	736	1,277	5,002	13,450	10,372	13,323	14,338	13,004	14,786	17,631
Borden	776	1,386	965	1,505	1,396	1,106	1,076	888	859	799	729	641	670
Brown	16,019	22,935	21,682	26,382	25,924	28,607	24,728	25,877	33,057	34,371	37,674	38,106	37,870
Coke	3,430	6,412	4,557	5,253	4,590	4,045	3,589	3,087	3,196	3,424	3,864	3,320	3,303
Coleman	10,077	22,618	18,805	23,669	20,571	15,503	12,458	10,288	10,439	9,710	9,235	8,895	8,415
Concho	1,427	6,654	5,847	7,645	6,192	5,078	3,672	2,937	2,915	3,044	3,966	4,087	4,311
Crane	51	331	37	2,221	2,841	3,965	4,699	4,172	4,600	4,652	3,996	4,375	4,713
Crockett	1,591	1,296	1,500	2,590	2,809	3,981	4,209	3,885	4,608	4,078	4,099	3,719	3,555
Ector	381	1,178	760	3,958	15,051	42,102	90,995	91,805	115,374	118,934	121,123	137,130	157,173
Glasscock	286	1,143	555	1,263	1,193	1,089	1,118	1,155	1,304	1,447	1,406	1,226	1,360
Howard	2,528	8,881	6,962	22,888	20,990	26,722	40,139	37,796	33,142	32,343	33,627	35,012	36,198
Irion	848	1,283	1,610	2,049	1,963	1,590	1,183	1,070	1,386	1,629	1,771	1,599	1,511
Kimble	2,503	3,261	3,581	4,119	5,064	4,619	3,943	3,904	4,063	4,122	4,468	4,607	4,406
Loving	33	249	82	195	285	227	226	164	91	107	67	82	136
Martin	332	1,549	1,146	5,785	5,556	5,541	5,068	4,774	4,684	4,956	4,746	4,799	5,562
Mason	5,573	5,683	4,824	5,511	5,378	4,945	3,780	3,356	3,683	3,423	3,738	4,012	4,203
McCulloch	3,960	13,405	11,020	13,883	13,208	11,701	8,815	8,571	8,735	8,778	8,205	8,283	7,960
Menard	2,011	2,707	3,162	4,447	4,521	4,175	2,964	2,646	2,346	2,252	2,360	2,242	2,121
Midland	1,741	3,464	2,449	8,005	11,721	25,785	67,717	65,433	82,636	106,611	116,009	136,872	165,386
Mitchell	2,855	8,956	7,527	14,183	12,477	14,357	11,255	9,073	9,088	8,016	9,698	9,403	8,232
Pecos [c]	2,360	2,071	3,857	7,812	8,185	9,939	11,957	13,748	14,618	14,675	16,809	15,507	15,618
Reagan [b]		392	377	3,026	1,997	3,127	3,782	3,239	4,135	4,514	3,326	3,367	3,700
Reeves	1,847	4,392	4,457	6,407	8,006	11,745	17,644	16,526	15,801	15,852	13,137	13,783	15,295
Runnels	5,379	20,858	17,074	21,821	18,903	16,771	15,016	12,108	11,872	11,294	11,495	10,501	10,333
Schleicher	515	1,893	1,851	3,166	3,083	2,852	2,791	2,277	2,820	2,990	2,935	3,461	2,995
Scurry	4,158	10,924	9,003	12,188	11,545	22,779	20,369	15,760	18,192	18,634	16,361	16,921	17,004
Sterling	1,127	1,493	1,053	1,431	1,404	1,282	1,177	1,056	1,206	1,438	1,393	1,143	1,301
Sutton	1,727	1,569	1,598	2,807	3,977	3,746	3,738	3,175	5,130	4,135	4,077	4,128	3,798
Tom Green [b]	6,804	17,882	15,210	36,033	39,302	58,929	64,630	71,047	84,784	98,458	104,010	110,224	117,689
Upton	48	501	253	5,968	4,297	5,307	6,239	4,697	4,619	4,447	3,404	3,355	3,661
Ward	1,451	2,389	2,615	4,599	9,575	13,346	14,917	13,019	13,976	13,115	10,909	10,658	11,423
Winkler	60	442	81	6,784	6,141	10,064	13,652	9,640	9,944	8,626	7,173	7,110	7,574
Region F Total	***81,985***	***179,172***	***154,850***	***268,329***	***279,422***	***370,027***	***480,996***	***457,545***	***526,626***	***565,212***	***578,814***	***623,354***	***685,107***
% Change		*119%*	*-14%*	*73%*	*4%*	*32%*	*30%*	*-5%*	*15%*	*7%*	*2%*	*6%*	*10%*

Notes:
a. Historical and estimated population data are from the U.S. Census Bureau[1]
b. Reagan County was formed from part of Tom Green County in 1903
c. Terrell County was formed from part of Pecos County in 1905.

Figure 1-2 shows graphically the total population of the region. The population of Region F has increased from 81,985 in 1900 to 623,354 in 2010. Since the 2010 census, it is estimated that the population of Region F increased to 683,918 in the year 2017.

Figure 1-2
Historical Population of Region F

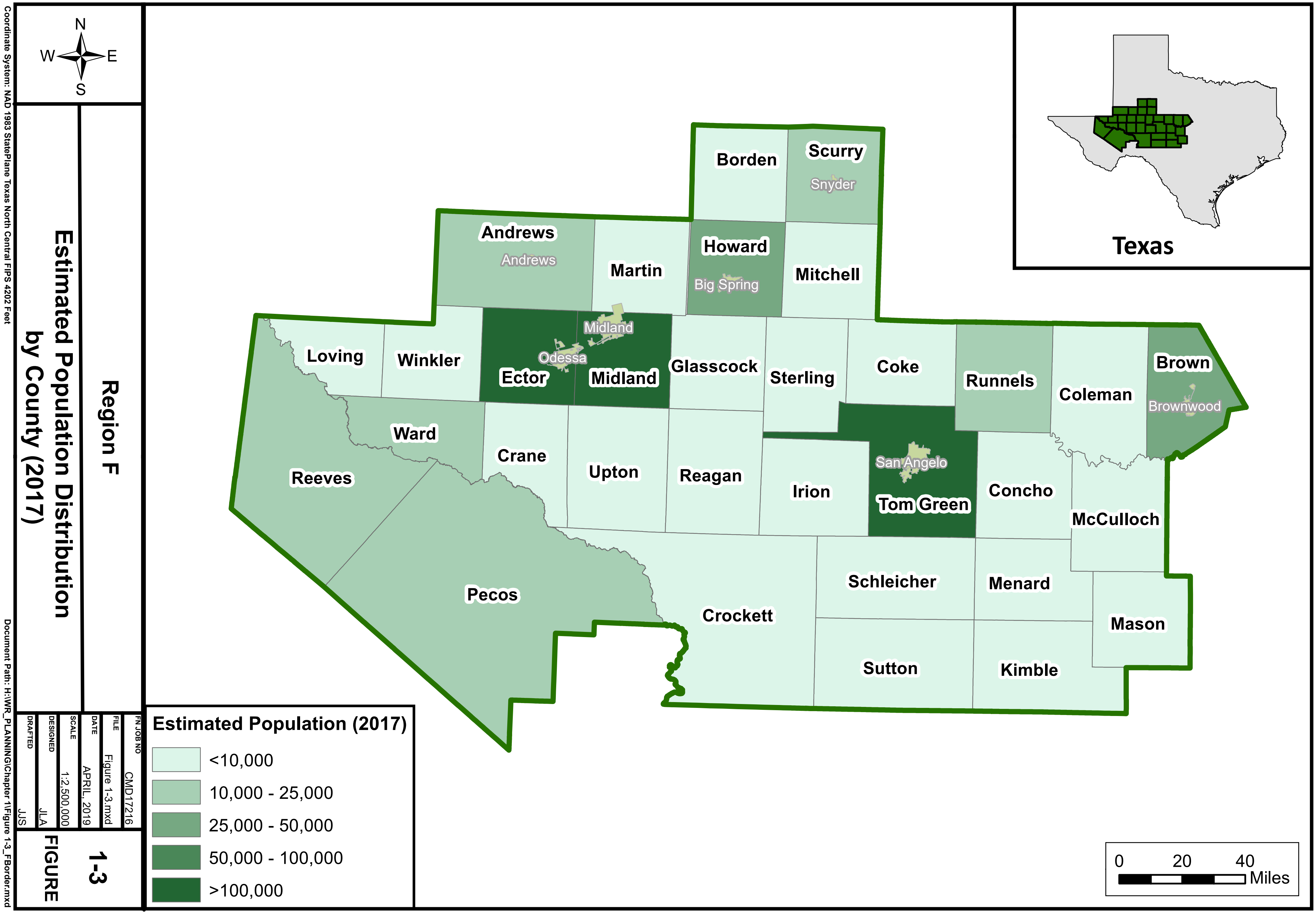


According to 2017 population estimates by the U.S. Census Bureau, Region F accounted for 2.5 percent of Texas' total population. Figure 1-3 shows the distribution of population in Region F counties based on the census data. Ector, Midland, and Tom Green were the three most populous counties in Region F, accounting for 65 percent of the region's population. Brown and Howard Counties were the next most populous counties with more than 35,000 people in each. Table 1-2 lists the seven cities in Region F with a 2017 population of more than 10,000, which encompass over 60 percent of the population in Region F.

Table 1-2
Region F Cities with a Year 2017 Population Greater than 10,000

City	Year 2017 Population
Midland	136,089
Odessa	116,861
San Angelo	100,119
Big Spring	27,905
Brownwood	18,831
Andrews	13,472
Snyder	11,320
Total	***424,597***

Data are from the 2017 US Census Bureau Estimates[1].


Estimated Population Distribution by County (2017)
Region F
FIGURE 1-3
N
W
E
S
Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet
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Texas
Borden
Scurry
Snyder
Andrews
Andrews
Martin
Howard
Big Spring
Mitchell
Loving
Winkler
Midland
Odessa
Ector
Midland
Glasscock
Sterling
Coke
Runnels
Coleman
Brown
Brownwood
Ward
Crane
Upton
Reagan
Irion
San Angelo
Tom Green
Concho
McCulloch
Reeves
Pecos
Crockett
Schleicher
Menard
Mason
Sutton
Kimble
Estimated Population (2017)
<10,000
10,000 - 25,000
25,000 - 50,000
50,000 - 100,000
>100,000
0
20
40
Miles

1.1.1 Economic Activity in Region F

Region F includes the Midland, Odessa, and San Angelo Metropolitan Statistical Areas (MSAs). The largest employment sectors in both the Midland and Odessa MSAs are the oil and gas industry, retail trade, and healthcare services[2]. Educational services, construction, and leisure and hospitality are also important employment sectors in these areas. In the San Angelo MSA the largest employment sectors are health services and retail trade, followed by educational services and leisure and hospitality.

Table 1-3 summarizes 2017 payroll data for Region F by county and economic sector[3]. Figure 1-4 shows the geographic distribution of total payroll in Region F. This figure shows that Ector, Midland and Tom Green Counties are the primary centers of economic activity in the region. These three counties account for 75 percent of the payroll and 70 percent of the employment in the region. Other major centers of economic activity are located in Brown and Howard Counties. The largest private business sectors in Region F in terms of payroll in 2017 are natural resources and mining, trade, transportation, and utilities, and professional and business services, which together account for 54 percent of the region's total payroll.

Over the past decade, the oil and gas industry has been growing rapidly in the Permian Basin, particularly over the last decade (see Section 1.4.3). Since 2007, the payroll for mining and natural resources has more than doubled from $2.0 billion to nearly $4.5 billion in 2017 in Region F[3]. In 2017, Region F counties accounted for nearly 15% of the total state payroll for natural resources and mining. This increase in production has led to increased population for many cities within the region and subsequently, increased water use. The Permian Basin underlies most of Region F, as shown in Figure 1-5.

Table 1-3
2017 County Payroll by Category ($1000)

Category	Andrews	Borden	Brown	Coke	Coleman	Concho	Crane	Crockett	Ector	Glasscock	Howard
Federal Government	728	31	6,956	494	1,480	598	244	225	10,916	273	68,034
State Government	1,567	315	41,237	608	1,171	781	475	1,655	82,367	0	27,087
Local Government	62,513	3,302	69,285	8,214	17,405	7,897	16,643	11,883	415,653	0	75,367
Private Industry, Total	376,534	3,545	465,699	14,019	45,703	19,929	47,626	47,733	3,481,114	18,135	453,729
Goods-Producing	212,224	1,286	215,066	3,559	8,872	2,424	24,907	21,846	1,646,308	12,941	198,156
Natural Resources and Mining	137,546	0	8,891	0	1,915	1,208	23,107	19,070	890,468	12,283	81,477
Construction	61,389	0	25,163	1,470	3,620	0	0	0	458,391	0	36,786
Manufacturing	13,289	0	181,012	0	3,337	0	0	0	297,449	0	79,892
Service Providing	164,310	2,259	250,633	10,460	36,831	17,506	22,719	25,887	1,834,806	5,194	255,573
Trade, Transportation, and Utilities	84,582	933	85,648	2,275	10,852	2,757	14,712	10,630	842,451	4,048	99,332
Information	5,098	0	5,606	0	0	0	0	0	21,396	0	4,726
Financial Activities	22,205	0	18,655	1,072	7,103	1,977	3,222	7,364	205,127	0	19,081
Professional and Business Services	26,144	998	20,439	5,523	1,795	0	1,852	1,675	228,501	0	22,201
Education and Health Services	5,411	0	93,147	554	11,208	4,386	1,900	0	251,741	0	75,277
Leisure and Hospitality	11,551	0	19,583	255	3,147	1,268	610	3,314	161,257	0	21,999
Other Services	9,044	239	7,205	0	1,124	261	0	2,289	123,357	0	12,755
Unclassified	274	0	349	0	0	0	0	0	976	7	202
Total Payroll	***441,341***	***7,193***	***583,178***	***23,334***	***65,759***	***29,206***	***64,987***	***61,495***	***3,990,051***	***23,412***	***624,217***
Total Employees	***7,187***	***194***	***15,851***	***676***	***2,131***	***717***	***1,189***	***1,536***	***70,917***	***546***	***12,693***

Table 1-3 (cont.)
2017 County Payroll by Category ($1000)

Category	Irion	Kimble	Loving	Martin	Mason	McCulloch	Menard	Midland	Mitchell	Pecos	Reagan
Federal Government	101	633	0	816	719	1,164	240	39,681	919	3,716	530
State Government	261	3,146	0	655	1,026	2,126	616	32,612	17,431	23,951	609
Local Government	3,830	6,699	0	23,320	8,232	17,061	5,440	392,007	24,622	54,449	16,892
Private Industry, Total	50,708	28,745	0	79,091	25,326	99,502	4,538	5,814,323	42,213	170,817	90,232
Goods-Producing	42,534	6,765	0	35,940	8,429	38,918	1,141	3,135,739	20,197	69,458	41,605
Natural Resources and Mining	40,035	1,071	1,487	0	5,336	28,718	576	2,625,271	16,648	50,133	38,139
Construction	0	3,354	0	23,256	2,322	2,695	0	305,992	0	13,899	3,466
Manufacturing	0	2,340	0	0	770	7,504	0	204,476	0	5,427	0
Service Providing	8,174	21,980	1,328	43,151	16,897	60,584	3,397	2,678,584	22,016	101,358	48,628
Trade, Transportation, and Utilities	5,795	7,972	0	29,945	6,107	34,784	1,903	1,024,227	11,284	57,872	44,098
Information	0	0	0	0	0	804	0	54,527	347	782	0
Financial Activities	0	2,194	0	2,360	3,657	4,496	676	275,627	2,338	10,747	957
Professional and Business Services	371	1,012	0	1,949	2,195	2,034	96	692,947	1,391	9,871	499
Education and Health Services	511	4,733	0	3,722	1,835	12,848	0	309,505	4,263	7,438	0
Leisure and Hospitality	0	4,933	0	1,297	2,007	4,030	462	194,901	1,861	11,971	2,033
Other Services	166	1,043	0	1,737	753	1,489	163	123,958	532	2,616	995
Unclassified	0	0	0	0	0	100	6	2,892	0	62	0
Total Payroll	***54,900***	***39,223***	***3,852***	***103,882***	***35,303***	***119,853***	***10,834***	***6,278,624***	***85,185***	***252,932***	***108,262***
Total Employees	***789***	***1,293***	***85***	***1,987***	***1,109***	***2,886***	***398***	***89,895***	***2,093***	***5,559***	***1,913***

Table 1-3 (cont.)
2017 County Payroll by Category ($1000)

Category	Reeves	Runnels	Schleicher	Scurry	Sterling	Sutton	Tom Green	Upton	Ward	Winkler	Region F Total
Federal Government	4,353	1,843	588	1,607	250	234	67,817	288	719	482	**216,679**
State Government	2,978	1,923	173	15,019	674	1,853	109,973	544	2,101	529	**375,463**
Local Government	66,081	25,837	7,675	54,755	4,627	14,545	197,584	20,300	32,036	23,215	**1,687,367**
Private Industry, Total	195,495	70,505	23,478	274,817	18,699	101,539	1,547,089	82,322	226,498	137,480	**14,057,183**
Goods-Producing	106,721	30,514	13,500	134,663	11,487	47,865	367,559	53,253	135,948	91,348	**6,741,172**
Natural Resources and Mining	39,841	6,888	0	115,792	10,429	35,877	80,493	48,143	108,247	55,966	**4,485,054**
Construction	43,737	4,258	9,205	9,312	1,058	6,444	103,342	5,110	18,965	34,668	**1,177,904**
Manufacturing	23,143	19,368	0	9,559	0	5,545	183,724	0	8,736	713	**1,046,284**
Service Providing	88,774	39,990	9,978	140,154	7,211	53,674	1,179,530	29,069	90,550	46,132	**7,317,339**
Trade, Transportation, and Utilities	51,012	20,900	5,170	75,013	4,638	44,044	339,096	19,499	55,029	27,620	**3,024,231**
Information	1,239	0	0	1,761	0	0	34,554	0	1,705	0	**132,547**
Financial Activities	11,950	3,781	1,036	10,568	1,473	2,514	133,267	1,536	11,883	4,856	**771,721**
Professional and Business Services	6,363	4,493	908	30,114	262	2,714	140,586	573	10,936	8,517	**1,226,957**
Education and Health Services	2,895	7,985	2,406	6,649	0	1,406	392,933	394	2,356	515	**1,206,021**
Leisure and Hospitality	13,342	1,931	0	7,339	0	2,156	97,361	274	6,864	1,963	**577,709**
Other Services	1,737	892	219	8,622	0	631	41,054	0	1,777	2,491	**347,147**
Unclassified	236	8	17	88	0	0	680	0	0	0	**5,897**
Total Payroll	***268,908***	***100,107***	***31,914***	***346,197***	***24,249***	***118,171***	***1,922,464***	***103,454***	***261,353***	***161,706***	***16,345,548***
Total Employees	***5,463***	***2,870***	***764***	***6,694***	***537***	***1,850***	***47,212***	***1,535***	***4,579***	***2,732***	***295,880***

Notes: Data are from U.S. Bureau of Labor Statistics 2017 Census of Employment and Wages data [3]

Region F

Estimated Payroll Distribution by County (2017)

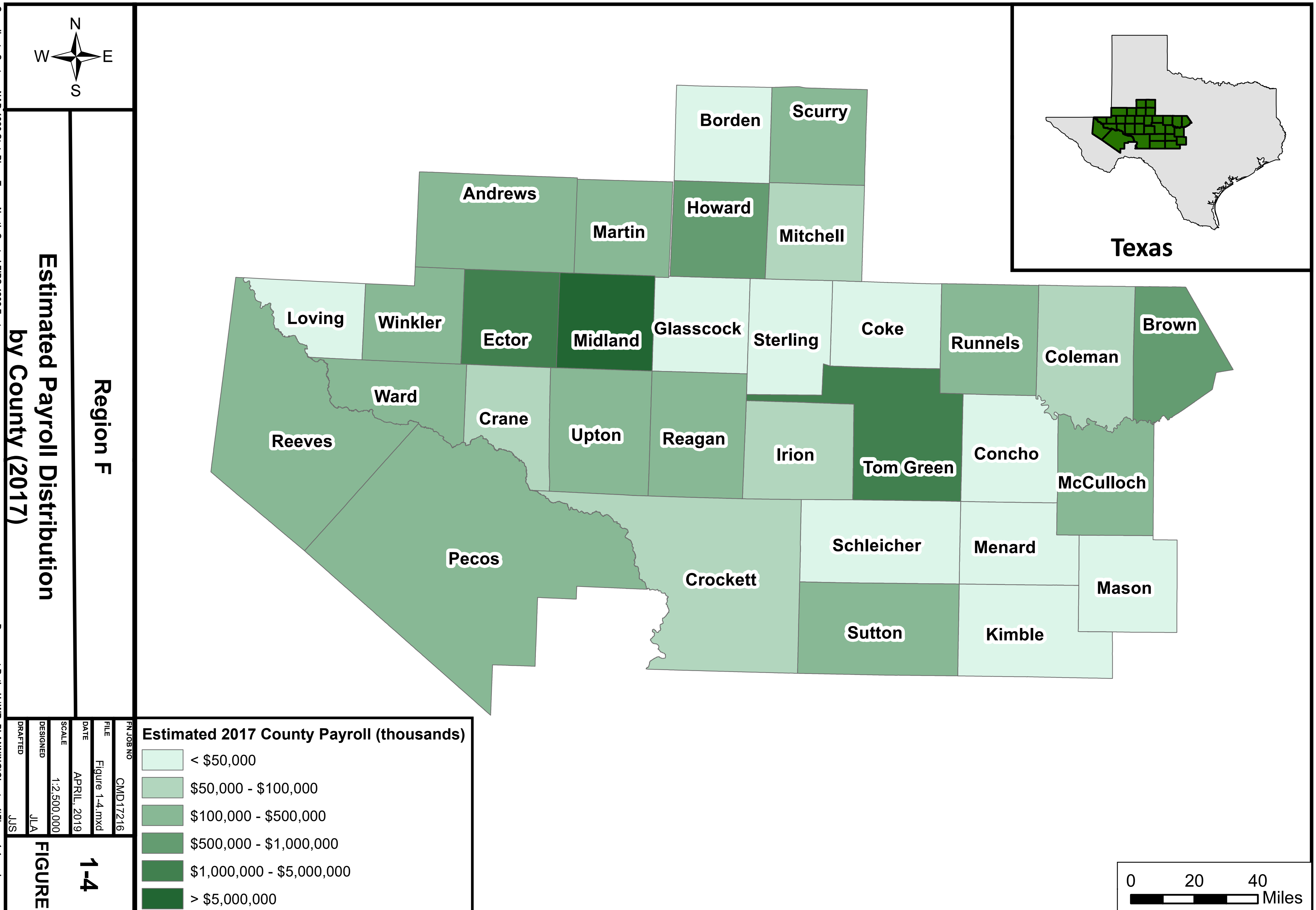

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FIGURE 1-4

Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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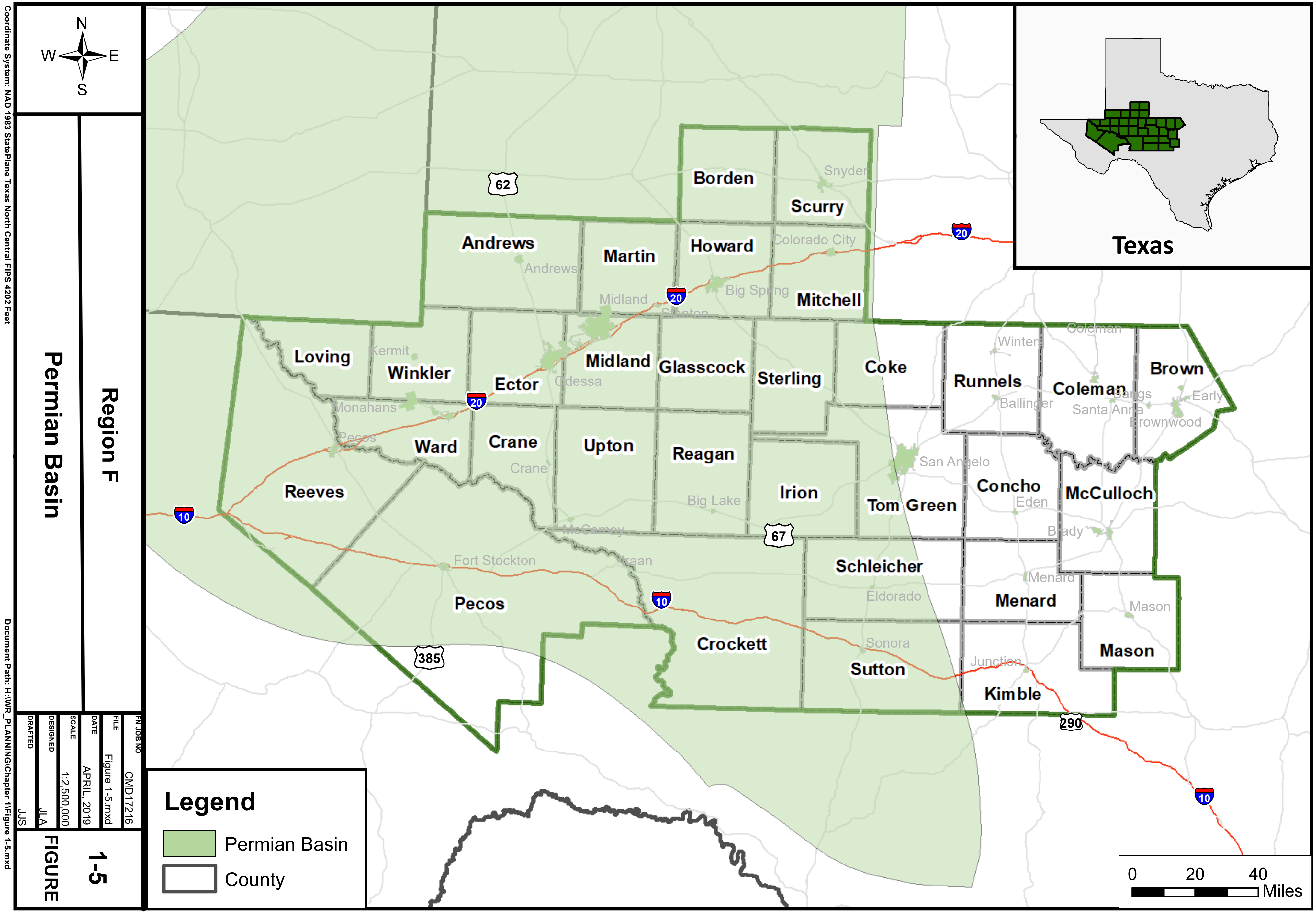
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FIGURE 1-5
Borden
Scurry
Snyder
Andrews
Martin
Howard
Colorado City
Mitchell
Big Spring
Midland
Stanton
Loving
Kermit
Winkler
Ector
Midland
Glasscock
Sterling
Coke
Runnels
Coleman
Brown
Winters
Ballinger
Bangs
Santa Anna
Early
Brownwood
Odessa
Monahans
Pecos
Ward
Crane
Upton
Reagan
Irion
Tom Green
San Angelo
Concho
Eden
McCulloch
Brady
Reeves
Big Lake
McCamey
Fort Stockton
Pecos
Schleicher
Eldorado
Menard
Mason
Crockett
Sonora
Sutton
Junction
Kimble
Texas
62
20
10
67
385
290
Legend
Permian Basin
County
0
20
40
Miles

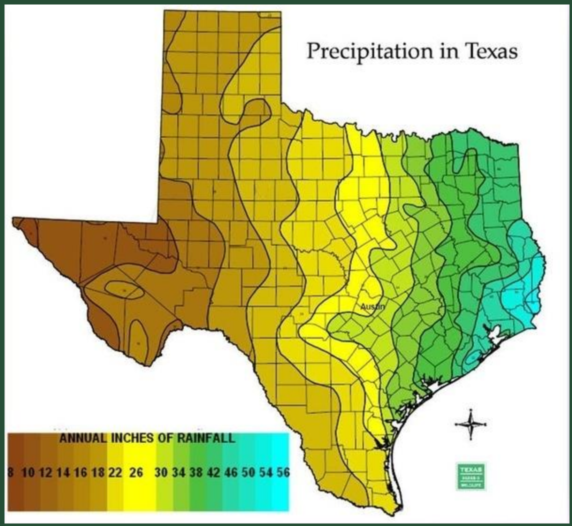
1.1.2 Water-Related Physical Features and Climate in Region F

Most of Region F is in the upper portion of the Colorado River Basin and in the Pecos River portion of the Rio Grande River Basin. A small part of the region is in the Brazos Basin. Figure 1-6 shows the surface water features in the Region F, which include the Colorado River, Concho River, Pecan Bayou, San Saba River, Llano River, and Pecos River.

Table 1-4 lists the 17 major water supply reservoirs in Region F. These reservoirs provide most of the region's surface water supply. Reservoirs are necessary to provide a reliable surface water supply in this part of the state because of the wide variations in natural streamflow. Reservoir storage serves to capture high flows when they are available and save them for use during times of normal or low flow.

Figure 1-7 shows the average annual precipitation throughout Region F[4]. Average precipitation ranges from slightly more than 11 inches per year in Reeves County to approximately 30 inches per year in Brown County. Precipitation generally increases from the western to the eastern portions of the region. Some of the highest evaporation rates in the state are in Region F, which often exceed rainfall throughout the region. Figure 1-8 illustrates the mean annual temperatures throughout Region F[4]. The mean annual temperatures for the entire region varied from a mean minimum temperature of 46.0 °F in Pecos County to a mean maximum temperature of 81.6 °F in Reeves County. The patterns of rainfall, runoff, evaporation, and temperature result in more abundant water supplies in the eastern portion of Region F.

Figure 1-9 shows the major aquifers in Region F, and Figure 1-10 shows the minor aquifers. There are 14 aquifers that supply water to the 32 counties of Region F. The major aquifers are the Edwards-Trinity Plateau, Ogallala, Pecos Valley, and a small portion of the Trinity. The minor aquifers are the Capitan Reef Complex, Cross Timbers, Dockum, Ellenberger-San Saba, Hickory, Igneous, Lipan, Marble Falls, and the Rustler. A small portion of the Edwards-Trinity High Plains extends into Region F but is not a major source of water. More information on these aquifers may be found in Chapter 3.



Water Related Facts for Region F:

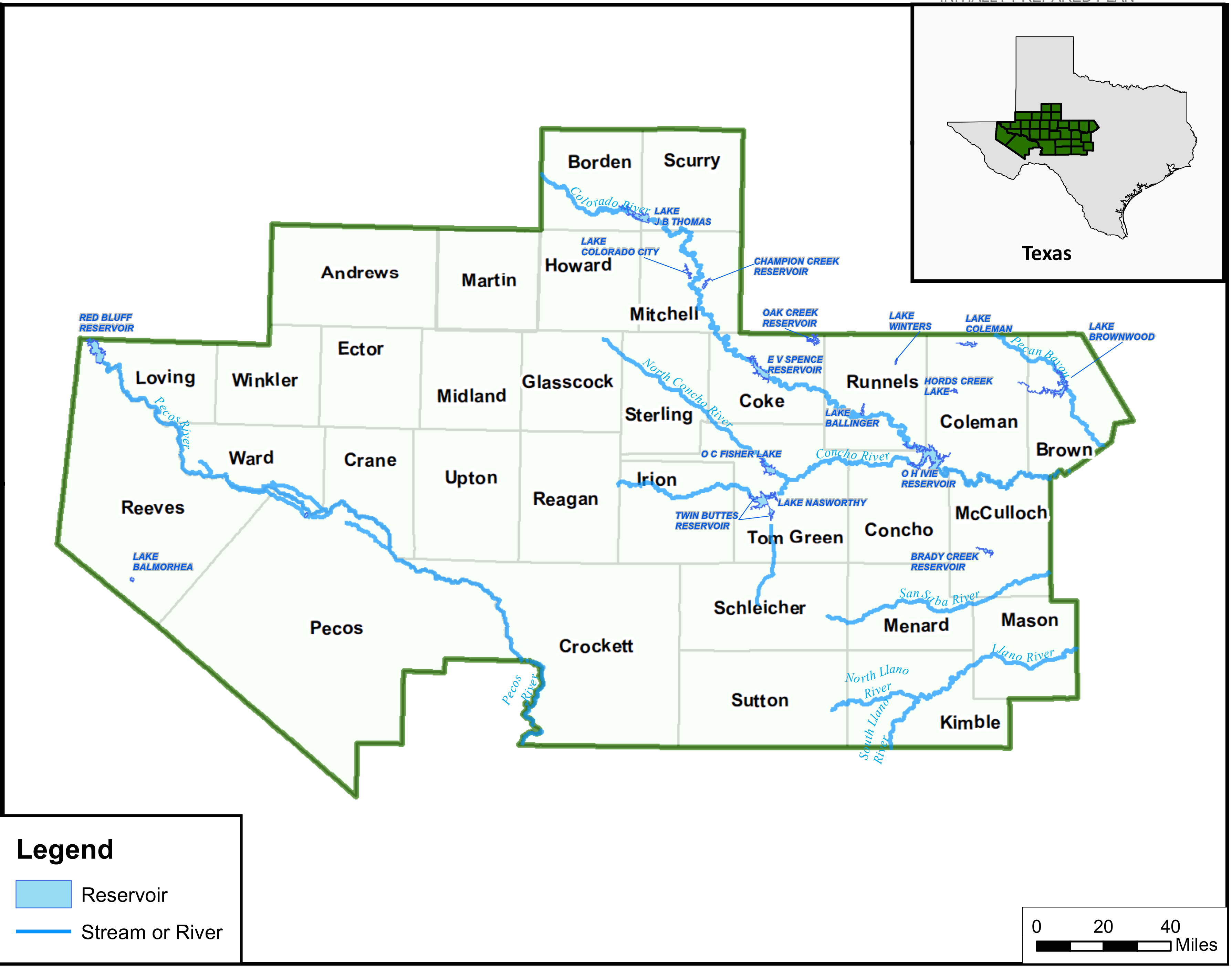
Three river basins in Region F: Colorado River, Pecos River, Brazos River
Four major aquifers
Ten minor aquifers
Precipitation ranges from 11 inches in the west to 30 inches in the east
Evaporative losses from area lakes can exceed 5 feet per year

Table 1-4
Major Water Supply Reservoirs in Region F[a,d]

Reservoir Name	Basin	Stream	County(ies)	Water Right Number(s)	Priority Date	Permitted Conservation Storage (Ac-Ft)	Permitted Diversion (Ac-Ft/Yr)	Year 2016 Use (Acre-Feet)	Owner	Water Rights Holder(s)
Lake J B Thomas	Colorado	Colorado River	Borden, Scurry	CA-1002	08/05/1946	204,000	30,000	11,167	CRMWD	CRMWD
Lake Colorado City	Colorado	Morgan Creek	Mitchell	CA-1009	11/22/1948	29,934	5,500	2,837	Luminant Generation	Luminant Generation
Champion Creek Reservoir	Colorado	Champion Creek	Mitchell	CA-1009	04/08/1957	40,170	6,750		Luminant Generation	Luminant Generation
Oak Creek Reservoir	Colorado	Oak Creek	Coke	CA-1031	04/27/1949	30,000	10,000	835	City of Sweetwater	City of Sweetwater
Lake Coleman	Colorado	Jim Ned Creek	Coleman	CA-1702	08/25/1958	40,000	9,000	546	City of Coleman	City of Coleman
E V Spence Reservoir	Colorado	Colorado River	Coke	CA-1008	08/17/1964	488,760	43,000	9,904	CRMWD	CRMWD
Mitchell County Reservoir	Colorado	Off-Channel	Mitchell		2/14/1990	27,266				
Lake Winters	Colorado	Elm Creek	Runnels	CA-1095	12/18/1944	8,374	1,755	No data	City of Winters	City of Winters
Lake Brownwood	Colorado	Pecan Bayou	Brown	CA-2454	09/29/1925	114,000	29,712	8,522	Brown Co. WID	Brown Co. WID
Hords Creek Lake	Colorado	Hords Creek	Coleman	CA-1705	03/23/1946	7,959	2,240	496	COE	City of Coleman
Lake Ballinger	Colorado	Valley Creek	Runnels	CA-1072	10/04/1946	6,850	1,000	260	City of Ballinger	City of Ballinger
O. H. Ivie Reservoir	Colorado	Colorado River	Coleman, Concho & Runnels	A-3866 P-3676	02/21/1978	554,340	113,000	32,534	CRMWD	CRMWD
O. C. Fisher Lake	Colorado	N. Concho River	Tom Green	CA-1190	05/27/1949	80,400	80,400	No data	COE	Upper Colorado River Authority
Twin Buttes Reservoir	Colorado	S. Concho River	Tom Green	CA-1318	05/06/1959	170,000	29,000	No data	U.S. Bureau of Reclamation	City of San Angelo
Lake Nasworthy	Colorado	S. Concho River	Tom Green	CA-1319	03/11/1929	12,500	25,000	No data	City of San Angelo	City of San Angelo
Brady Creek Reservoir	Colorado	Brady Creek	McCulloch	CA-1849	09/02/1959	30,000	3,500	1	City of Brady	City of Brady
Red Bluff Reservoir	Rio Grande	Pecos River	Loving and Reeves	CA-5438	01/01/1980	300,000	292,500	48,147	Red Bluff Water Power Control District	Red Bluff Water Power Control District
Lake Balmorhea	Rio Grande	Toyah Creek	Reeves	A-0060 P-0057	10/05/1914	13,583	41,400	8,266	Reeves Co WID #1	Reeves Co WID #1
Total						***2,158,136***	***723,757***	***123,515***		

a. A major reservoir has more than 5,000 acre-feet of storage.
b. Total diversions under CA 1002 and CA 1008 limited to 73,000 acre-feet per year. CA 1008 allows up to 50,000 acre-feet per year of diversion. For purposes of this table, the limitation is placed on CA 1008.
c. Permitted storage is reported for water conservation storage. UCRA has permission to use water from the sediment pool.
d. Data are from TCEQ active water rights list[5], TCEQ water rights permits[6], and TCEQ historical water use by water right[7]. Year 2016 use is consumptive.

CA: Certificate of Adjudication; A: Application; P Permit; COE: Corps of Engineers; NA – Data Not Available



Major Surface Water Features

Region F

Legend

- Reservoir
- Stream or River

Coordinate System: Custom

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FIGURE 1-6

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Region F

Mean Annual Precipitation (in/yr) from 1981 - 2010

FIGURE 1-7

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Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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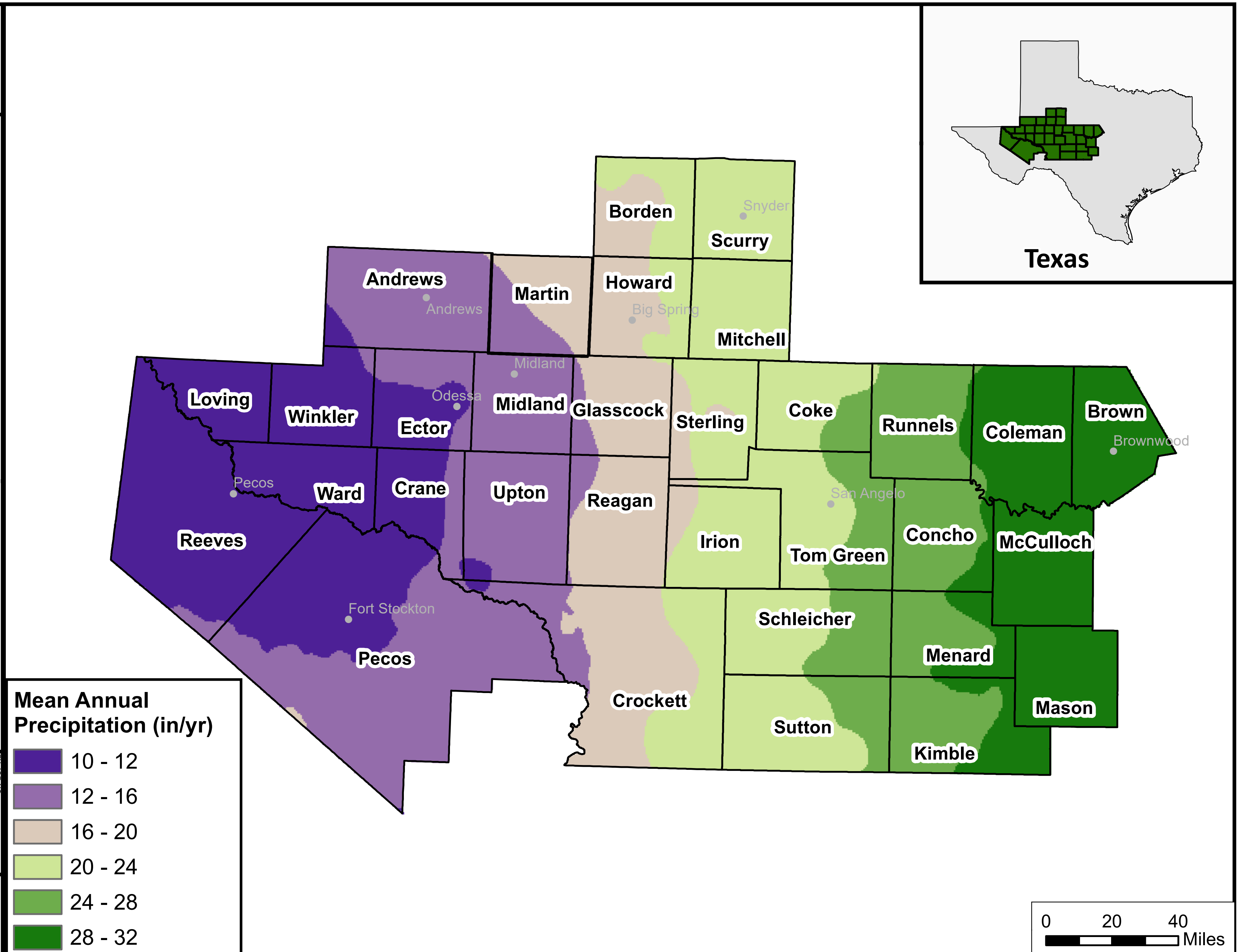

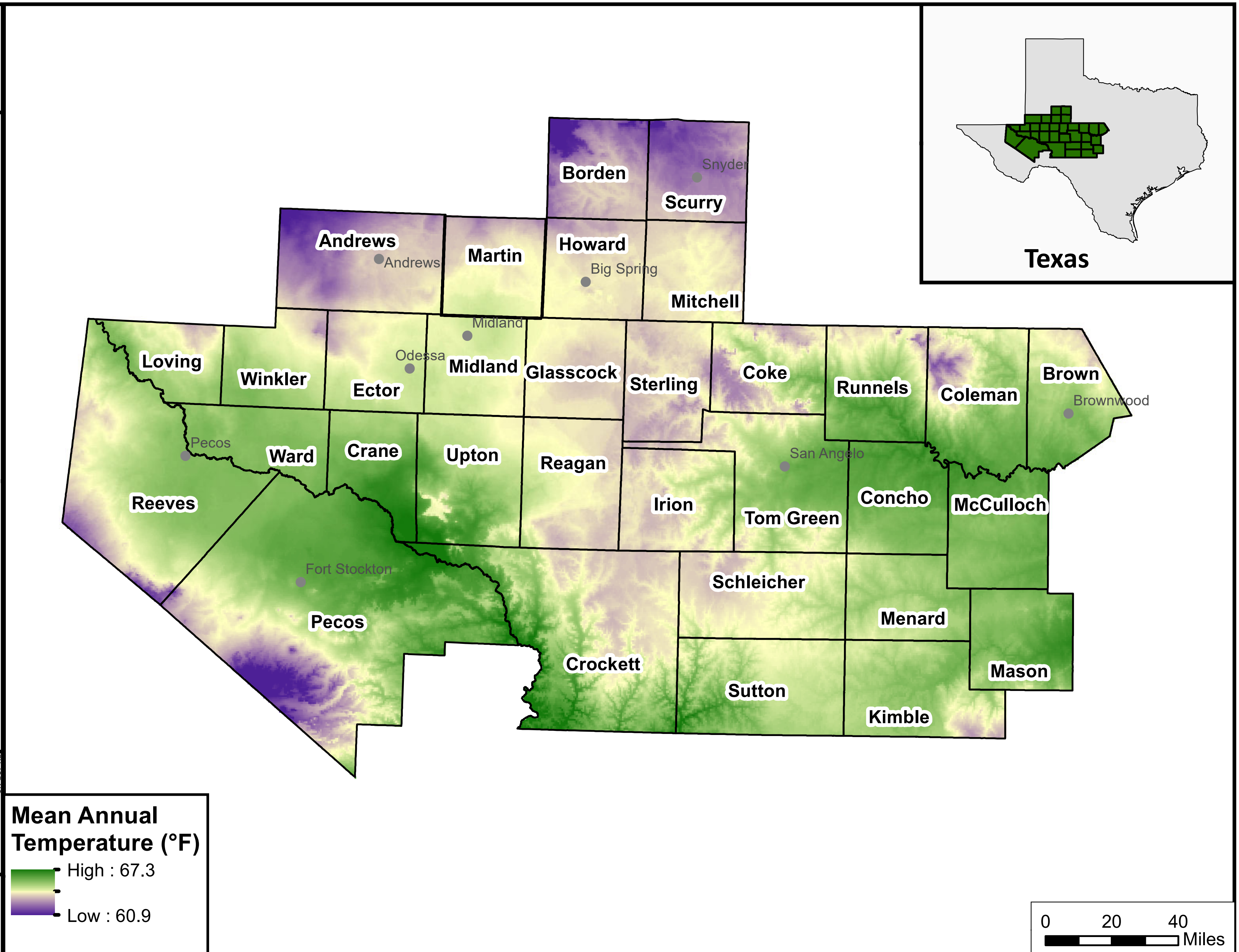

Region F

Mean Annual Temperature (°F) from 1981 - 2010

FIGURE 1-8

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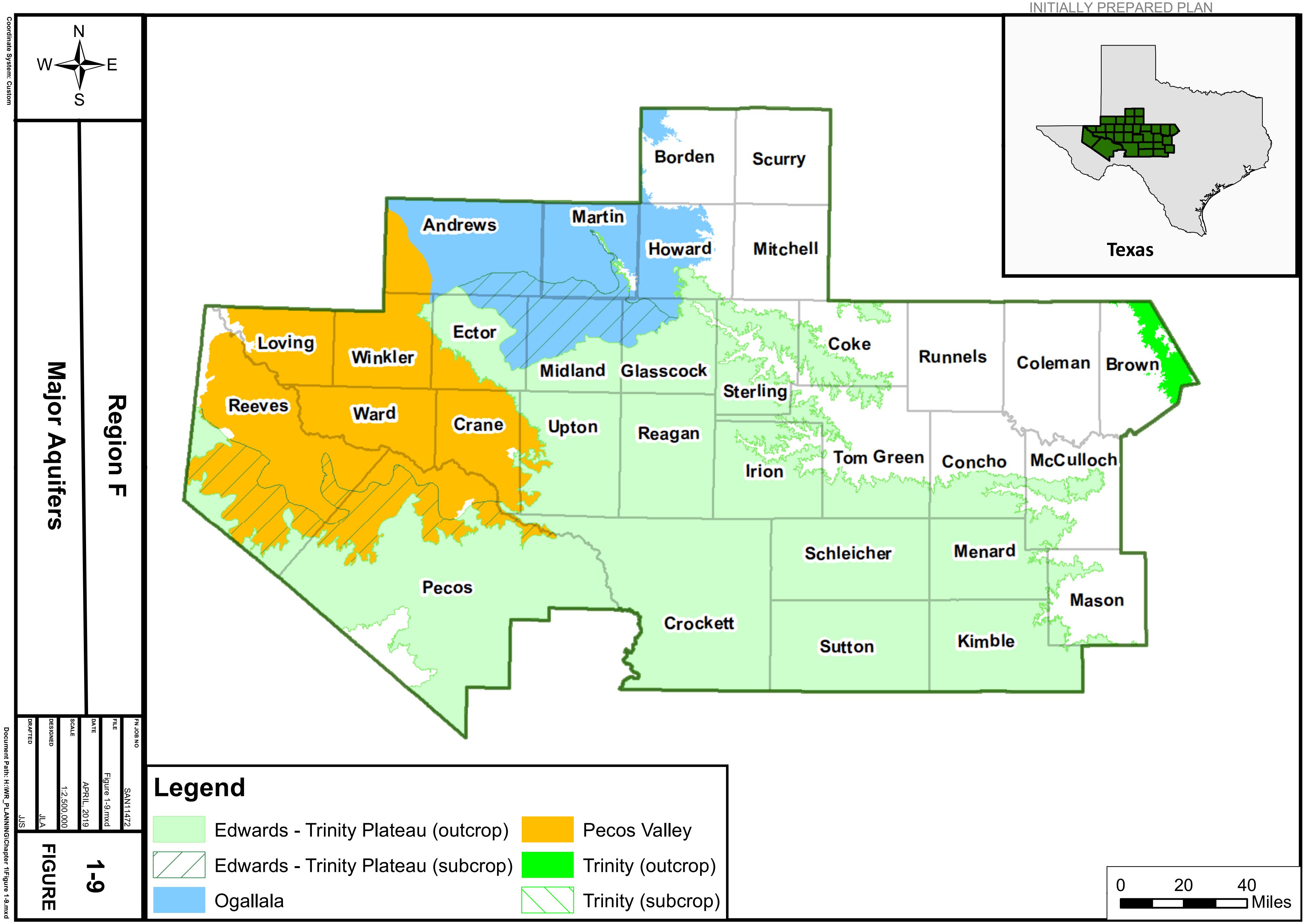

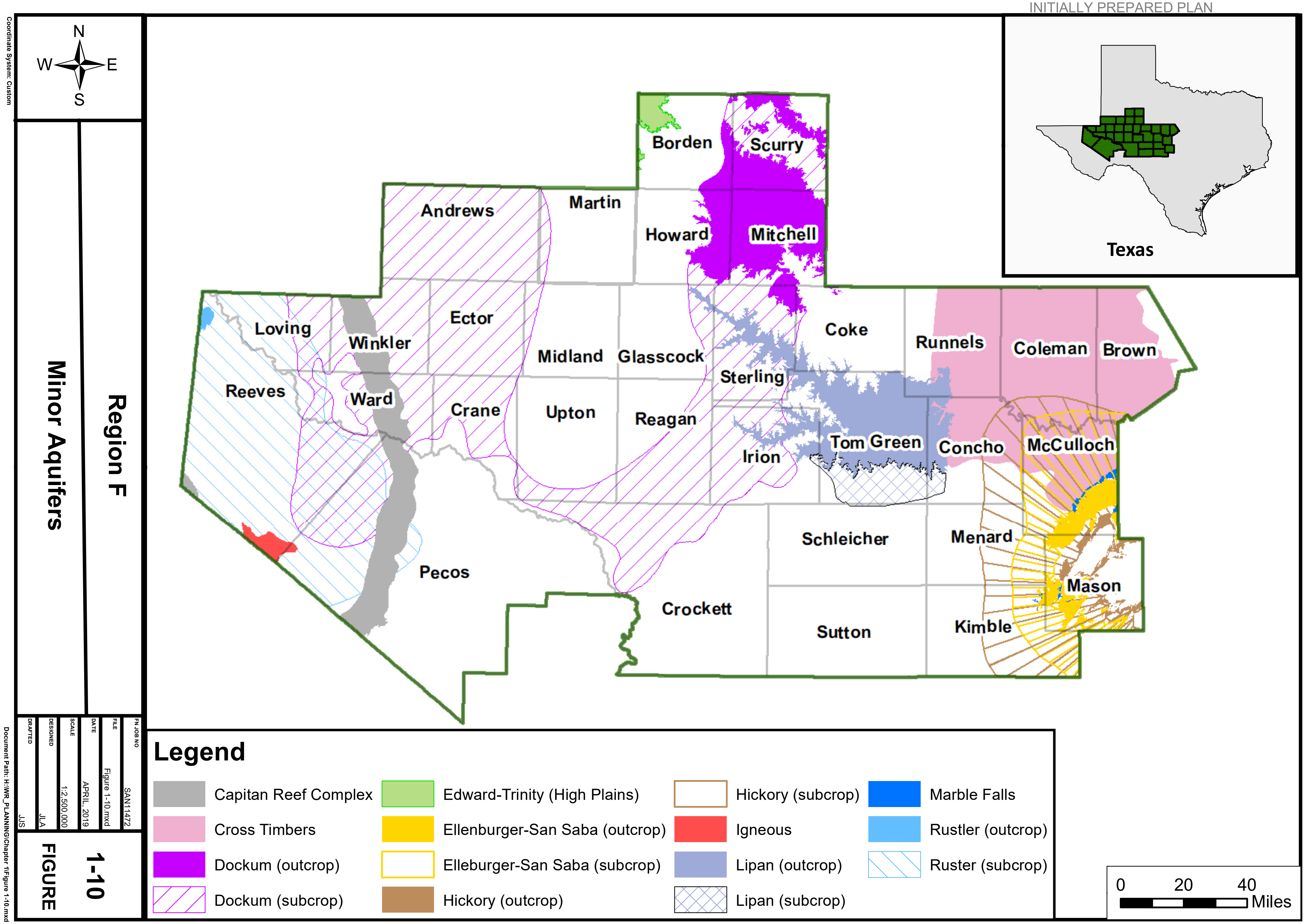
Region F
Minor Aquifers
FIGURE
1-10
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N
S
E
W
Texas
Borden
Scurry
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Coke
Runnels
Coleman
Brown
Reeves
Ward
Crane
Upton
Reagan
Sterling
Tom Green
Irion
Concho
McCulloch
Schleicher
Menard
Pecos
Crockett
Sutton
Kimble
Mason
Legend
Capitan Reef Complex
Cross Timbers
Dockum (outcrop)
Dockum (subcrop)
Edward-Trinity (High Plains)
Ellenburger-San Saba (outcrop)
Elleburger-San Saba (subcrop)
Hickory (outcrop)
Hickory (subcrop)
Igneous
Lipan (outcrop)
Lipan (subcrop)
Marble Falls
Rustler (outcrop)
Ruster (subcrop)
0
20
40
Miles

1.2 CURRENT WATER USES AND DEMAND CENTERS IN REGION F

Table 1-5 shows water use from 2006-2016 by TWDB use category and Figure 1-11 illustrates a graph of the data.[8] Table 1-6 shows the total water use by county in Region F for the same period. Water use in Region F increased between 2006 and 2016 and has generally increased in recent years. Since 2008, mining activity and its associated water use has markedly increased.

Table 1-5
Historical Water Use by Category in Region F (Values in acre-feet)

Year	Municipal	Manufacturing	Irrigation	SEP	Mining	Livestock	Total
2006	158,671	10,839	418,636	3,731	4,922	15,206	612,005
2007	114,630	12,704	408,888	3,670	4,253	14,690	558,835
2008	119,335	11,718	381,254	6,081	21,136	14,409	553,933
2009	148,843	13,383	446,157	6,010	20,399	14,343	649,135
2010	142,873	10,363	458,658	6,068	22,354	13,905	654,221
2011	162,266	6,898	494,192	3,567	33,362	14,006	714,291
2012	117,781	5,955	447,476	3,747	29,394	11,597	615,951
2013	123,902	5,913	466,502	3,601	27,234	10,094	637,246
2014	130,839	5,524	470,242	3,573	38,730	10,187	659,095
2015	119,988	5,892	438,822	3,202	62,454	10,001	640,359
2016	115,624	5,716	459,192	9,249	74,438	10,170	674,389
State Total in 2016	*4,412,828*	*1,068,124*	*7,831,789*	*464,763*	*168,312*	*325,385*	*14,271,201*
% of State Total in Reg F	*2.62%*	*0.54%*	*5.86%*	*1.99%*	*44.23%*	*3.13%*	*4.73%*

Note: Data are from the Texas Water Development Board.[8]

Figure 1-11
Historical Water Use by Category in Region F

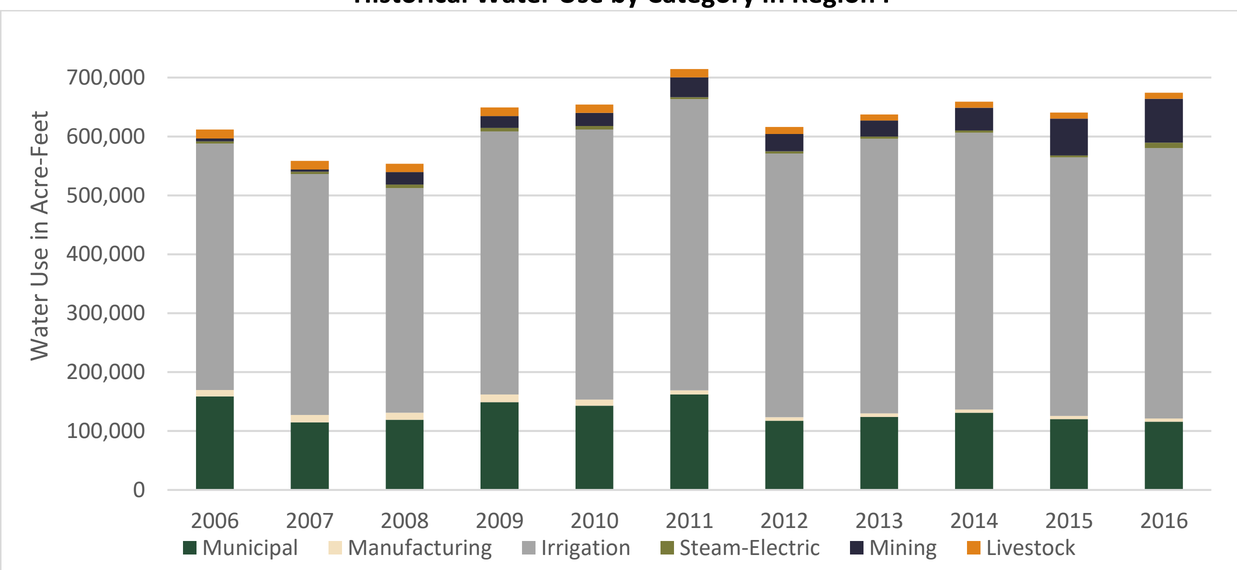

Table 1-6
Historical Total Water Use by County in Region F (Values in acre-feet)

County	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Andrews	34,637	42,249	35,479	29,221	28,083	29,204	29,788	23,873	20,293	20,836	22,162
Borden	2,788	2,951	2,888	4,592	2,180	4,326	3,848	4,450	2,300	2,238	2,682
Brown	18,145	12,380	18,534	16,447	17,592	18,451	14,708	13,699	12,842	13,708	12,803
Coke	1,825	1,392	1,621	1,638	2,028	2,246	1,430	1,269	1,070	963	1,259
Coleman	3,461	2,891	3,161	3,244	2,769	2,962	2,458	2,223	2,305	2,330	2,705
Concho	9,009	6,496	10,807	3,667	8,224	3,911	5,706	6,010	5,593	5,464	5,484
Crane	1,869	1,665	2,515	1,768	1,617	1,987	1,939	1,859	1,709	2,118	1,315
Crockett	2,518	2,386	2,646	2,274	2,315	3,182	3,857	4,579	4,632	3,595	3,129
Ector	29,334	25,246	25,788	26,985	28,743	30,510	23,750	25,968	24,263	22,005	25,458
Glasscock	46,925	38,203	43,775	46,868	58,316	55,648	48,750	52,337	54,900	30,093	41,496
Howard	10,285	16,717	14,120	15,329	15,935	18,641	13,146	13,299	14,778	15,741	16,752
Irion	1,120	812	1,308	2,226	2,268	3,238	3,777	4,235	4,300	3,353	2,871
Kimble	4,355	2,744	4054	4693	4812	4670	4367	4204	3912	3,900	3,708
Loving	108	67	147	209	258	477	839	326	543	4,411	6,006
Martin	16,187	26,412	29,740	38,263	37,706	38,303	35,181	44,968	41,722	42,873	35,629
Mason	8,903	4,884	7,811	9,032	5,864	8,065	7,174	6,483	6,880	6,422	6,399
McCulloch	8,685	6,858	10,893	12,095	13,203	13,205	7,518	6,866	8,086	8,457	8,062
Menard	3,228	2,771	1,675	2,471	3,048	6,067	2,622	5,827	5,104	4,766	4,312
Midland	53,624	44,433	53,691	55,170	42,420	57,661	45,287	29,345	36,468	55,081	72,169
Mitchell	9,152	11,622	13,113	16,841	14,832	15,626	21,212	18,671	20,400	17,916	16,832
Pecos	74,827	63,436	63,644	98,399	132,030	187,827	115,433	145,945	165,572	163,235	161,528
Reagan	20,274	17,882	21,047	18,415	21,002	28,707	23,223	24,316	31,317	28,194	26,384
Reeves	94,549	84,066	31,535	63,449	63,896	57,984	59,368	81,055	60,411	61,286	78,841
Runnels	5,922	4,449	6,163	5,607	5,657	4,416	5,573	5,262	5,219	6,235	5,421
Schleicher	2,037	1,536	2,248	2,600	2,587	3,371	3,160	2,833	3,099	2,613	3,004
Scurry	9,005	8,087	8,121	10,586	9,365	10,078	12,691	10,287	10,623	8,932	9,411
Sterling	1,169	1,005	1,349	1,672	1,337	1,630	1,501	1,785	1,675	1,414	1,199
Sutton	3,295	3,265	2,208	2,210	2,728	3,343	2,669	2,460	2,671	2,324	2,356
Tom Green	70,393	92,453	106,446	92,724	67,915	36,919	76,657	56,306	64,204	74,598	64,504
Upton	8,370	7,156	11,965	10,569	12,014	17,486	13,876	12,459	14,722	13,655	15,249
Ward	12,650	9,895	7,643	11,324	10,747	9,935	5,069	4,785	7,011	7,807	9,794
Winkler	11,372	9,787	4,691	5,522	4,900	6,707	6,405	5,180	5,927	3,796	5,465
Total	***580,021***	***556,196***	***550,826***	***616,110***	***626,391***	***686,783***	***602,982***	***623,164***	***644,551***	***640,359***	***674,389***

Note: Data are from the Texas Water Development Board.[8]
Data for Reeves County after 2003 includes all water released from the Red Bluff Reservoir. Approximately 25% of this water is delivered to customers in Pecos, Reeves, Ward and Loving Counties. The remaining 75% of the water is lost to evaporation and stream losses.

2016 Water Use in Region F:

- 2016 water use was higher than previous years but less than 2011 water use
- Municipal water use continues to decline. 2016 was the lowest total municipal use year.
- Continued increases in water use for mining
- Declining water use for manufacturing
- Irrigation continues to be the largest water user
- Midland County had the highest total water use in 2016 in the past decade

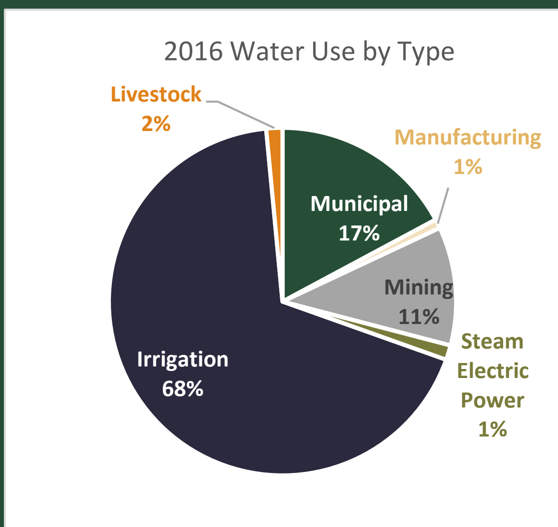

Table 1-7 shows water use by category and county in 2016, and Figure 1-12 shows the distribution of water use by county.

The areas with the highest water use are Midland, Pecos, Reeves, and Tom Green Counties, accounting for over half of the total water used in the region. Most of the municipal water use occurred in Ector, Midland, and Tom Green Counties, location of the cities of Odessa, Midland, and San Angelo, respectively. In the 2016, these counties accounted for about 60 percent of the water use in this category. Other significant municipal demand centers include Brown County (Brownwood), Pecos County (Fort Stockton), Reeves County (Pecos), & Howard County (Big Spring).

Manufacturing water use is small in Region F. Use in this category is concentrated in Kimble and Tom Green counties.

Reeves, Pecos, and Tom Green Counties accounted for most of the reported irrigation water use in 2016, accounting for more than a half of the irrigation water use in the region. However, some of the water reported for irrigation in Reeves County is associated with delivery losses from the Red Bluff Reservoir. The actual use of irrigation water in Reeves County is somewhat less than shown. Other significant demand centers for irrigation water include Glasscock, Martin, and Reagan Counties.

Steam-electric power generation water use occurred only in Ector, Howard, Mitchell, Scurry, and Ward Counties during the year 2016. Facilities in other counties have temporarily or permanently ceased operations.

Most of the water used for mining purposes occurred in Martin, Midland, Reeves, and Upton Counties, accounting for approximately 58 percent of the total use. Mining activities across the region have increased significantly since 2007. Region F accounted for nearly 45% of the mining water use in the entire state in 2016.

Livestock is a small water use category in Region F. Most of the livestock water use occurred in Brown, Coleman, Mason, Pecos, and Tom Green Counties.

In addition to the consumptive water uses discussed previously, water-oriented recreation is important in Region F. Table 1-8 summarizes recreational opportunities at major reservoirs in the region[7]. Smaller lakes and streams provide opportunities for fishing, boating, swimming, and other water-related recreational activities. Water in streams and lakes is also important to fish and wildlife in the region, providing a wide variety of habitats.

Table 1-7
Year 2016 Water Use by Category and County (Values in acre-feet)

County	Municipal	Manu-facturing	Irrigation	Steam-Electric	Mining	Livestock	Total
ANDREWS	3,396	42	16,536	0	1,997	191	22,162
BORDEN	161	0	2,214	0	178	129	2,682
BROWN	4,785	387	6,622	0	0	1,009	12,803
COKE	488	31	511	0	8	221	1,259
COLEMAN	1,789	1	273	0	0	642	2,705
CONCHO	530	0	4,622	0	0	332	5,484
CRANE	919	288	0	0	43	65	1,315
CROCKETT	1,080	33	17	0	1550	449	3,129
ECTOR	18,960	355	804	4853	387	99	25,458
GLASSCOCK	122	35	37,376	0	3,852	111	41,496
HOWARD	5,076	2,569	3,662	331	4,894	220	16,752
IRION	148	5	910	0	1,606	202	2,871
KIMBLE	562	546	2,376	0	0	224	3,708
LOVING	23	0	0	0	5948	35	6,006
MARTIN	669	0	28,245	0	6,629	86	35,629
MASON	639	0	4,894	0	187	679	6,399
MCCULLOCH	1,289	72	1,168	0	5,048	485	8,062
MENARD	274	0	3,738	0	0	300	4,312
MIDLAND	34,391	227	19,322	0	17,958	271	72,169
MITCHELL	1,352	2	11,943	3,180	0	355	16,832
PECOS	6,427	221	153,014	0	1,235	631	161,528
REAGAN	623	0	20,244	0	5,368	149	26,384
REEVES[b]	5,145	6	65,423	0	7,791	476	78,841
RUNNELS	1,268	4	3,559	0	6	584	5,421
SCHLEICHER	467	0	2,209	0	10	318	3,004
SCURRY	1,982	117	5,995	845	64	408	9,411
STERLING	235	0	720	0	7	237	1,199
SUTTON	870	1	1,140	0	0	345	2,356
TOM GREEN	15,773	701	47,400	0	1	629	64,504
UPTON	821	41	6,685	0	7,566	136	15,249
WARD	3,570	0	4,830	40	1,292	62	9,794
WINKLER	1,790	32	2,740	0	813	90	5,465
REGIONAL TOTAL	115,624	5,716	459,192	9,249	74,438	10,170	674,389
STATE TOTAL	4,412,828	1,068,124	7,831,789	464,763	168,312	325,385	14,271,201

Note: Data are from the Texas Water Development Board.[8]

a. Great Plains sells water to a Steam Electric Facility in Ector County

b. Data for Reeves County includes all water released from the Red Bluff Reservoir.

Region F

2016 Historical Water Use by County Type (Acre-Feet per Year)

FIGURE 1-12

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Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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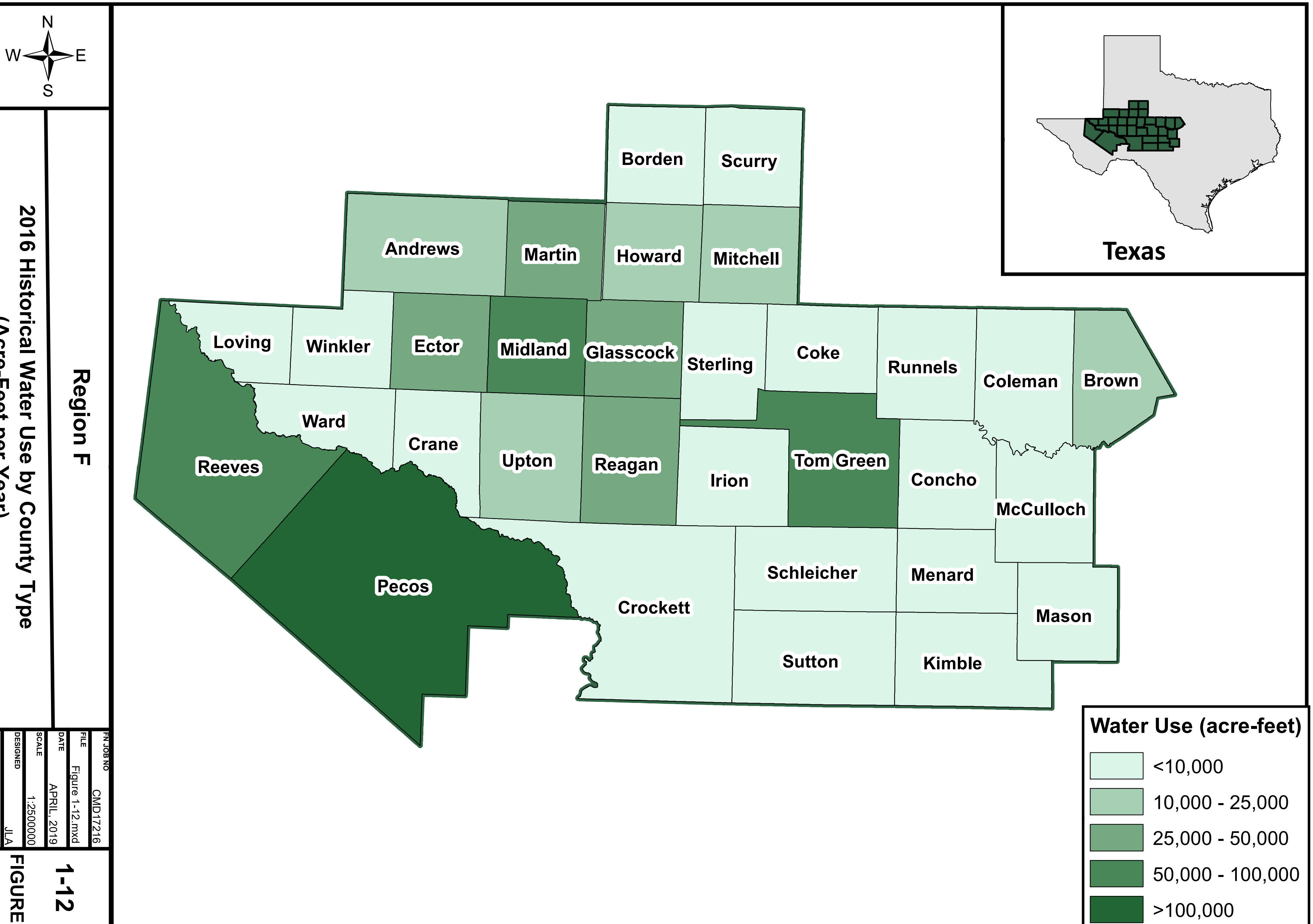


Table 1-8
Recreational Use of Reservoirs in Region F

Reservoir Name	County	Fishing	Boat Launch	Swimming Area	Marina	Picnic Area	Camping	Hiking Trails	Bicycle Trails	Equestrian Trails	Pavilion Area
Lake J. B. Thomas	Borden and Scurry	X	X			X	X				X
Lake Colorado City	Mitchell	X	X	X		X	X	X	X		X
Champion Creek Reservoir	Mitchell	X	X			X	X				
Oak Creek Reservoir	Coke	X	X	X	X	X	X				
Lake Coleman	Coleman	X	X	X	X	X	X				
E. V. Spence Reservoir	Coke	X	X	X	X	X	X				X
Lake Winters/ New Lake Winters	Runnels	X	X	X		X	X	X			X
Lake Brownwood	Brown	X	X	X		X	X	X	X		X
Hords Creek Lake	Coleman	X	X	X		X	X	X	X		X
Lake Ballinger / Lake Moonen	Runnels	X	X	X		X	X				
O. H. Ivie Reservoir	Concho and Coleman	X	X		X	X	X				X
O. C. Fisher Lake	Tom Green	X	X	X		X	X	X	X	X	X
Twin Buttes Reservoir	Tom Green	X	X	X		X	X	X			
Lake Nasworthy	Tom Green	X	X	X	X	X	X	X	X		X
Brady Creek Reservoir	McCulloch	X	X	X	X	X	X	X		X	X
Mountain Creek Lake	Coke										
Red Bluff Reservoir	Reeves and Loving	X	X			X	X				
Lake Balmorhea	Reeves	X	X	X		X	X				

Note: "X" indicates that the activity is available at the specified reservoir.

1.3 CURRENT SOURCES OF WATER

Table 1-9 summarizes the total surface water, groundwater, and reuse water use in Region F from 2006 through 2016, and Figure 1-13 graphically illustrates the same data. Total water use increased by approximately 62,000 acre-feet (10 percent) between 2006 and 2016. Groundwater use increased by more than 130,000 feet (34.1 percent) and surface water use decreased by over 95,000 acre-feet (48.2 percent) over the same period. Estimates of reuse water and brackish water (for mining) use were first recorded by the TWDB on a countywide basis in the year 2015. Between 2015 and 2016, there was an increase of over 7,000 acre-feet (11 percent) of reuse water use.

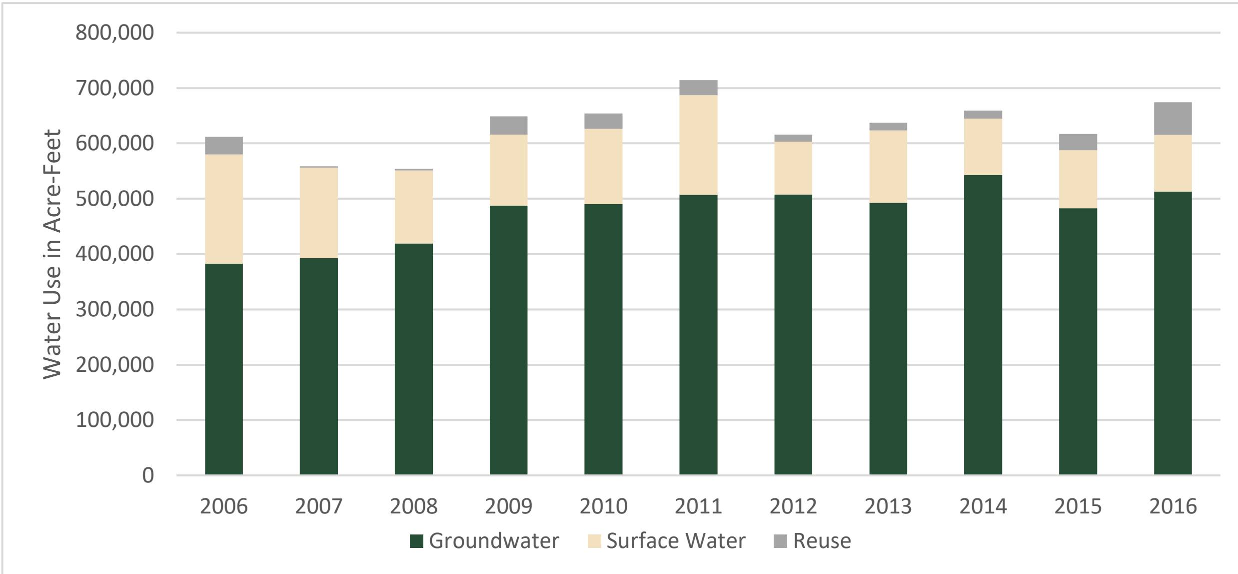
Figure 1-15 shows the percentage of supply from groundwater, broken down by county, in the region in the year 2016. Overall, groundwater use has shown an increasing trend ranging from 62 percent of total water use in 2006 to 76 percent in 2016. In contrast, surface water use has shown a decreasing trend ranging from 32 percent of total water use in 2006 to 15 percent in 2016.

Table 1-9
Historical Groundwater, Surface Water, and Reuse Water Use in Region F

Year	Water Use in Acre-Feet			
	Groundwater	Surface Water	Reuse[a]	Total
2006	382,461	197,560	31,984	580,021
2007	392,721	163,475	2,639[b]	556,196
2008	419,370	131,456	3,107[b]	550,826
2009	487,538	128,572	33,025	616,110
2010	490,590	135,801	27,830	626,391
2011	507,301	179,482	27,508	686,783
2012	507,814	95,166	12,969	602,980
2013	492,875	130,285	14,082	623,160
2014	542,963	101,589	14,544	644,552
2015	482,762	104,603	52,994	640,359
2016	512,919	102,416	59,054	674,389

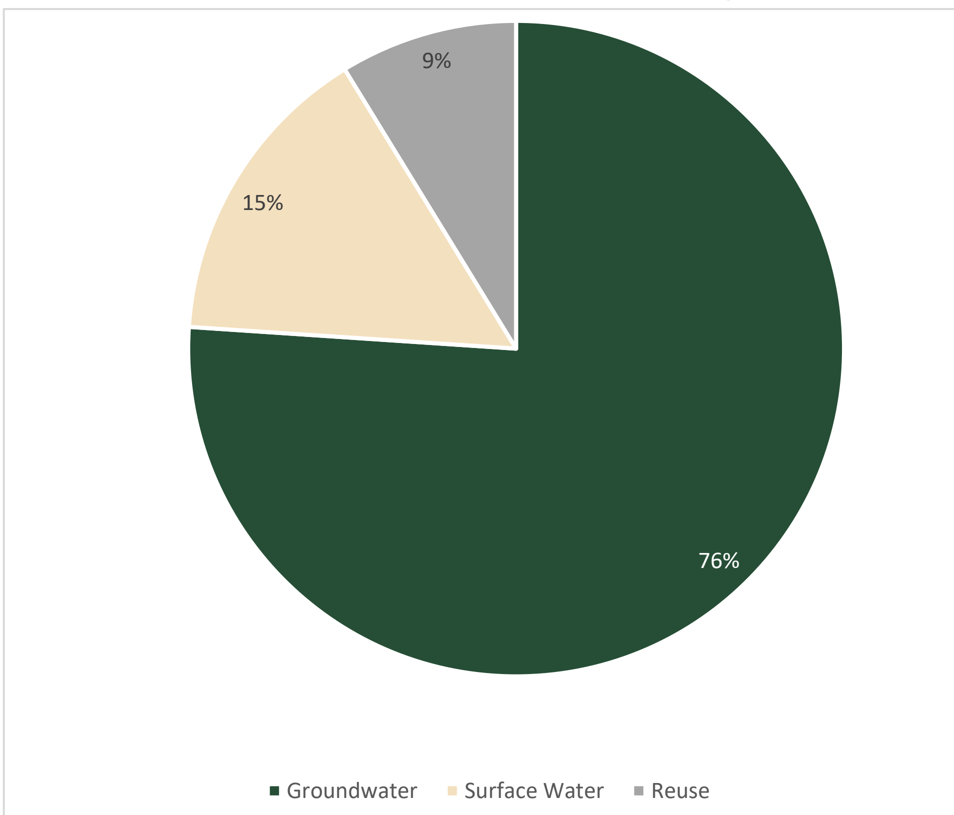
Note: Data are from Texas Water Development Board.[8]
a. Values from 2000-2014 only reflect entities that reported water reuse during that year.
Annual reuse and brackish water (for mining) use was not reported through all of Region F until 2015.
b. Odessa reported substantially less water reuse in 2007 and 2008.

Figure 1-13
Historical Groundwater, Surface Water, and Reuse Water Use in Region F*



*Values from 2000-2014 only reflect entities that reported water reuse during that year. Annual water reuse was not reported through all of Region F until 2015.

Figure 1-14
Groundwater, Surface Water, and Reuse Water Use in Region F in 2016



Region F

Percent Supplies from Groundwater by County (2016)

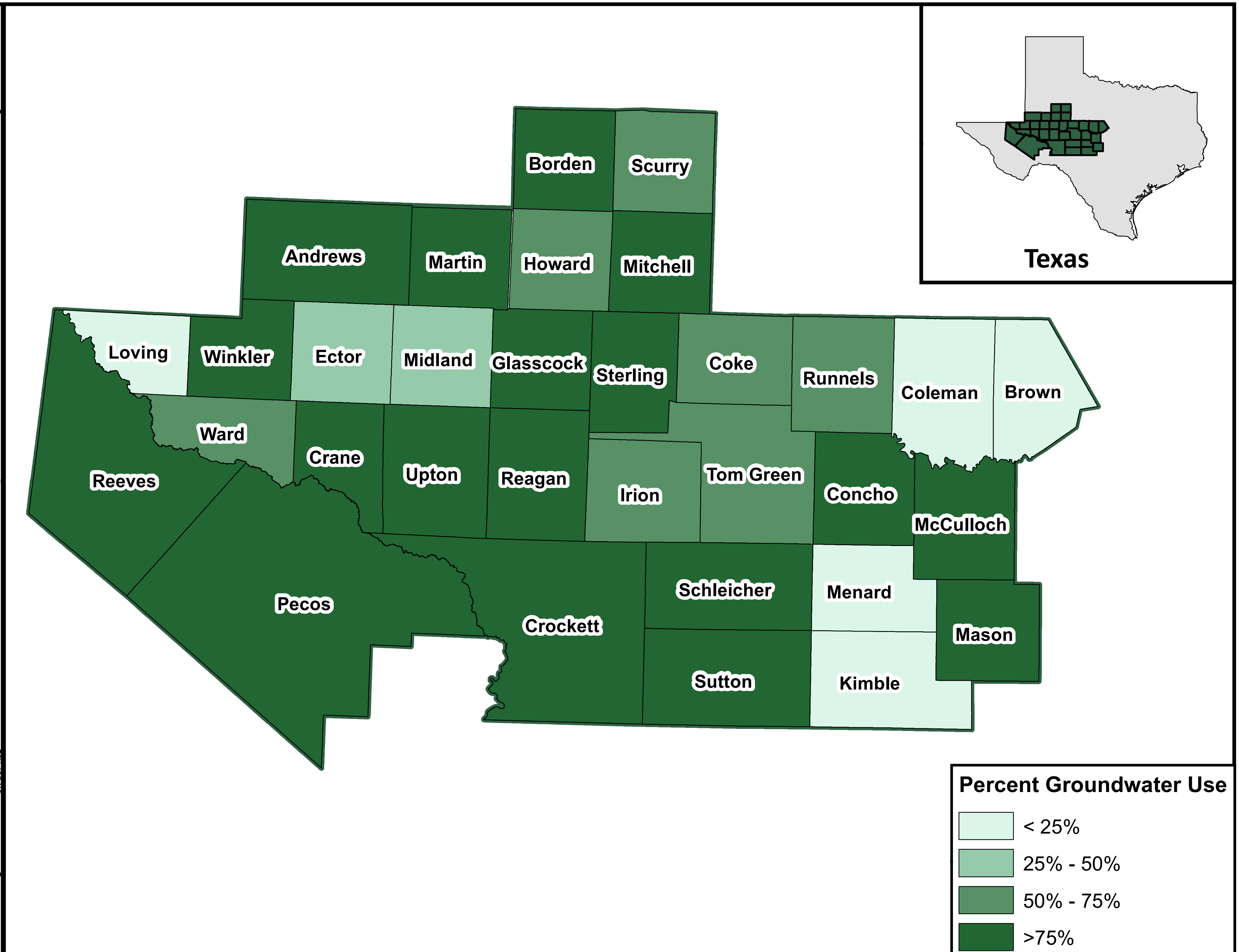


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FIGURE 1-15

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Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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1.3.1 Surface Water Sources

Table 1-10 summarizes permitted surface water diversions by use category for each county in Region F. (These categories differ slightly from the demand categories used by TWDB for regional water planning.) Table 1-10 does not include non-consumptive use categories such as recreation. Figure 1-16 shows the distribution of permitted diversions by county and use type. Most of the large surface water diversions in Region F are associated with major reservoirs. Table 1-4 in Section 1.1.2 lists the permitted diversions and the reported year 2016 water use from major water supply reservoirs in the region.

Region F does not import a significant amount of surface water from other regions. Region F exports water to two cities in Region G: Sweetwater and Abilene. The City of Sweetwater owns and operates Oak Creek Reservoir, a 30,000 acre-feet reservoir in Coke County. The City of Abilene has a contract with the Colorado River Municipal Water District (CRMWD) for 16.54% of the safe yield of O.H. Ivie Reservoir. Facilities to transfer water from Lake O.H. Ivie to Abilene became operational in September 2003. Small amounts of surface water are supplied to the Cities of Lawn and Rotan, which are both in Region G. Several rural water supply corporations also supply small amounts of surface water to neighboring regions.

Lake Ivie
Colorado River Municipal Water District

Lake Brownwood
Brown County Water Improvement District #1

Table 1-10
Surface Water Rights by County and Category

County	Permitted Surface Water Diversions (Acre-Feet per Year)					
	Municipal	Industrial	Irrigation	Mining	Other	Total
Borden	200	0	63	0	0	263
Brown	29,712	0	8,729	0	0	38,441
Coke	44,865	6,000	969	16,361[a]	0	68,195
Coleman [b]	110,890	14,509	6,522	0	20	131,941
Concho	35	0	2,356	0	16	2,407
Ector	0	0	3,200	0	0	3,200
Howard	1,700	0	89	8,215	0	10,004
Irion	0	0	5,426	0	0	5,426
Kimble	1,000	2,472	8,450	60	0	11,982
Martin	0	2,500	0	0	0	2,500
Mason	0	0	356	0	0	356
McCulloch	3,500	0	2,152	0	0	5,652
Menard	1,016	0	10,586	3	2	11,607
Mitchell	8,200	4,050	123	0	0	12,373
Pecos	0	0	66,902	0	0	66,902
Reeves [c]	0	0	347,366	0	0	347,366
Runnels	2,919	0	7,024	70	0	10,013
Schleicher	0	0	38	3	0	41
Scurry [d]	30,000	0	503	0	0	30,503
Sterling	0	0	168	0	0	168
Sutton	0	0	99	3	0	102
Tom Green	108,069	8,002	40,985	0	16	157,072
Total	***342,106***	***37,533***	***512,105***	***24,715***	***54***	***916,513***

a. Includes up to 6,000 acre-feet per year that can be diverted and used in Mitchell or Howard Counties

b. Includes water rights for Ivie Reservoir, which is located in Coleman, Concho and Runnels Counties.

c. Includes rights for Red Bluff Reservoir, which is located in Loving and Reeves Counties.

d. Includes rights for Lake J.B. Thomas, which is located in Borden and Scurry Counties.

Note: Data are from TCEQ's active water rights list.[5] Other counties have no permitted water rights on the TCEQ list. Does not include recreation rights.

Region F

Permitted Diversion (Acre - Feet per Year)

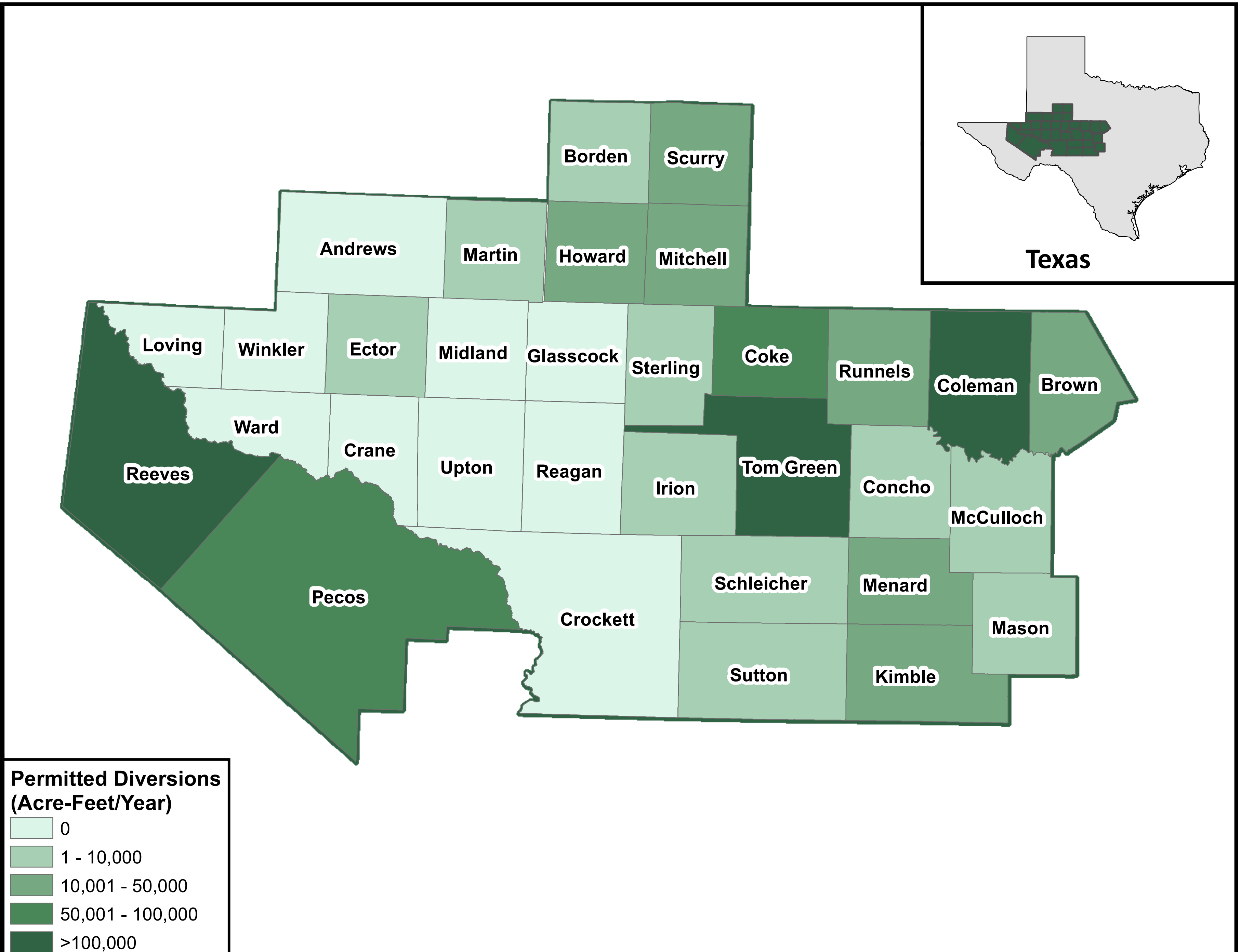

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FIGURE 1-16

1.3.2 Groundwater Sources

As previously discussed in section 1.1.2, there are 14 aquifers that supply water to the 32 counties of Region F: four major aquifers (Edwards-Trinity Plateau, Ogallala, Pecos Valley, and Trinity) and ten minor aquifers (Capitan Reef Complex, Cross Timbers, Dockum, Edwards-Trinity High Plains, Ellenberger-San Saba, Hickory, Igneous, Lipan, Marble Falls, and Rustler). The TWDB defines a major aquifer as an aquifer that supplies large quantities of water to large areas.[9] Minor aquifers supply large quantities of water to small areas, or relatively small quantities of water to large areas. The Trinity aquifer is considered a major aquifer by the TWDB because it supplies large quantities of water in other regions. However, the Trinity aquifer covers only a small portion of Region F in Brown County and supplies a relatively small amount of water in the region.

Table 1-11 shows the 2016 groundwater use by county and aquifer.[8] The Edwards-Trinity Plateau, Pecos Valley, and Ogallala are the largest sources of groundwater in Region F, providing 35.7 percent, 20.2 percent, and 13.0 percent of the total groundwater pumped in 2016, respectively. The Lipan aquifer provided approximately 5.4 percent of the 2016 totals, with all remaining aquifers contributing 25.7 percent combined. Groundwater pumping is highest in Glasscock, Martin, Pecos, Reeves, Reagan, and Tom Green Counties. Approximately 70 percent of the regions total pumping occurs in these six counties.

Groundwater conservation districts are the preferred method for managing groundwater in the State of Texas. There are 16 Underground Water Conservation Districts (GCDs) in Region F (Figure 1-17). These entities are required to develop and adopt comprehensive management plans, permit wells that are drilled, completed or equipped to produce more than 25,000 gallons per day, keep records of well completions, and make information available to state agencies. Other powers granted to GCDs are prevention of waste, conservation, recharge projects, research, distribution and sale of water, and making rules regarding transportation of groundwater outside of the district.[10]

Fifteen of the GCDs in Region F form the West Texas Regional Groundwater Alliance, an organization that promotes the conservation, preservation and beneficial use of water and related resources in the region. Seven of the GCDs are also members of the West Texas Weather Modification Association, a group that performs rainfall enhancement activities in a seven-county area.

The GCDs are also required to participate in joint groundwater planning through Groundwater Management Areas (GMAs). There are 16 GMAs in the State of Texas whose boundaries generally coincide with major aquifers. Each GMA is tasked with determining Desired Future Conditions for the aquifers in the management area for planning purposes. There are four GMAs that include one or more counties in Region F: GMA-7, GMA-3, GMA-2, and GMA-8 (Figure 1-17). Additional information on GCDs, the GMA process, and groundwater availability is included in Chapter 3.

In areas, where no there is no GCD, the state may designate a Priority Groundwater Management Area (PGMA). The Priority Groundwater Management Area (PGMA) process is initiated by the TCEQ, who designates a PGMA when an area is experiencing critical groundwater problems, or is expected to do so within 25 years. These problems include shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, or contamination of groundwater supplies.

Table 1-11
Groundwater Pumping by County and Aquifer 2016 (Values in Acre-Feet)

County	Edwards-Trinity Plateau	Ogallala	Pecos Valley	Lipan	Hickory	Dockum	Trinity	Ellen-berger-San Saba	Marble Falls	Edwards-Trinity High Plains	Rustler	Capitan Reef Complex	Igneous	Other[a]	*Total*
Andrews	2	19,815	138	0	0	10	0	0	0	0	0	0	0	1,360	21,325
Borden	0	2,008	0	0	0	23	0	0	0	9	0	0	0	521	2,561
Brown	0	0	0	0	0	0	958	0	0	0	0	0	0	95	1,053
Coke	92	0	0	0	0	0	0	0	0	0	0	0	0	706	798
Coleman	0	0	0	0	0	0	0	0	0	0	0	0	0	65	65
Concho	149	0	0	2,642	425	0	0	0	0	0	0	0	0	1,792	5,008
Crane	0	0	1,055	0	0	175	0	0	0	0	0	0	0	29	1,259
Crockett	1,578	0	0	0	0	2	0	0	0	0	0	0	0	1,054	2,634
Ector	2,453	165	0	0	0	67	10	0	0	0	0	0	0	255	2,950
Glasscock	32,455	4,849	0	0	0	0	0	0	0	0	0	0	0	3,000	40,304
Howard	1,585	2,932	0	0	0	314**	0	0	0	0	0	0	0	3,604	8,435
Irion	419	0	0	1,132*	0	1	0	0	0	0	0	0	0	0*	1,552
Kimble	272	0	0	0	25	0	2	4	0	0	0	0	0	255	558
Loving	0	0	36	0	0	19	0	0	0	0	1	0	0	1,192	1,248
Martin	0	30,190	0	0	0	0**	0	0	0	0	0	0	0	4,505	34,695
Mason	10	0	0	0	5,798	0	1	73	0	0	0	0	0	244	6,126
McCulloch	77	0	0	0	8,941	0	0	198	17	0	0	0	0	119	9,352
Menard	376	0	0	0	400	0	0	4	0	0	0	0	0	207	987
Midland	5,978	6,055	0	0	0	1**	0	0	0	0	0	0	0	11,996	24,030
Mitchell	0	0	1	0	0	13,413	0	0	0	0	0	0	0	17	13,431
Pecos	94,824	0	40,771	0	0	0	0	0	0	0	4,271	3,206	0	11,975	155,047
Reagan	20,918	0	0	0	0	78	0	0	0	0	0	0	0	3,730	24,726
Reeves	6,625	0	44,873	0	0	2,332	0	0	0	0	3,014	0	372	3,691	60,907
Runnels	13	0	0	29	0	0	0	0	0	0	0	0	0	3,267	3,309
Schleicher	2,978	0	0	0	0	0	0	0	0	0	0	0	0	7	2,985
Scurry	0	0	0	0	0	6,981	0	0	0	0	0	0	0	56	7,037
Sterling	460	0	0*	469*	0	7	0	0	0	0	0	0	0	69*	1,005
Sutton	2,167	0	0	0	0	0	0	0	0	0	0	0	0	182	2,349
Tom Green	1,657	0	0	25,065	0	0	0	0	0	0	0	0	0	16,413	43,135
Upton	6,868	116	1	0	0	117	0	0	0	0	0	0	0	5,063	12,165
Ward	0	0	6,989	0	0	35	0	0	0	0	2	0	0	922	7,948
Winkler	2	0	9,364	0	0	1,473	0	0	0	0	0	0	0	549	11,388
Total	181,958	66,130	103,297	27,736	15,589	25,048	971	279	17	9	7,288	3,206	372	78,472	510,372

a. "Other" aquifer category is the sum of groundwater pumping from aquifers not listed and unknown sources of pumping

*Reclassified based on input from the Sterling County Underground Water District

**Historical use from the Dockum in Howard, Martin, and Midland counties is likely underestimated by the TWDB. The Dockum is being used for mining purposes in these counites.

Note: Data are from the Texas Water Development Board.[9]

Once an area is designated a PGMA, landowners have two years to create a Groundwater Conservation District (GCD). Otherwise, the TCEQ is required to create a GCD or to recommend that the area be added to an existing district. The TWDB works with the TCEQ to produce a legislative report every two years on the status of PGMAs in the state. The PGMA process is completely independent of the current Groundwater Management Area (GMA) process and each process has different goals. The goal of the PGMA process is to establish GCDs in these designated areas so that there will be a regulating entity to address the identified groundwater issues. PGMAs are still relevant as long as there remain portions within these designated areas without GCDs. There is one PGMA in Region F, the Reagan, Upton, and Midland County PGMA as shown in Figure 1-18.

There have been previous efforts to create GCDs in Upton and Midland Counties. In November 1991, landowners in Midland County attempted to join the Permian Basin UWCD but were unsuccessful. In 1999, House Bill 437 proposed to expand the authority of the existing Upton County Water District, and subsequently failed.

The Santa Rita UWCD (created in 1989) includes all but 65,000 acres of Reagan County, which were incorporated into the existing Glasscock GCD in 1989 and 1990, when landowners petitioned to join the Glasscock GCD. The Reagan, Upton and Midland County PGMA was designated in 1990. The name of the PGMA is somewhat of a misnomer because it only includes portions of Midland and Upton Counties as shown in Figure 1-16. All portions of Reagan County are included in either Glasscock or Santa Rita GCD.

The TCEQ Executive Director is authorized to petition the Commission to establish groundwater management in PGMAs in areas that have no GCD. The Executive Director of the TCEQ published a final report in February 2017 addressing the options available to the portions of Midland and Upton Counties that are located within the PGMA boundary[11].

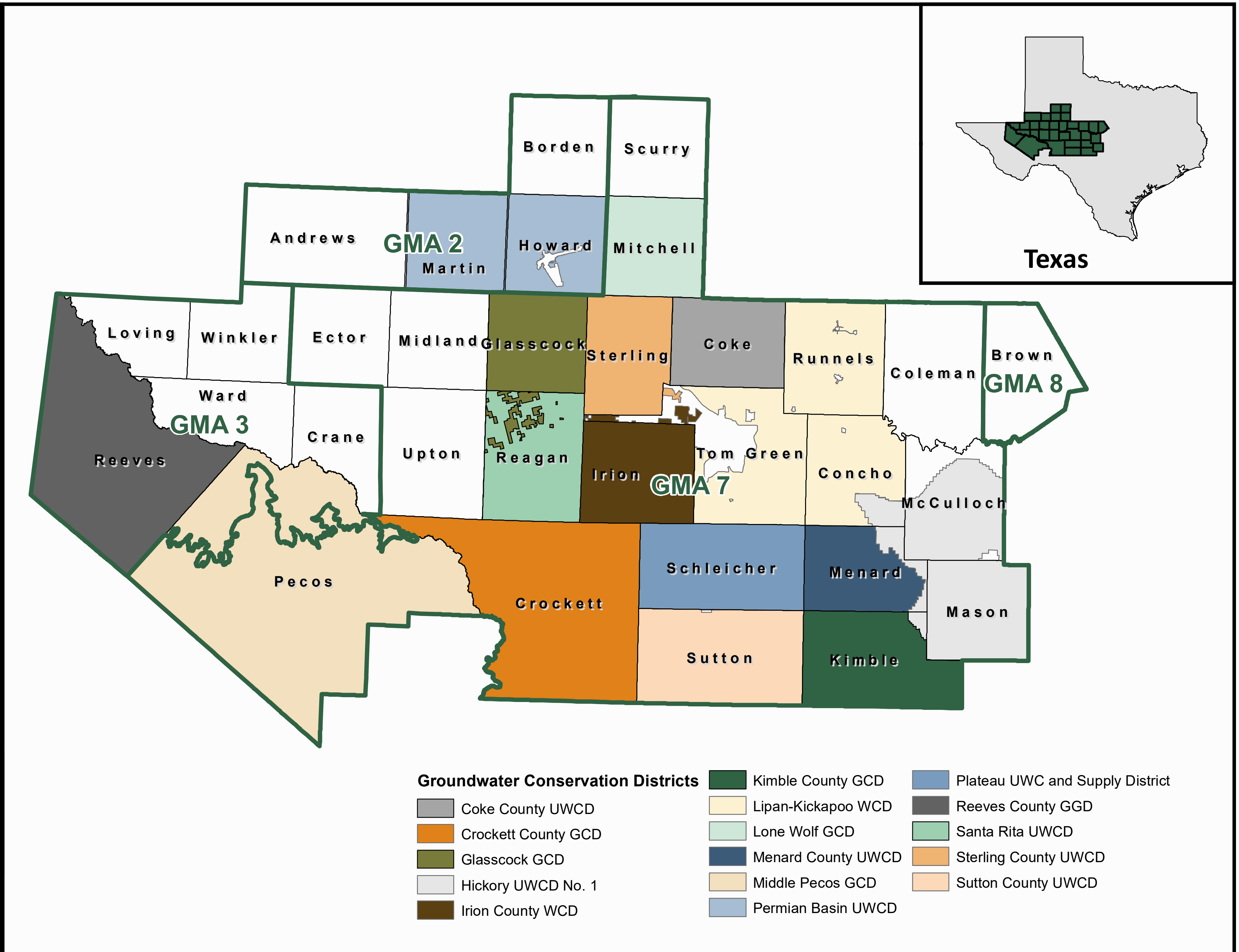
In this report, the Executive Director recommended that the TCEQ issue an order for option 1, to add the PGMA-bound portions of both counties to the Glasscock GCD, due to its feasible, practical, and economic benefits for landowners in the PGMA to secure groundwater management of the Edwards-Trinity Plateau aquifer. As of this time, no order has been issued by TCEQ and no county commissioner's court has promulgated groundwater regulations or availability values for areas within the PGMA that have no GCD. However, TCEQ administrative actions will continue for the establishment of groundwater management in these areas and the matter is proceeding to the contested case process at the State Office of Administrative Hearings[7].

Options proposed by TCEQ for PGMA Area:

- Adding PGMA-bound portions of both counties to the Glasscock GCD (Option 1),
- Adding PGMA-bound portions of both counties to the Santa Rita GCD (Option 2),
- Add the PGMA-bound portion of Midland County to the Glasscock GCD and add the PGMA-bound portion of Upton County to the Santa Rita GCD (Option 3),
- Create a new and separate GCD for the portions in both counties (Option 4), or
- Create two new GCDs for the portions in both counties splitting the GCDs at the county line (Option 4).

Groundwater Conservation Districts and Groundwater Management Areas

Region F



Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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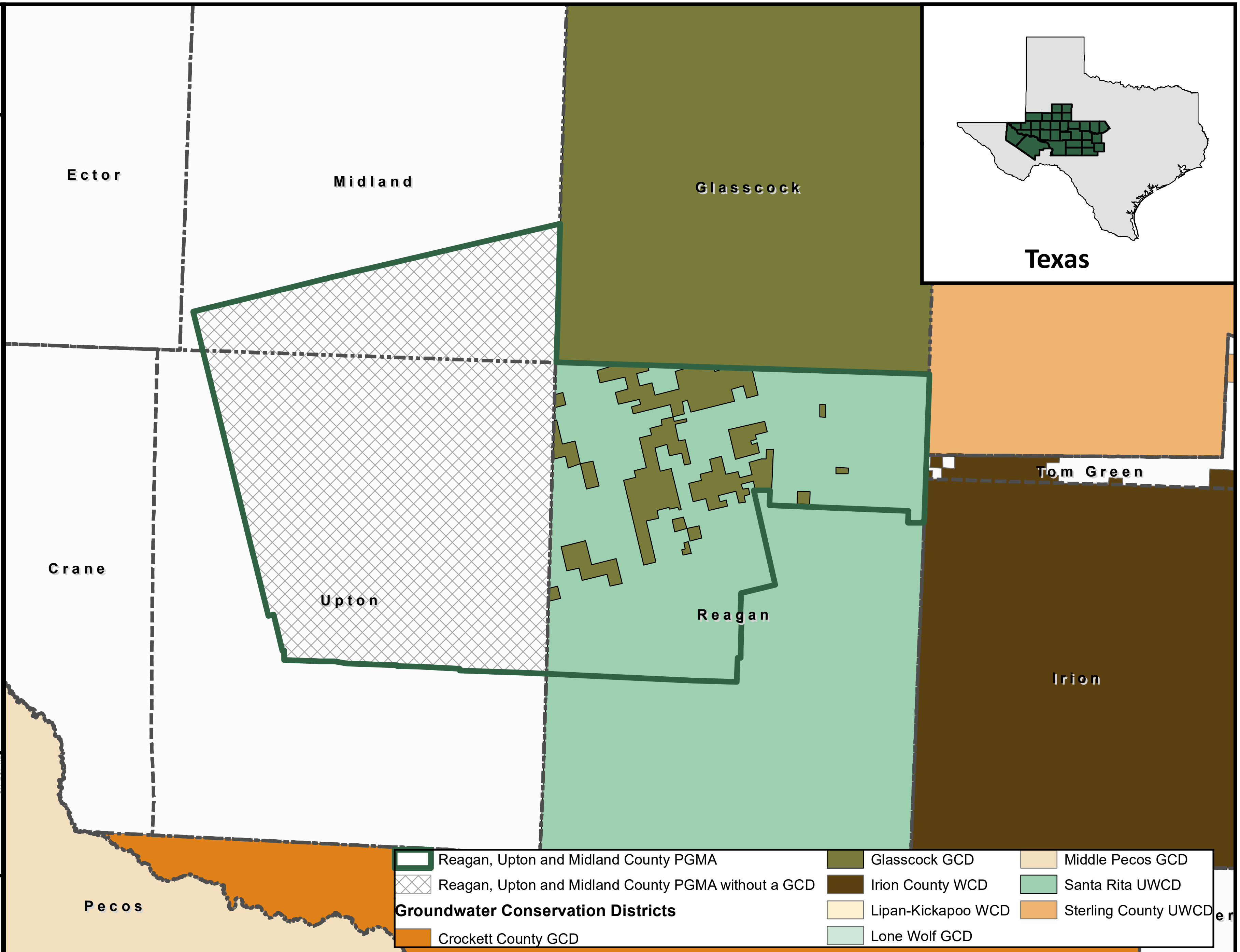
FIGURE 1-17



Region F

Groundwater Conservation Districts and Priority Groundwater Management Area

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FIGURE 1-18

1.3.3 Springs in Region F

Springs in Region F have been important sources of water supply since prehistoric times and have had great influence on early transportation routes and patterns of settlement. However, groundwater development and the resulting water level declines have caused some springs to disappear over time and have greatly diminished the flow from many of those that remain. Even though spring flows are declining throughout the region due to groundwater development, brush infestation, and climatic conditions, many springs are still important sources of water. Several rivers in Region F have significant spring-fed flows, including tributary creeks to the Concho and the San Saba Rivers, which are directly or indirectly used for municipal and irrigation purposes in the region.

Many springs are also important to the region for natural resources purposes. The Diamond Y Springs in northern Pecos County stopped flowing in 2018 but have maintained very low discharge volumes since that occurred. The Balmorhea spring complex in southern Reeves County flow continuously and are important habitat for endangered species. Also, in Pecos County, the historically significant Comanche Springs flow occasionally during winter months when there is less stress on the underlying aquifer.

The Region F Planning Group has identified 14 major springs in the region that are important for water supply or natural resources protection. Figure 1-19 contains a map of the major springs in Region F. For convenience, the following spring descriptions are grouped into related geographic areas. Discussions pertaining to the historical significance of these springs are taken from *Springs of Texas*, by Gunner Brune.[12,13]

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 has resulted in diminishing flows from these springs.

San Solomon Springs are in Balmorhea State Park and are the largest spring in Reeves County. The spring's importance begins with its

Region F Springs:

- Anson Springs
- Balmorhea Area Springs
- Clear Creek (or Wilkinson) Springs
- Comanche Springs
- Diamond Y Springs
- Dove Creek Springs
- East Sandia Springs
- Giffin Springs
- Kickapoo Spring
- Lipan Spring
- Rocky Creek Springs
- San Saba Springs
- San Solomon Springs
- Santa Rosa Spring
- Spring Creek Springs
- West Sandia Springs

recreational use, then its habitat for endangered species in the ditches leading from the pool,[14] 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 and 30 cubic feet per second (cfs). After strong rains, the spring flow often increases rapidly and becomes somewhat turbid. These bursts in spring flow 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 3 and 4 cfs. Discharge from Giffin Springs responds much more closely to precipitation than 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. 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.[15] 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. The Nature Conservancy manages the 246-acre Sandia Springs Preserve to sustain the unique spring habitat and its vulnerable species.

Fort Stockton Area Springs

Comanche Springs flow 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) are 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. The springs stopped flowing in 2018 but have maintained very low discharge volumes since that occurred.

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 (or 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 spring flow 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 (or Government or Main Springs) are 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 (or Wilkinson Springs) form 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.

Major Springs

Region F

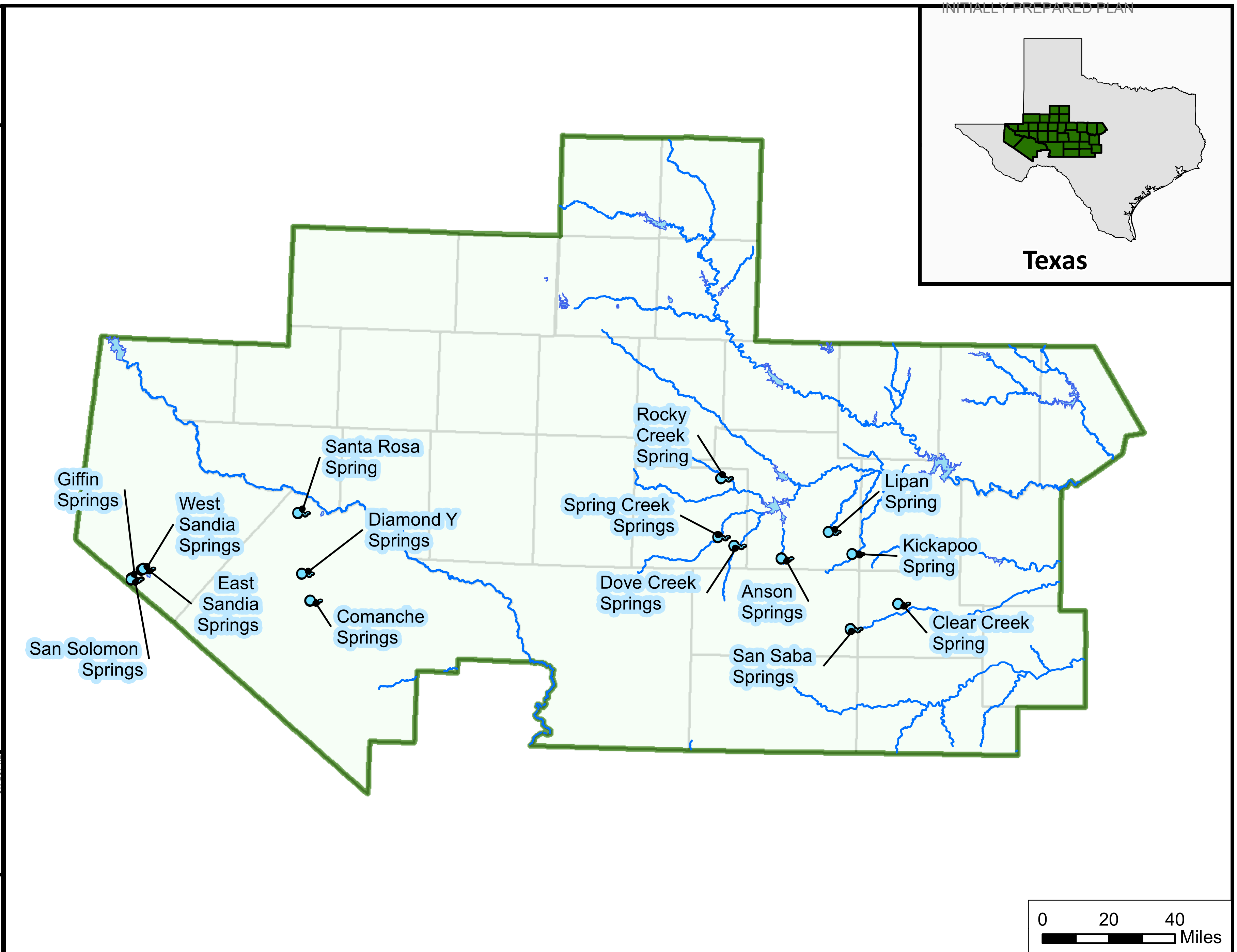

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FIGURE 1-19

Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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1.4 AGRICULTURAL AND NATURAL RESOURCES IN REGION F

This section describes agricultural and natural resources in Region F. Specifically, it addresses the endangered and threatened species known to be present or potentially present in the region. It also describes the natural resources, including prime farmland, agricultural, and mineral resources.

1.4.1 Endangered or Threatened Species

Table 1-12 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 any 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. There are nine federal and sixteen state species listed as endangered that are known to, or may occur, in counties in Region F. The Northern Aplomado Falcon, Whooping Crane, and Rio Grande Silvery Minnow are the federally listed endangered species most frequently cited in Table 1-12 for counties in Region F. The Black-capped Viero and Pecos Gambusia are the state listed endangered species most frequently cited in Table 1-12 for counties in Region F.

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. There are 44 species identified by the state as threatened or endangered that are known to, or may potentially occur in Region F.

Table 1-12
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
Bald Eagle	*Haliaeetus leucocephalus*	R	T	B	B	B	B	B	B	B	S	B	B	B	B	B	F	B	B	B	B	B	B	S	B		B	B	B	B	S	B	B	B	B
Black-Capped Vireo	*Vireo atricapilla*	R	E				B	B	B		B		F	F	B	B			B	B	B		F	B	B		B	B		B	B	B	F		
Common Black-Hawk	*Buteogallus anthracinus*		T																													S			
Golden-Cheeked Warbler	*Setophaga chrysoparia*	E	E													B			B		F														
Lesser Prairie-Chicken	*Falco femoralis septentrionalis*	C		F														F																	
Least Tern	*Sterna antillarum*	E																														F			
Mexican Spotted Owl	*Strix occidentalis lucida*	T																						F		F									
Northern Aplomado Falcon	*Tympanuchus pallidicinctus*	E		F								F					F							F		F								F	F
Piping Plover	*Charadrius melodus*	T			F																								F						
Red Knot	*Calidris canutus rufa*	T		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Reddish Egret	*Egretta rufescens*		T																							S									
Sooty Tern	*Onychoprion fuscatus*		T				S																									S			
White-Faced Ibis	*Plegadis chihi*		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
Whooping Crane	*Grus americana*	E	E			B		B										F	F	F															
Zone-Tailed Hawk	*Buteo albonotatus*		T			S	S		S		S		S		S	S			S	S	S	S		S	S	S		S		S	S	S	S		
Crustaceans																																			
Diminutive Amphipod	*Gammarus hyalelloides*	E	E														F							F		B								F	
Pecos Amphipod	*Gammarus pecos*	E	E																					B											
Fish																																			
Blue Sucker	*Cycleptus elongatus*		T	S		S	S	S	S	S	S	S	S	S			S			S			S	S		S	S	S	S		S	S	S	S	S
Clear Creek Gambusia	*Gambusia heterochir*		E																		B														
Comanche Springs Pupfish	*Cyprinodon elegans*		E																					S		B									
Devils River Minnow	*Dionda diaboli*		T								S																	S			S				
Leon Springs Pupfish	*Cyprinodon bovinus*		E																					B											
Pecos Gambusia	*Gambusia nobilis*		E							S	S													B		B									
Pecos Pupfish	*Cyprinodon pecosensis*		T							S	S						S							S		S							S	S	S
Proserpine Shiner	*Cyprinella proserpina*		T							S	S													S	S						S	S	S		
Rio Grande Darter	*Etheostoma grahami*		T							S	S													S							S	S	S		
Rio Grande Silvery Minnow	*Hybognathus amarus*	E									F													F		F									
Sharpnose Shiner	*Notropis oxyrhynchus*	E																											F						
Smalleye Shiner	*Notropis buccula*	E			F																								F						
Mammals																																			
White-Nosed Coati	*Nasua narica*		T								S					S															S				
Reptiles																																			
Brazos Water Snake	*Nerodia harteri*		T				S	S	S											S			S				S					S			
Chihuahuan Desert Lyre Snake	*Trimorphodon vilkinsonii*		T								S																				S				
Chihuahuan Mud Turtle	*Kinosternon hirtipes murrayi*		T																										S						
Concho Water Snake	*Nerodia paucimaculata*	R				F	F	F	F											F			F				F					F			
Mountain Short-Horned Lizard	*Phrynosoma hernandesi*		T																										S						
Reticulate Collared Lizard	*Crotaphytus reticulatus*		T								S																								
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	S	S
Texas Tortoise	*Gopherus berlandieri*		T			S		S								S															S				
Trans-Pecos Black-Headed Snake	*Tantilla cucullata*		T																					S											
Lloyd's Mariposa Cactus	*Echinomastus mariposensis*																							F											
Pecos Sunflower	*Helianthus paradoxus*	T	T																					B		B									

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
Texas Poppy-Mallow	*Callirhoe scabriuscula*	R	E				B																B				B		S						
Tobusch Fishhook Cactus	*Sclerocactus brevihamatus ssp. tobuschii*	T	E													B																			
Mollusks																																			
Diamond Y Springsnail	*Pseudotryonia adamantina*		E																					B											
False Spike Mussel	*Fusconaia mitchelli*	C	T			F		F	B							B			B	B	B						F	F			F				
Gonzales Tryonia	*Tryonia circumstriata*		E																					B											
Pecos Assiminea Snail	*Assiminea pecos*		E																					B		B									
Phantom Springsnail	*Pyrgulopsis texana*		E																							B									
Phantom Tryonia	*Tryonia cheatumi*		E																					S		B									
Smooth Pimpleback	*Quadrula houstonensis*	C	T			B	F	S	B							F			S	S	S						S								
Texas Fatmucket	*Lampsilis bracteata*	C	T			F	B	B	B		F				B	B			B	B	B						B	B			B	B			
Texas Fawnsfoot	*Truncilla macrodon*		T			S		S	S						S	S			S	S	S						S					S			
Texas Hornshell	*Popenaias popeii*		T							S	S						S							S		S								S	
Texas Pimpleback	*Cyclonaias petrina*	C	T			B		B	B							S			B	B	B		F				B	F		B	F	B			

***Status:**
T - Threatened
E - Endangered
R - Recovery
C - Candidate

Key:
F - Federal listings only (US Fish and Wildlife Service. 2019. Endangered Species List. http://www.fws.gov/endangered/)
S - State listings only (Texas parks and Wildlife Department. 2019. Annotated County Lists of Rare Species. http://tpwd.texas.gov/gis/rtest/)[16]
B - both Federal and State listings

1.4.2 Agriculture and Prime Farmland

Agriculture plays a significant role in the economy of Region F. Table 1-13 provides basic data regarding agricultural production in Region F.[17] Region F includes approximately 22,342,000 acres in farms and over 2,420,000 acres of potential cropland. In 2017, the market value of agriculture products (crops and livestock) for Region F was over $717,000,000, with livestock accounting for approximately 50 percent of the total.

Figure 1-20 shows the distribution of prime farmland in Region F.[18] 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 1-20** represents the percentage of the total acreage that is considered prime farmland of any kind.

A number of counties in Region F have significant prime farmland acreage. Those with the largest acreage include Andrews, Crockett, Pecos, Reeves, Sutton, and Tom Green Counties. These six counties accounted for about 18 percent of the total land in farms and 44 percent of the total crop value for Region F in 2017.

It is interesting to note that major agricultural production also occurs in some counties with a relatively small amount of prime farmland. For example, Brown, Glasscock, Martin, Runnels, and Scurry Counties have 10 percent or less acreage identified as prime farmland. However, these five counties combined accounted for approximately 24 percent of the total land in farms and 24 percent of the crop value for the region in 2017.

Texas Criteria for Prime Farmland:

- Moisture Most of Region F lies in Zone 3, which must have water capacity >4 inches in the upper 40-inch zone
- Temperature must be > 32 degrees at a depth of 20 inches
- pH should be between 4.5 and 8.4
- Mineral characteristics (salinity and calcium carbonate)
- Flooding occurs less than once in 2 years
- Slope and erosion considerations (including wind erodibility)
- Permeability rate > 0.6 inch per hour
- Rock fragments limited based on size

Table 1-13
2017 U.S. Department of Agriculture County Census Data for Region F

Category	Andrews	Borden	Brown	Coke	Coleman	Concho	Crane	Crockett
Farms	156	127	1,838	449	976	396	30	219
Irrigated Land (acres)	12,823	2,214	4,080	749	709	4,265	(D)	13
Land in Farms (acres)								
- Crop Land[a]	78,257	90,753	76,623	42,989	146,339	108,538	222	6,266
- Pasture Land	805,283	396,182	364,878	410,458	472,806	417,448	243,832	1,514,135
- Other	3,225	7,494	105,267	15,856	53,136	35,011	41	13,705
- Total	886,765	494,429	546,768	469,303	672,281	560,997	244,095	1,534,106
Market Value ($1,000)								
- Crops	$5,128	$17,039	$9,245	$1,253	$13,354	$13,389	(D)	(D)
- Livestock	$5,487	$11,749	$36,725	$6,586	$16,988	$14,730	(D)	(D)
- Total	$10,615	$28,788	$45,970	$7,839	$30,342	$28,119	(D)	(D)

Category	Ector	Glasscock	Howard	Irion	Kimble	Loving	Martin	Mason
Farms	275	175	373	175	602	8	356	680
Irrigated Land (acres)	881	39,669	6,925	923	8,506	(D)	12,227	3,935
Land in Farms (acres)								
- Crop Land[a]	1,891	180,347	148,291	4,349	15,535	(D)	298,913	21,761
- Pasture Land	548,732	311,171	342,072	594,105	700,515	467,485	136,372	457,747
- Other	7,266	4,696	30,600	14,193	84,590	(D)	9,273	59,905
- Total	557,889	496,214	520,963	612,647	694,230	468,140	444,558	539,413
Market Value ($1,000)								
Crops	$256	$47,444	$20,266	$301	(D)	(D)	$52,494	$2,316
Livestock	$3,126	$3,201	$6,600	$8,974	$6,709	(D)	$1,804	$19,363
Total	$3,382	$50,645	$26,866	$9,275	$6,709	(D)	$54,298	$21,679

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

Table 1-13 (Cont'd)
2017 U.S. Department of Agriculture County Census Data for Region F

Category	McCulloch	Menard	Midland	Mitchell	Pecos	Reagan	Reeves	Runnels
Farms	682	346	410	362	309	112	224	833
Irrigated Land (acres)	1,936	1,152	7,404	3,039	12,887	8,098	8,138	5,563
Land in Farms (acres)								
- Crop Land[a]	83,660	10,541	75,819	153,108	50,780	55,572	54,659	256,203
- Pasture Land	443,595	469,138	239,436	419,021	(D)	652,405	996,558	392,384
- Other	35,855	27,888	29,733	10,888	(D)	28,355	12,682	23,717
- Total	563,110	507,567	344,988	583,017	2,867,712	736,332	1,063,899	672,304
Market Value ($1,000)								
Crops	$6,856	$567	$13,013	$13,584	$24,371	$11,947	$5,175	$31,877
Livestock	$15,635	$8,505	$3,326	$8,158	$21,793	$6,256	$5,716	$21,557
Total	$22,491	$9,072	$16,339	$21,742	$46,164	$18,203	$10,891	$53,434

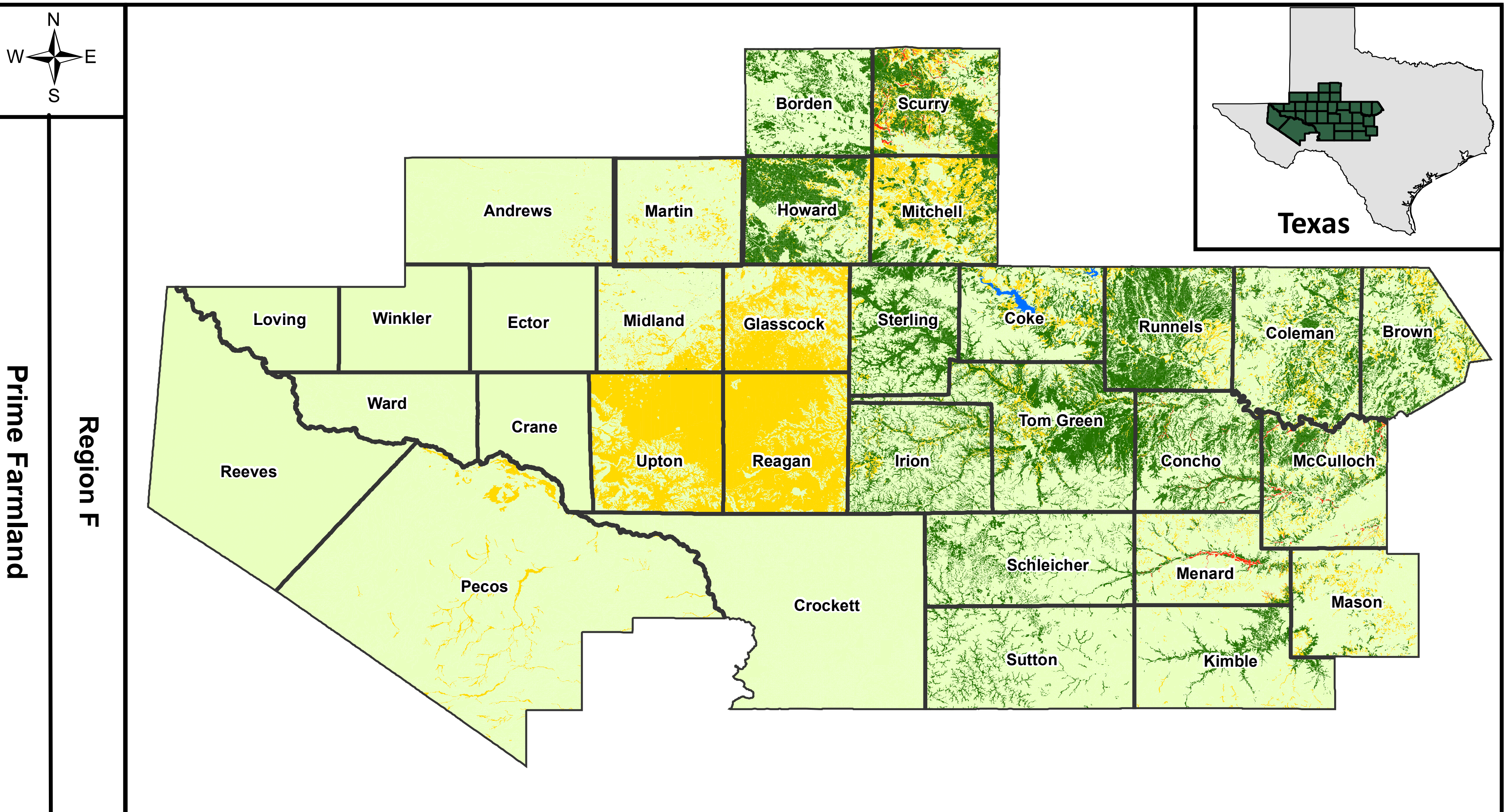
Category	Schleicher	Scurry	Sterling	Sutton	Tom Green	Upton	Ward	Winkler	Total
Farms	327	560	76	261	1,303	98	102	46	12,886
Irrigated Land (acres)	1,412	5,509	411	341	19,604	15,778	3,276	(D)	192,467
Land in Farms (acres)									
- Crop Land[a]	30,559	201,705	9,421	12,412	125,014	74,922	6,457	(D)	2,421,906
- Pasture Land	777,107	312,248	574,488	851,546	668,092	(D)	396,350	479,950	15,855,539
- Other	3,316	16,851	381	36,906	19,779	(D)	2,983	(D)	693,592
- Total	810,982	530,804	584,290	900,864	812,885	725,139	405,790	489,230	22,341,711
Market Value ($1,000)									
Crops	$3,439	$24,361	(D)	$131	$29,864	$13,873	(D)	(D)	361,543
Livestock	$14,351	$20,791	(D)	$10,219	$70,166	$5,190	$1,361	(D)	355,066
Total	$17,790	$45,152	(D)	$10,350	$100,030	$19,063	$1,361	(D)	716,609

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, 2017).[17]



Legend

- All areas are prime farmland
- Not prime farmland
- Prime farmland if irrigated
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Water
- Counties

Prime Farmland

Region F

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FIGURE 1-20

Coordinate System: GCS WGS 1984

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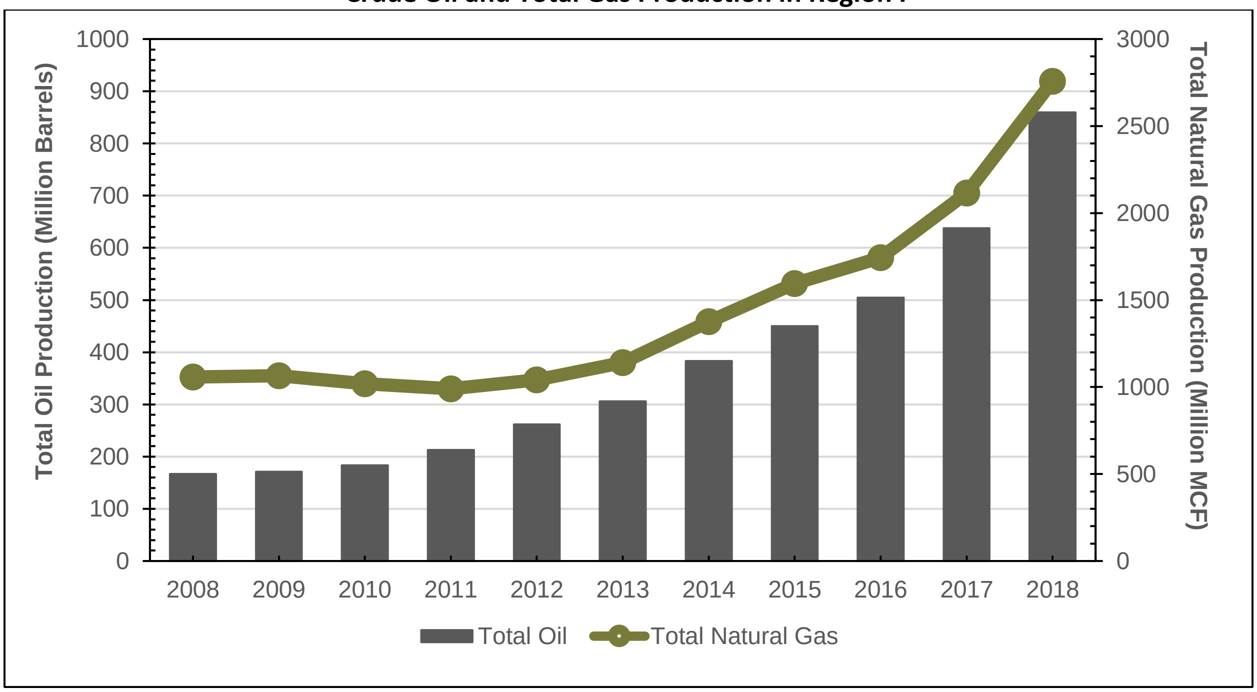
1.4.3 Mineral Resources

Oil and natural gas fields are significant natural resources throughout Region F. Recent developments in drilling technology along with increased commodity prices have led to significant oil and gas production in the Permian Basin. Other significant mineral resources in Region F include bituminous coal resources in Brown, Coleman, and McCulloch Counties, and stone, sand and gravel in various parts of the region.

Petroleum Production

Oil and gas fields are a valuable natural resource throughout most of Region F. As discussed previously in Section 1.1.1, the petroleum industry heavily influences the Region F economy. Over the last decade, Region F has experienced a notable increase in oil and gas production, as technological advancements have made it feasible for companies to develop petroleum in the continental United States. In particular, the Permian Basin (Figure 1-5), which underlies a significant portion of the counties in Region F, has experienced a rapid growth and has become the second largest producer of oil and gas shale in the world[19]. According to data from the Railroad Commission of Texas, annual total oil production (including crude oil and condensate) has increased by over 400% and annual total natural gas (including gas well gas and casinghead gas) production has increased by over 150% in Region F since 2008 (Figure 1-21)[20].

Figure 1-21
Crude Oil and Total Gas Production in Region F

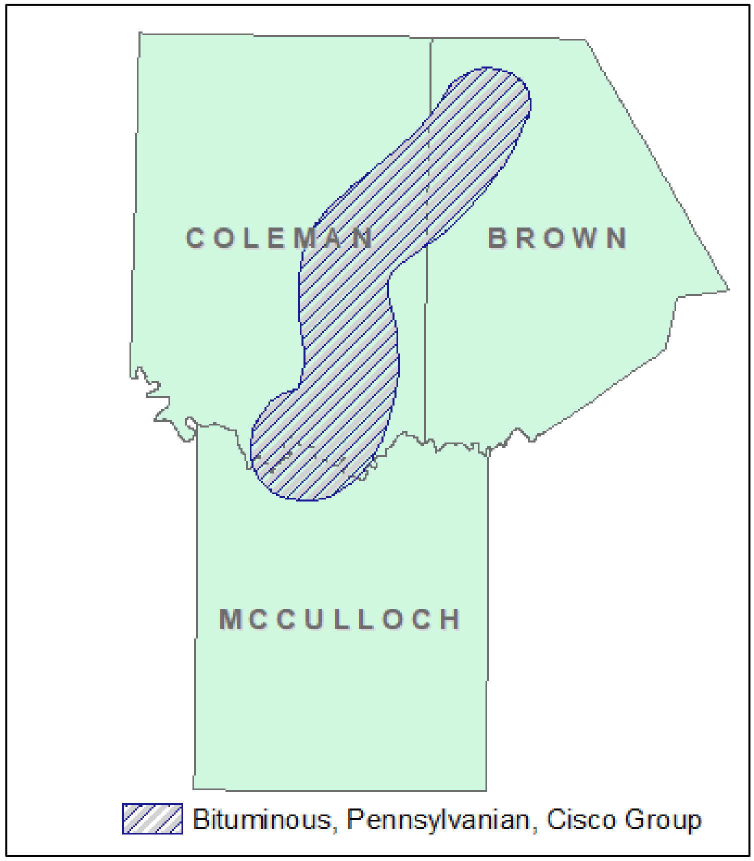


Counties in Region F play an integral role in oil and gas production throughout the state of Texas. In fact, in the year 2018, Region F counties accounted for over 55% of the state's total oil production and over 30% of state's total natural gas production[20]. Six of the top ten largest total oil producing counties (Midland, Reeves, Loving, Martin, Upton, Howard) and three of the top ten largest total natural gas producing counties (Reeves, Loving and Midland) in the state of Texas are located in Region F. In 2018, Midland County alone produced 144.2 million barrels (BBL) of crude oil, which accounted for over 10% of the crude oil production in the entire state.

In 2018, every county in Region F, with the exception of Martin County, produced some form of oil (crude oil or condensate). Furthermore, in 2018, every county, with the exception of Martin and McCulloch Counties, produced some form of natural gas (gas well gas and/or casinghead gas). Figure 1-22and Figure 1-23 illustrate the distribution of total oil (BBL) and total natural gas (MCF) production in each Region F county during the year 2018, respectively.

Coal Mining

Mining activity for bituminous coal resources have historically occurred in Coleman, Brown, and McCulloch Counties in Region F[21]. The coal resources are historically mined in the Cisco Group, which consists of shale, lenticular sandstone, many thin beds of limestone, and minor amounts of coal. The group has a thickness of about 350 feet in outcrops along the west side of the Llano region in Brown and Coleman Counties. According to the Railroad Commission (RRC), there are a total of seven, five, and three historical mining sites in McCulloch, Coleman, and Brown Counties, respectively. These mining sites are now part of the Abandoned Mine Land (AML) Program, which aims to reclaim and restore the land and water resources within previous mining areas. There are no active coal mining permits in Region F.



Region F

Total Oil Production (including Crude Oil and Condensate) by County (2018)

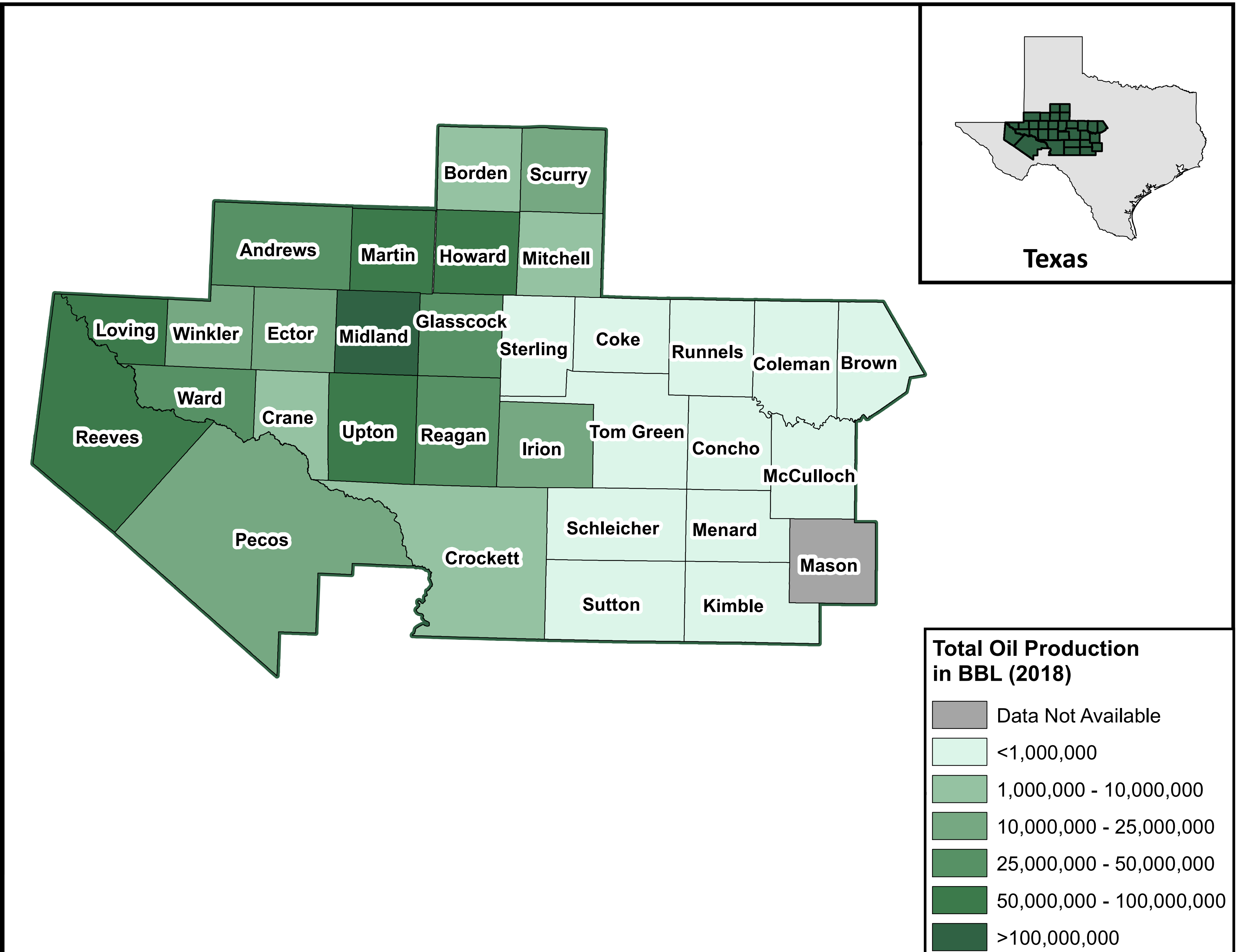


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FIGURE 1-22

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Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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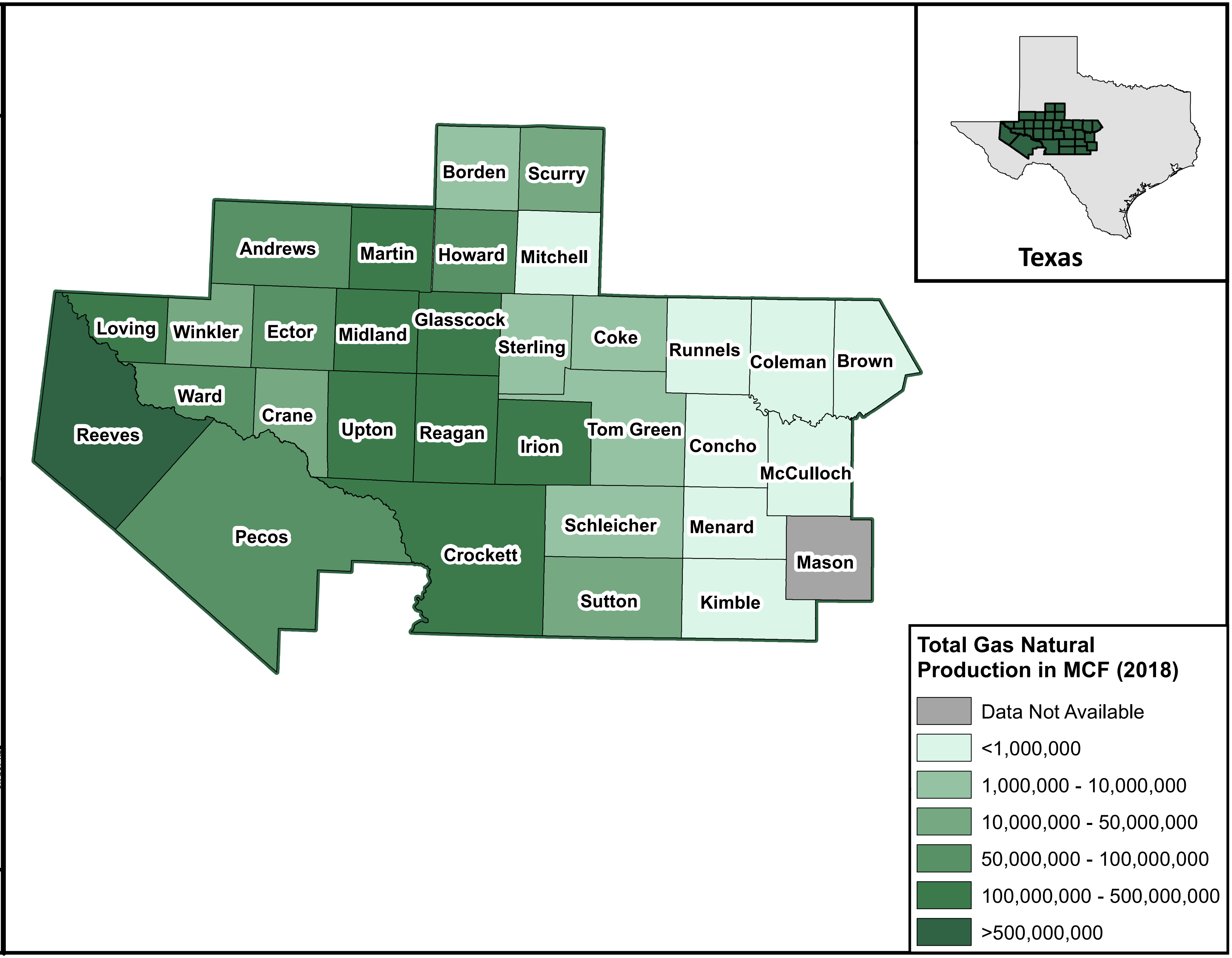

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Region F

Total Natural Gas Production (including Gas Well and Casinghead Gas) by County (2018)

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FIGURE 1-23

Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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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 Major Water Providers

The TWDB defines the term major water provider (MWP) as "a water user group or wholesale water provider of particular significance to the regions' water supply as determined by the RWPG."[22] Five major water providers have been identified by the Region F RWPG:

- Colorado River Municipal Water District (CRMWD)
- Brown County Water Improvement District Number One (BCWID)
- City of Odessa
- City of Midland
- City of San Angelo

There are no implications of designation as a "major water provider" except for the additional data required by TWDB. The major 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.

Brown County Water Improvement District Number One (BCWID).

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.

City of Midland

The City of Midland has several well fields for groundwater supply and purchases water from CRMWD. As the largest city in Region F, Midland provides retail water to over 134,000 municipal users and small quantities of water to manufacturing within city limits. In addition, Midland has a contract to sell treated wastewater effluent to the mining industry. Increased oil and gas activities in the Permian Basin (discussed in Section 1.4.3) around Midland have caused a rapid growth in city population and water service areas.

City of Odessa

The City of Odessa is a member city of CRMWD. Odessa sells retail and wholesale treated water to the Ector County Utility District, Ector County Other, and manufacturing users. In addition, Odessa sells raw wastewater to the Gulf Coast Water Authority (GCA) to treat and sell to the mining industry, as well as treated wastewater directly to the mining industry.

City of San Angelo

The City of San Angelo's sources of supply are Lake O.C. Fisher (water is purchased from Upper Colorado River Authority), Twin Buttes Reservoir, Lake Nasworthy, local surface water rights, and O.H. Ivie Reservoir (purchased from CRMWD). San Angelo also developed a groundwater supply from the Hickory aquifer near Melvin, Texas (McCullough County). As part of an agreement with UCRA, San Angelo treats water for customers of UCRA. San Angelo also provides water to the Goodfellow Air Force Base.

1.6 EXISTING PLANS FOR WATER SUPPLY DEVELOPMENT

In 2017, the Texas Water Development Board released the State Water Plan, Water for Texas – 2017, which was a compilation of the 16 regional water plans developed under SB1.[23] The Region F Water Planning Group published the Region F Regional Water Plan in January 2016. Some of the findings of the 2016 Region F plan included:

- Approximately 70 water user groups had projected water shortages over the planning period (through 2070). In the event of a drought Region F was projected to have a total water supply shortage of 183,000 acre-feet by 2020 and 237,000 acre-feet by 2070. Many of these shortages were associated with diminishing supplies under new drought of record conditions and decreased groundwater due to a new definition of availability. In total, 291 water management strategies and 145 projects were developed to address these needs.
- Groundwater availability was significantly lower in the 2016 plan compared to previous plans due to the new definition of groundwater availability. In accordance with TWDB rules, the groundwater availability in the 2016 plan was determined by estimates from the Modeled Available Groundwater (MAG). This was the first cycle of planning that required groundwater estimates developed through the state-sponsored groundwater joint planning process.
- Decreases in surface water availability were attributed to ongoing drought of record conditions, which reduced reservoir yields from the TCEQ WAM priority analysis of surface water supplies. Also, the priority analysis does not reflect actual surface water operation in the Upper Colorado River Basin. Subordination of Lower Colorado River Basin water rights provide a significant amount of surface water supplies to Region F. However, these supplies were less in the 2016 regional plan than previous plans, due to ongoing drought conditions.
- The majority of water supply deficits were associated with irrigated agriculture. Sixteen counties had a collective irrigation need of nearly 114,000 acre-feet per year by 2020 and 110,000 acre-feet by 2070. No water supply is readily available to meet this need. Improved irrigation efficiency strategies 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.
- A relatively small volume of municipal needs remained unmet in Region F in large cities, e.g., Midland and Andrews. Studies are planned to assess potential options for future water supplies. Additionally, conservation was recommended as a strategy to reduce unmet needs and protect human health and safety.
- General water management strategies recommended in the plan included: subordination, water conservation, brush control, weather modification, wastewater reuse, and desalination.
- Water conservation strategies accounted for 48 percent of the total volume associated with all recommended strategies in 2070. The majority of this volume is associated with irrigation demand reduction. Conservation strategies were also recommended for discrete municipal and other (rural municipal) water users.
- Innovative technologies, such as direct potable reuse, aquifer storage and recovery (ASR), and groundwater desalination accounted for approximately 7 percent of the total volume of recommended strategies in 2070.

The City of San Angelo recently completed a Water Supply Engineering Feasibility Study.[24] The study considered twenty-four possible water supply options and completed a detailed assessment of four options. One of those options was groundwater and three were different versions of potable reuse. The study recommended a potable reuse strategy termed the "Concho River Water Supply" which entailed potable reuse of Concho River water. This option provided the lowest unit cost, the highest yield, and improves the treatment infrastructure of the City.

The cities of Abilene, Midland, and San Angelo formed the West Texas Water Partnership (the Partnership) to evaluate long-term water supplies the Partnership could develop jointly. The Partnership is conducting a separate study to determine the most feasible water management strategies for these cities, but the results were not available at the writing of this plan.

There are no known publicly available plans for agricultural, manufacturing, and commercial water users in Region F. To the extent these types of plans are known, they are considered by the Region F Water Planning Group in the development of the Regional Water Plan.

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 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. This plan recommends water conservation for all cities including those without shortages. As part of this plan, model water conservation plans can be accessed online at www.regionfwater.org and clicking on the Documents tab (http://regionfwater.org/index.aspx?id=Documents). These models can serve as templates for entities to develop or update their water conservation plan. More information on water conservation planning, including recommended strategies to conserve water may be found in Subchapter 5B.

1.6.2 Water Loss Audits

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 water audit reporting requirements follow the International Water Association (IWA) and American Water Works Association (AWWA) Water Loss Control Committee methodology.[25]

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 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, 24 public water suppliers submitted a water loss audit to TWDB[26]. The average total water loss for Region

F is 14.5 percent. The amount of reported losses in Region F totaled 1.1 billion gallons in 2017. This represents 6.8 percent of the total estimated municipal water demand for the region. This information was used in developing municipal conservation strategies. Table 1-14summarizes the water loss audit information that was collected by the TWDB for 2017. The region encourages the reduction in water loss where feasible.

Table 1-14
Summary of TWDB Water Loss Audits

Total Water Loss	WUGS	SUDS/WSCs
≤ 10%	14	0
10% - 25%	4	0
≥ 25%	2	4

Source: 2017 Water Loss Audit Dataset from TWDB[26]

1.6.3 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. The Lower Colorado River Authority (LCRA) determined that the 2008-2016 drought surpassed the historic drought-of-record from the 1950s for LCRA's Highland Lakes and the lower basin and is now the new drought of record. This is significant for Region F because some of the eastern portion of Region F is in the watershed for the Highland Lakes System, which is located in Region K, east of Region F. The low inflows into the Highland Lakes parallels the lower than normal runoff that has occurred in Region F as well. A detailed discussion of the impact of drought on water supplies and water suppliers is included in Chapter 7.

Model drought contingency plans were developed for Region F and can be accessed online at www.regionfwater.org. Each plan identifies four drought stages: mild, moderate, severe and emergency. The recommended responses range from notification of drought conditions and voluntary reductions in the "mild" stage to mandatory restrictions during an "emergency" stage. Entities using the model plan can select the trigger conditions for the different stages and appropriate responses for each stage.

1.6.4 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, Water Supply Enhancement Program, 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. Among its many other provisions, SB1 set out formal criteria for the permitting of interbasin transfers for water supply.

Texas Pollutant Discharge Elimination System (TPDES) Program

The TPDES is the state program to carry out the National Pollutant Discharge Elimination System (NPDES) promulgated under the Clean Water Act. The Railroad Commission of Texas maintains authority in Texas over discharges associated with oil, gas, and geothermal exploration and development activities. The TPDES program covers all permitting, inspection, public assistance, and enforcement associated with:

- discharges of industrial or municipal waste;
- discharges and land application of manure from concentrated animal feeding

operations;

- discharges of industrial and construction site storm water;
- discharges of storm water associated with city storm sewers;
- oversight of municipal pretreatment programs; and
- disposal and use of sewage sludge.

Wellhead Protection Areas

The Texas Water Code provides for a wellhead source water protection zone around public water supply wells extending to activities within a 0.25 mile radius. Specific types of sources of potential contamination within this wellhead/source water protection zone may be further restricted by TCEQ rule or regulation. For example, wellhead/source water protection zones have been designated for many public water supply wells within or near Pantex (May and Block, 1997). More specific information on well head protection zones is available from TCEQ.

The Texas Water Code further provides for all wells to be designed and constructed according to TCEQ well construction standards (30 TAC 290). These standards require new wells to be encased with concrete extending down to a depth of 20 feet, or to the water table or a restrictive layer, whichever is the lesser. An impervious concrete seal must extend at least 2 feet laterally around the well head and a riser installed at least 1 foot high above the impervious seal.

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.[27]

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." [28]

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 and infrastructure projects that may affect wetlands or rivers. 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.

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 and updated the Implementation Plan (further information on the updated plan is included in Section 1.7.1).

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.[29] 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.

Water Supply Enhancement Program

The Water Supply Enhancement Program, formerly known as the State Brush Control Program, was developed pursuant to Chapter 203 of the Texas Agricultural Code. Feasibility studies have been conducted for seven watersheds in the region including Lake Brownwood, O.C. Fisher, O.H. Ivie Lake Basin, E.V. Spence, Lake J.B. Thomas, Twin Buttes Reservoir, and Upper Llano River. These projects are discussed further in Subchapter 5C.

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. 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 5C.

Bio-Terrorism Preparedness and Response Act

Following the events of September 11th, Congress passed the Bio-Terrorism Preparedness and Response Act. Drinking water utilities serving more than 3,300 people were required and have completed vulnerability preparedness assessments and response plans for their water, wastewater, and stormwater facilities. The U.S. Environmental Protection Agency (EPA) funded the development of three voluntary guidance documents, which provide practical advice on improving security in facilities of all sizes. The guidance document for water utilities can be found through the American Water Works Association.

1.7 SUMMARY OF THREATS AND CONSTRAINTS TO WATER SUPPLY

1.7.1 Threats to Water Supply

Threats to water supply in Region F include:

- Water quality concerns in several areas of the region,
- The impact of drought,
- Changes in groundwater regulation,
- Rainfall/runoff patterns in the Upper Colorado River Basin, and
- Strict enforcement of State's Priority System for Surface Water.

Brief discussions of each of these concerns is presented in this section. The water quality concerns are discussed by source. 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. Surface water quality concerns identified by the TCEQ within Region F are summarized in Table 1-15. The Region F Plan was developed under the guiding principal that the designated water quality and related water uses shall be improved or maintained.

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, chlorides, and sulfates. 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.[30] 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. In 2007, the TCEQ adopted Two Total Maximum Daily Loads for Chlorides and Total Dissolved Solids for the Colorado River below the E.V. Spence Reservoir. Later that year, the TCEQ approved the Implementation plan (I-plan) to achieve the pollutant reduction identified in the TMDL report.[31] The Railroad Commission has since eliminated many potential sources of contamination and the Texas State Soil and Water Conservation Board removed salt cedar in the watershed. Prior to the current drought, the salinity levels in the segment of stream were improving. However, the drought has lowered water levels in Spence, leading to a re-concentration of chloride and TDS. In 2014, the Upper Colorado River Authority (UCRA) and TCEQ updated the I-plan. In 2016, stakeholders met to discuss progress of the I-Plan to evaluate actions taken, identify actions that may not be working, and make any changes necessary. Continued monitoring of the area should show improving water quality as the I- Plan is implemented.[32]

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.[33] Further analysis of data collected near Paint Rock shows an increasing trend in chloride, which is likely attributed to lower inflows from the Lipan aquifer due to drought, increased irrigation withdrawals, and brush infestation.[34]

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. The implementation of this program has proved to be successful as water quality has shown significant improvement and fish kills have been virtually eliminated. In 2016, water quality data in the North Concho River indicate that concentrations of E. coli have decreased, and TCEQ proposed to remove the bacteria impairment from the list of impaired waters[35].

Table 1-15
Summary of Identified Surface Water Quality Problems in Region F

<table>
<tr><th>Segment ID</th><th>Segment Name</th><th>Concern Location</th><th>Water Quality Concern</th><th>Status</th></tr>
<tr><td>1411</td><td>E.V. Spence Reservoir</td><td>From Robert Lee Dam in Coke County to a point immediately upstream of the confluence of Little Silver Creek in Coke County, up to the normal pool elevation of 1898 feet (impounds Colorado River)</td><td>Chloride</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td>1412</td><td>Colorado River Below J.B Thomas</td><td>From the confluence of Beals Creek upstream to the dam below Barber Reservoir pump station</td><td>bacteria</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td>1412 B</td><td>Beals Creek</td><td>From the confluence of Gutherie Draw upstream to the confluence of Mustang Draw and Sulphur Springs Draw in Howard County</td><td>bacteria</td><td>A review of the standards for one or more parameters will be conducted before a management strategy is selected, including the possible revision to the water quality standards.</td></tr>
<tr><td rowspan="3">1413</td><td rowspan="3">Lake J. B. Thomas</td><td rowspan="3">From Colorado River Dam in Scurry County up to normal pool elevation of 2258 feet (impounds Colorado River)</td><td>chloride</td><td rowspan="3">Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td>sulfate</td></tr>
<tr><td>total dissolved solids</td></tr>
<tr><td>1416</td><td>San Saba River</td><td>From the confluence with the Colorado River in San Saba County upstream to US 190</td><td>bacteria</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td>1416 A</td><td>Brady Creek</td><td>From FM 714 upstream to Brady Lake dam</td><td>depressed dissolved oxygen</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td>1421</td><td>Concho River</td><td>North Concho River, from the confluence with the South Concho River upstream to O.C. Fisher dam</td><td>depressed dissolved oxygen</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td rowspan="2">1425</td><td rowspan="2">O.C. Fisher Lake</td><td rowspan="2">From San Angelo Dam in Tom Green County up to normal pool elevation of 1908 feet (impounds North Concho River)</td><td>chloride</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td>total dissolved solids</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td>1432</td><td>Upper Pecan Bayou</td><td>From a point immediately upstream of the confluence of Willis Creek in Brown County to Lake Brownwood Dam in Brown County</td><td>bacteria</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td>2311</td><td>Upper Pecos River</td><td>From US Hwy 67 upstream to the Ward Two Irrigation Turnout</td><td>depressed dissolved oxygen</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td rowspan="2">2312</td><td rowspan="2">Red Bluff Reservoir</td><td rowspan="2">From Red Bluff Dam to mid-lake
From mid-lake to the Texas/New Mexico state line</td><td>chloride</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
<tr><td>sulfate</td><td>Additional data and information will be collected before a TMDL is scheduled.</td></tr>
</table>

Source: Data from 2016 Draft 303(d) list (October 17, 2018)[36]

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 while other users have implemented radionuclide removal systems. 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. Generally, agricultural use is not impaired by the presence of the radionuclides.

Dockum Aquifer

Water quality in the Dockum aquifer ranges from fresh (TDS < 1,000 mg/L) in outcrop areas and the edges of the depositional basin to brines with over 50,000 mg/L TDS in the center of the basin. Upward movement of water in some areas, such as Andrews County, can result in poorer water quality in the overlying Ogallala aquifer. In Ector County, Dockum wells produce groundwater with TDS concentrations between 2,000 and 7,000 mg/L and sulfate and chloride concentrations up to 2,500 mg/L from wells that are less than 750 feet deep. The presence of uranium minerals in the Dockum Group has long been recognized and is the source of some radiological constituents (radium-226 and -228) reported in some Dockum aquifer groundwater samples. The concentrations of some trace metals, including antimony, beryllium, cadmium, lead, mercury, selenium, and thallium, were reported to exceed drinking water regulatory limits in several counties.

Other Groundwater Quality Issues

Other groundwater quality issues in Region F include elevated levels of fluoride, nitrate, arsenic and perchlorate.

Table 1-16 shows the percentage of water wells sampled by the TWDB that exceed drinking water standards for dissolved fluoride, dissolved nitrate (nitrogen as NO_3), and dissolved 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 Borden, Howard, Martin, and Runnels Counties. The highest percentages of wells exceeding arsenic standards are found in Andrews, Borden, Howard, 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] Texas has not established an MCL for perchlorate. However, in 2001, TCEQ did establish an Interim Action Level (IAL) of 0.004 mg/L for perchlorate, and in its 2006 guidance for assessing the health of surface waters for the purposes of drinking water quality, TCEQ required monitoring and reporting of perchlorate levels that exceed 0.022 mg/L.[38]

Table 1-16
Percentage of Sampled Water Wells Exceeding Drinking Water Standards for Fluoride, Nitrate (as NO_3) and Arsenic

County	Fluoride	Nitrate	Arsenic
Andrews	27%	6%	38%
Borden	13%	33%	48%
Brown	2%	16%	0%
Coke	0%	3%	0%
Coleman	4%	24%	0%
Concho	1%	17%	0%
Crane	7%	18%	24%
Crockett	0%	0%	0%
Ector	3%	5%	24%
Glasscock	3%	13%	7%
Howard	16%	33%	35%
Irion	0%	0%	3%
Kimble	0%	9%	0%
Loving	0%	2%	6%
Martin	45%	35%	71%
Mason	0%	11%	0%
McCulloch	1%	5%	0%
Menard	0%	5%	0%
Midland	10%	9%	32%
Mitchell	6%	21%	0%
Pecos	0%	0%	0%
Reagan	1%	0%	3%
Reeves	2%	6%	6%
Runnels	0%	9%	1%
Schleicher	2%	74%	0%
Scurry	2%	14%	5%
Sterling	0%	1%	0%
Sutton	0%	0%	0%
Tom Green	0%	1%	0%
Upton	0%	14%	0%
Ward	0%	4%	0%
Winkler	1%	9%	1%

Data are from the Texas Water Development Board 06-2019[39]

Regional Drought

Most of Region F has experienced drought-of-record conditions since the mid-1990s. These conditions have led to reduced inflow, high evaporation and low lake levels limiting the supply. Many suppliers in the region responded by implementing their drought contingency plans and in some cases expedited implementation of water supply strategies. Drought conditions also have a negative impact on water quality. As water levels decline, reservoirs tend to concentrate dissolved materials. Without significant freshwater inflows the water quality in a reservoir degrades. The lack of recharge to aquifers has a similar effect on groundwater. A detailed discussion of the impact of drought on water supplies and water suppliers is included in Chapter 7.

Changes in Groundwater Regulation

Changes in groundwater regulation can have a major impact on water supply in Region F, especially during drought conditions when surface water is not available. Recent droughts have helped identify the importance of groundwater supplies to Region F and how they serve to balance water supply sources and serve as a critical safety net for several major cities in the region. Many cities and wholesale water providers plan to use surface water and groundwater conjunctively to optimize and maximize water supplies in the region by using as much surface water as possible when it is available in order to reduce evaporation losses and to conserve groundwater. When surface water is not available, groundwater will be used as necessary to meet demands. This shift towards a fully-integrated conjunctive use approach is dependent upon adequate groundwater availability during drought conditions. If groundwater availability is reduced (either physically or through regulatory restrictions), the safety net for the region can be significantly impaired. Under current law, and in counties with GCDs to enforce Desired Future Conditions (DFCs), groundwater availability could be significantly reduced by adoption of more restrictive DFCs. Additionally, TWDB funding for water projects might be limited by DFCs and MAGs even in areas without GCDs where physical groundwater availability is adequate to meet projected demands.

Rainfall and Runoff Patterns in the Upper Colorado River Basin

Region F surface water supply is heavily dependent upon consistent streamflow (runoff) throughout the Colorado River Basin. In 2017, a detailed evaluation of historical rainfall-runoff patterns in the Upper Colorado River Basin determined that observed flow trends have declined over the period of record (1940-2016)[40]. Analysis of naturalized flows from the Colorado Basin WAM indicated that most of this diminishing trend is likely caused by construction of large reservoir systems and historical water use, which are both associated with existing water rights in the basin area. Additionally, all sites in the study demonstrated some decline in naturalized flow, signifying that activities not accounted for in the naturalization flow process could have impacted observed flows. Further investigations determined that four activities had some effect on the trend of observed and naturalized flows over the study period: (1) the proliferation of noxious brush; (2) the construction of small reservoirs, not accounted for in naturalized flows; (3) groundwater use and aquifer water level declines; and (4) changes in average temperature in drought conditions. If this declining trend of observed and naturalized flows continue, and these activities continue to cause negative effects, then threats to surface water supplies in the Upper Colorado River Basin will likely persist and could potentially magnify.

Strict Enforcement of State's Priority System for Surface Water

Texas surface water is governed by a priority system, which means "first in time, first in right." The TCEQ is charged with regulating the state's surface water, including issuing water rights and enforcing those rights. Historically, the TCEQ has only enforced the priority system when there was a request for water from a senior downstream water right holder, referred to as a priority call. Even then, the TCEQ would consider public health and safety when requiring pass-through of inflows from upstream to downstream users. With the development of the Water Availability Models (WAMs), which models strict interpretation of the priority system, it became apparent that many of the Region F reservoirs have little to no reliable supply, given that assumption. The WAM interpretation applies to the priority system to both storage and diversion that results in more water passed through to downstream water right holders than previously modeled for supply analyses.

During the recent drought (2011-2013), there were several priority calls across the state. As part of the response to these calls, TCEQ considered public health and safety as a factor in requiring pass-throughs. However, recent judicial decisions have stated that the state must enforce the priority system without regard to the type of use. If the state enforces the priority system in accordance with the assumptions in the WAMs, surface water supplies in Region F would be significantly impacted. More discussions on these impacts is included in Chapter 3 and Subchapter 5C.

1.7.2 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 and/or existing 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.

As previously discussed, 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 rural with limited resources. 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.

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.

1.8 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.

1.8.1 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. Based on current use, agricultural demand exceeds the available groundwater supply in several counties. Parts of three counties (Midland, Reagan and Upton) were declared a Priority Groundwater Management Area by the TCEQ in 1990. Since that time the Santa Rita GCD has formed for most of Reagan County with Glasscock GCD covering small portions of the county as well. In February 2017, the Executive Director of TCEQ provided a report for northeastern Upton and southeastern Midland Counties recommending these areas be added to the Glasscock GCD.

1.8.2 Water Related Threats to Natural Resources

Reservoir development and invasion by brush and giant reed 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 conditions.

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2 POPULATION AND WATER DEMANDS

In April 2018[1], the Texas Water Development Board (TWDB) approved population and water demand projections for Region F for use in the 2021 Regional Water Plan. The water demand projections include both municipal and non-municipal water use over the planning period of 2020 to 2070. As part of the 2021 Regional Water Plan update, the TWDB redefined municipal water users based on retail service area rather than by political city limit boundaries. This resulted in minor changes to population and municipal water demands for many municipal water providers. Non-municipal water demands were initially developed by the TWDB using updated information and new protocols. The Region F RWPG reviewed and revised the projections as needed to more accurately reflect the expected water demands for the region.

Continued interest in oil and gas production in the Permian Basin resulted in significant increases in projected mining water demand for 2020-2040 in parts of Region F. Municipal water demand projections were also revised to reflect the new population projections in certain counties due to oil and gas activities. In most cases, the baseline per capita usage from the 2016 Plan was maintained for the 2021 Plan, which was based on 2011 per capita use to represent dry year demands. However, due to prolonged extreme drought, some users experienced restricted deliveries during 2011, and the historical use was not representative of a dry year demand and was thus adjusted. Furthermore, some entities have experienced a declining trend in per capita usage in recent years due to permanent conservation measures implemented as a response to the recent drought. These include conservation-oriented rate structures and changed behavior patterns. These entities' baseline per capita use numbers were adjusted downward to capture the recent trends. Despite an increase in population, municipal water demands for the region decreased slightly from the previous plan.

Overall, water demand projections in Region F are estimated to be roughly 765,200 acre-feet in 2020 and decrease to about 744,400 acre-feet in 2070. Irrigation, steam electric power, livestock, and manufacturing demands are predicted to remain steady over the planning horizon. Mining demand is predicted to continue its upward trend, peaking at about 109,800 acre-feet in 2040. However, mining demand is expected to significantly decrease after 2040, with a predicted demand of only 34,500 acre-feet by 2070. This sizeable decrease in mining demand more than offsets the increase in municipal demand, which is projected to grow from roughly 137,700 acre-feet in 2020 to 190,300 acre-feet by 2070. Despite the increase in population and municipal demand over the planning horizon, the reduction in heavy mining demand results in an overall decreasing trend in total water demand over the planning horizon.

A Water User Group (WUG) is one of the following:

- Privately-owned utilities that provide an average of more than 100 acre-feet per year for municipal use for all owned water systems,
- Water systems serving institutions or facilities owned by the state or federal government that provide more than 100 acre-feet per year for municipal use,
- All other retail public utilities that provide more than 100 acre-feet per year for municipal use,
- Rural/unincorporated areas of municipal water use, known as County Other (aggregated on a county/basin basis),
- Manufacturing (aggregated on a county/basin basis),
- Steam electric power (aggregated on a county/basin basis),
- Mining (aggregated on a county/basin basis),
- Irrigation (aggregated on a county/basin basis), or
- Livestock (aggregated on a county/basin basis).

More detailed discussion of the development of population and water demands is presented in the following subsections. To understand the data development and presentation, it is important to understand the terminology used for regional water planning. The TWDB distributes its population and demand projections into Water User Groups (WUGs). Each WUG has an associated water demand. Only municipal WUGs have population projections.

The Region F Water Plan also recognizes wholesale water providers (WWPs) and major water providers (MWPs). A wholesale water provider is an entity that sells water wholesale to another water provider. These providers are considered in the development and understanding of how water is distributed in the region. However, demands for wholesale water providers are not specifically developed and presented in this chapter unless the WWP is also identified by the region as a MWP. The MWP is an entity selected by the RWPG as having a significant role in providing water in the region. A MWP may be a WUG or WWP. Region F has identified five MWPs for the 2021 Plan. Projected water demands for each MWP are discussed in Section 2.3.

To simplify the presentation of these data, all WUG projections in this chapter are aggregated by county. Projections divided by WUG, county and basin may be found in Appendix I, *Database (DB22) Reports*. The projections were developed by decade and cover the period from 2020 to 2070.

2.1 Population Projections

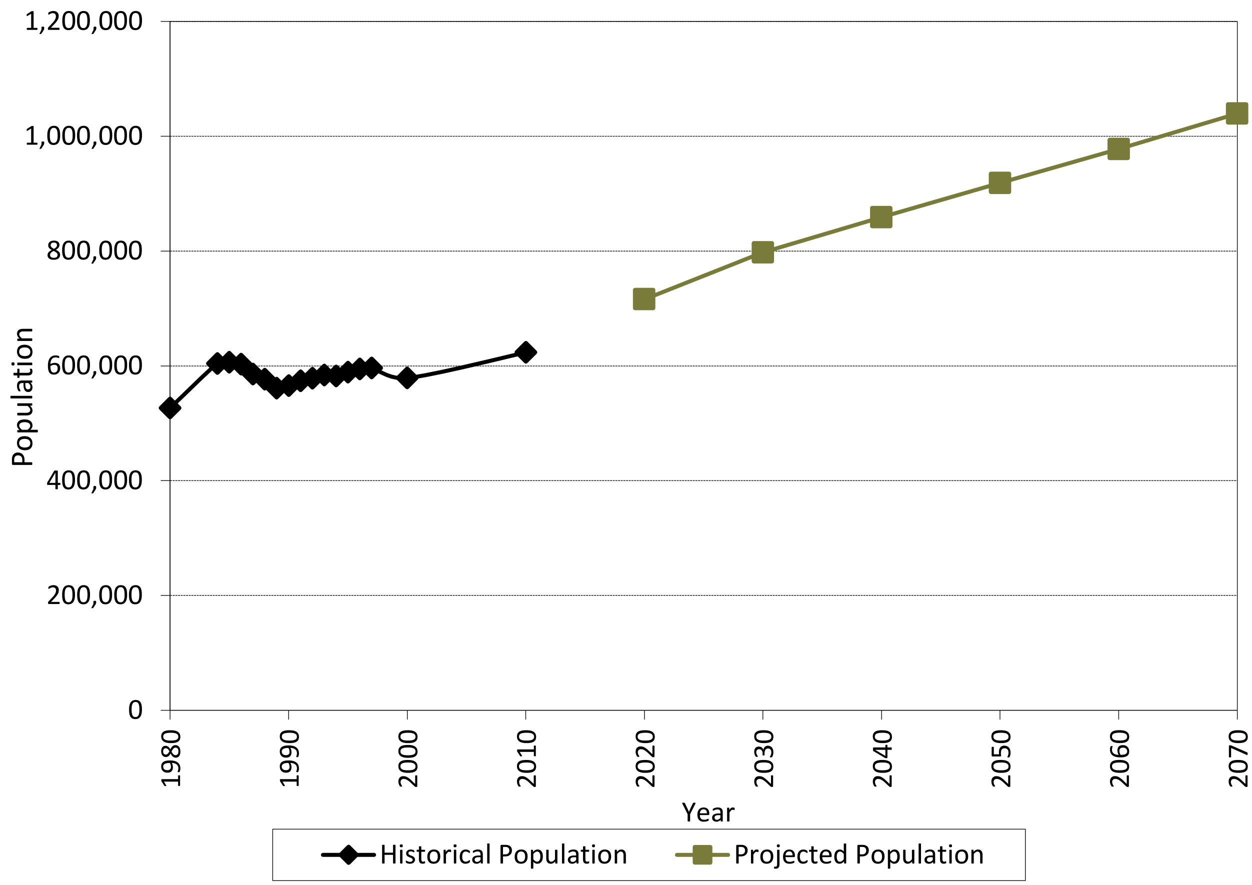
Table 2-1 presents the historical year 2010 and projected populations for the counties in Region F. Figure 2-1 compares the region's historical population from 1980 to 2010 and the projected population through 2070. Figure 2-2 shows the geographical distribution of the population projections for the years 2010 and 2070. Population projections divided by WUG, county and basin are included in the Appendix 2A at the end of this chapter.

Table 2-1
Historical and Projected Population by County

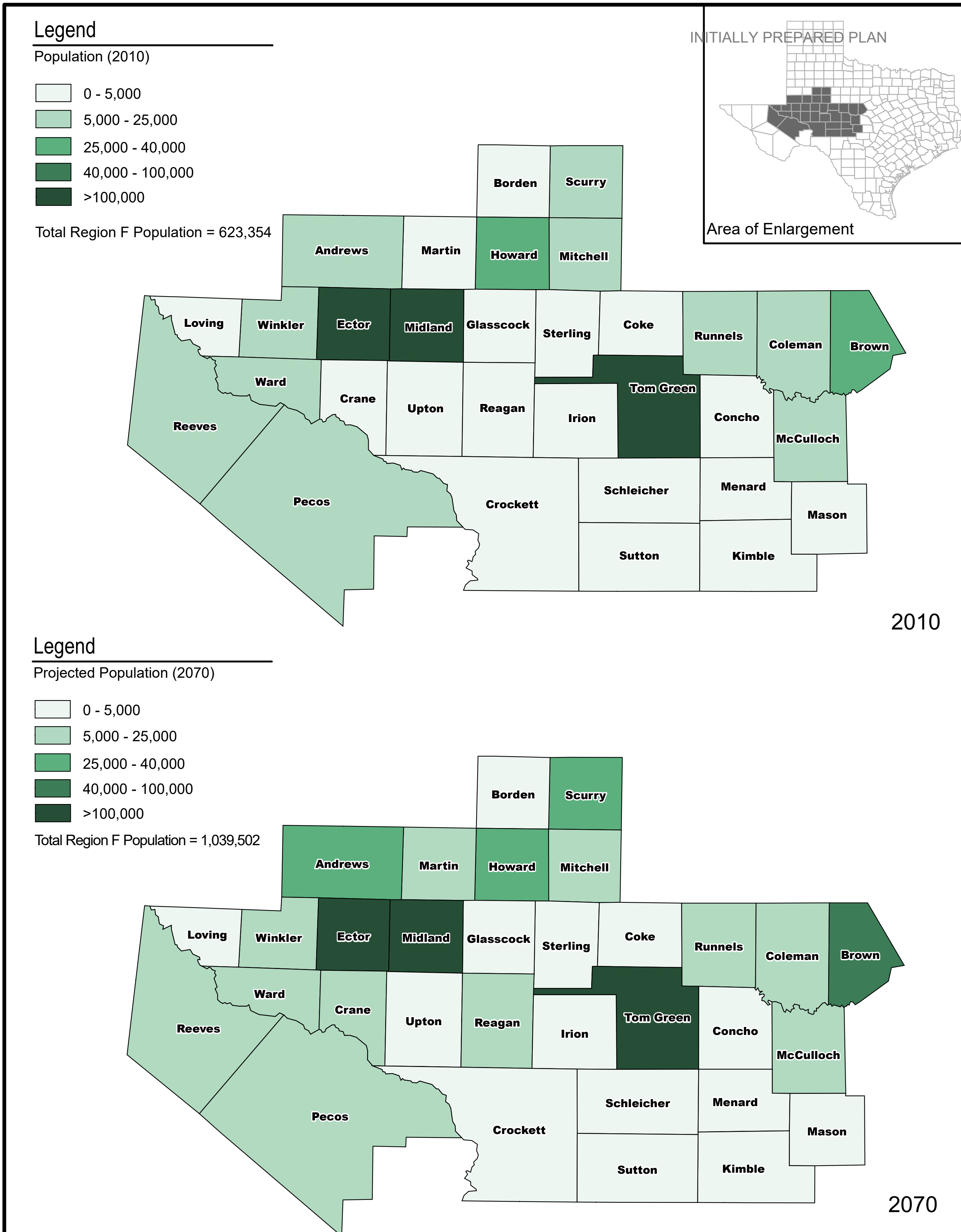
County	Historical[2]	Projected Population					
	2010	2020	2030	2040	2050	2060	2070
Andrews	14,786	19,089	22,847	26,246	30,111	34,526	39,574
Borden	641	659	671	671	671	671	671
Brown	38,106	39,761	40,717	40,717	40,717	40,717	40,717
Coke	3,320	3,320	3,320	3,320	3,320	3,320	3,320
Coleman	8,895	9,103	9,307	9,307	9,307	9,307	9,307
Concho	4,087	2,781	2,852	2,852	2,852	2,852	2,852
Crane	4,375	5,056	5,713	6,241	6,737	7,151	7,501
Crockett	3,719	4,111	4,386	4,446	4,486	4,500	4,506
Ector	137,130	164,289	187,604	210,926	233,048	255,083	278,740
Glasscock	1,226	1,341	1,429	1,429	1,429	1,429	1,429
Howard	35,012	37,310	38,936	39,603	39,603	39,603	39,603
Irion	1,599	1,684	1,702	1,702	1,702	1,702	1,702
Kimble	4,607	4,710	4,754	4,754	4,754	4,754	4,754
Loving	82	82	82	82	82	82	82
Martin	4,799	5,433	5,986	6,382	6,735	7,000	7,205
Mason	4,012	4,012	4,012	4,012	4,012	4,012	4,012
McCulloch	8,283	8,635	9,000	9,030	9,125	9,152	9,165
Menard	2,242	2,242	2,242	2,242	2,242	2,242	2,242
Midland	136,872	169,062	195,286	213,581	232,357	250,264	269,070

County	Historical[2]	Projected Population					
	2010	2020	2030	2040	2050	2060	2070
Mitchell	9,403	10,531	11,329	11,566	11,706	11,826	11,930
Pecos	15,507	17,718	19,224	20,802	22,021	23,109	24,090
Reagan	3,367	3,853	4,303	4,571	4,812	4,980	5,102
Reeves	13,783	15,125	16,193	17,057	17,650	18,106	18,443
Runnels	10,501	10,883	11,300	11,300	11,300	11,300	11,300
Schleicher	3,461	3,811	4,106	4,259	4,350	4,406	4,440
Scurry	16,921	19,911	22,497	24,249	26,236	28,246	30,322
Sterling	1,143	1,215	1,260	1,275	1,275	1,275	1,275
Sutton	4,128	3,817	4,094	4,198	4,279	4,322	4,347
Tom Green	110,224	123,052	137,486	145,685	154,230	163,215	172,642
Upton	3,355	3,690	3,990	4,128	4,272	4,360	4,421
Ward	10,658	11,454	12,144	12,634	13,029	13,329	13,557
Winkler	7,110	8,033	8,817	9,459	10,147	10,702	11,181
Total	*623,354*	*715,773*	*797,589*	*858,726*	*918,597*	*977,543*	*1,039,502*

Figure 2-1
Historical and Projected Population of Region F



Historical data provided by the Texas Water Development Board.[3] Some historical data are not available. Projected population was approved by TWDB for this round of regional water planning and adopted for this plan.



Region F

Population Distribution by County 2010-2070

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FIGURE 2-2

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The population projections for each county are derived from the 2010 U.S. Census. The projections use a standard methodology known as the cohort-component method. This method is based upon historical birth and survival rates of the region's population. More information on the methodology used for the population projections may be found in the TWDB publication Projection Methodology – Draft Population and Municipal Water Demands.[4]

TWDB projects the region's total population to increase from 715,773 in 2020 to 1,039,502 in 2070, an average growth rate of 0.90 percent per year. TWDB projects the total population for Texas to increase from 29,683,671 in 2020 to 51,458,748 in 2070, an average growth rate of 1.47 percent per year.

The relative distribution of population in Region F is expected to remain stable throughout the 50-year planning period. Almost 80 percent of the people in Region F live in urban areas or small- to moderate-sized rural communities. Three counties, Midland, Ector and Tom Green, account for more than half of the region's population. These counties contain the cities of Midland, Odessa and San Angelo, respectively. Each of these cities had a year 2010 population between 93,000 and 112,000, and a 2016 population estimate between 100,000 and 134,000. Some of the more rural communities are poised for growth should the oil and gas activities continue and expand into the adjoining shales in the Permian Basin.

Twenty-nine of the thirty-two counties that comprise Region F are generally rural. Twenty-one counties have populations of less than 10,000. Two of these counties, Loving and Borden, have populations of less than 1,000. These twenty-nine counties are expected to remain primarily rural throughout the planning period. The Permian Basin portions of Region F are experiencing or are expected to experience a population increase due to renewed interest in the exploration and production of oil, especially in Midland and Ector counties. This population growth is expected to continue as the oil play develops over the planning horizon.

2.2 Historical and Projected Water Demands

Municipal water use is the only category subdivided into individual water utilities. All other categories are aggregated into county/basin units.

Each category has annual water demand projections for the years 2020, 2030, 2040, 2050, 2060, and 2070. These projections are not the same as the average day and peak-day projections used in planning for municipal water supply distribution systems.

The average day projection is the amount of water expected to be delivered during a normal day. A peak-day projection is the maximum amount of water expected to be delivered during the highest demand day, typically expressed in million gallons per day (MGD). The TWDB water demand projections are the

TWDB Uses Six Water Use Categories

- **Municipal** – residential and commercial uses, including landscape irrigation,
- **Manufacturing** – various types of heavy industrial use,
- **Irrigation -** irrigated commercial agriculture,
- **Steam Electric Power Generation** – water consumed in the production of electricity,
- **Livestock Watering** – water used in commercial livestock production, and
- **Mining** – water used in the commercial production of various minerals, as well as water used in the production of oil and gas.

volumes of water expected to be used during a dry year and are usually expressed in acre-feet per year (one acre-foot equals 325,851 gallons). These projections would be comparable to a year's worth of average day deliveries.

The water demand projections for the 2021 Region F Plan were developed in conjunction with the TWDB and regional stakeholders. The Region F RWPG solicited input from retail water providers, including cities, water supply corporations, special utility districts, and other providers identified as a WUG. Region F representatives for non-municipal water use were also contacted for input on non-municipal demands. The projections were then compared to historical data and other projections and evaluated for anomalies such as recent water use exceeding future predictions, changes in trends in per capita water use, etc. The final recommended demands were approved by the region and the TWDB for the 2021 Region F Water Plan.

Figure 2-3 and Figure 2-4 present the TWDB-approved total water demand projections for the region by water-use type through 2070. Table 2-2 and Figure 2-5 summarize the water demand projections in the region by use category.

Figure 2-3
2020 Water Demand in Region F by Use

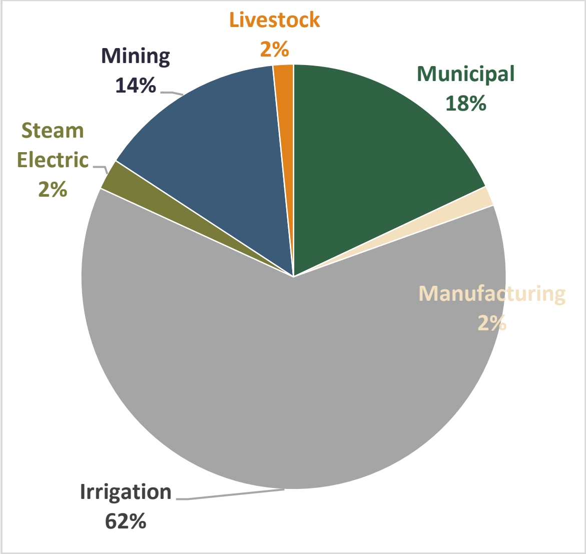
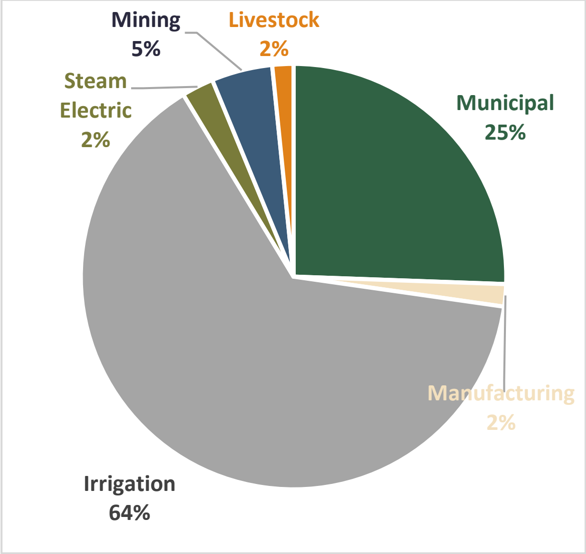


Figure 2-4
2070 Water Demand in Region F by Use



Water Demand by Use Category in Region F

Irrigated agriculture is by far the largest water use category in Region F throughout the planning horizon.
Municipal water use is the second largest water use category and it is projected to grow over time.
Mining is a significant water use in the early decades but is expected to decline over time as oil and gas deposits are fully developed.
Manufacturing, livestock, and steam electric power are all relatively small use categories in Region F over the planning horizon.

Table 2-2
Water Demand Projections for Region F by Use Category
-Values in Acre-Feet per Year-

Use Category	Historical	Projected					
	2010	2020	2030	2040	2050	2060	2070
Municipal	115,407	137,727	150,060	158,957	168,702	179,098	190,290
Manufacturing	9,753	11,591	12,607	12,607	12,607	12,607	12,607
Irrigation	458,658	476,941	476,941	476,941	476,941	476,941	476,941
Steam Electric	6,068	18,092	18,092	18,092	18,092	18,092	18,092
Mining	22,354	108,841	109,847	90,970	66,812	46,251	34,478
Livestock	13,905	11,958	11,958	11,958	11,958	11,958	11,958
Total	*626,145*	*765,150*	*779,505*	*769,525*	*755,112*	*744,947*	*744,366*

Source: Data are from the TWDB[5].

Figure 2-5
Projected Water Demand in Region F by Use Category

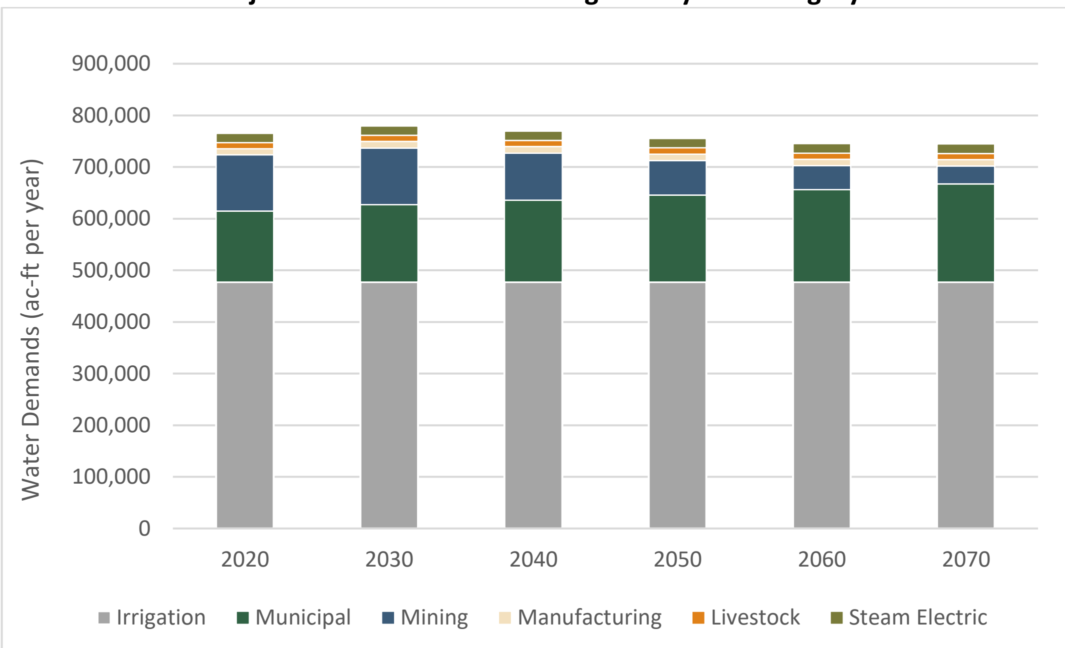
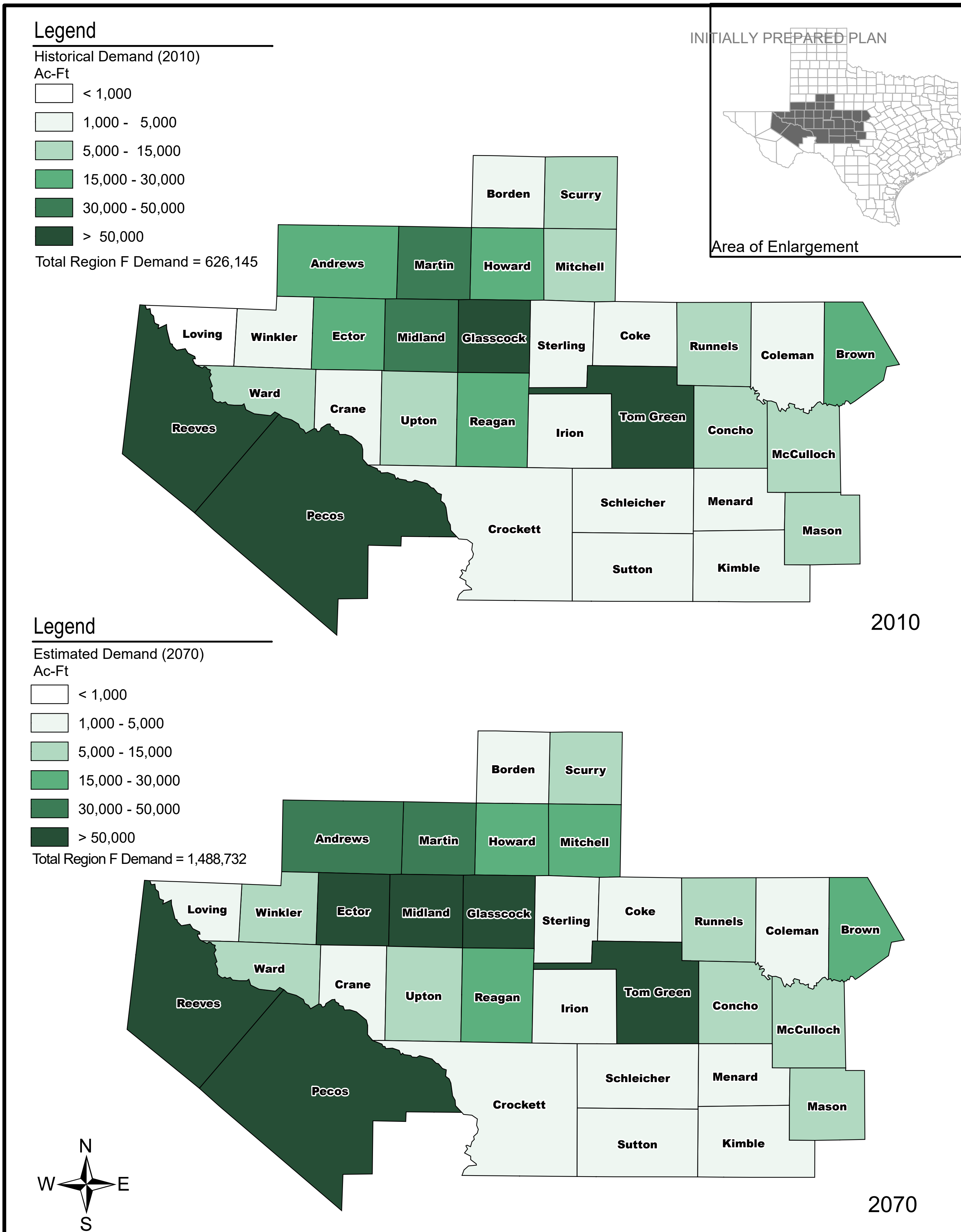


Table 2-3 summarizes the historical year 2010 use and the projected water use by county. Figure 2-6 shows the geographical distribution of the year 2010 historical water use and year 2070 total water demand projections by county. A discussion of the demand projections by each use type is presented in Sections 2.3.1 through 2.3.6.

Table 2-3
Total Historical and Projected Water Demand by County
-Values in Acre-Feet per Year-

County	Historical	Projected					
	2010	2020	2030	2040	2050	2060	2070
Andrews	28,083	29,833	30,505	30,772	31,059	31,608	32,472
Borden	2,180	3,981	4,229	4,083	3,793	3,543	3,420
Brown	17,423	16,790	16,878	16,753	16,683	16,665	16,661
Coke	2,028	2,169	2,148	2,083	2,024	1,975	1,933
Coleman	2,769	2,650	2,633	2,588	2,568	2,556	2,548
Concho	8,224	6,178	6,173	6,112	6,053	6,004	5,963
Crane	1,547	2,575	2,926	3,040	2,967	2,890	2,838
Crockett	2,315	6,736	6,838	5,450	4,066	2,871	2,574
Ector	28,743	39,201	43,140	46,313	49,433	52,781	56,583
Glasscock	58,316	57,487	57,499	56,094	54,794	53,693	53,093
Howard	15,934	22,067	22,237	21,247	20,193	19,379	19,079
Irion	2,268	6,096	6,092	4,786	3,483	2,483	1,983
Kimble	4,812	4,481	4,570	4,552	4,544	4,542	4,542
Loving	258	7,542	7,542	6,641	5,441	4,341	3,441
Martin	37,706	44,682	44,742	42,982	41,125	39,564	38,694
Mason	5,864	7,634	7,535	7,288	7,140	7,030	6,942
McCulloch	13,203	14,330	13,876	12,146	11,141	10,353	9,721
Menard	3,048	5,485	5,459	5,331	5,204	5,093	4,998
Midland	42,420	62,184	66,621	67,009	67,389	68,341	70,719
Mitchell	14,832	26,225	26,502	26,407	26,284	26,186	26,122
Pecos	132,030	158,139	158,559	159,011	157,851	156,781	155,982
Reagan	21,002	33,614	33,685	30,827	27,573	24,905	23,829
Reeves	63,896	76,288	76,518	76,225	74,174	72,188	70,677
Runnels	5,657	5,493	5,487	5,415	5,376	5,345	5,322
Schleicher	2,587	3,730	3,866	3,704	3,541	3,396	3,307
Scurry	9,365	11,244	11,709	11,895	12,011	12,150	12,340
Sterling	1,337	2,221	2,399	2,258	1,967	1,715	1,585
Sutton	2,728	3,199	3,538	3,599	3,427	3,255	3,137
Tom Green	67,915	66,035	67,983	68,945	70,090	71,501	73,026
Upton	12,014	19,091	19,189	17,722	15,864	14,390	13,708
Ward	10,747	10,954	11,091	10,983	10,687	10,368	10,131
Winkler	4,894	6,816	7,336	7,264	7,167	7,055	6,996
Total	*626,145*	*765,150*	*779,505*	*769,525*	*755,112*	*744,947*	*744,366*

Source: Data are from the TWDB.[5]



Region F

Water Demand Distribution by County 2010-2070

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FIGURE

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2.2.1 Municipal Water Demand Projections

Municipal water demand consists of both residential and commercial use, including water used for landscape irrigation. Residential use includes water used in single and multi-family households. Commercial use includes business establishments, public spaces and institutions, but does not include most industrial water use. Industrial water demand projections are included in the manufacturing category.

Municipal projections were developed for each retail water provider that provided an average of 100 acre-feet per year or more of municipal water supplies. TWDB aggregates rural populations that use less than 100 acre-feet per year into the County Other classification. The municipal projections are the only projections developed for individual water providers such as cities and other retail water providers. TWDB aggregates all other demand categories by county and river basin.

TWDB used a four-step process to calculate municipal water demands. First, population projections were developed for each municipal WUG. (Population projections are discussed in Section 2.2). Second, per capita water use projections were developed based on historical water use. Third, estimates of water savings associated with implementation of plumbing fixtures were calculated and per capita use was adjusted. Finally, the adjusted per capita water demand projections were multiplied by the population projections to determine the annual municipal water demand for each WUG.

Per Capita Water Use Projections

Future water use is calculated by multiplying the population of a region, county or city by a calculated per capita water use. Per capita water use, expressed in gallons per capita per day (gpcd), is the average daily municipal water use divided by the population of the area. It includes the amount of water used by each person in their daily activities, water used for commercial purposes, and landscape watering. This definition of per capita water use does not include water used for manufacturing or other non-municipal purposes (if it can be distinguished from other uses), or water sold to another entity. (This definition of per capita use is not the same as the definition adopted by the Water Conservation Implementation Task Force. The Task Force definition does not differentiate between municipal use and non-municipal use or outside sales.[6])

2011 was the worst single year drought for the State of Texas. The TWDB based the per capita water demand projections on year 2011 annual municipal water use divided by the 2011 population. For the 2021 Plan, the per capita use was adjusted to reflect service area use and population in 2011, resulting in some minor changes from the 2016 Plan, which also used 2011 per capita as its base gpcd. In some cases, the per capita water use was adjusted if the year 2011 water use was not indicative of historical water use by a WUG. In Region F, some WUGs were under water use restrictions in 2011 and their per capita water use was adjusted based on use in other years. For some WUGs in Region F, the drought of 2011 caused water conservation-oriented behavior changes, resulting in a trend towards lower per capita

$$\textit{Municipal Water Demand} = \textit{projected population} \times (\textit{historical gpcd} - \textit{estimated water savings})$$

usage. This trend is even greater than the expected plumbing code savings already incorporated into these plans. This is partially caused by the implementation of increasing rate structures by some providers to encourage water conservation. Thus, in some cases, the base per capita usage was lowered to reflect these changes.

The TWDB assumes that per capita water use will show a downward trend over the planning period as a result of the State Water-Efficiency Plumbing Act[7]. Among other things, the Plumbing Act requires that only water-saving plumbing fixtures may be sold in Texas. The TWDB determined the per capita water demand savings based upon the expected rate of replacement of old plumbing fixtures with water-conserving models and the number of new housing units expected in the region. The actual amount of estimated savings can vary somewhat depending upon the age of housing units in a WUG's service area.

Table 2-4 shows the average per capita water use for each decade in Region F and compares these values to average values for the state. Average per capita water use for Region F is expected to decline from 172 gpcd in 2020 to 163 gpcd in 2070, a reduction of seven percent. This compares to the statewide average of 157 gpcd in 2020 declining to 148 gpcd by 2070.

Demand

The TWDB calculated the municipal water demand projections by multiplying the population projections by the per capita water use projections. As shown in Table 2-5, the total municipal water demand for Region F is expected to increase from 137,727 acre-feet per year in 2020 to 190,290 acre-feet per year in 2070, an increase of 38 percent over the planning period. This compares to an expected 63 percent increase in municipal demand statewide.

The total estimated water savings associated with the implementation of the State Water-Efficiency Plumbing Act by county is presented in Table 2-6. Water-saving plumbing fixtures are expected to save over 20,300 acre-feet per year by 2070.

Table 2-4
Comparison of Per Capita Water Use and Municipal Conservation Trends

Region F	2020	2030	2040	2050	2060	2070
Per Capita Use (gpcd)	172	168	165	164	164	163
Statewide	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Per Capita Use (gpcd)	157	153	151	150	149	148

Source: Data are from TWDB.[5]

Municipal Water Demand Projections

Over the planning horizon, per capita water demands are expected to decline due to municipal conservation. However, increased permanent population growth causes an overall increase in water demand through 2070.

Table 2-5
Municipal Water Demand Projections for Region F Counties
-Values in Acre-Feet per Year-

	Historical	Projected					
County	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Andrews	3,105	4,719	5,603	6,403	7,358	8,487	9,797
Borden	108	178	178	175	175	175	175
Brown	5,991	6,055	6,035	5,907	5,836	5,822	5,822
Coke	635	686	671	658	653	652	652
Coleman	1,465	1,370	1,354	1,319	1,310	1,307	1,307
Concho	487	414	415	406	402	400	400
Crane	1,138	1,431	1,546	1,639	1,735	1,819	1,891
Crockett	1,419	1,560	1,661	1,673	1,689	1,694	1,697
Ector	24,669	29,280	32,803	36,214	39,686	43,336	47,334
Glasscock	144	161	165	160	160	159	159
Howard	4,992	7,405	7,552	7,562	7,508	7,494	7,494
Irion	194	205	200	194	191	191	191
Kimble	845	880	868	850	842	840	840
Loving	4	10	10	9	9	9	9
Martin	676	872	932	972	1,015	1,054	1,084
Mason	814	931	914	900	892	890	890
McCulloch	1,619	1,905	1,945	1,921	1,930	1,933	1,936
Menard	390	442	431	422	420	419	419
Midland	25,446	32,253	36,494	39,282	42,362	45,514	48,892
Mitchell	1,462	2,139	2,270	2,281	2,297	2,317	2,338
Pecos	4,771	5,994	6,394	6,846	7,186	7,516	7,817
Reagan	603	800	871	913	959	991	1,015
Reeves	3,731	4,097	4,308	4,515	4,664	4,778	4,867
Runnels	1,618	1,401	1,397	1,354	1,345	1,340	1,340
Schleicher	617	909	934	942	949	955	959
Scurry	2,576	2,788	3,047	3,206	3,442	3,698	3,967
Sterling	226	308	313	313	312	312	312
Sutton	929	1,186	1,251	1,269	1,287	1,299	1,306
Tom Green	19,095	20,511	22,323	23,246	24,398	25,787	27,290
Upton	932	1,178	1,253	1,286	1,328	1,354	1,372
Ward	2,891	3,302	3,439	3,531	3,635	3,716	3,779
Winkler	1,815	2,357	2,483	2,589	2,727	2,840	2,939
Total	*115,407*	*137,727*	*150,060*	*158,957*	*168,702*	*179,098*	*190,290*

Source: Data are from the TWDB.[5]

Table 2-6
Expected Savings from Implementation of Plumbing Code for Region F Counties
-Values in Acre-Feet per Year-

County	2020	2030	2040	2050	2060	2070
Andrews	235	386	515	630	732	844
Borden	7	11	13	14	14	14
Brown	419	597	724	795	809	809
Coke	35	51	64	68	69	69
Coleman	99	147	182	191	194	194
Concho	27	38	46	51	52	52
Crane	58	93	121	139	149	157
Crockett	50	75	91	93	95	95
Ector	1,564	2,524	3,369	4,009	4,455	4,891
Glasscock	16	24	29	29	30	30
Howard	396	588	717	772	785	786
Irion	18	26	32	35	35	35
Kimble	49	70	88	96	98	98
Loving	1	1	2	2	2	2
Martin	63	99	127	145	152	157
Mason	39	56	70	78	80	80
McCulloch	89	134	165	177	181	181
Menard	23	34	43	45	46	46
Midland	1,845	2,939	3,850	4,533	4,962	5,360
Mitchell	120	182	222	234	240	243
Pecos	198	307	401	461	491	513
Reagan	46	74	90	97	102	105
Reeves	167	258	295	313	327	334
Runnels	119	181	224	233	236	237
Schleicher	39	59	74	82	84	85
Scurry	239	381	489	554	606	653
Sterling	14	21	25	26	26	26
Sutton	43	66	81	88	90	91
Tom Green	1,361	2,168	2,715	3,105	3,341	3,548
Upton	43	68	82	87	90	91
Ward	131	202	257	270	281	286
Winkler	91	141	179	194	206	214
Total	*7,646*	*12,002*	*15,383*	*17,644*	*19,059*	*20,323*

Source: Data are from the TWDB.[5]

2.2.2 Manufacturing Demand Projections

Manufacturing use is the water used by industries in producing various products. In Region F, much of the manufacturing water use is associated with the generation of products from sand and gravel operations and the energy industry. The 2020 manufacturing water demand for each county is based on the highest aggregated manufacturing water use in the county in the most recent five years of data from the annual water use survey. The most recent ten-year projections of employment growth from the Texas Workforce Commission were used to calculate the 2030 projection. The manufacturing demand was held constant for the remaining decades of the planning horizon. Adjustments were made to the manufacturing demands in Ector, McCulloch, Pecos, and Tom Green counties due to closures and openings of facilities. Altogether, these adjustments lowered the overall manufacturing demand in the region by roughly 400 acre-feet per year over the planning period.

Manufacturing water demand accounts for only two percent of the region's total water use and is concentrated in a few counties. Total manufacturing water use is expected to increase from 11,591 acre-feet in 2020 to 12,607 acre-feet by 2070, an increase of nine percent (see Table 2-7). Ector, Howard, Midland, and Tom Green Counties are expected to have the largest manufacturing demands for the region with a combined total use of over 8,000 acre-feet per year by 2070. While manufacturing is expected to remain a relatively small amount of the region's total demands, the statewide manufacturing demand volume is expected to increase by 14 percent over the same period (maintaining eight percent of overall statewide water demand over the planning period).

Table 2-7
Manufacturing Water Demand Projections for Region F Counties
-Values in Acre-Feet per Year-

County	Historical	Projected					
	2010	2020	2030	2040	2050	2060	2070
Andrews	580	580	617	617	617	617	617
Borden	0	0	0	0	0	0	0
Brown	351	548	651	651	651	651	651
Coke	0	0	0	0	0	0	0
Coleman	1	2	2	2	2	2	2
Concho	0	0	0	0	0	0	0
Crane	131	455	468	468	468	468	468
Crockett	10	14	15	15	15	15	15
Ector	1,930	2,152	2,381	2,381	2,381	2,381	2,381
Glasscock	3	25	33	33	33	33	33
Howard	3,171	3,723	3,746	3,746	3,746	3,746	3,746
Irion	1	6	7	7	7	7	7
Kimble	518	605	706	706	706	706	706
Loving	0	0	0	0	0	0	0
Martin	0	0	0	0	0	0	0
Mason	0	0	0	0	0	0	0
McCulloch	1	523	609	609	609	609	609

County	Historical	Projected					
	2010	2020	2030	2040	2050	2060	2070
Menard	0	0	0	0	0	0	0
Midland	156	981	1,177	1,177	1,177	1,177	1,177
Mitchell	0	4	5	5	5	5	5
Pecos	247	413	433	433	433	433	433
Reagan	0	0	0	0	0	0	0
Reeves	286	286	305	305	305	305	305
Runnels	7	10	11	11	11	11	11
Schleicher	0	0	0	0	0	0	0
Scurry	156	156	186	186	186	186	186
Sterling	0	0	0	0	0	0	0
Sutton	0	3	3	3	3	3	3
Tom Green	2,029	850	962	962	962	962	962
Upton	126	184	207	207	207	207	207
Ward	7	7	7	7	7	7	7
Winkler	42	64	76	76	76	76	76
Total	*9,753*	*11,591*	*12,607*	*12607*	*12,607*	*12,607*	*12,607*

Source: Data are from the TWDB.[5]

2.2.3 Irrigation Demand Projections

Irrigation use for agriculture is the largest user of water in Region F. Irrigation use can vary substantially from year to year depending on the number of irrigated acres, weather, crop prices, government programs, and other factors.

The irrigation projections proposed for Region F by the TWDB for 2020 were based on a five-year average (2010-2015) of the historical TWDB annual irrigation water use estimates. The estimates were developed by multiplying the number of reported irrigated acres by the water need for each crop type. The baseline dry-year irrigation demand, as determined by the five-year average volume, is held constant over the planning period. Table 2-8 summarizes the irrigation demands for the region for each decade and compares these to statewide totals.

Table 2-9 shows the irrigation water demands by county in Region F. Figure 2-7 compares historical irrigation water use data to the Region F irrigation projections.

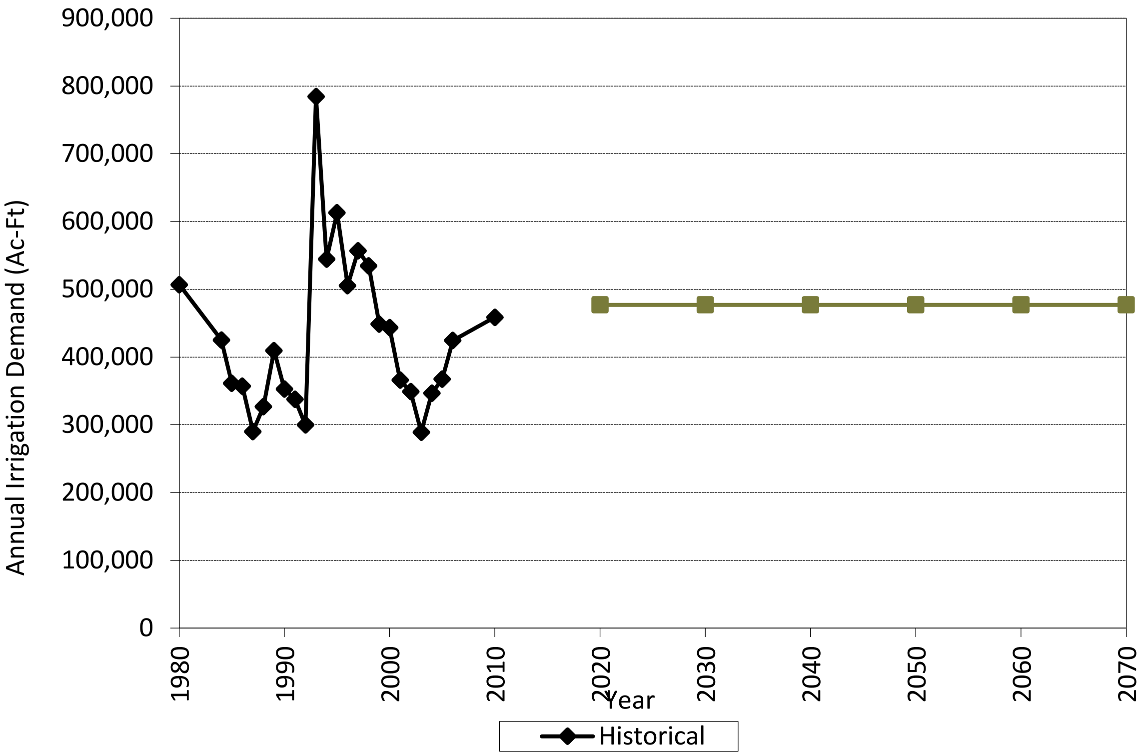
Agricultural use accounted for 73 percent of Region F's total water use in 2010. In 2070, irrigation is expected to still be a major water use and could be as much as 64 percent of the region's total water demand. Statewide irrigation demand is projected to be 53 percent of total demand in the year 2020 and 40 percent of statewide demand in 2070. The counties with the largest irrigation water use are Andrews, Glasscock, Martin, Midland, Pecos, Reagan, Reeves, and Tom Green. These counties are expected to account for 82 percent of the region's irrigation demand in 2070. Pecos County alone is expected to have 30 percent of the regional irrigation demand.

Table 2-8
Comparison of Region F Irrigation Demand Projections to Statewide Projections

Region F	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Irrigation (ac-ft)	476,941	476,941	476,941	476,941	476,941	476,941
Statewide	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Irrigation (ac-ft)	9,448,246	9,382,611	8,703,497	8,153,688	7,737,353	7,594,132
Decline from Year 2020	0	65,635	744,749	1,294,558	1,710,893	1,854,114
% Decline	0%	1%	8%	14%	18%	20%

Source: Data are from the TWDB.[5]

Figure 2-7
Comparison of Historical Water Use to Projected Irrigation Water Demand for Region F



Irrigation Water Demand

Irrigation is the largest category of water use in Region F, accounting for over 475,000 acre-feet per year of water demand, which represents over 60 percent of the water demand for the REgion. It accounts for over 475,000 acre-feet of water demand. Most of this demand is centered in Andrews, Glasscock, Martin, Midland, Pecos, Reagan, Reeves, and Tom Green counties.

Table 2-9
Irrigation Water Demand Projections for Region F Counties
-Values in Acre-Feet per Year-

	Historical	Projected					
County	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Andrews	23,354	20,365	20,365	20,365	20,365	20,365	20,365
Borden	1,616	2,949	2,949	2,949	2,949	2,949	2,949
Brown	8,901	8,125	8,125	8,125	8,125	8,125	8,125
Coke	871	689	689	689	689	689	689
Coleman	470	465	465	465	465	465	465
Concho	7,167	4,902	4,902	4,902	4,902	4,902	4,902
Crane	0	0	0	0	0	0	0
Crockett	148	135	135	135	135	135	135
Ector	1,050	756	756	756	756	756	756
Glasscock	57,164	51,254	51,254	51,254	51,254	51,254	51,254
Howard	6,721	6,883	6,883	6,883	6,883	6,883	6,883
Irion	1,386	1,053	1,053	1,053	1,053	1,053	1,053
Kimble	2,975	2,657	2,657	2,657	2,657	2,657	2,657
Loving	0	0	0	0	0	0	0
Martin	36,160	36,491	36,491	36,491	36,491	36,491	36,491
Mason	3,922	4,966	4,966	4,966	4,966	4,966	4,966
McCulloch	2,558	2,324	2,324	2,324	2,324	2,324	2,324
Menard	2,074	3,663	3,663	3,663	3,663	3,663	3,663
Midland	14,969	18,107	18,107	18,107	18,107	18,107	18,107
Mitchell	9,443	12,787	12,787	12,787	12,787	12,787	12,787
Pecos	126,033	143,345	143,345	143,345	143,345	143,345	143,345
Reagan	19,385	22,031	22,031	22,031	22,031	22,031	22,031
Reeves	58,369	58,937	58,937	58,937	58,937	58,937	58,937
Runnels	3,053	3,105	3,105	3,105	3,105	3,105	3,105
Schleicher	1,442	1,811	1,811	1,811	1,811	1,811	1,811
Scurry	5,978	7,559	7,559	7,559	7,559	7,559	7,559
Sterling	688	899	899	899	899	899	899
Sutton	1,143	1,120	1,120	1,120	1,120	1,120	1,120
Tom Green	44,366	42,493	42,493	42,493	42,493	42,493	42,493
Upton	9,609	10,403	10,403	10,403	10,403	10,403	10,403
Ward	5,040	3,160	3,160	3,160	3,160	3,160	3,160
Winkler	2,603	3,507	3,507	3,507	3,507	3,507	3,507
Total	*458,658*	*476,941*	*476,941*	*476,941*	*476,941*	*476,941*	*476,941*

Source: Data are from the TWDB.[5]

2.2.4 Steam Electric Power Demand Projections

The steam electric power water demand, as determined by the TWDB, uses the highest county water use in the most recent five years of data from the annual water use survey of steam electric power water users. Unlike previous plans, the water use data for the 2021 Plan includes water use from reuse and brackish or saline water sources. In addition to the historical highest county water use, anticipated water use for new facilities was added and use from retiring facilities was subtracted. Near-term plans for new and retiring plants were based on the Electric Reliability Council of Texas (ERCOT) Capacity, Demand, and Reserves Report (CDR). The demand is held constant over the planning horizon. Based on the adopted projections, steam electric water demand in Region F is expected to increase to 18,092 acre-feet per year by 2020. Most of this increase is associated with a proposed new FGE Texas, LLC. facility in Mitchell County. Table 2-10 summarizes the projections for steam electric demands. Statewide, steam electric demand is expected to increase only marginally, from 929,116 acre-feet in 2020 to 932,907 acre-feet in 2070[4].

Table 2-10
Steam Electric Water Demand Projections for Region F Counties
-Values in Acre-Feet per Year-

	Historical	Projected					
County	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Andrews	0	0	0	0	0	0	0
Borden	0	0	0	0	0	0	0
Brown	0	0	0	0	0	0	0
Coke	0	0	0	0	0	0	0
Coleman	0	0	0	0	0	0	0
Concho	0	0	0	0	0	0	0
Crane	0	0	0	0	0	0	0
Crockett	0	0	0	0	0	0	0
Ector	0*	4,837	4,837	4,837	4,837	4,837	4,837
Glasscock	0	0	0	0	0	0	0
Howard	387	427	427	427	427	427	427
Irion	0	0	0	0	0	0	0
Kimble	0	0	0	0	0	0	0
Loving	0	0	0	0	0	0	0
Martin	0	0	0	0	0	0	0
Mason	0	0	0	0	0	0	0
McCulloch	0	0	0	0	0	0	0
Menard	0	0	0	0	0	0	0
Midland	0	0	0	0	0	0	0
Mitchell	3,179	10,326	10,326	10,326	10,326	10,326	10,326
Pecos	0	0	0	0	0	0	0
Reagan	0	0	0	0	0	0	0
Reeves	0	0	0	0	0	0	0
Runnels	0	0	0	0	0	0	0
Schleicher	0	0	0	0	0	0	0
Scurry	0	0	0	0	0	0	0
Sterling	0	0	0	0	0	0	0
Sutton	0	0	0	0	0	0	0
Tom Green	0	0	0	0	0	0	0
Upton	0	0	0	0	0	0	0
Ward	2,502	2,502	2,502	2,502	2,502	2,502	2,502
Winkler	0	0	0	0	0	0	0
Total	*6,068*	*18,092*	*18,092*	*18,092*	*18,092*	*18,092*	*18,092*

Source: Data are from the TWDB.[5]

*Historical water use for Ector County does not include the Odessa Ector Power Partners facility that has been in operation since 2001. This facility uses approximately 2 to 3 MGD.

2.2.5 Mining Demand Projections

The mining category includes water used in both the production of minerals and the production of oil and gas. (Water used in the processing of minerals or oil and gas into a finished product is considered under the manufacturing use category.) The TWDB mining water demand projections are based on a study conducted by the Bureau of Economic Geology (BEG) Report[8]. The original study was published in 2011 and was updated in 2012 to better account for the increased activities in the oil and gas sector of mining. The BEG reports used data collected from trade organizations, government agencies, and other industry representatives. Using this study, the TWDB predicts that water demand for oil and gas production will increase through 2020 and 2030 as the shale oil plays develop. The expected water demand will then decline after 2040 and continue to decrease through 2070.

Since the BEG report was updated in 2012, the oil and gas industry has continued to play an important role in the development of West Texas and still accounts for a large percentage of its total payroll. Region F lies in the heart of the Permian Basin, which is one of the largest oil and gas shale formations in the country. Over the past five years the region has seen increased mining activity as the price of crude oil has increased, with activities focused predominately within the Delaware and Midland Basins. For select counties where oil and gas activity has greatly increased since the publication the BEG's report, Region F examined the historical water use trend over the past 5 years and extended the trend line to establish an estimated 2020 demand. For planning purposes, it was assumed that the projected demands for 2020 would be maintained through 2030 to 2040, and then decline from 2040 to 2070 at the same rate developed by the TWDB. Other mining activities, such as sand, gravel and stone production, represent a small portion of the region's economy and water demands.

The mining demands for Region F are projected to be 108,841 acre-feet in 2020 (nearly double the 2020 projection in the 2016 plan), and then decrease to 34,478 acre-feet in 2070. This water use represents about 14 percent of the total water demand in Region F in 2020, and only five percent in 2070. Statewide, mining use is expected to account for 2 percent of the state's water demands. Table 2-11 compares Region F's mining projections to statewide projections. A summary of the projected mining demands by county is presented in Table 2-12.

Table 2-11
Comparison of Region F Mining Projections to Statewide Totals

Region F	**2020**	**2030**	**2040**	**250**	**2060**	**2070**
Mining (ac-ft)	108,841	109,847	90,970	66,812	46,251	34,478
Change from Yr 2020	0	1,006	-17,871	-42,029	-62,590	-74,363
% Increase	0%	1%	-16%	-39%	-58%	-68%
Statewide [a]	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Mining (ac-ft)	406,830	408,772	364,596	323,178	287,150	281,061
Change from Yr 2020	0	1,942	-42,234	-83,652	-119,680	-125,769
% Change	0%	0%	-10%	-21%	-29%	-31%

Source: Data are from the TWDB.[5]

Table 2-12
Mining Water Demand Projections for Region F Counties
-Values in Acre-Feet per Year-

County	Historical	Projected					
	2010	2020	2030	2040	2050	2060	2070
Andrews	821	3,959	3,710	3,177	2,509	1,929	1,483
Borden	239	679	927	784	494	244	121
Brown	942	943	948	951	952	948	944
Coke	146	488	482	430	376	328	286
Coleman	42	108	107	97	86	77	69
Concho	124	480	474	422	367	320	279
Crane	201	617	840	861	692	531	407
Crockett	146	4,500	4,500	3,100	1,700	500	200
Ector	845	1,977	2,164	1,926	1,574	1,272	1,076
Glasscock	832	5,900	5,900	4,500	3,200	2,100	1,500
Howard	415	3,400	3,400	2,400	1,400	600	300
Irion	412	4,600	4,600	3,300	2,000	1,000	500
Kimble	21	19	19	19	19	19	19
Loving	223	7,500	7,500	6,600	5,400	4,300	3,400
Martin	723	7,200	7,200	5,400	3,500	1,900	1,000
Mason	560	1,023	941	708	568	460	372
McCulloch	7,849	8,927	8,347	6,641	5,627	4,836	4,201
Menard	264	1,086	1,071	952	827	717	622
Midland	1,593	10,600	10,600	8,200	5,500	3,300	2,300
Mitchell	351	593	738	632	493	375	290
Pecos	239	7,700	7,700	7,700	6,200	4,800	3,700
Reagan	798	10,600	10,600	7,700	4,400	1,700	600
Reeves	1,207	12,600	12,600	12,100	9,900	7,800	6,200
Runnels	77	272	269	240	210	184	161
Schleicher	84	621	732	562	392	241	148
Scurry	107	280	456	483	363	246	167
Sterling	173	780	953	812	522	270	140
Sutton	169	446	720	763	573	389	264
Tom Green	984	1,056	1,080	1,119	1,112	1,134	1,156
Upton	1,242	7,200	7,200	5,700	3,800	2,300	1,600
Ward	205	1,900	1,900	1,700	1,300	900	600
Winkler	320	787	1,169	991	756	531	373
Total	*22,354*	*108,841*	*109,847*	*90,970*	*66,812*	*46,251*	*34,478*

Source: Data are from the TWDB.[5]

2.2.6 Livestock Watering

Livestock watering accounted for two percent of the water use in Region F in 2010 and is predicted to remain the same. The livestock projections are based on the water needs per head for each type of livestock and each type of livestock operation. The number of head in each county was estimated from information provided by the Texas Department of Agriculture and the National Agricultural Statistics Service. TWDB used the average of the 2010-2014 water use estimates as a base. Projections are only available for counties and are not available for specific livestock operations.

Livestock demand in Region F is expected to remain constant at 11,958 acre-feet per year throughout the planning period (see Table 2-13). Statewide livestock demand is expected to be 382,200 acre-feet per year in 2070, which represents two percent of total statewide demand.

Table 2-13
Livestock Water Demand Projections for Region F Counties
-Values in Acre-Feet per Year-

County	Historical	Projected					
	2010	2020	2030	2040	2050	2060	2070
Andrews	223	210	210	210	210	210	210
Borden	217	175	175	175	175	175	175
Brown	1,238	1,119	1,119	1,119	1,119	1,119	1,119
Coke	376	306	306	306	306	306	306
Coleman	791	705	705	705	705	705	705
Concho	446	382	382	382	382	382	382
Crane	77	72	72	72	72	72	72
Crockett	592	527	527	527	527	527	527
Ector	249	199	199	199	199	199	199
Glasscock	173	147	147	147	147	147	147
Howard	248	229	229	229	229	229	229
Irion	275	232	232	232	232	232	232
Kimble	453	320	320	320	320	320	320
Loving	31	32	32	32	32	32	32
Martin	147	119	119	119	119	119	119
Mason	568	714	714	714	714	714	714
McCulloch	1,176	651	651	651	651	651	651
Menard	320	294	294	294	294	294	294
Midland	256	243	243	243	243	243	243
Mitchell	397	376	376	376	376	376	376
Pecos	740	687	687	687	687	687	687
Reagan	216	183	183	183	183	183	183
Reeves	303	368	368	368	368	368	368
Runnels	902	705	705	705	705	705	705
Schleicher	444	389	389	389	389	389	389
Scurry	548	461	461	461	461	461	461
Sterling	250	234	234	234	234	234	234
Sutton	487	444	444	444	444	444	444
Tom Green	1,441	1,125	1,125	1,125	1,125	1,125	1,125
Upton	105	126	126	126	126	126	126
Ward	102	83	83	83	83	83	83
Winkler	114	101	101	101	101	101	101
Total	*13,905*	*11,958*	*11,958*	*11,958*	*11,958*	*11,958*	*11,958*

Source: Data are from the TWDB.[5]

2.3 Major Water Providers

As part of the development of the 2021 Regional Water Plan, demands were identified for major water providers (MWPs) in Region F. An MWP is defined by the TWDB as a water user group or a wholesale water provider of particular significance to the region's water supply, as determined by the RWPG . The major water providers in Region F are the Colorado River Municipal Water District (CRMWD), the Brown County Water Improvement District Number 1 (BCWID), and the cities of Odessa, Midland and San Angelo. The sections below contain descriptions of the identified demands and the associated volumes for each Region F MWP. Attachment 2A contains projected water demands for each of these MWPs broken down by category of use for each decade.

Region F Major Water Providers

- Colorado Municipal Water District
- Brown County Water Improvement District No. 1
- City of Odessa
- City of Midland
- City of San Angelo

2.3.1 Colorado River Municipal Water District

The Colorado Municipal Water District (CRMWD) provides wholesale raw water supplies to multiple member cities and customers. CRMWD's operations and contractual obligations are challenging to represent under the existing regional planning framework required by TWDB rule. For planning purposes, the demands on CRMWD are described as two separate systems: the Lake Ivie Non-System Demands and the CRMWD System demands.

The Lake Ivie Non-System Demands represent contractual demands from Midland, San Angelo, and Abilene for a percentage of the yield of Lake Ivie and an 1,100-acre-foot reservoir contract with Millersview-Doole WSC. These users can only be supplied by Lake Ivie and CRMWD would not provide them other water supplies if supply from Lake Ivie is inadequate. Table 2-14 shows the projected water demands CRMWD's Lake Ivie Non-System customers.

Table 2-14
Expected Lake Non-System Demands for the Colorado River Municipal Water District
-Values in Acre-Feet per Year-

WUG Name	County(ies)	Basin	2020	2030	2040	2050	2060	2070
Abilene	Jones, Taylor	Brazos	5,020	4,850	4,679	4,509	4,338	4,168
San Angelo	Tom Green	Colorado	5,020	4,850	4,679	4,509	4,338	4,168
Midland	Midland	Colorado	5,020	4,850	4,679	4,509	4,338	4,168
Millersview-Doole WSC[a]	Concho, McCulloch, Runnels, Tom Green	Colorado	600	600	600	600	600	600
Ballinger	Runnels	Colorado	500	500	500	500	500	500
Ivie System Total	Jones, Taylor	Brazos	**16,160**	**15,650**	**15,137**	**14,627**	**14,114**	**13,604**

[a] Millersview-Doole WSC contract expires in October 2041.

CRMWD's System demands include both its member cities and others through various contracts. CRMWD operates its main system conjunctively using multiple groundwater, surface water, and reuse sources as needed. CRMWD provides all the water used by its member cities: Odessa, Big Spring and Snyder. The remaining municipal contract holders rely entirely on CRMWD for water. Manufacturing water is provided through municipal users. Table 2 15 shows the projected water demands for current CRMWD system customers. Potential future customers are discussed in Chapter 5D.

Table 2-15
Expected Main System Demands for the Colorado River Municipal Water District
-Values in Acre-Feet per Year-

WUG Name	County(ies)	Basin	2020	2030	2040	2050	2060	2070
Odessa	Ector	Colorado	24,523	27,724	30,382	33,254	36,278	39,632
Odessa	Midland	Colorado	481	605	709	817	924	1,037
Ector County UD	Ector	Colorado	2,385	2,645	2,935	3,240	3,556	3,880
Manufacturing	Ector	Colorado	1,902	1,952	1,952	1,952	1,952	1,952
Irrigation	Ector	Colorado	1,197	1,194	1,192	1,191	1,190	1,189
Irrigation	Midland	Colorado	23	26	28	29	30	31
Steam Electric Power	Ector	Colorado	1,121	1,121	1,121	1,121	1,121	1,121
Big Spring	Howard	Colorado	6,227	6,368	6,379	6,327	6,316	6,316
Coahoma	Howard	Colorado	526	534	537	537	536	536
Manufacturing	Howard	Colorado	1,500	1,500	1,500	1,500	1,500	1,500
Steam Electric Power	Howard	Colorado	209	209	209	209	209	209
Snyder	Scurry	Colorado	1,980	2,201	2,320	2,499	2,686	2,882
County-Other, Scurry	Scurry	Colorado	300	300	300	300	300	300
Rotan	Fisher	Brazos	178	170	165	164	163	163
Midland[a]	Midland	Colorado	18,798	0	0	0	0	0
Stanton[b]	Martin	Colorado	320	320	320	320	320	320
Irrigation	Ector	Colorado	400	400	400	400	400	400
County-Other, Ward	Ward	Rio Grande	100	--	--	--	--	--
Grandfalls	Ward	Rio Grande	135	141	145	149	--	--
		CRMWD Total Demand	***62,305***	***47,410***	***50,594***	***54,009***	***57,481***	***61,468***
		Additional Supply for Odessa (Losses)	3,930	3,930	3,930	3,930	3,930	3,930
		Howard County Manufacturing (Sales from Big Spring)		500	500	500	500	500
		Greater Gardendale WSC (Sales from Odessa)		375	445	445	445	445
		Ector County - Other (ECUD Expanded Service Area, Sales from Odessa)		1,200	2,500	2,500	2,500	2,500
		Scurry County-Other (Sales from Snyder)	373	414	447	491	547	607
		CRMWD Potential Future Demand	***4,303***	***6,419***	***7,822***	***7,866***	***7,922***	***7,982***
		CRMWD Total (Current and Potential Future)	***66,608***	***53,829***	***58,416***	***61,726***	***65,403***	***69,450***

a. Midland 1966 contract expires in December 2029 but will continue for 3 months into 2030.
b. Contract expires in 2019.

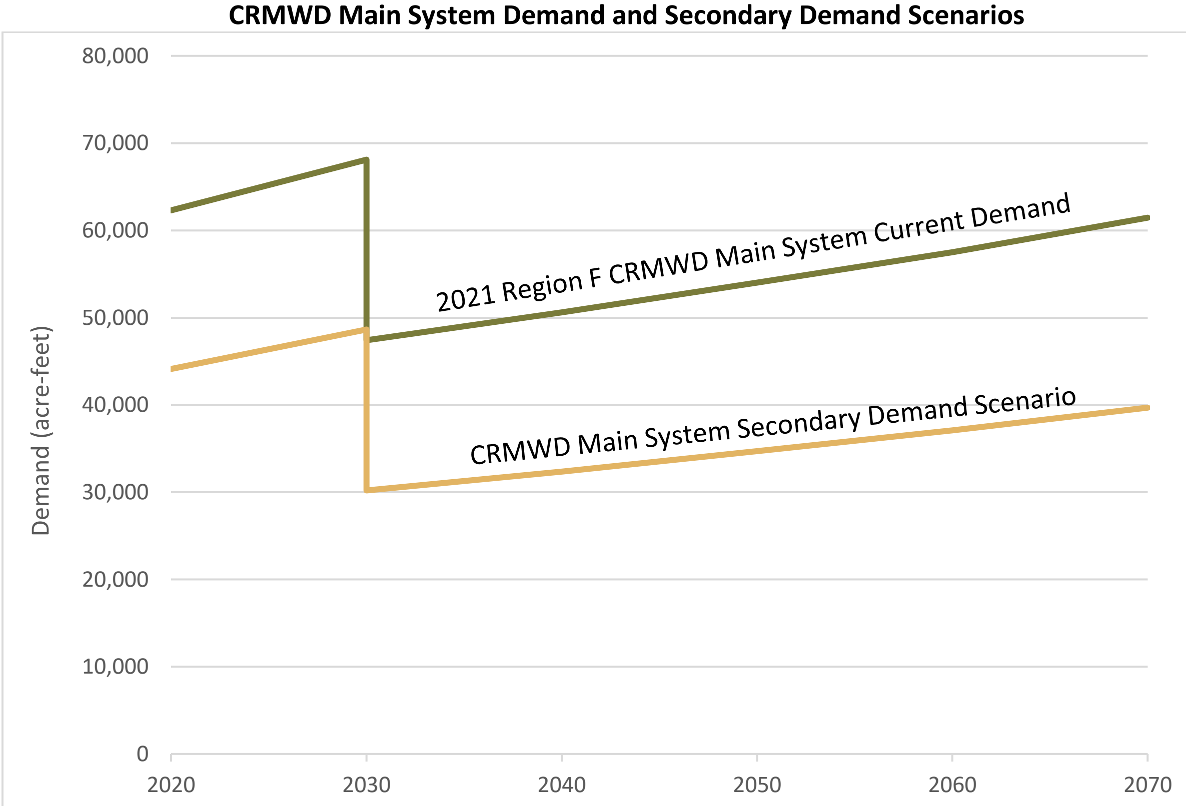
A secondary demand scenario for CRMWD's main system, shown in Table 2-16, was developed based on historical gpcd data reported by CRMWD for the years 2012 – 2016. The demand projections for certain entities were adjusted based on the historical gpcds, which are lower than the dry year demands used in the Region F Water Plan. The secondary demand scenario is included here for comparison. No secondary demand scenario was developed for the Lake Ivie Non-System since those demands are based on contracts.

Table 2-16
Secondary Demand Scenario for the Colorado River Municipal Water District a
-Values in Acre-Feet per Year-

WUG Name	County(ies)	Basin	2020	2030	2040	2050	2060	2070
Odessa and Customers[b]	Ector, Midland	Colorado	17,852	19,694	21,715	23,910	26,256	28,644
Big Spring and Customers[b]	Howard	Colorado	6,825	7,006	7,038	6,992	6,983	6,983
Snyder and Customers[b]	Scurry	Colorado	2,421	2,638	2,755	2,939	3,132	3,335
Midland[c]	Midland	Colorado	16,071	0	0	0	0	0
Stanton	Martin	Colorado	320	320	320	320	320	320
Irrigation	Ector	Colorado	400	400	400	400	400	400
County-Other, Ward	Ward	Rio Grande	100					
Grandfalls	Ward	Rio Grande	135	141	145	149		
CRMWD Total for Secondary Demand Scenario			***44,124***	***30,199***	***32,373***	***34,710***	***37,091***	***39,682***

a. Does not include potential new customers identified in the planning process or contract renewals.
b. Demand projections were updated based on historical gpcds for 2012 – 2016.
c. 2020 demand is based on the historical gpcds for 2012 – 2016; system contract expires in 2029 but extends 3 months into 2030.

Figure 2-8
CRMWD Main System Demand and Secondary Demand Scenarios



2.3.2 Brown County Water Improvement District No. 1

BCWID provides both raw and treated water for municipal, manufacturing, and irrigation purposes. Most BCWID customers are in Brown County. BCWID provides treated water to the Cities of Brownwood, Bangs, and Early and to Brookesmith SUD and Zephyr WSC. BCWID provides water to the City of Santa Anna in Coleman County, Coleman County SUD, and to users in Coleman and Mills Counties through Brookesmith SUD. Coleman County SUD has customers in Coleman, Brown, Runnels, Callahan and Taylor Counties. For the purposes of this plan, it is assumed that half of the demand for Coleman County SUD will be met by supplies from BCWID. BCWID also currently provides raw water to industries and irrigation. The demands in Table 2-17 are for current BCWID customers.

Table 2-17
Expected Demands for the Brown County Water Improvement District No. 1
-Values in Acre-Feet per Year-

WUG Name	County(ies)	Basin	2020	2030	2040	2050	2060	2070
Bangs	Brown	Colorado	310	305	296	291	290	290
Brookesmith SUD	Brown	Colorado	1,199	1,195	1,170	1,156	1,153	1,153
Brookesmith SUD	Coleman	Colorado	6	6	6	6	6	6
Brookesmith SUD	Mills	Colorado	7	7	7	7	8	8
Santa Anna	Coleman	Colorado	156	154	149	149	148	148
Coleman County SUD	Brown	Colorado	12	12	12	12	12	12
Coleman County SUD	Coleman	Colorado	182	179	174	171	170	170
Coleman County SUD	Runnels	Colorado	10	10	10	10	10	10
Coleman County SUD	Callahan	Colorado	15	16	16	16	16	16
Coleman County SUD	Taylor	Colorado	10	10	10	10	10	10
Brownwood	Brown	Colorado	3,717	3,713	3,640	3,600	3,593	3,593
County-Other, Brown	Brown	Colorado	129	129	129	129	129	129
Early	Brown	Colorado	292	287	277	271	270	270
Zephyr WSC	Brown	Colorado	343	339	330	325	324	324
Zephyr WSC	Mills	Colorado	3	3	3	3	3	3
Manufacturing	Brown	Colorado	548	651	651	651	651	651
Irrigation	Brown	Colorado	5,000	5,000	5,000	5,000	5,000	5,000
		BCWID Total	**11,939**	**12,016**	**11,880**	**11,807**	**11,793**	**11,793**

2.3.3 City of Odessa

Table 2-18 shows the expected demands for the City of Odessa. The City of Odessa is a CRMWD member city. Odessa sells treated water to the Ector County Utility District, Ector County-Other, and manufacturing and steam electric power in Ector County. A portion of the City's wastewater is sold to the Gulf Coast Water Authority (GCA) who treats the effluent and sells the supply to the mining industry. The remainder of the City of Odessa's effluent is treated by the City and sold to Pioneer Natural Resources (mining). The City also provides water for manufacturing in Ector County, which is supplied by raw water. Odessa also provides raw water to irrigation customers in Ector and Midland counties. Potential future customers are discussed in Chapter 5D.

Table 2-18
Expected Demands for the City of Odessa
-Values in Acre-Feet per Year-

WUG Name	County(ies)	Basin	2020	2030	2040	2050	2060	2070
Odessa	Ector	Colorado	24,523	27,724	30,382	33,254	36,278	39,632
Odessa	Midland	Colorado	481	605	709	817	924	1,037
Ector County UD	Ector	Colorado	2,385	2,645	2,935	3,240	3,556	3,880
Manufacturing	Ector	Colorado	450	500	500	500	500	500
Steam Electric Power	Ector	Colorado	1,121	1,121	1,121	1,121	1,121	1,121
Subtotal Treated Water Demand			*28,960*	*32,595*	*35,647*	*38,932*	*42,379*	*46,170*
Mining (Reuse)	Ector	Colorado	9,530	9,530	9,530	9,530	9,530	9,530
Subtotal Reuse Demand			*9,530*	*9,530*	*9,530*	*9,530*	*9,530*	*9,530*
Manufacturing	Ector	Colorado	1,452	1,452	1,452	1,452	1,452	1,452
Irrigation	Ector	Colorado	1,197	1,194	1,192	1,191	1,190	1,189
Irrigation	Midland	Colorado	23	26	28	29	30	31
Subtotal Raw Demand			*2,672*	*2,672*	*2,672*	*2,672*	*2,672*	*2,672*
Greater Gardendale WSC			0	375	445	445	445	445
Ector County - Other (ECUD Expanded Service Area)			0	1,200	2,500	2,500	2,500	2,500
Additional Supply for Odessa (Losses)			3,930	3,930	3,930	3,930	3,930	3,930
Total Future Potable Demand			*3,930*	*5,505*	*6,875*	*6,875*	*6,875*	*6,875*
City of Odessa Total Demand			**45,092**	**50,302**	**54,724**	**58,009**	**61,456**	**65,247**

2.3.4 City of Midland

The City of Midland is the largest city in Region F. It provides retail water service to over 134,000 people, and small quantities of water to manufacturing within the city limits. The City has experienced rapid growth within its service area in recent years, primarily due to increased oil and gas activities within the Permian Basin. The City is also home to many workers that commute from other areas of the State during the work week. While these workers are not considered in Midland's permanent population estimate, they do contribute to the water demands on the City. Recent reports indicate the oil and gas activities will continue in the Permian Basin for several decades, contributing to the expected growth of the City and its water demands.

Midland also has a contract to sell treated effluent to Pioneer Resources for mining use. The contract is for up to 15 MGD, but actual wastewater discharges average 10 MGD. Improvements at the wastewater treatment plant are expected to be completed by 2020, which will increase the City's treatment capacity and quality. As shown in Table 2-19, the expected demands on Midland are 39,329 acre-feet per year in 2020 and increase to 53,619 acre-feet year by 2070.

Table 2-19
Expected Demands for the City of Midland
-Values in Acre-Feet per Year-

WUG Name	County(ies)	Basin	2020	2030	2040	2050	2060	2070
Midland	Midland	Colorado	27,972	31,803	34,256	36,811	39,405	42,232
Manufacturing	Midland	Colorado	147	177	177	177	177	177
		Subtotal Treated Water Demand	*28,119*	*31,980*	*34,433*	*36,988*	*39,582*	*42,409*
Mining	Midland	Colorado	2,803	2,803	2,803	2,803	2,803	2,803
Mining	Martin	Colorado	2,803	2,803	2,803	2,803	2,803	2,803
Mining	Reagan	Colorado	2,803	2,803	2,803	2,803	2,803	2,803
Mining	Upton	Colorado	2,801	2,801	2,801	2,801	2,801	2,801
		Subtotal Reuse Demand	*11,210*	*11,210*	*11,210*	*11,210*	*11,210*	*11,210*
		City of Midland Total	**39,329**	**43,190**	**45,643**	**48,198**	**50,792**	**53,619**

2.3.5 City of San Angelo

Table 2-20 shows the expected demands for current customers of the City of San Angelo. The City provides water to the Upper Colorado River Authority (UCRA) in exchange for UCRA's O.C. Fisher water rights. UCRA then sells to several entities outside of the City. The City also provides water to the Goodfellow Air Force Base located in San Angelo and about half of the water used for manufacturing in Tom Green County.

Table 2-20
Expected Demands for the City of San Angelo
-Values in Acre-Feet per Year-

WUG Name	County(ies)	Basin	2020	2030	2040	2050	2060	2070
San Angelo	Tom Green	Colorado	17,924	19,657	20,494	21,556	22,847	24,250
UCRA			1,000	1,000	1,000	1,000	1,000	1,000
Goodfellow Air Force Base	Tom Green	Colorado	513	568	596	629	666	707
Manufacturing	Tom Green	Colorado	425	481	481	481	481	481
City of San Angelo Total			***19,862***	***21,706***	***22,571***	***23,666***	***24,994***	***26,438***

ATTACHMENT 2A

WATER DEMANDS BY DECADE AND CATEGORY OF USE FOR MAJOR WATER PROVIDERS

Major Water Provider Demands by Category of Use in Each Decade
(acre-feet per year)

Major Water Provider	Category of Use	2020	2030	2040	2050	2060	2070
BCWID #1	Irrigation	5,000	5,000	5,000	5,000	5,000	5,000
	Livestock	0	0	0	0	0	0
	Manufacturing	548	651	651	651	651	651
	Mining	0	0	0	0	0	0
	Municipal	6,391	6,365	6,229	6,156	6,142	6,143
	Steam Electric Power	0	0	0	0	0	0
	Total	**11,939**	**12,016**	**11,880**	**11,807**	**11,793**	**11,794**
CRMWD	Irrigation	1,620	1,620	1,620	1,620	1,620	1,620
	Livestock	0	0	0	0	0	0
	Manufacturing	3,402	3,952	3,952	3,952	3,952	3,952
	Mining	0	0	0	0	0	0
	Municipal	76,416	62,577	66,651	69,600	72,615	76,152
	Steam Electric Power	1,330	1,330	1,330	1,330	1,330	1,330
	Total	**82,768**	**69,479**	**73,553**	**76,502**	**79,517**	**83,054**
Midland	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	147	177	177	177	177	177
	Mining	11,210	11,210	11,210	11,210	11,210	11,210
	Municipal	27,972	31,803	34,256	36,811	39,405	42,232
	Steam Electric Power	0	0	0	0	0	0
	Total	**39,329**	**43,190**	**45,643**	**48,198**	**50,792**	**53,619**
Odessa	Irrigation	1,220	1,220	1,220	1,220	1,220	1,220
	Livestock	0	0	0	0	0	0
	Manufacturing	1,902	1,952	1,952	1,952	1,952	1,952
	Mining	9,530	9,530	9,530	9,530	9,530	9,530
	Municipal	31,319	36,479	40,901	44,186	47,633	51,424
	Steam Electric Power	1,121	1,121	1,121	1,121	1,121	1,121
	Total	**45,092**	**50,302**	**54,724**	**58,009**	**61,456**	**65,247**
San Angelo	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	425	481	481	481	481	481
	Mining	0	0	0	0	0	0
	Municipal	19,437	21,225	22,090	23,185	24,513	25,957
	Steam Electric Power	0	0	0	0	0	0
	Total	**19,862**	**21,706**	**22,571**	**23,666**	**24,994**	**26,438**

LIST OF REFERENCES

[1] Texas Water Development Board. *2021 Regional Water Plan Water Demand Projections,* April, 2018. <http://www.twdb.texas.gov >.

[2] U.S. Census Bureau. *2010 Census Demographic Profile*, August, 2011.

[3] Texas Water Development Board. *Historical Water Use Summary Data for Region F*, June 2018. <www.twdb.texas.gov>.

[4] Texas Water Development Board*. Draft Population and Municipal Water Demands Projection Methodology for the 2021 Regional Water Plans*, 2018. <www.twdb.texas.gov>.

[5] Texas Water Development Board. DB22 database, 2018.

[6] Texas Water Development Board. *Water Conservation Implementation Task Force Report to the 79th Legislature*, November 2004.

[7] Texas Health and Safety Code. *Water Saving Performance Standards*, Title 5, Subtitle B § 372.002, 2014.

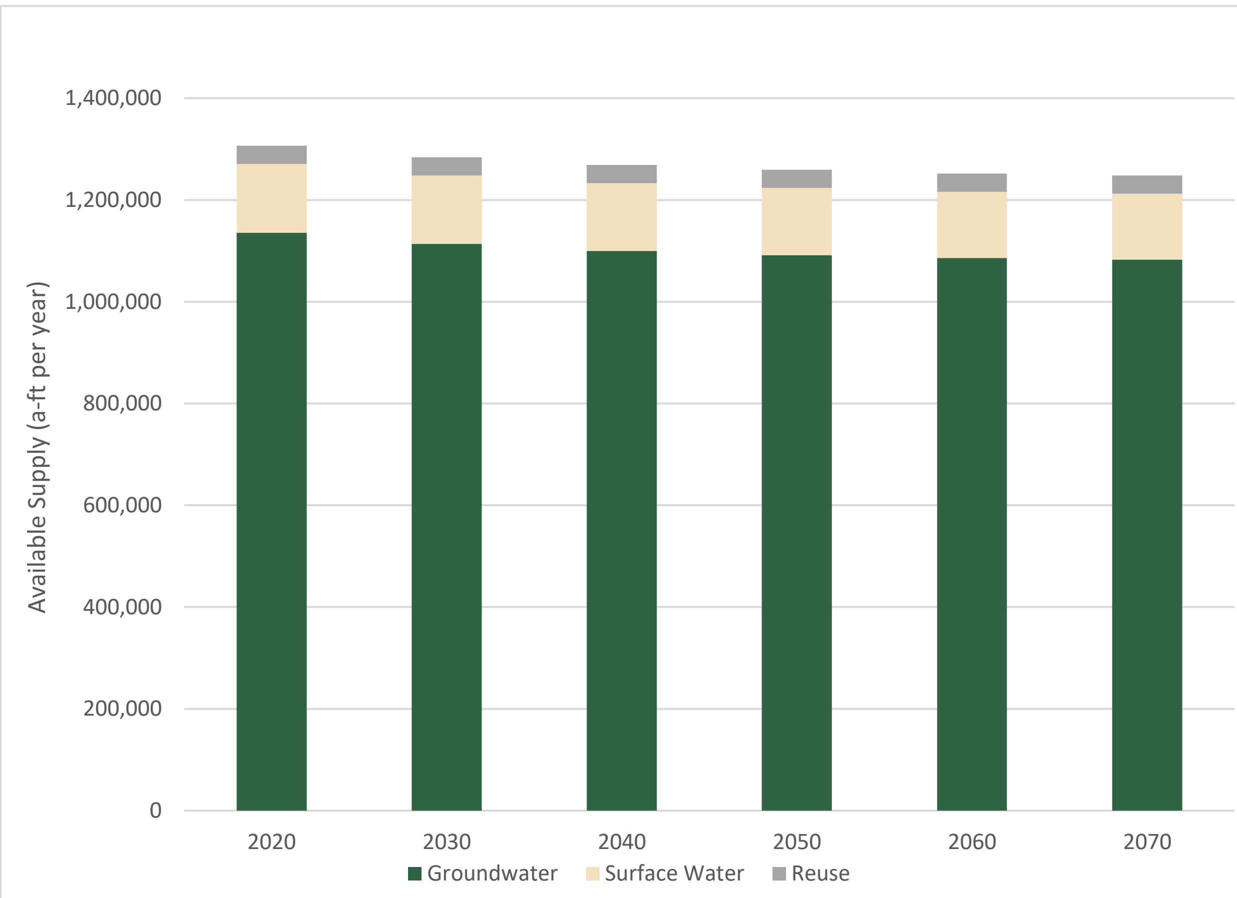
[8] Bureau of Economic Geology. *Oil & Gas Water Use in Texas: Update to the 2011 Mining Water Use Report.* Prepared for Texas Oil & Gas Association, September 2012.

3 WATER SUPPLY ANALYSIS

In Region F, water comes from surface water sources such as run-of-the-river supplies and reservoirs, groundwater from individual wells or well fields, and reuse. Figure 3-1 shows that Region F has approximately 1.3 million acre-feet per year of water that is available for use. It includes all developed surface water and reuse supplies and both developed and undeveloped groundwater supplies. Groundwater is the largest source of water supply available in Region F, accounting for 87 percent of the total water available. Surface water supplies in Figure 3-1 total approximately 135,500 acre-feet per year. These supplies are lower than historical use, which is partly due to the on-going drought and partly due to the assumptions inherent in the Colorado River Basin Water Availability Model (WAM) (see Section 3.2). In addition to the groundwater and surface water source, a relatively small amount of reuse is currently being used in the region for both potable and non-potable uses.

Chapter 3 provides a description of groundwater, surface water, and reuse water supply resources and their overall availability in Region F. The chapter also includes a summary of the supplies currently availability to Water User Groups and Major Water Providers, which are limited by what can be used today under existing contracts, permits, and infrastructure constraints.

Figure 3-1
Water Availability by Source Type



3.1 Groundwater Supplies

Groundwater is primarily found in four major and ten minor aquifers in Region F and is used for municipal, industrial and agricultural purposes. Groundwater represents a major resource in the region. With 14 named aquifer formations and multiple other groundwater sources, the quantity, quality, and reliability of this resource varies across formations and the region.

Based on historic groundwater estimates (2012-2016), regional groundwater sources supplied an average of 478,890 acre-feet of water annually, accounting for 60 percent of all water used in the region. Groundwater provides most of the irrigation water used in the region, as well as a significant portion of the water used for municipal and other purposes.

Region F historical groundwater pumping by aquifer for years 2012 through 2016 is shown in

Figure 3-2. These data were calculated using the TWDB historical groundwater pumping estimates. The Edwards-Trinity (Plateau) supplied 39 percent of the region's groundwater, the Pecos Valley supplied 19 percent, and the Ogallala provided 16 percent. The minor aquifers provided the remaining 26 percent.

The same historical data set is presented in

Figure 3-3 by use category. Irrigation accounted for 86 percent of groundwater pumped in the region. Municipal pumping consumed eleven percent of the groundwater and the remaining use categories collectively accounted for about three percent of total usage in the five-year period.

The following discussion describes each major and minor aquifer in Region F, including their current use and potential availability. Section 3.4.3 discusses the supply of brackish groundwater potentially available for advanced treatment.

Figure 3-2
Historical Groundwater Pumping (2012-2016) by Aquifer

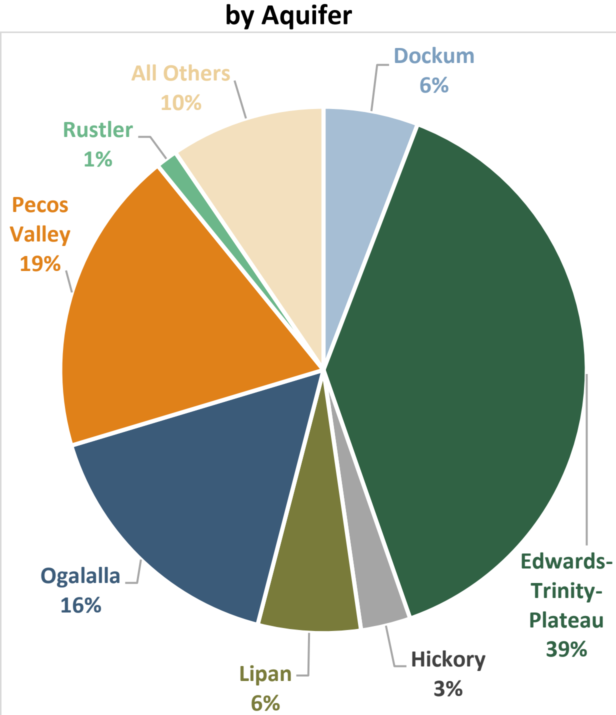
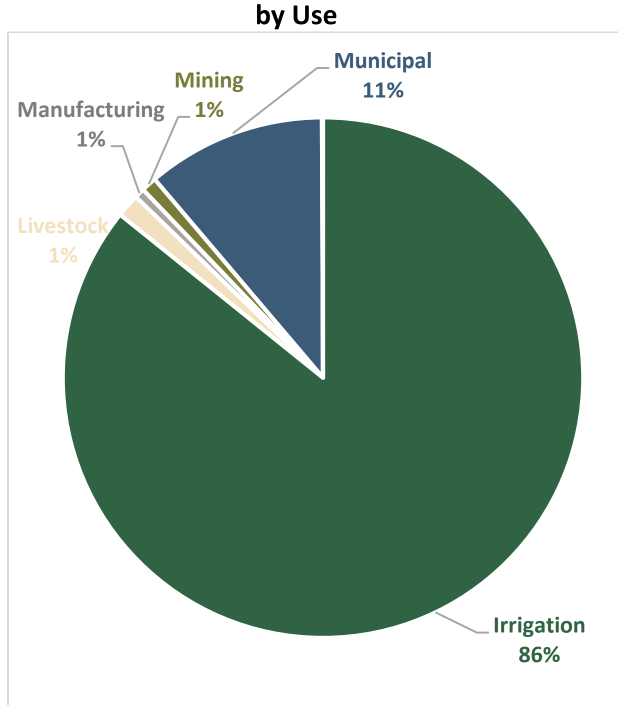
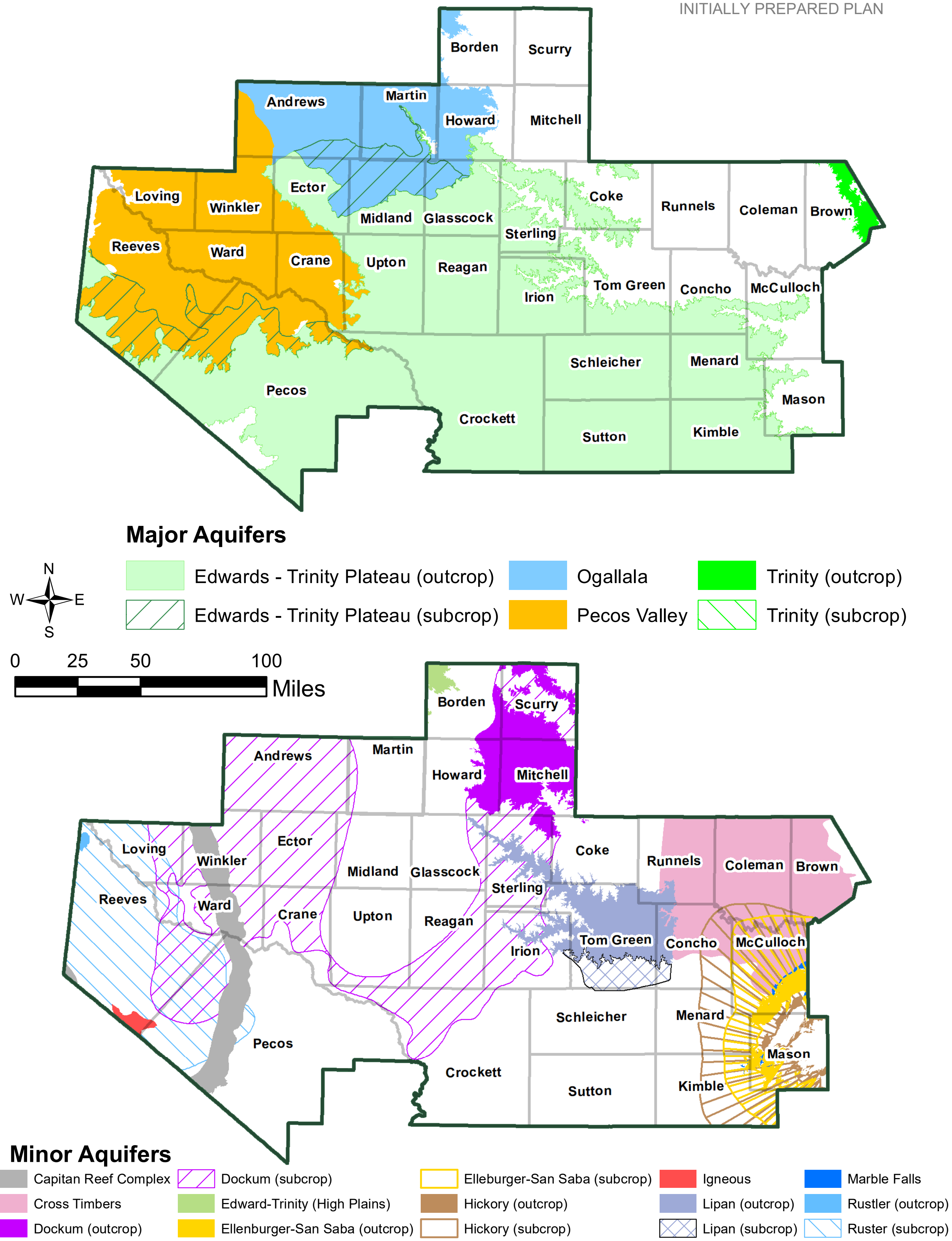


Figure 3-3
Historical Groundwater Pumping (2012-2016) by Use





Region F

Major and Minor Aquifers

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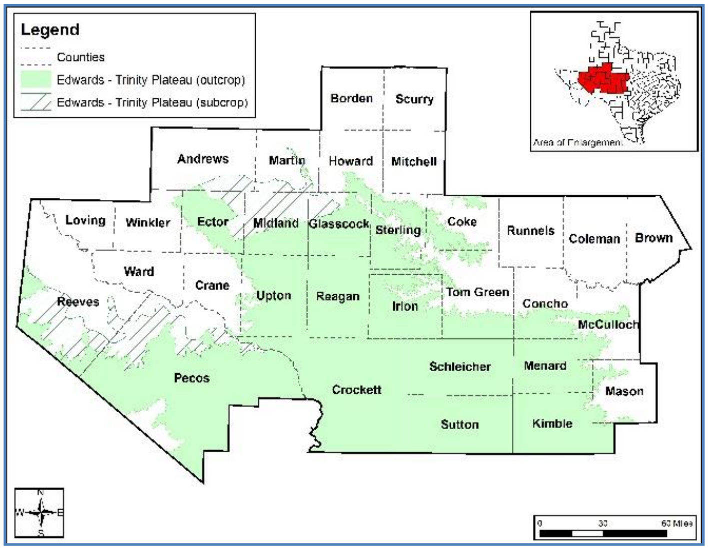
3.1.1 Edwards-Trinity (Plateau) Aquifer

Extending from the Hill Country of Central Texas to the Trans-Pecos region of West Texas, the Edwards-Trinity (Plateau) aquifer is the largest aquifer in areal extent in Region F, occurring in 21 of the 32 Region F counties. This aquifer is comprised of water-bearing portions of the Edwards Formation and underlying formations of the Trinity Group and is one of the largest contiguous karst regions in the United States. Regionally, this aquifer is categorized by the TWDB as one aquifer. However, in other parts of the state, the Edwards and Trinity components are not hydrologically connected and are considered separate aquifers. The Trinity aquifer is also present as an individual aquifer in eastern Brown County within Region F and is discussed in Section 3.1.5. More groundwater is produced from the Edwards-Trinity (Plateau) aquifer (approximately 39 percent) than any other aquifer in the region, about 86 percent of which is used for irrigation. Many communities in the region use the aquifer for their public drinking-water supply. Municipal use accounts for eleven percent of use.

The Edwards-Trinity (Plateau) aquifer is comprised of lower Cretaceous formations of the Trinity Group and limestone and dolomite formations of the overlying Edwards, Comanche Peak, and Georgetown formations. These strata are relatively flat lying and located atop



relatively impermeable pre-Cretaceous rocks. The saturated thickness of the entire aquifer is generally less than 400 feet, although the maximum thickness can exceed 1,500 feet. Recharge is primarily through the infiltration of precipitation on the outcrop, in particular where the limestone formations outcrop. Discharge is to wells and to rivers in the region. Groundwater flow in the aquifer generally flows in a south-southeasterly direction but may vary locally. The hydraulic gradient averages about 10 feet/mile.

Long-term water-level declines have been observed in areas of heavy pumping, most notably in Glasscock, Reagan, Upton, and Midland Counties, in the Odessa area in Ector County, and in the Belding Farm area in Pecos County. Figure 3-5, Figure 3-6, and Figure 3-7 show selected hydrographs for the Edwards-

Region F Aquifers

- Edwards-Trinity (Plateau)
- Edwards-Trinity (High Plains)
- Ogallala
- Pecos Valley
- Trinity
- Dockum
- Hickory
- Lipan
- Ellenburger San Saba
- Marble Falls
- Rustler
- Capitan Reef
- Blaine
- Cross Timbers
- Other
    - San Andres

Trinity (Plateau) aquifer in Region F. As noted above, some areas have shown consistent water-level declines, as shown in Figure 3-5. In some cases, these declines have stopped due to cessation or reduction in pumpage, and are possibly recovering, as shown by Well 54-40-805 in Crockett County. Figure 3-6 shows selected wells with increases in water levels over time. However, most Edwards-Trinity (Plateau) wells in the region show fairly stable water levels, or are slightly declining, as shown by the hydrographs in Figure 3-7. Well 52-16-802 in Pecos County (Figure 3-7) shows the water level variations throughout the year as pumpage increases in the summer and stops in the winter.

Edwards Formation

Groundwater is produced from the Edwards Formations portion of the Edwards-Trinity (Plateau) aquifer in most of the region. Groundwater in the Edwards and associated limestones occurs primarily in solution cavities that have developed along faults, fractures, and joints in the limestone. These formations are the main water-producing units in about two-thirds of the aquifer extent. The largest single area of pumpage from the Edwards portion of the aquifer in Region F is in the Belding Farms area of Pecos County.

Due to the nature of groundwater flow in the Edwards, it is very difficult to estimate aquifer properties for this portion of the Edwards-Trinity (Plateau) aquifer. However, based on aquifer characteristics of the Edwards elsewhere, wells producing from the Edwards portion of the Edwards-Trinity (Plateau) aquifer are expected to be much more productive than from the Trinity portion of the aquifer.

The chemical quality of the Edwards and associated limestones is generally better than that in the underlying Trinity aquifer. Groundwater from the Edwards and associated limestones is fairly uniform in quality, with water being a very hard, calcium bicarbonate type, usually containing less than 500 mg/l total dissolved solids (TDS), although in some areas the TDS can exceed 1,000 mg/l.

Trinity Group

Water-bearing units of the Trinity Group are used primarily in the northern third and on the southeastern edge of the aquifer. In most of the region, the Trinity is seldom used due to the presence of the Edwards above it, which produces better quality water at generally higher rates. In the southeast portion, the Trinity consists of, in ascending order, the Hosston, Sligo, Cow Creek, Hensell and Glen Rose Formations. In the north where the Glen Rose pinches out, all of the Trinity Group is referred to collectively as the Antlers Sand. The greatest withdrawal from the Trinity (Antlers) portion of the aquifer is in Glasscock, Reagan, Upton, and Midland Counties.

Reported well yields from the Trinity portion of the Edwards-Trinity (Plateau) aquifer commonly range from less than 50 gallons per minute (gpm) from the thinnest saturated section to as much as 1,000 gpm. Higher yields occur in locations where wells are completed in jointed or cavernous limestone. Specific capacities of wells range from less than 1 to greater than 20 gpm/ft.

The water quality in the Trinity tends to be poorer than in the Edwards. Water from the Antlers is of the calcium bicarbonate/sulfate type and very hard, with salinity increasing towards the west. Salinities in the Antlers typically range from 500 to 1,000 mg/l TDS, although groundwater with greater than 1,000 mg/l TDS is common.

Figure 3-5
Selected Hydrographs from the Edwards-Trinity (Plateau) Aquifer
Showing Declining Water Levels

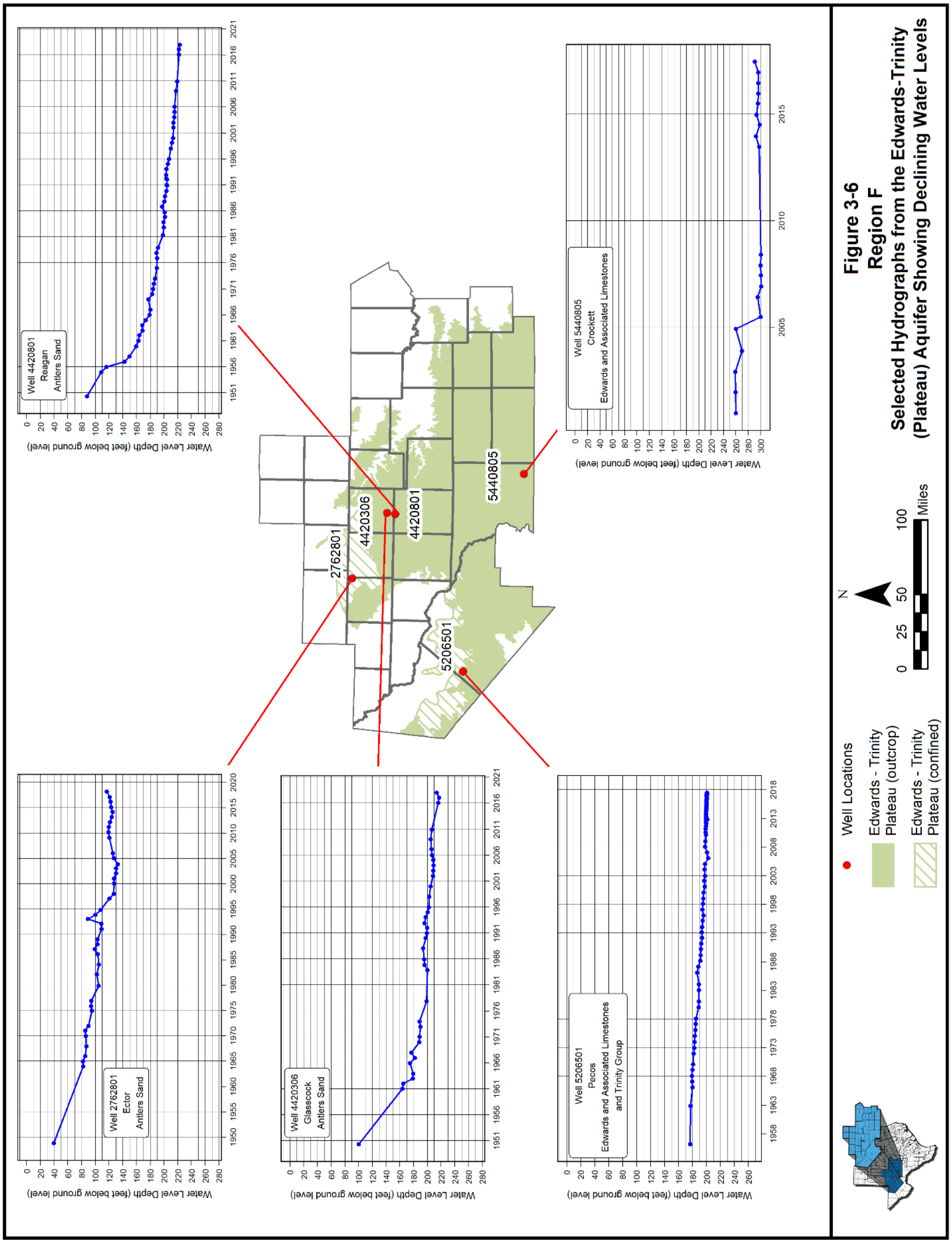


Figure 3-6
Selected Hydrographs from the Edwards-Trinity (Plateau) Aquifer Showing Rising Water Levels

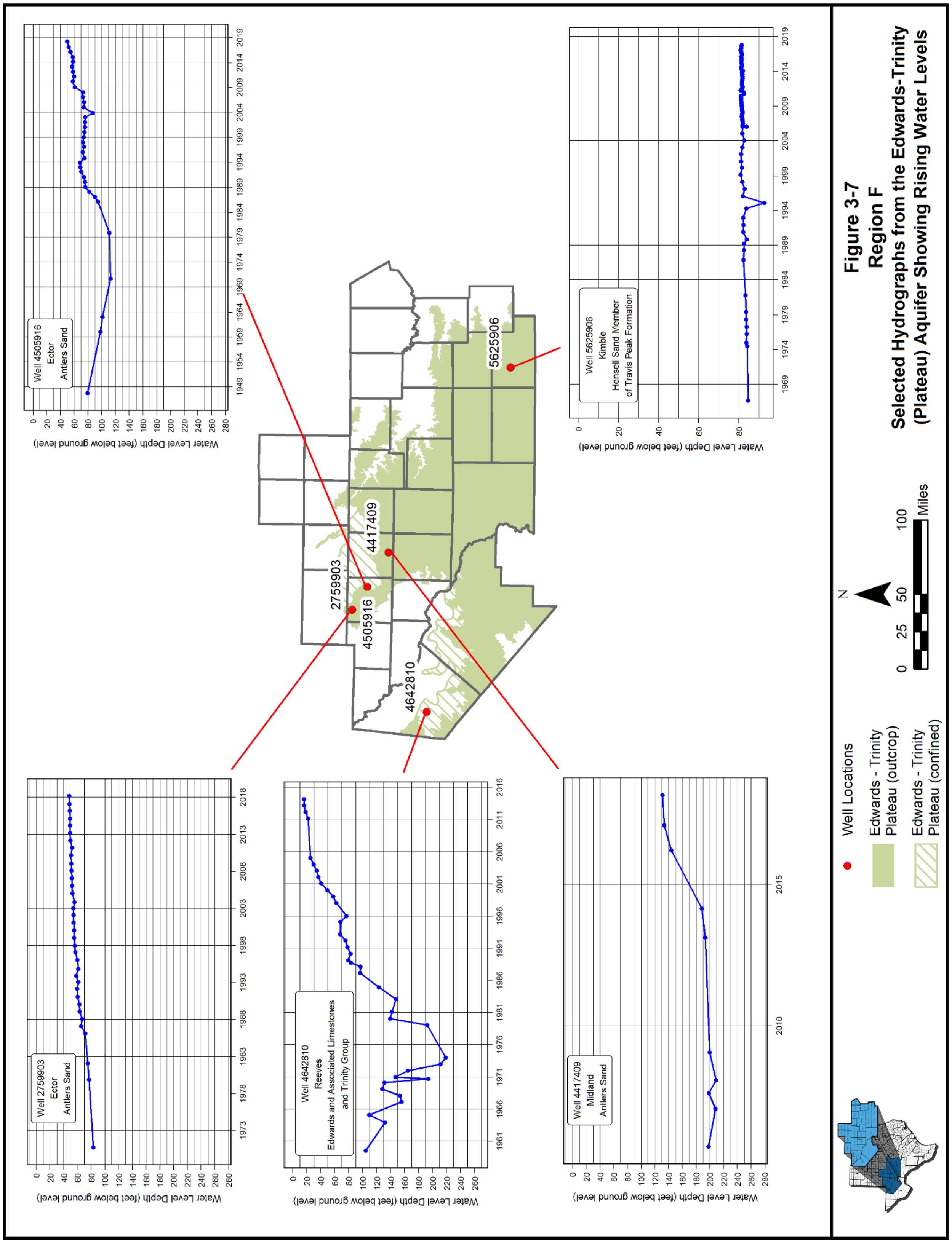
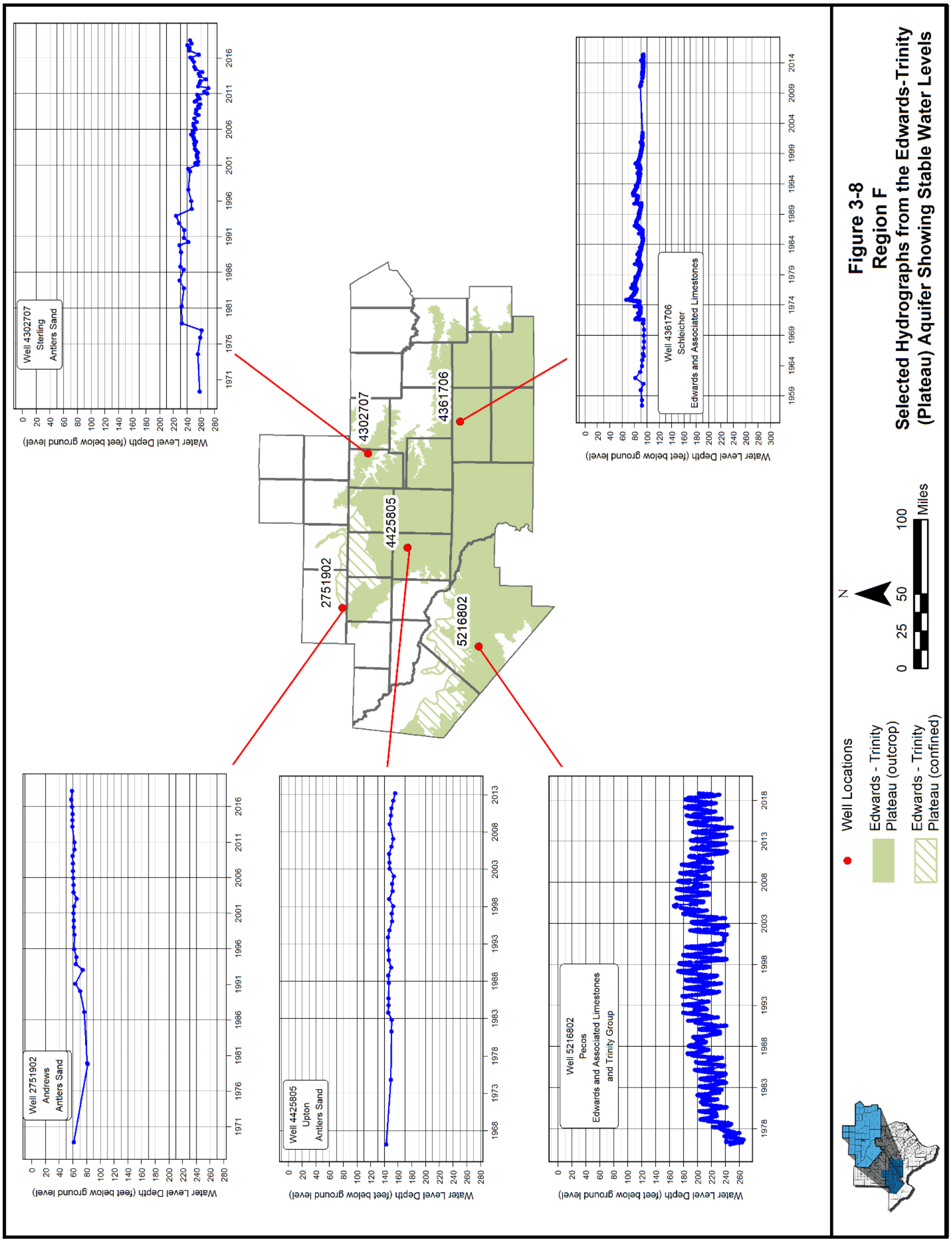
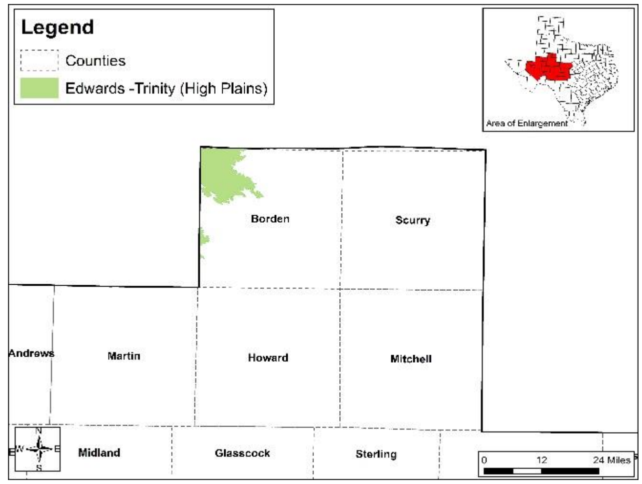


Figure 3-7
Selected Hydrographs from the Edwards-Trinity (Plateau) Aquifer Showing Stable Water Levels



3.1.2 Edwards-Trinity (High Plains) Aquifer

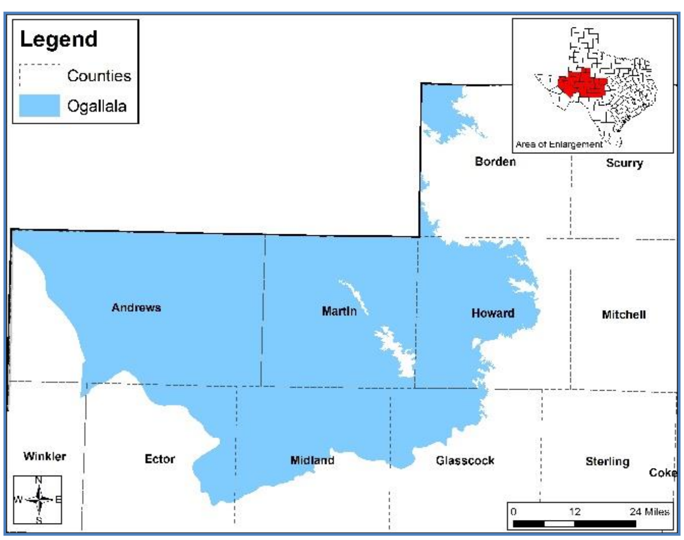
The Edwards-Trinity (High Plains) aquifer underlies the Ogallala aquifer in western Texas and eastern New Mexico and provides water to all or parts of 13 Texas counties. The aquifer's water-producing units include sandstone of the Antlers Formation (Trinity Group) and limestone of the overlying Comanche Peak and Edwards formations. Recharge to the aquifer is primarily due to downward leakage from the younger Ogallala aquifer and typically flows in a southeasterly direction. Water quality found in the Edwards-Trinity (High Plains) aquifer is slightly saline, with total dissolved solids ranging from 1,000 to 2,000 milligrams per liter.



The aquifer extends into the northwestern corner of Borden County where it is a minor source of water used for irrigation purposes.

3.1.3 Ogallala Aquifer

The Ogallala is one of the largest sources of groundwater in the United States, extending from South Dakota to the Southern High Plains of the Texas Panhandle. In Region F, the aquifer occurs in seven counties in the northwestern part of the region including Andrews, Borden, Ector, Howard, Glasscock, Martin and Midland Counties. The aquifer provides approximately 16 percent of all groundwater used in the region. The formation is hydrologically connected to the underlying Edwards-Trinity (Plateau) aquifer in southern Andrews and Martin Counties, and northern Ector, Midland and Glasscock Counties.

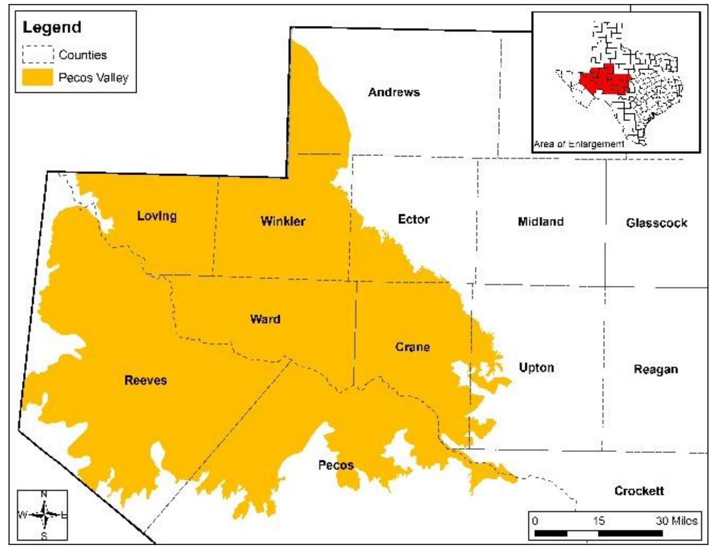


In Region F, agricultural irrigation accounts for approximately 85 percent of the total use of Ogallala groundwater. Municipal use accounts for approximately 12 percent. Most of the withdrawals from the aquifer occur in Midland, Martin, and Andrews Counties.

The Ogallala is composed of coarse to medium grained sand and gravel in the lower strata grading upward into fine clay, silt and sand. Recharge occurs principally by infiltration of precipitation on the surface and to a lesser extent by upward leakage from underlying formations. Highest recharge infiltration rates occur in areas overlain by sandy soils and in some playa lake basins. Groundwater in the aquifer generally moves slowly in a southeastwardly direction. Water quality of the Ogallala in the Southern High Plains ranges from fresh to moderately saline, with dissolved solids averaging approximately 1,500 mg/l.

3.1.4 Pecos Valley Aquifer

The Pecos Valley aquifer is located in the upper part of the Pecos River Valley of West Texas in Andrews, Crane, Crockett, Ector, Loving, Pecos, Reeves, Upton, Ward and Winkler Counties. Consisting of up to 1,500 feet of alluvial fill, the Pecos Valley occupies two hydrologically separate basins: the Pecos Trough in the west and the Monument Draw Trough in the east. The aquifer is hydrologically connected to underlying water-bearing strata, including the Edwards-Trinity in Pecos and Reeves Counties, the Triassic Dockum in Ward and Winkler Counties, and the Rustler in Reeves County.



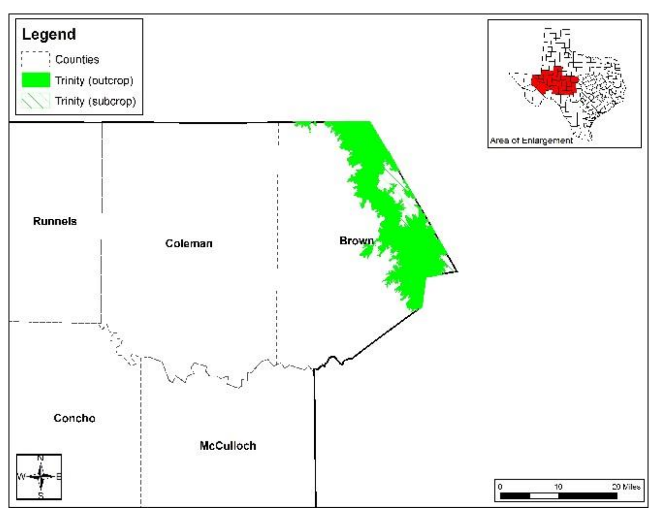
The western basin (Pecos Trough) contains poorer quality water and is used most extensively for irrigation of salt-tolerant crops. The eastern basin (Monument Draw Trough) contains relatively good quality water that is used for a variety of purposes, including industrial use, power generation, and public water supply. Most pumping occurs in Pecos and Reeves Counties for irrigation.

The Pecos Valley is the third most used aquifer in the region, representing approximately 19 percent of total groundwater use. Agricultural irrigation accounts for approximately 80 percent of the total, while municipal consumption and power generation account for about 16 percent of aquifer use.

Lateral subsurface flow from the Rustler aquifer into the Pecos Valley has significantly affected the chemical quality of groundwater in the overlying western Pecos Trough aquifer. Most of this basin contains water with greater than 1,000 mg/l TDS, and a significant portion is above 3,000 mg/l TDS. The eastern Monument Draw Trough is underlain by the Dockum aquifer but is not as significantly affected by its quality difference. Water levels in the past fifty years have generally been stable. However, in Reeves County just south of the City of Pecos, water levels in state well number 46-44-501 have dropped an average of 40 feet since 1995.

3.1.5 Trinity Aquifer

The Trinity aquifer is a primary groundwater source for eastern Brown County. Small isolated outcrops of Trinity Age rocks also occur in south central Brown County and northwest Coleman County. However, these two areas are not classified as the contiguous Trinity aquifer by the TWDB and the TWDB did not estimate a groundwater availability for the Trinity aquifer in Coleman County. Agricultural related consumption (irrigation and livestock) accounts for approximately 70 percent of the total withdrawal from the aquifer.



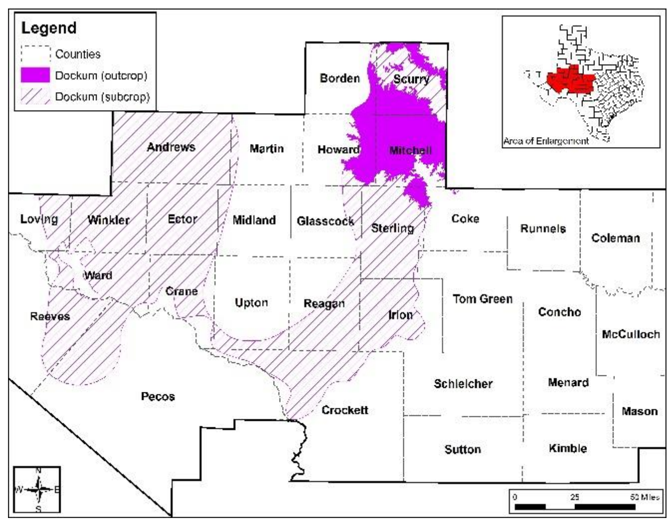
The Trinity was deposited during the Cretaceous Period and is comprised of (from bottom to top) the Twin Mountains, Glen Rose and Paluxy Formations. The Twin Mountains is further divided into the Hosston (lower) and Hensell (upper) with increasing thickness (downdip to the east). In western Brown and Coleman Counties, the Glen Rose is thin or missing and the Paluxy and Twin Mountains coalesce to form the Antlers Sand. The Paluxy consists of sand and shale and is capable of producing small quantities of fresh to slightly saline water. The Twin Mountains formation is composed of sand, gravel, shale, clay and occasional conglomerate, sandstone and limestone beds. It is the principal aquifer and yields moderate to large quantities of fresh to slightly saline water. Maximum thickness of the Trinity aquifer is approximately 200 feet in this area.

Trinity aquifer water quality is acceptable for most municipal, industrial, and irrigation purposes. Dissolved solids range from approximately 150 to over 7,000 mg/l in Brown County; however, most wells have dissolved solids concentrations of less than 1,000 mg/l. The potential for updip movement of poor quality water exists where large and ongoing water level declines have reversed the natural water level gradient and have allowed water of elevated salinity to migrate back updip toward pumpage centers.

3.1.6 Dockum Aquifer

The Dockum aquifer is used for water supply in 12 counties in Region F, including Andrews, Crane, Ector, Howard, Loving, Mitchell, Reagan, Reeves, Scurry, Upton, Ward, and Winkler Counties. The Dockum outcrops in Scurry and Mitchell Counties, and elsewhere underlie rock formations comprising the Ogallala, Edwards-Trinity, and Pecos Valley aquifers. Although the Dockum aquifer underlies much of the region, its low water yield and generally poor quality results in its classification as a minor aquifer.

Almost six percent of groundwater withdrawn in the region is from the Dockum. Agricultural irrigation and livestock use account for 77 percent of Dockum pumpage. Most Dockum water used for irrigation is withdrawn in Mitchell and Scurry Counties, while public supply use of Dockum water occurs mostly in Mitchell, Reeves, Scurry and Winkler Counties. Municipal use of Dockum water accounts for about 20 percent of total Dockum use. Mining uses (which include drilling and hydraulic fracing) account for less than one percent (based on historical use for years 2012 through 2016).



The primary water-bearing zone in the Dockum Group, commonly called the "Santa Rosa", consists of up to 700 feet of sand and conglomerate interbedded with layers of silt and shale. The Santa Rosa abuts the overlying Trinity aquifer along a corridor that traverses Sterling, Irion, Reagan and Crockett Counties. Within this corridor, the Trinity and Dockum are hydrologically connected, thus forming a thicker aquifer section. A similar hydrologic relationship occurs in Ward and Winkler Counties, where the Santa Rosa unit of the Dockum is in direct contact with the overlying Pecos Valley aquifer. Local groundwater reports use the term "Allurosa" aquifer in reference to this combined section of water-bearing sands.

Recharge to the Dockum primarily occurs in Scurry and Mitchell Counties where the formation outcrops at the land surface. Recharge potential also occurs where water-bearing units of the Trinity and Pecos Valley directly overlie the Santa Rosa portion of the Dockum. Elsewhere, the Dockum is buried deep below the land surface, is finer grained, and receives very limited lateral recharge. Groundwater pumped from the aquifer in these areas will come directly from storage and will result in water level declines.

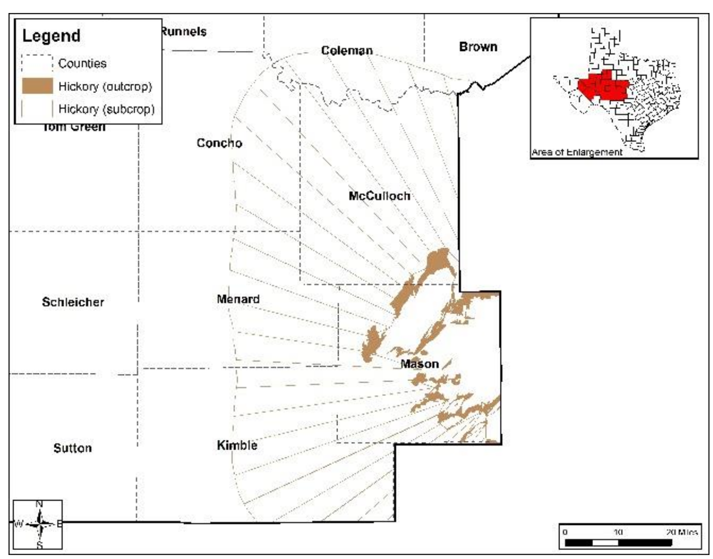
The chemical quality of water from the Dockum aquifer ranges from fresh in outcrop areas to very saline in the deeper central basin area. Groundwater pumped from the aquifer in Region F has average dissolved solids ranging from 550 mg/l in Winkler County to over 2,500 mg/l in Andrews, Crane, Ector, Howard, Reagan and Upton Counties.

3.1.7 Hickory Aquifer

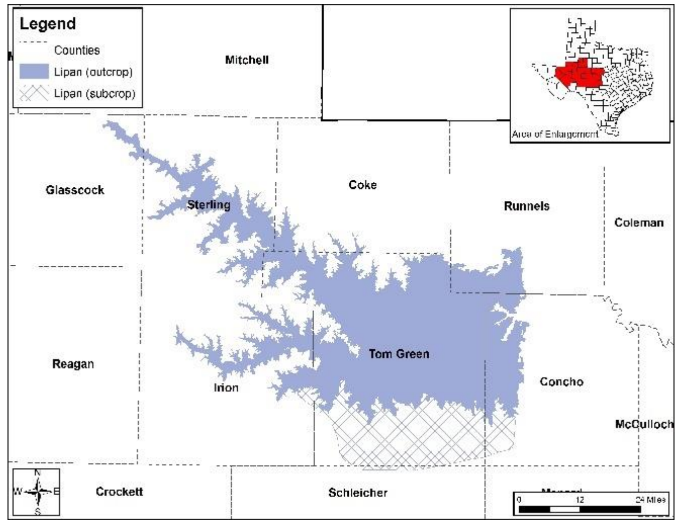
The Hickory aquifer is located in the eastern portion of Region F and outcrops in Mason and McCulloch Counties. This aquifer also supplies groundwater to Concho, Kimble and Menard Counties. The Hickory Sandstone Member of the Cambrian Riley Formation is composed of some of the oldest sedimentary rocks in Texas. Irrigation and livestock account for approximately 59 percent of the total pumpage, while municipal water use accounts for approximately 23 percent. Mason County uses the greatest amount of water from the Hickory aquifer, most of which is used for irrigation. McCulloch County pumpage is primarily for mining (45 percent) and municipal use (28 percent) based on 2012 through 2016 historical pumping. In most northern and western portions of the aquifer, the Hickory Sandstone Member can be differentiated into lower, middle and upper units, which reach a maximum thickness of 480 feet in southwestern McCulloch County. Block faulting has compartmentalized the Hickory aquifer, which locally limits the occurrence, movement, productivity, and quality of groundwater within the aquifer.

Hickory aquifer water is generally fresh, with dissolved solids concentrations ranging from 300 to 500 mg/l. Much of the water from the Hickory aquifer exceeds drinking water standards for alpha particles, beta particles, and radium particles in the downdip portion of the aquifer. The middle Hickory unit is believed to be the source of alpha, beta, and radium concentrations in excess of drinking water standards. The water may also contain radon gas. The upper unit of the Hickory aquifer produces groundwater containing concentrations of iron in excess of drinking water standards. Wells in the shallow Hickory and the outcrop areas have local concentrations of nitrate in excess of drinking water standards.

Yields of large-capacity wells usually range between 200 and 500 gpm. Some wells have yields in excess of 1,000 gpm. Highest well yields are typically found northwest of the Llano Uplift, where the aquifer has the greatest saturated thickness.



3.1.8 Lipan Aquifer



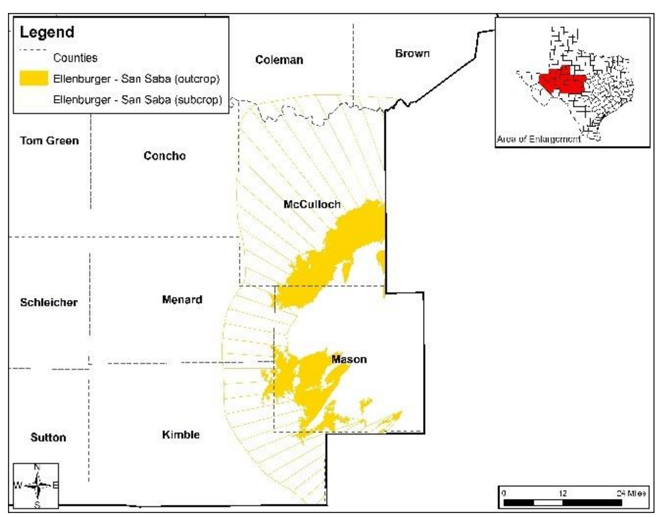
The Lipan aquifer is located primarily in Tom Green County and extends into neighboring counties. The aquifer accounts for about six percent of regional groundwater use and is principally used for irrigation (94 percent) with limited rural domestic and livestock use. Most pumpage occurs in Tom Green County. The Lipan aquifer is comprised of saturated alluvial deposits of the Leona Formation and the updip portions of the underlying Permian-age Choza Formation, Bullwagon Dolomite, and Standpipe Limestone that are hydrologically connected to the Leona. Total thickness of the Leona alluvium ranges from a few feet to about 125 feet. However, most of the groundwater is contained within the underlying Permian units.

Typical irrigation practice in the area is to withdraw water held in storage in the aquifer during the growing season with expectation of recharge recovery during the winter months. The Lipan-Kickapoo Water Conservation District controls overuse by limiting well density.

Groundwater in the Leona Formation ranges from fresh to slightly saline and is very hard, while water in the underlying updip portions of the Choza, Bullwagon and Standpipe tends to be slightly saline. The chemical quality of groundwater in the Lipan aquifer generally does not meet drinking water standards but is suitable for irrigation. In some cases, Lipan water has TDS concentrations in excess of drinking water standards due to influx of water from lower formations. In other cases, the Lipan has excessive nitrates because of agricultural activities in the area. Well yields generally range from 20 to 500 gpm with the average well yielding approximately 200 gpm.

Most of the water in the Lipan aquifer is brackish due to the dissolution of gypsum and other minerals from the aquifer matrix. Additionally, irrigation return flow has concentrated minerals in the water through evaporation and the leaching of natural salts from the unsaturated zone.

3.1.9 Ellenburger San Saba Aquifer



Including the downdip boundary as designated by the TWDB, the Ellenburger-San Saba aquifer occurs in Brown, Coleman, Kimble, Mason, McCulloch and Menard Counties within Region F. Currently, the aquifer supplies less than one percent of total regional use and most pumpage occurs in McCulloch County. About 73 percent of all use is for livestock and about 13 percent is for municipal use. Most of the aquifer in the subcrop area contains water in excess of 1,000 mg/l TDS. The downdip boundary of the aquifer, which represents the extent of water with less than 3,000 mg/l TDS, is roughly estimated due to lack of data.

The Ellenburger-San Saba aquifer is comprised of the Cambrian-age San Saba member of the Wilberns Formation and the Ordovician-age Ellenburger Group, which includes the Tanyard, Gorman, and Honeycut Formations. Discontinuous outcrops of the aquifer generally encircle older rocks in the core of the Llano Uplift. The maximum thickness of the aquifer is about 1,100 feet. In some areas, where the overlying beds are thin or absent, the Ellenburger-San Saba aquifer may be hydrologically connected to the Marble Falls aquifer. Local and regional block faulting has significantly compartmentalized the Ellenburger-San Saba, which locally limits the occurrence, movement, productivity, and quality of groundwater within the aquifer.

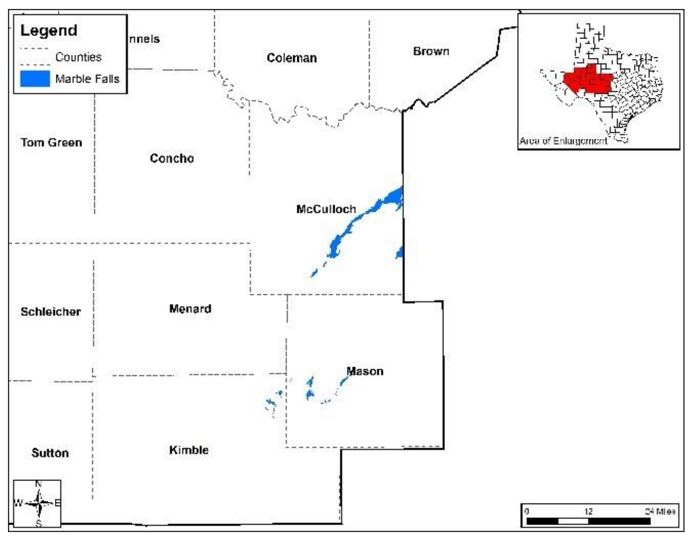
Water produced from the aquifer has a range in dissolved solids between 200 and 3,000 mg/l, but is usually less than 1,000 mg/l. The quality of water deteriorates rapidly away from outcrop areas. Approximately 20 miles or more downdip from the outcrop, water is typically unsuitable for most uses. All the groundwater produced from the aquifer is inherently hard.

Principal use from the aquifer is for livestock supply in Mason and McCulloch Counties, and a minor amount in Menard County. Maximum yields of large-capacity wells generally range between 200 and 600 gpm, most other wells typically yield less than 100 gpm.

3.1.10 Marble Falls Aquifer

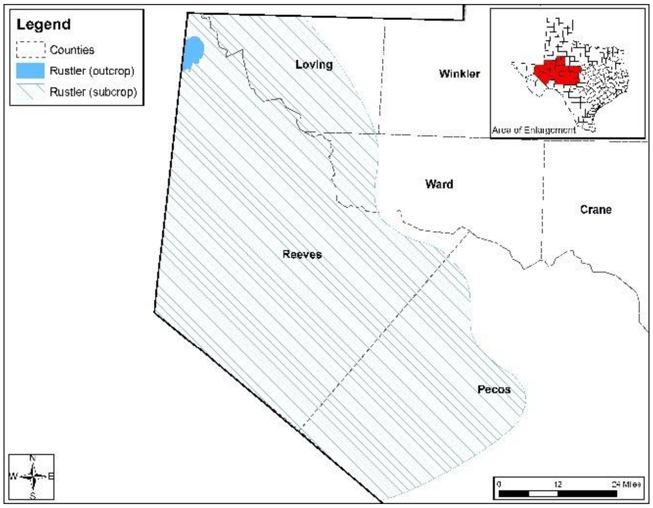
The Marble Falls is the smallest aquifer in the region, occurring in very limited outcrop areas in Kimble, Mason and McCulloch Counties. The aquifer supplies less than one percent of total regional use. Irrigation accounts for 71 percent of use and livestock about 17 percent. Groundwater in the aquifer occurs in fractures, solution cavities, and channels in the limestones of the Marble Falls Formation of the Pennsylvanian-age Bend Group. Where underlying beds are thin or absent, the Marble Falls and Ellenburger-San Saba aquifers may be hydrologically connected.

A limited amount of well data suggests that water quality is acceptable for most uses only in wells located on the outcrop and in wells that are less than 300-feet deep in the downdip portion of the aquifer. The downdip artesian portion of the aquifer is not extensive, and water becomes significantly mineralized within a relatively short distance downdip from the outcrop area. Most water produced from the aquifer occurs in McCulloch County.



3.1.11 Rustler Aquifer

The Rustler Formation outcrops outside of Region F in Culberson County, but the majority of its downdip extent occurs in Region F in Loving, Pecos, Reeves and Ward Counties. The Rustler Formation consists of 200 to 500 feet of anhydrite and dolomite with a basal zone of sandstone and shale deposited in the ancestral Permian-age Delaware Basin. Water is produced primarily from highly permeable



solution channels, caverns and collapsed breccia zones.

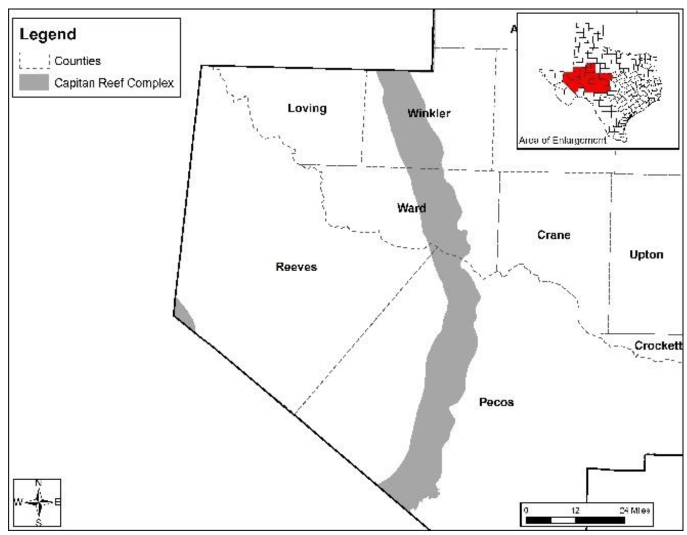
Groundwater from the Rustler Formation may locally migrate upward, impacting water quality in the overlying Edwards-Trinity and Pecos Valley aquifers. The Rustler is the source for about one percent of regional groundwater and is primarily used for irrigation (99 percent) in Pecos and Reeves Counties.

Throughout most of its extent, the Rustler is relatively deep below the land surface, and generally contains water with dissolved constituents (TDS) well in excess of 3,000 mg/l. Only in western Pecos, eastern Loving and southeastern Reeves Counties has water been identified that contains less than 3,000 mg/l TDS. The dissolved-solids concentrations increase down gradient, eastward into the basin, with a shift from sulfate to chloride as the predominant anion. No groundwater from the Rustler aquifer has been located that meets drinking water standards.

3.1.12 Capitan Reef Aquifer

The Capitan Reef formed along the margins of the ancestral Delaware Basin, an embayment covered by a shallow sea in Permian time. In Texas, the reef parallels the western and eastern edges of the basin in two arcuate strips 10 to 14 miles wide and is exposed in the Guadalupe, Apache and Glass Mountains. From its exposure in the Glass Mountains in Brewster and southern Pecos Counties, the reef plunges underground to a maximum depth of 4,000 feet in northern Pecos County. The reef trends northward into New Mexico where it is a major source of water in the Carlsbad area.

The aquifer is composed of 2,000 feet of massive, vuggy to cavernous dolomite, limestone and reef talus. Water-bearing formations associated with the aquifer system include the Capitan Limestone, Goat Sheep Limestone, and most of the Carlsbad facies of the Artesia Group, which includes the Grayburg, Queen, Seven Rivers, Yates, and Tansill Formations. The Capitan Reef aquifer underlies



the Pecos Valley, Edwards-Trinity (Plateau), Dockum, and Rustler aquifers in Pecos, Ward, and Winkler Counties.

The aquifer generally contains water of marginal quality, with TDS concentrations ranging between 3,000 and 22,000 mg/l. High salt concentrations in some areas are probably caused by migration of brine waters injected for secondary oil recovery. The freshest water is located near areas of recharge where the reef is exposed at the surface. Yields of wells commonly range from 400 to 1,000 gpm.

Most of the groundwater pumped from the aquifer has historically been used for oil reservoir water-flooding operations in Ward and Winkler Counties. Historical use estimates for years 2012 through 2016 attribute 99 percent of use to irrigation in Pecos County only. The Capitan supplies about three percent of total groundwater pumpage in Region F. Very little reliance has been placed on this aquifer due to its depth, limited extent, and marginal quality. The Capitan Reef aquifer may be a potential brackish water supply for desalination and oilfield supply.

3.1.13 Blaine Aquifer

The Blaine aquifer extends from Wheeler County in the Panhandle to Coke County in West-Central Texas. In Region F, there are only isolated outliers of the aquifer in Coke County. Most of the groundwater currently produced from the Blaine is used for irrigation purposes because the water quality is poor. The Permian age Blaine Formation is composed of shale, sandstone, and beds of gypsum, halite, and anhydrite, some of which can be 10 to 30 feet in thickness. Overall, the Blaine Formation can be up to 1,200 feet thick. Groundwater in the Blaine occurs in dissolution channels that have formed in the aquifer matrix.

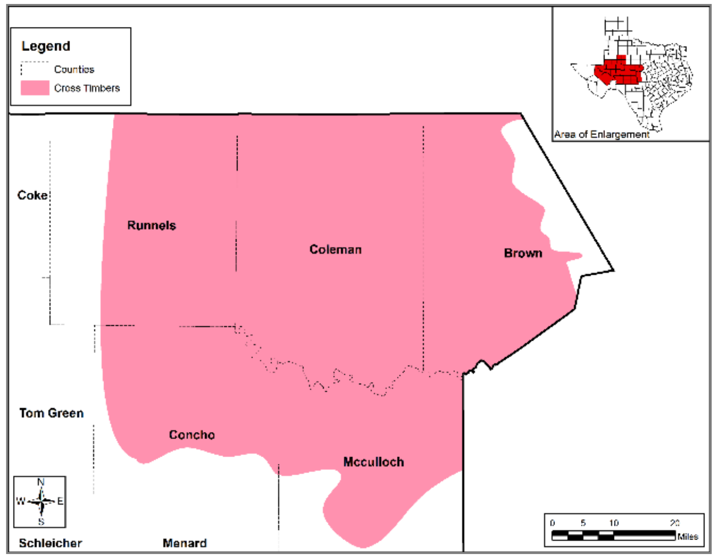
Yields from wells completed in the Blaine aquifer can be quite high. However, the productivity of a well depends on the number and size of dissolution channels intersected by the well. Because of this, it is very difficult to accurately describe hydraulic characteristics or anticipate potential well yields in the Blaine. Recharge to the Blaine aquifer is through the infiltration of precipitation on the outcrop. This recharge then moves downdip predominantly along dissolution channels in the gypsum, anhydrite, and halite beds. The recharge water discharges in topographically low areas to salt seeps and springs. As the water moves downdip, it further dissolves the gypsum/anhydrite/ halite beds, increasing the number and size of solution channels that water can move through and also increasing the salinity of the groundwater. The water that discharges into salt seeps and springs tends to be very high in TDS, and will contaminate surface water bodies, which is a long-recognized problem in the area.

The water quality from the Blaine aquifer varies greatly but is generally slightly- to moderately-saline. Most of the groundwater produced from the Blaine is highly mineralized because the water is largely being produced from dissolution channels within gypsum, halite, and anhydrite beds. For this reason, it is largely unsuitable for any purposes except for salt tolerant irrigation. Total dissolved solids range from less than 1,000 to greater than 10,000 mg/L. Fresh groundwater from the Blaine is uncommon and is usually found in topographically higher areas where the formation crops out, and where recharge from precipitation or possibly from overlying alluvium occurs. Groundwater from the Blaine throughout much of the outcrop area typically has between 2,000 and 4,000 mg/L TDS.

3.1.14 Cross Timbers Aquifer

The Cross Timbers aquifer consists of Paleozoic-aged formations that have an outcrop area of 11,800 square miles and encompass all or part of 31 counties between the Red and Colorado Rivers. In Region F, the Cross Timbers occurs in Brown, Coleman, Concho, McCulloch, and Runnels Counties. In the southern portion of the aquifer, the formations of the Wichita (Permian), Cisco, Canyon, and Strawn (Pennsylvanian) Groups generally dip to the west, and in the northern portion of the aquifer, where they are overlain by the Cretaceous Trinity Group, they dip to the north and east. The formations predominantly consist of limestone, shale and sandstone.

Groundwater is typically unconfined, shallow, and laterally discontinuous, occurring primarily in the sandstone layers. Aquifer properties, well yields, and water quality are highly variable. Most of the wells that are completed in the Cross Timbers have historically been used for domestic and livestock purposes; however, there are also a few public supply wells.



A TWDB contract for a conceptual model report for the Cross Timbers aquifer is scheduled to be completed by October 31, 2021.

3.1.15 Groundwater Local Supplies (Other Aquifer)

Groundwater local supplies refer to localized pockets of groundwater that are not classified as either a major or minor aquifer of the state. These areas are termed "other" aquifer. Other aquifer supplies are generally small but can be locally significant.

San Andres Aquifer

The San Andres aquifer is a formation located in norther Pecos County near Imperial, Texas. In 1957, there were at least 27 groundwater wells completed in the San Andres Formation. The wells flowed at the surface when they were drilled but due to continuous discharge and decreasing formation pressure, only about eight of these wells currently flow. In 1957, the withdrawals were estimated to have been 10,000 acre-feet. Additional water may be available from this source, but more studies are needed. Water quality is characterized by total dissolved solid concentrations that exceed 5,000 milligrams per liter, hydrogen sulfide gas presence in the groundwater, and sulfur that precipitates out upon oxidation at the surface[1].Uses included irrigation, secondary recovery via waterflooding, and livestock. Advanced treatment would be required for municipal use.

Environmental problems created by the flowing wells include: sink holes (caused by the dissolution of evaporates by the vertical migration of San Andres waters), malodorous brackish water ponding at the surface, road collapse and reroutes, vegetation kills, potential non-native species encroachment, salt loading of soils, and destruction of land use.

The Capitan Reef Complex is located about four miles to the west of the flowing San Andres Formation wells. The underlying San Andres Formation is structurally high in the area west of Imperial, functions as the base of the backreef sequence, and has good hydrogeological communication with the Capitan Reef Complex [2]. However, the source of water to the flowing wells is the San Andres Formation [3].

3.1.16 Overview of Groundwater Regulation in Texas and Region F

Groundwater supplies are intricately linked to groundwater regulation and permitting throughout Texas and in Region F. It is difficult to discuss availability from groundwater supplies without understanding the basic regulatory framework that controls those supplies. Therefore, the discussion of available regional groundwater supplies begins with a discussion of the regulatory framework for groundwater.

In June 1997, the 75th Texas Legislature enacted Senate Bill 1 (SB 1) to establish a comprehensive statewide water planning process to help ensure that the water needs of all Texans are met. SB1 mandated that representatives serve as members of Regional Water Planning Groups (RWPGs) to prepare regional water plans for their respective areas. These plans map out how to conserve water supplies, meet future water supply needs, and respond to future droughts in the planning areas. Additionally, SB 1 established that groundwater conservation districts (GCDs) were the preferred entities for groundwater management and contained provisions that required the GCDs to prepare management plans.

In 2001, the Texas Legislature enacted Senate Bill 2 (SB 2) to build on the planning requirements of SB 1 and to further clarify the actions necessary for GCDs to manage and conserve groundwater resources. As part of SB 2, the Legislature called for the creation of Groundwater Management Areas (GMAs) which were based largely on hydrogeologic and aquifer boundaries instead of political boundaries. The TWDB divided Texas into 16 GMAs, and most contain multiple GCDs. One of the purposes for GMAs was to manage groundwater resources on a more aquifer-wide basis. Figure 3-8 shows the regulatory boundaries of the GCDs and GMAs within Region F.

Key Groundwater Terms

Groundwater Management Areas (GMAs)

GMAs provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence caused by withdrawal of water from those groundwater reservoirs or their subdivisions. Many GMAs contain multiple GCDs.

Groundwater Conservation Districts (GCDs)

Local entity responsible for aquifer planning and developing the amount of groundwater available for use and/or development by the RWPGs.

Desired Future Condition (DFC)

The desired, quantified condition of groundwater resources (such as water levels, spring flows, or volumes) within a management area at one or more specified future times as defined by participating groundwater conservation districts within a groundwater management area as part of the joint groundwater planning process.

Groundwater Availability Model (GAM)

Models used by TWDB to perform quantitative analysis to determine the amount of groundwater available for production to meet the DFC. The GAM is used to develop the MAG.

Modeled Available Groundwater (MAG)

The maximum amount of groundwater that can be used for existing uses and new strategies in Regional Water Plans

The Texas Legislature enacted significant changes to the management of groundwater resources in Texas with the passage of House Bill 1763 (HB 1763) in 2005. A main goal of HB 1763 was intended to clarify the authority and conflicts between GCDs and RWPGs. The new law clarified that GCDs would be responsible for aquifer planning and developing the amount of groundwater available for use and/or development by the RWPGs. To accomplish this, the law directed that all GCDs within each GMA to meet and participate in joint groundwater planning efforts. The focus of joint groundwater planning was to determine the Desired Future Conditions (DFCs) for the groundwater resources within the GMA boundaries (before September 1, 2010, and at least once every 5 years after that).

Desired Future Conditions are defined by statute to be "the desired, quantified condition of groundwater resources (such as water levels, spring flows, or volumes) within a management area at one or more specified future times as defined by participating groundwater conservation districts within a groundwater management area as part of the joint groundwater planning process." DFCs are quantifiable management goals that reflect what the GCDs want to protect in their particular area. The most common DFCs are based on the volume of groundwater in storage over time, water levels (limiting decline within the aquifer), water quality (limiting deterioration of quality), or spring flow (defining a minimum flow to sustain). If a GMA determines an aquifer or portion of an aquifer should not be regulated by a DFC, it is declared “non-relevant” and no DFC is set. Table 3-1 summarizes the DFCs for the aquifers in Region F.

After the DFCs are determined by the GMAs, the TWDB performs quantitative analysis to determine the amount of groundwater available for production to meet the DFC. For aquifers where a Groundwater Availability Model (GAM) exists, the GAM is used to develop the Modeled Available Groundwater (MAG). For aquifers without a GAM or non-relevant aquifers, other quantitative approaches may be used to estimate the availability.

In 2011, Senate Bill 660 required that GMA representatives must participate within each applicable RWPG. It also required the Regional Water Plans be consistent with the DFCs in place when the regional plans are initially developed. TWDB technical guidelines for the current round of planning establishes that the MAG (within each county and basin) is the maximum amount of groundwater that can be used for existing uses and new strategies in Regional Water Plans. In other words, the MAG volumes are a cap on existing and future groundwater production for TWDB planning purposes.

Groundwater Conservation Districts and Groundwater Management Areas

Region F

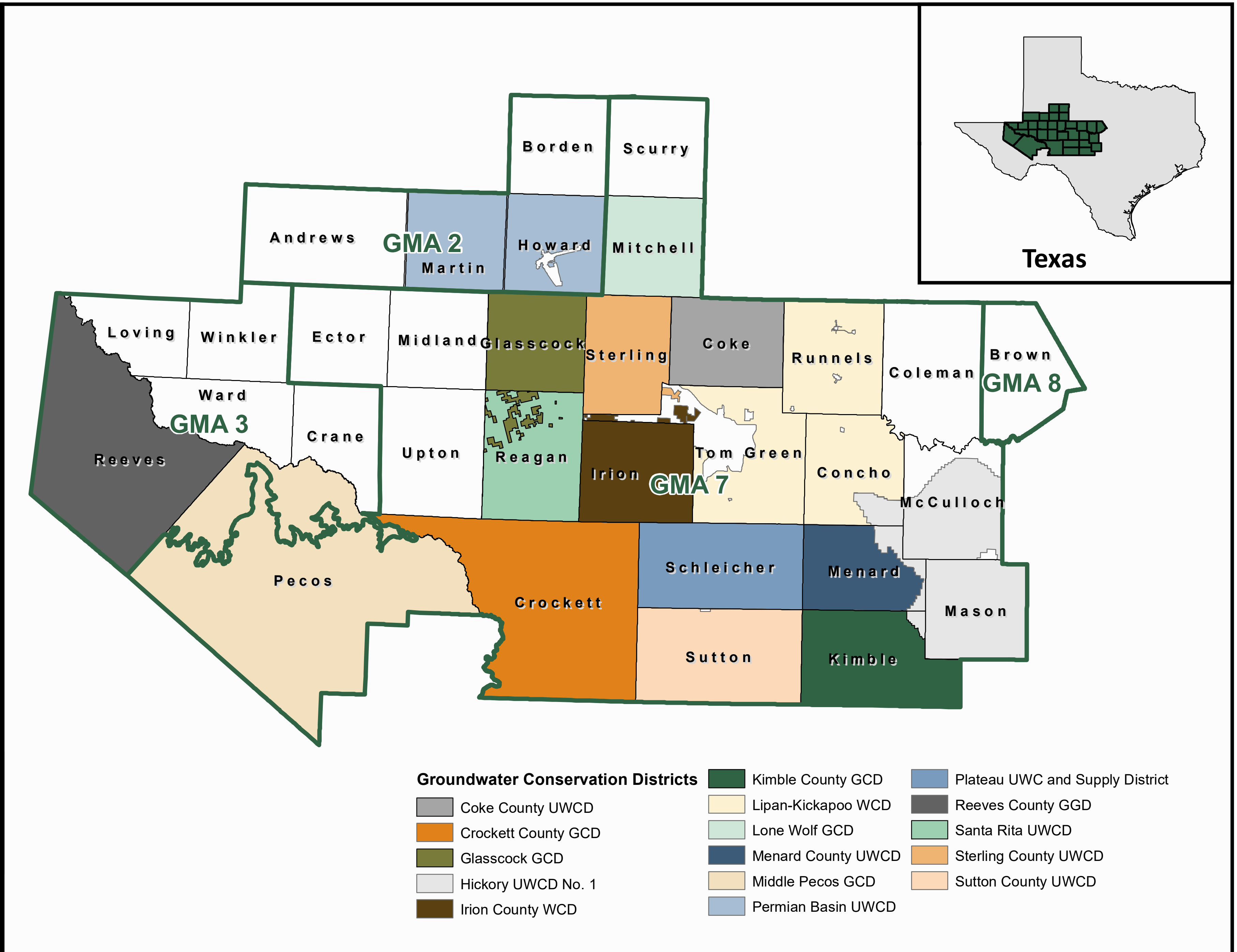


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FIGURE 3-8

Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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Table 3-1
Desired Future Conditions for Region F Aquifers

Aquifer	Groundwater Management Area[1]	Desired Future Condition (DFC)	Region F Non-Relevant
Edwards-Trinity (Plateau)	3 and 7	Net water level decline over 50 years varies by county from 0 ft. in Coke County to 161 ft. in Winkler County.	Andrews, Howard, Martin Counties (GMA 2) Within Hickory UWCD1, Lipan-Kickapoo WCD, Lone Wolf GCD, and Wes-Tex GCD (GMA 7)
Edwards-Trinity (High Plains)	2	DFC is grouped with Ogallala for Border County.	None
Ogallala	2 and 7	Net water level declines vary from 6 ft. in Glasscock County to between 23 and 27 ft. for all of GMA 2.	Midland, Ector (GMA 7)
Pecos Valley	3 and 7	DFC set collectively with Edwards-Trinity (Plateau).	Andrews (GMA 2)
Trinity (Brown County)	8	Set by formation: Average drawdown not to exceed 2 ft. in Glen Rose and Antlers, or 1 ft. in Travis Peak, Hensell, and Hosston.	None
Dockum	2, 3 and 7	Net drawdown by 2070 is 27 ft. for all counties in GMA 2. For GMA 3, net drawdown ranges from 0 ft. (Crane County) to 52 ft. (Pecos County). In GMA 7, net drawdown is 14 ft. (Reagan) and 52 ft. (Pecos)	Ector, Upton, Crockett, Irion, Midland, Sterling, Coke, Glasscock, Mitchell, Scurry, Nolan, Tom Green
Hickory	7	Total drawdown ranges from 6 ft. in San Saba (Region K) to 46 ft. (Menard County).	Brown (GMA 8)
Lipan	7	None set. Assumes all water is used on annual basis.	All counties
Ellenburger-San Saba	7	Total drawdown ranges from 5 ft. (Region K) to 46 ft. (Menard).	None
Marble Falls	7	None set.	All counties
Rustler	3 and 7	Average water level decline in GMA 3 ranges from 28 ft. (Loving) to 69 ft. (Pecos). For GMA 7, declines not to exceed 94 ft. (Pecos).	Crane
Capitan Reef	3 and 7	Total decline not to exceed 4 ft. in Pecos (GMA 3) and 2 ft. in Ward and Winkler Counties. In GMA 7, decline in Pecos County not to exceed 56 ft.	Reeves
Blaine	7	None set.	All counties in GMA 7

3.1.17 Existing Groundwater Availability

As discussed in the previous section, the Modeled Available Groundwater (MAG) set through the joint planning process with the Groundwater Management Areas (GMAs), is a cap on the amount of groundwater considered available for use in the Region F Plan. Table 3-2 presents the MAG numbers by county, aquifer, and river basin for planning years 2020 through 2070. MAG volumes are an estimate of the largest amount of water that can be withdrawn from a given source without violating DFCs. Table 3-2 only includes county aquifer combinations where a DFC has been defined by a GCD/ GMA and the MAG subsequently has been determined by the TWDB using the GAM.

Table 3-2
Modeled Available Groundwater in Region F
-Values in Acre-Feet per Year-

County	Aquifer	Basin	2020	2030	2040	2050	2060	2070
Andrews	Dockum	Colorado	1,319	1,319	1,319	1,319	1,319	1,319
		Rio Grande	0	0	0	0	0	0
	Ogallala	Colorado	24,937	21,375	19,795	18,774	18,040	17,474
		Rio Grande	0	0	0	0	0	0
Borden	Dockum	Brazos	284	284	284	284	284	284
		Colorado	617	617	617	617	617	617
	Ogallala and Edwards-Trinity (High Plains)	Brazos	842	699	635	597	572	555
		Colorado	5,080	3,940	3,433	3,140	2,849	2,657
Brown	Ellenburger-San Saba	Colorado	131	131	131	131	131	131
	Hickory	Colorado	12	12	12	12	12	12
	Marble Falls	Colorado	25	25	25	25	25	25
	Trinity	Brazos	51	51	51	51	51	51
		Colorado	1,399	1,399	1,399	1,399	1,399	1,399
Coke	Edwards-Trinity (Plateau)	Colorado	997	997	997	997	997	997
Coleman	---	Colorado	---	---	---	---	---	---
Concho	Hickory	Colorado	27	27	27	27	27	27
Crane	Dockum	Rio Grande	94	94	94	94	94	94
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	4,991	4,991	4,991	4,991	4,991	4,991
Crockett	Edwards-Trinity (Plateau)	Colorado	20	20	20	20	20	20
		Rio Grande	5,427	5,427	5,427	5,427	5,427	5,427
Ector	Edwards-Trinity (Plateau) and Pecos Valley	Colorado	4,925	4,925	4,925	4,925	4,925	4,925
		Rio Grande	617	617	617	617	617	617
Glasscock	Edwards-Trinity (Plateau)	Colorado	65,186	65,186	65,186	65,186	65,186	65,186
	Ogallala	Colorado	7,925	7,673	7,372	7,058	6,803	6,570
Howard	Ogallala	Colorado	19,835	17,391	16,264	15,638	15,281	15,066
	Dockum	Colorado	1,589	1,589	1,589	1,589	1,589	1,589
Irion	Edwards-Trinity (Plateau)	Colorado	3,289	3,289	3,289	3,289	3,289	3,289
Kimble	Edwards-Trinity (Plateau)	Colorado	1,282	1,282	1,282	1,282	1,282	1,282

County	Aquifer	Basin	2020	2030	2040	2050	2060	2070
	Ellenburger-San Saba	Colorado	521	521	521	521	521	521
	Hickory	Colorado	165	165	165	165	165	165
Loving	Dockum	Rio Grande	453	453	453	453	453	453
	Pecos Valley	Rio Grande	2,982	2,982	2,982	2,982	2,982	2,982
	Rustler	Rio Grande	200	200	200	200	200	200
McCulloch	Ellenburger-San Saba	Colorado	4,364	4,364	4,364	4,364	4,364	4,364
	Hickory	Colorado	24,377	24,377	24,377	24,377	24,377	24,377
Martin	Ogallala	Colorado	63,463	51,126	43,861	39,793	37,210	35,425
	Dockum	Colorado	8	8	8	8	8	8
Mason	Ellenburger-San Saba	Colorado	3,237	3,237	3,237	3,237	3,237	3,237
	Hickory	Colorado	13,212	13,212	13,212	13,212	13,212	13,212
Menard	Edwards-Trinity (Plateau)	Colorado	2,217	2,217	2,217	2,217	2,217	2,217
	Ellenburger-San Saba	Colorado	309	309	309	309	309	309
	Hickory	Colorado	2,725	2,725	2,725	2,725	2,725	2,725
Midland	Edwards-Trinity (Plateau)	Colorado	23,233	23,233	23,233	23,233	23,233	23,233
Pecos	Capitan Reef	Rio Grande	26,168	26,168	26,168	26,168	26,168	26,168
	Dockum	Rio Grande	8,164	8,164	8,164	8,164	8,164	8,164
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	240,208	240,208	240,208	240,208	240,208	240,208
	Rustler	Rio Grande	7,043	7,043	7,043	7,043	7,043	7,043
Reagan	Dockum	Colorado	302	302	302	302	302	302
	Edwards-Trinity (Plateau)	Colorado	68,205	68,205	68,205	68,205	68,205	68,205
		Rio Grande	28	28	28	28	28	28
Reeves	Dockum	Rio Grande	2,539	2,539	2,539	2,539	2,539	2,539
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	189,744	189,744	189,744	189,744	189,744	189,744
	Rustler	Rio Grande	2,387	2,387	2,387	2,387	2,387	2,387
Schleicher	Edwards-Trinity (Plateau)	Colorado	6,403	6,403	6,403	6,403	6,403	6,403
		Rio Grande	1,631	1,631	1,631	1,631	1,631	1,631
Sterling	Edwards-Trinity (Plateau)	Colorado	2,495	2,495	2,495	2,495	2,495	2,495
Sutton	Edwards-Trinity (Plateau)	Colorado	388	388	388	388	388	388
		Rio Grande	6,022	6,022	6,022	6,022	6,022	6,022
Upton[1]	Edwards-Trinity (Plateau) and Pecos Valley	Colorado	18,343	18,343	18,343	18,343	18,343	18,343
		Rio Grande	4,026	4,026	4,026	4,026	4,026	4,026
Ward	Capitan Reef	Rio Grande	103	103	103	103	103	103

County	Aquifer	Basin	2020	2030	2040	2050	2060	2070
	Dockum	Rio Grande	2,150	2,150	2,150	2,150	2,150	2,150
	Pecos Valley	Rio Grande	49,976	49,976	49,976	49,976	49,976	49,976
	Rustler	Rio Grande	0	0	0	0	0	0
Winkler	Capitan Reef	Rio Grande	274	274	274	274	274	274
	Dockum	Colorado	13	13	13	13	13	13
		Rio Grande	5,987	5,987	5,987	5,987	5,987	5,987
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	49,949	49,949	49,949	49,949	49,949	49,949

1) A MAG reallocation request transferring 2,900 afy from the Colorado River Basin to the Rio Grande River Basin in Upton County was approved by TWDB on January 7, 2019. The numbers in the table reflect the MAG volumes approved for regional planning.

Non-relevant aquifers are areas determined by the GCDs that have aquifer characteristics, groundwater demands, and current groundwater uses that do not warrant adoption of a desired future condition. It is anticipated that there will be no large-scale production from non-relevant aquifers. Additionally, it is assumed that what production does occur will not affect conditions in relevant portions of the aquifer(s).

In the absence of a DFC, the RWPG may use an alternate methodology to estimate availability from the aquifer. In some cases, the TWDB published "DFC-compatible availability values." For the county-aquifer-basin areas that did not have TWDB DFC-compatible availability values, the volumes were estimated using various methodologies, such as well productivity (Coke County Dockum and Lipan aquifers), historic use, and previous studies. Table 3-3 presents groundwater availability numbers for the non-relevant aquifers in Region F (in acre-feet per year).

Table 3-3
Non-Relevant Groundwater Supplies in Region F
-Values in Acre-Feet per Year-

County	Aquifer	Basin	2020	2030	2040	2050	2060	2070
Andrews	Edwards-Trinity (Plateau) and Pecos Valley	Colorado	1,198	1,198	1,198	1,198	1,198	1,198
	Pecos Valley	Rio Grande	150	150	150	150	150	150
Coke	Dockum	Colorado	100	100	100	100	100	100
	Lipan	Colorado	160	160	160	160	160	160
Coleman	Hickory	Colorado	500	500	500	500	500	500
Concho	Edwards-Trinity (Plateau)	Colorado	459	459	459	459	459	459
	Lipan	Colorado	1,893	1,893	1,893	1,893	1,893	1,893
Crane	Rustler	Rio Grande	1,000	1,000	1,000	1,000	1,000	1,000
Crockett	Dockum	Colorado	2	2	2	2	2	2
	Dockum	Rio Grande	2	2	2	2	2	2
Ector	Dockum	Colorado	13	13	13	13	13	13
	Dockum	Rio Grande	515	515	515	515	515	515
	Ogallala	Colorado	8,026	7,730	7,171	7,135	6,727	6,727
Glasscock	Dockum	Colorado	900	900	900	900	900	900
	Lipan	Colorado	10	10	10	10	10	10
Howard	Edwards-Trinity (Plateau)	Colorado	672	672	672	672	672	672
Irion	Dockum	Colorado	150	150	150	150	150	150
	Lipan	Colorado	13	13	13	13	13	13
Kimble	Edwards-Trinity (Plateau)	Colorado	104	104	104	104	104	104
	Marble Falls	Colorado	100	100	100	100	100	100
McCulloch	Edwards-Trinity (Plateau)	Colorado	148	148	148	148	148	148
	Marble Falls	Colorado	50	50	50	50	50	50
Martin	Edwards-Trinity (Plateau)	Colorado	242	242	242	242	242	242
Mason	Edwards-Trinity (Plateau)	Colorado	18	18	18	18	18	18
	Marble Falls	Colorado	100	100	100	100	100	100
Menard	Edwards-Trinity (Plateau)	Colorado	377	377	377	377	377	377
Midland	Dockum	Colorado	400	400	400	400	400	400
	Ogallala	Colorado	38,388	36,824	34,623	32,693	31,325	31,325

County	Aquifer	Basin	2020	2030	2040	2050	2060	2070
Mitchell	Dockum	Colorado	14,018	14,018	14,018	14,018	14,018	14,018
Pecos	Igneous	Rio Grande	80	80	80	80	80	80
Reeves	Capitan Reef Complex	Rio Grande	1,007	1,007	1,007	1,007	1,007	1,007
	Igneous	Rio Grande	300	300	300	300	300	300
Runnels	Lipan	Colorado	45	45	45	45	45	45
Schleicher	Lipan	Colorado	0	0	0	0	0	0
Scurry	Dockum	Brazos	306	306	306	306	306	306
	Dockum	Colorado	903	903	903	903	903	903
	Seymour	Brazos	10	10	10	10	10	10
Sterling	Dockum	Colorado	10	10	10	10	10	10
	Lipan	Colorado	850	850	850	850	850	850
Tom Green	Dockum	Colorado	200	200	200	200	200	200
	Edwards-Trinity (Plateau)	Colorado	2,797	2,797	2,797	2,797	2,797	2,797
	Lipan	Colorado	43,568	43,568	43,568	43,568	43,568	43,568
Upton	Dockum	Rio Grande	1,000	1,000	1,000	1,000	1,000	1,000
Winkler	Ogallala	Rio Grande	40	40	40	40	40	40
	Rustler	Rio Grande	500	500	500	500	500	500

Table 3-4 includes availability estimates for other aquifers. Other aquifers are localized pockets of water that are not recognized as a major or minor aquifer. They are generally small but can be locally significant. To estimate the volume available from other aquifers, the maximum annual use from 2012-2015 was used. An exception to this methodology is Borden County, where the maximum historical use (2009) was adopted. Another exception is the Pecos County volume of 10,000 acre-feet for water from the San Andres Formation, which is further described previously in Section 3.1.15.

To determine potential needs and conflicts between where pumping has occurred historically and MAG availability, historical pumping estimates for years 2012 through 2016 were compared to the MAGs (Table 3-4). The highlighted county-aquifer-basin combinations represent 5-year average historical use that exceeds the year 2020 MAG.

Table 3-4
Groundwater Supplies from Other Aquifers

County	Aquifer Name	Basin	2021 Availability
Borden	Other Aquifer	Colorado	2,598
Brown	Other Aquifer | Cross Timbers	Colorado	993

Coke	Other Aquifer	Colorado	2,100
Coleman	Other Aquifer	Colorado	109
	Other Aquifer | Cross Timbers	Colorado	108
Concho	Other Aquifer	Colorado	5,964
Mason	Other Aquifer	Colorado	873
McCulloch	Other Aquifer	Colorado	103
	Other Aquifer | Cross Timbers	Colorado	103
Mitchell	Other Aquifer	Colorado	789
Pecos	Other Aquifer |San Andres	Rio Grande	10,000
Runnels	Other Aquifer	Colorado	5,001
Scurry	Other Aquifer	Brazos	74
		Colorado	315

The pumping estimates are based on reported pumping (from TWDB surveys) as well as non-surveyed estimates. Non-surveyed estimates can comprise a significant portion of the historical estimates data. Irrigation estimates are based on Farm Service Administration crop acreage data and irrigation depths are based on evapotranspiration. Livestock estimates are based on Texas Agricultural Statistics Service livestock population statistics with use per animal derived from Texas Agricultural Experiment Station research. Oilfield surveys help provide estimates for mining use. TWDB estimates water use for non-surveyed cities with a population greater than 500.

Based on the comparison shown in Table 3-5, four county-aquifer-basin combinations have estimated historical use that exceeds the 2020 MAG. These include: Andrews – Ogallala - Rio Grande, Andrews – Dockum - Rio Grande, Concho – Hickory - Colorado, and Crockett – Edwards-Trinity (Plateau) - Colorado.

Region F Groundwater Fast Facts

- Accounts for 87% of the available water supply in Region F.
- Accounts for 60% of historical water used in Region F over the past 5 years.
- Irrigators are the largest user of groundwater in the Region. 86% of groundwater use went towards this purpose.
- Municipal users are the second largest user, accounting for 11% of groundwater use.
- Other uses (livestock, mining, manufacturing, steam electric power) collectively account for only 3% of the historic groundwater use.

Table 3-5
Modeled Available Groundwater and Historical Pumping Estimates (2012-2016)
-All Values are in Acre-Feet per Year-

County	Aquifer	Basin	MAG 2020	Historical Pumping Average (2012-2016)
Andrews	Dockum	Colorado	1,319	2
		Rio Grande	0	*9
	Ogallala	Colorado	24,937	20,656
		Rio Grande	0	*836
Borden	Dockum	Brazos	284	0
		Colorado	617	28
	Ogallala and Edwards-Trinity (High Plains)	Brazos	842	760
		Colorado	5,080	1,611
Brown	Ellenburger-San Saba	Colorado	131	1
	Hickory	Colorado	12	0
	Marble Falls	Colorado	25	0
	Trinity	Brazos	51	28
		Colorado	1,399	1,050
Coke	Edwards-Trinity (Plateau)	Colorado	997	121
Coleman	---	Colorado	---	---
Concho	Hickory	Colorado	27	*410
Crane	Dockum	Rio Grande	94	*130
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	4,991	1,506
Crockett	Edwards-Trinity (Plateau)	Colorado	20	*922
		Rio Grande	5,427	965
Ector	Edwards-Trinity (Plateau) and Pecos Valley	Colorado	4,925	2,833
		Rio Grande	617	*1,155
Glasscock	Edwards-Trinity (Plateau)	Colorado	65,186	36,166
	Ogallala	Colorado	7,925	5,409
Howard	Ogallala	Colorado	19,835	3,659
	Dockum	Colorado	1,589	409
Irion	Edwards-Trinity (Plateau)	Colorado	3,289	411
Kimble	Edwards-Trinity (Plateau)	Colorado	1,282	356
	Ellenburger-San Saba	Colorado	521	6
	Hickory	Colorado	165	20
Loving	Dockum	Rio Grande	453	17
	Pecos Valley	Rio Grande	2,982	33
	Rustler	Rio Grande	200	1
McCulloch	Ellenburger-San Saba	Colorado	4,364	218
	Hickory	Colorado	24,377	7,922
Martin	Ogallala	Colorado	63,463	38,532
	Dockum	Colorado	8	0
Mason	Ellenburger-San Saba	Colorado	3,237	77
	Hickory	Colorado	13,212	6,074

County	Aquifer	Basin	MAG 2020	Historical Pumping Average (2012-2016)
Menard	Edwards-Trinity (Plateau)	Colorado	2,217	449
	Ellenburger-San Saba	Colorado	309	4
	Hickory	Colorado	2,725	213
Midland	Edwards-Trinity (Plateau)	Colorado	23,233	5,881
Pecos	Capitan Reef	Rio Grande	26,168	3,075
	Dockum	Rio Grande	8,164	0
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	240,208	130,026
	Rustler	Rio Grande	7,043	4,096
Reagan	Dockum	Colorado	302	80
	Edwards-Trinity (Plateau)	Colorado	68,205	21,710
		Rio Grande	28	10
Reeves	Dockum	Rio Grande	2,539	1,827
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	189,744	39,714
	Rustler	Rio Grande	2,387	2,280
Schleicher	Edwards-Trinity (Plateau)	Colorado	6,403	2,047
		Rio Grande	1,631	795
Sterling	Edwards-Trinity (Plateau)	Colorado	2,495	601
Sutton	Edwards-Trinity (Plateau)	Colorado	388	206
		Rio Grande	6,022	2,113
Upton	Edwards-Trinity (Plateau) and Pecos Valley	Colorado	21,243	8,172
		Rio Grande	1,126	334
Ward	Capitan Reef	Rio Grande	103	0
	Dockum	Rio Grande	2,150	33
	Pecos Valley	Rio Grande	49,976	7,796
	Rustler	Rio Grande	0	2
Winkler	Capitan Reef	Rio Grande	274	0
	Dockum	Colorado	13	0
		Rio Grande	5,987	1,634
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	49,949	7,238
* Average historical pumping exceeds MAG				

3.2 Existing Surface Water Supplies

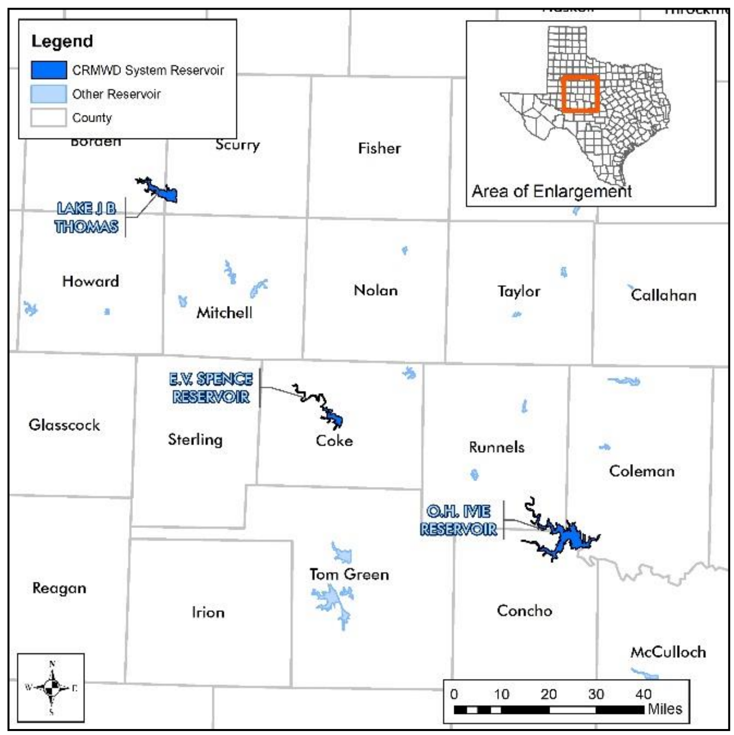
Existing surface water includes supplies from reservoirs, river diversions, and local stock tanks for livestock use. While surface water provides only a fraction of the total water supplies in the region, it is a very important source for municipal and industrial use. In the year 2016, surface water provided only 17 percent of the total water used in the region, yet surface water accounted for 56 percent of the municipal water supply in Region F. Nearly all of the municipal surface water supplies are from reservoirs. Run-of-the-river water rights are used primarily for irrigation. Only the cities of Menard and Junction use run-of-the-river rights for municipal supply. Table 3-6 shows information regarding the 17 major reservoirs in Region F. Figure 3-9 shows the location of these reservoirs. Additional information regarding water rights and historical water use may be found in Chapter 1.

3.2.1 Description of Major Reservoirs

Fifteen of the 17 major reservoirs in Region F are located in the Colorado River Basin. Two are located in the Pecos River Basin, which is part of the Rio Grande River Basin. Most of the water from the in-region reservoirs are used in Region F, but some water is supplied to users in other regions. A brief description of these reservoirs and/or systems is presented below.

Colorado River Municipal Water District Surface Water System

The Colorado River Municipal Water District (CRMWD) owns and operates three major reservoirs, Lake J.B. Thomas, E.V. Spence Reservoir and O.H. Ivie Reservoir, for water supply. CRMWD also operates several impoundments for salt water control. The CRMWD reservoirs are located in the Upper Colorado River Basin, with Lake J.B. Thomas at the upstream end of the system in Scurry and Borden Counties and O.H. Ivie at the downstream end in Concho and Coleman Counties. E.V. Spence Reservoir is located in Coke County near the City of Robert Lee. Water from the reservoir system is supplemented with groundwater from several well fields and is used to supply three-member cities and other customers. Collectively, the three reservoirs are permitted for 1,247,100 acre-feet of storage and 186,000 acre-feet per year of diversions. Recent droughts have left the two upper reservoirs (J.B. Thomas and E.V. Spence) at storage levels less than 2 percent of conservation capacity prior to capturing some water after 2013. In January 2019, the CRMWD surface water reservoirs were at 38 percent of the combined capacity, with the greatest amount of stored water in O.H. Ivie.

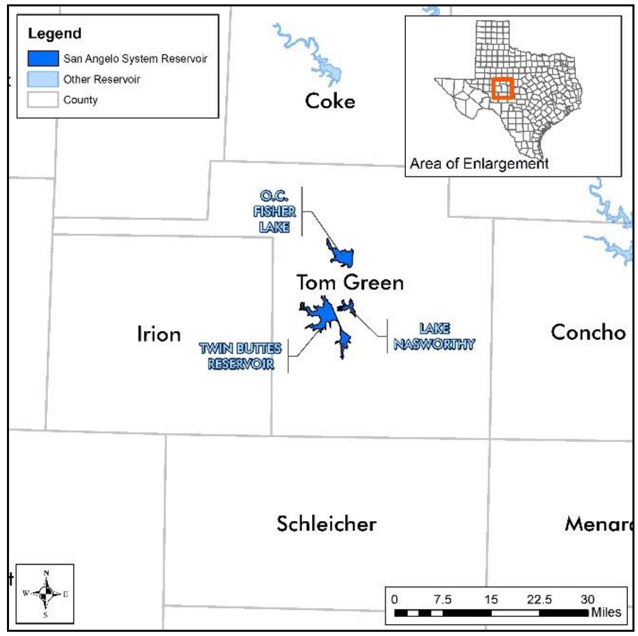


Lake Colorado City/Champion Creek Reservoir System

Lake Colorado City and Champion Creek Reservoir are located in Mitchell County, south of Colorado City. Lake Colorado City was built in 1949 on Morgan Creek to supply cooling water for the Morgan Creek Power Plant and municipal supply to Colorado City. Colorado City no longer receives water from these lakes. Lake Colorado City is permitted to store 29,934 acre-feet and divert 5,500 acre-feet per year for municipal, industrial and steam electric power use. Champion Creek Reservoir was constructed 10 years later in 1959 to supplement supplies from Lake Colorado City. A 30-inch pipeline is used to transfer water from Champion Creek Reservoir to Lake Colorado City when the lake's water levels are low. Champion Creek Reservoir is permitted to store 40,170 acre-feet and divert 6,750 acre-feet per year.

San Angelo System

The San Angelo surface water system, as defined for regional water planning purposes, includes Twin Buttes Reservoir, Lake Nasworthy, and O.C. Fisher Reservoir. These lakes, while owned and operated by different authorities, are used collectively as a system for water supply to San Angelo and its customers.



Twin Buttes Reservoir

Twin Buttes Reservoir is located on the Middle Concho River, Spring Creek and the South Concho River southwest of San Angelo in Tom Green County. The reservoir is owned by the Bureau of Reclamation. The dam was completed in 1963. The reservoir has permitted conservation storage of 170,000 acre-feet and permitted diversion of 29,000 acre-feet per year for municipal and irrigation use. Twin Buttes reservoir is operated with Lake Nasworthy to provide municipal water to San Angelo through the San Angelo Water Supply Corporation. Irrigation water is released directly from the reservoir to a canal system for irrigation use in Tom Green County. Due to recent droughts, little supply has been available for irrigation purposes in recent years.

Lake Nasworthy

Lake Nasworthy is located on the South Concho River, approximately 6 miles southwest of San Angelo in Tom Green County. Lake Nasworthy was completed in 1930 to provide municipal, industrial and irrigation water to the City of San Angelo. The lake is permitted to store 12,500 acre-feet and divert 25,000 acre-feet per year of water for municipal and industrial purposes. This permitted diversion amount includes water diverted by San Angelo from the Twin Buttes Reservoir for municipal purposes. Lake Nasworthy is operated as a system with Twin Buttes Reservoir.

O.C. Fisher Reservoir

O.C. Fisher Reservoir is on the North Concho River, located northwest of San Angelo in Tom Green County. The reservoir was constructed by the U.S. Army Corps of Engineers for flood control and water supply. The project was fully operational in 1952. The Upper Colorado River Authority (UCRA) holds water rights to impound 80,400 acre-feet and divert 80,400 acre-feet per year for water for municipal, industrial and mining use. The Cities of San Angelo and Miles have contracts for water from this source. During the 2011-2015 drought, there was little water available from O.C. Fisher. In January 2019 the reservoir was at 14.5 percent capacity

Table 3-6 Major Reservoirs in Region F [a]

Reservoir Name	Basin	Stream	County(ies)	Water Right Number(s)	Priority Date	Permitted Conservation Storage (Acre-Feet)	Permitted Diversion (Acre-Feet)	2016 Use (Acre-Feet)	Owner	Water Rights Holder(s)
Lake J B Thomas	Colorado	Colorado River	Borden and Scurry	CA-1002	8/5/1946	204,000	30,000	11,167	CRMWD	CRMWD
Lake Colorado City	Colorado	Morgan Creek	Mitchell	CA-1009	11/22/1948	29,934	5,500	2,837	Luminant	Luminant
Champion Creek Reservoir	Colorado	Champion Creek	Mitchell	CA-1009	4/8/1957	40,170	6,750		Luminant	Luminant
Oak Creek Reservoir	Colorado	Oak Creek	Coke	CA-1031	4/27/1949	30,000	10,000	835	City of Sweetwater	City of Sweetwater
Lake Coleman	Colorado	Jim Ned Creek	Coleman	CA-1702	8/25/1958	40,000	9,000	546	City of Coleman	City of Coleman
E V Spence Reservoir	Colorado	Colorado River	Coke	CA-1008	8/17/1964	488,760	43,000	9,904	CRMWD	CRMWD
Mitchell County Reservoir	Colorado	Off-Channel	Mitchell		2/14/1990	27,266				
Lake Winters	Colorado	Elm Creek	Runnels	CA-1095	12/18/1944	8,374	1,755	No data	City of Winters	City of Winters
Lake Brownwood	Colorado	Pecan Bayou	Brown	CA-2454	9/29/1925	114,000	29,712	8,522	Brown Co. WID	Brown Co. WID
Hords Creek Lake	Colorado	Hords Creek	Coleman	CA-1705	3/23/1946	7,959	2,240	496	COE	City of Coleman
Lake Ballinger	Colorado	Valley Creek	Runnels	CA-1072	10/4/1946	6,850	1,000	260	City of Ballinger	City of Ballinger
O.H. Ivie Reservoir	Colorado	Colorado River	Coleman, Concho, and Runnels	A-3886 P-3676	2/21/1978	554,340	113,000	32,534	CRMWD	CRMWD
O.C. Fisher Lake	Colorado	North Concho River	Tom Green	CA-1190	5/27/1949	80,400	80,400	No data	COE	Upper Colorado River Authority
Twin Buttes Reservoir	Colorado	S. Concho River	Tom Green	CA-1318	5/6/1959	170,000	29,000	No data	U.S. Bureau of Reclamation	City of San Angelo
Lake Nasworthy	Colorado	S. Concho River	Tom Green	CA-1319	3/11/1929	12,500	25,000	No data	City of San Angelo	City of San Angelo
Brady Creek Reservoir	Colorado	Brady Creek	McCulloch	CA-1849	9/2/1959	30,000	3,500	1	City of Brady	City of Brady
Red Bluff Reservoir	Rio Grande	Pecos River	Loving and Reeves	CA-5438	1/1/1980	300,000	292,500	48,147	Red Bluff WCD	Red Bluff WCD
Lake Balmorhea	Rio Grande	Toyah Creek	Reeves	A-0060 P-0057	10/5/1914	13,583	41,400	8,266	Reeves County WID #1	Reeves County WID #1
Total						***2,158,136***	***723,757***	***123,515***		

a. A major reservoir has more than 5,000 acre-feet of storage.

b. Total diversions under CA 1002 and CA 1008 limited to 73,000 acre-feet per year. CA 1008 allows up to 50,000 acre-feet per year of diversion. For purposes of this table, the limitation is placed on CA 1008.

c. Permitted storage reported is for water conservation storage. UCRA has permission to use water from the sediment pool.

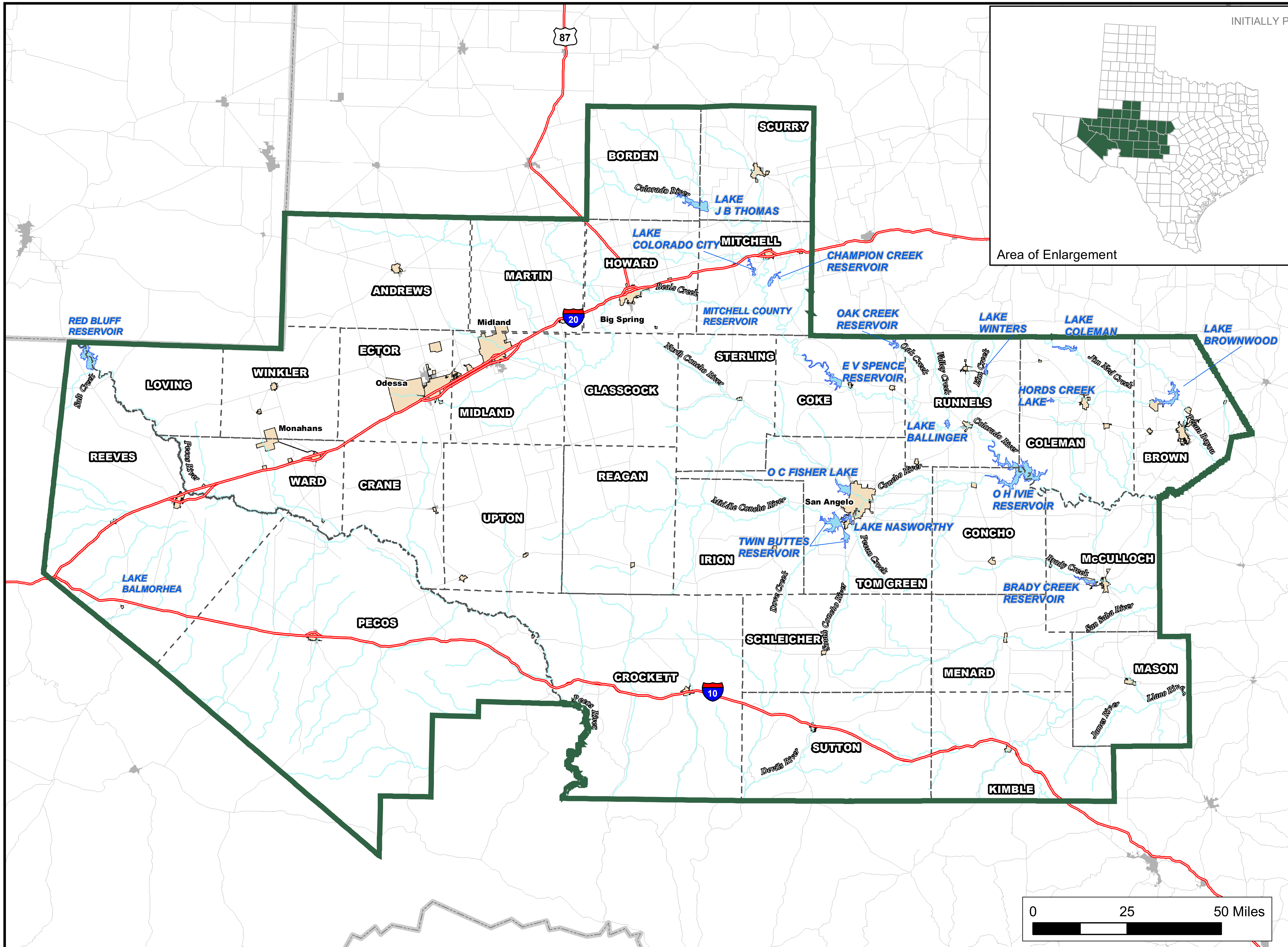


Figure 3-9

Major Reservoirs

Region F

FN JOB NO	CMD17216
FILE	H:\Chapter3\Fig3-9.mxd
DATE	MARCH 2020
SCALE	1:1,584,000
DESIGNED	JJR
DRAFTED	JJR

Oak Creek Reservoir

Oak Creek Reservoir is located on Oak Creek in northeastern Coke County. The reservoir was completed in 1953, and is permitted to store 30,000 acre-feet and divert 10,000 acre-feet per year for municipal and industrial use. The reservoir is owned by the City of Sweetwater, which is located in the Brazos G Region. Municipal water from the lake supplies the Cities of Sweetwater, Blackwell, and Bronte Village. In the past, the reservoir also provided cooling water for a power plant. That facility is no longer operating.

Lake Coleman

Lake Coleman is constructed on Jim Ned Creek in Coleman County, approximately 14 miles north of the City of Coleman. It is located in the Pecan Bayou watershed of the Colorado River Basin, upstream of Lake Brownwood. The lake was completed in 1966 and has a permitted conservation capacity of 40,000 acre-feet. The City of Coleman holds water rights to use 9,000 acre-feet per year for municipal and industrial purposes.

Lake Brownwood

Lake Brownwood is located on Pecan Bayou, north of the City of Brownwood in Brown County. The lake is owned and operated by the Brown County Water Improvement District #1. Construction was completed on Lake Brownwood in 1933. It is permitted to store 114,000 acre-feet of water and divert 29,712 acre-feet per year for municipal, industrial and irrigation purposes. This lake provides much of the municipal and industrial water supply in Brown County and surrounding areas.

Hords Creek Lake

Hords Creek Lake is located on Hords Creek in western Coleman County. Construction of the dam was completed in 1948 and impoundment of water began. The lake has a permitted conservation capacity of 7,959 acre-feet and a permitted diversion of 2,240 acre-feet per year. The lake is jointly owned by the City of Coleman and the U.S. Army Corps of Engineers, and is used for flood control and as a municipal water supply.

Lake Winters

Lake Winters/ New Lake Winters is on Elm Creek, about five miles east of the City of Winters in northeast Runnels County. The City of Winters owns and operates the lake for municipal water supply. The original lake was constructed in 1944 and expanded in 1983. The lake is permitted to store 8,347 acre-feet of water and divert up to 1,755 acre-feet per year.

Lake Ballinger/Lake Moonen

Lake Ballinger is located on Valley Creek in Runnels County. The lake is owned and operated by the City of Ballinger for municipal water supply. The original dam was completed in 1947 (Lake Ballinger). A larger dam was constructed downstream of Lake Ballinger in 1985 (Lake Moonen). The two lakes are permitted to impound 6,850 acre-feet and divert 1,000 acre-feet per year.

Brady Creek Reservoir

Brady Creek Reservoir is located on Brady Creek in central McCulloch County. The lake is owned and operated by the City of Brady for municipal and industrial water supply. Construction of the dam was completed, and impoundment of water began in 1963. The reservoir has a permitted conservation storage capacity of 30,000 acre-feet and a permitted diversion of 3,500 acre-feet per year.

Red Bluff Reservoir

Red Bluff Reservoir is located on the Pecos River in Reeves and Loving counties, approximately 45 miles north of the City of Pecos, and extends into Eddy County, New Mexico. The reservoir is owned and operated by the Red Bluff Water Control District. Construction of the dam was completed in 1936 and water use started in 1937. The reservoir is permitted to store 300,000 acre-feet and divert 292,500 acre-feet per year for irrigation purposes.

Seven water districts form the Red Bluff Water Control District, which supplies irrigation water to Loving, Pecos, Reeves and Ward Counties. Hydropower is no longer generated at the dam. With much of the drainage area of the reservoir in New Mexico, water is released from New Mexico to Red Bluff Reservoir in accordance with the Pecos River Compact. At this time, New Mexico has a credit towards its Texas deliveries, which could substantially reduce water supplies to Red Bluff Reservoir during drought.

Water is released from Red Bluff to irrigation users through the bed and banks of the Pecos River and canal systems. Due to high evaporative rates and infiltration, approximately 75 percent of the water released is lost during transport. Naturally occurring salt springs above the reservoir and high evaporative losses contribute to high concentrations of total dissolved solids and chlorides in the water. Irrigation water with total dissolved solids concentrations greater than 1,500 mg/l impacts agricultural production and concentrations greater than 4,500 mg/l damages the land and is not suitable for irrigation. The salinity in Red Bluff Reservoir can exceed these thresholds during dry years, making the available water unusable for its intended purpose. Imperial Lake, which is located in Pecos County and considered part of the Red Bluff system, currently has total dissolved solids concentrations greater than 10,000 mg/l. Other water quality concerns include low dissolved oxygen and golden algae.

Lake Balmorhea

Lake Balmorhea is located on Sandia Creek in the Pecos River Basin in southern Reeves County, southeast of the City of Balmorhea. The Reeves County Water Improvement District No. 1 owns and operates the lake. Construction began on the earthfill dam in 1916 and was completed in 1917. The lake is permitted to store 13,583 acre-feet of water and divert 41,400 acre-feet per year for irrigation purposes. The lake is predominantly spring fed. In addition to water from Sandia Creek, Lake Balmorhea receives water from Kountz Draw from the south and Toyah Creek, which receives water from Solomon Springs, through Madera Diversion Dam and its canals. Surplus water from Phantom Lake Canal, which is supplied by several springs, is also stored in Lake Balmorhea until it is needed for irrigation.

3.2.2 Available Surface Water Supply

Surface water supplies in this chapter are derived from Water Availability Models (WAMs) developed by the Texas Commission on Environmental Quality (TCEQ). The TWDB requires the use of the Full Authorization Run (Run 3) of the approved TCEQ WAM for each basin as the basis for water availability in regional water planning[4]. Full Authorization assumes that all water rights will be fully met in priority order. Three WAM models are available in Region F: (a) the Colorado WAM, which covers most of the central and eastern portions of the region, (b) the Rio Grande WAM, which covers the Pecos River Basin, and (c) the Brazos WAM. There are approximately 493,000 acre-feet of permitted diversions in the Colorado Basin in Region F, more than half of the permitted diversions in the region. There are 416,158 acre-feet of permitted diversions in the Rio Grande Basin. There is one water right in the Brazos Basin in Region F with a permitted diversion of 63 acre-feet per year.

After 2013, the TCEQ extended the Colorado WAM through December 2013 to better capture current conditions (previous WAM hydrology only went through 1998). The TCEQ also made other corrections to the model at that time. The updated Colorado River WAM was released in early 2018 and was the basis for surface water supply availability in Region F. Under the updated Colorado WAM, many sources have no yields and some sources have lower firm and safe yields from the previous estimates due to the on-going drought of record. Table 3-7 and Table 3-8 show the supplies available under the TCEQ WAM Run 3. Additional information on the derivation of the yields using the WAM can be found in Appendix B.

Table 3-7
Region F Reservoir Supplies in Year 2020
-Values in Acre-Feet per Year-

Reservoir Name	Basin	WAM Firm Yield	WAM Safe Yield
Lake J. B. Thomas	Colorado	0	0
E. V. Spence Reservoir	Colorado	0	0
O. H. Ivie Reservoir	Colorado	35,700	30,350
Lake Colorado City	Colorado	0	0
Champion Creek Reservoir	Colorado	0	0
Oak Creek Reservoir	Colorado	0	0
Lake Coleman	Colorado	0	0
Lake Winters/ New Lake Winters	Colorado	0	0
Lake Brownwood	Colorado	24,000	18,900
Hords Creek Lake	Colorado	0	0
Lake Ballinger / Lake Moonen	Colorado	0	0
O. C. Fisher Lake	Colorado	0	0
Twin Buttes Reservoir	Colorado	0	0
Lake Nasworthy	Colorado	0	0
Brady Creek Reservoir	Colorado	0	0
Red Bluff Reservoir	Rio Grande	38,630	30,050
Lake Balmorhea	Rio Grande	18,800	18,800
Total		***117,130***	***98,100***

Table 3-8
Region F Run-of-the-River Supplies by County and River Basin[a]
-Values in Acre-Feet per Year-

County	WAM Supplies	County	WAM Supplies
Colorado River Basin			
Andrews	0	Mitchell	0
Borden	0	Reagan	14
Brown	276	Reeves	0
Coke	16	Runnels	0
Coleman	25	Schleicher	262
Concho	244	Scurry	0
Crane	0	Sterling	0
Crockett	0	Sutton	30
Ector	0	Tom Green	2
Howard	0	Upton	1,969
Irion	221	Ward	0
Kimble	1,113	Winkler	0
Loving	0	*Rio Grande River Basin*	
Martin	0	Pecos	18,672
Mason	0	Reeves	573
McCulloch	69	Ward	881
Menard	2,090		
Midland	0	***Total***	***26,457***

a. Does not include unpermitted supplies for livestock or diverted water from CRMWD chloride projects.

3.2.3 Surface Water Local Supplies

Local surface water supplies generally refer to stock ponds or on farm supplies used to provide water to livestock. The available supply from these sources is based on the historical usage data collected by the TWDB. Table 3-9 shows the availability in each county and river basin.

Table 3-9
Local Supplies in Region F
-Values in Acre-Feet per Year-

County	Basin	Local Supply	County	Basin	Local Supply
Borden	Brazos	12	McCulloch	Colorado	235
Borden	Colorado	152	Menard	Colorado	48
Brown	Brazos	12	Midland	Colorado	3
Brown	Colorado	1,050	Mitchell	Colorado	308
Coke	Colorado	84	Pecos	Rio Grande	37
Coleman	Colorado	769	Reagan	Colorado	60
Concho	Colorado	223	Runnels	Colorado	475
Crane	Rio Grande	4	Schleicher	Colorado	17
Crockett	Colorado	14	Schleicher	Rio Grande	6
Crockett	Rio Grande	16	Scurry	Brazos	88
Ector	Colorado	25	Scurry	Colorado	352
Glasscock	Colorado	38	Sterling	Colorado	25
Howard	Colorado	39	Sutton	Colorado	172
Irion	Colorado	57	Sutton	Rio Grande	214
Kimble	Colorado	138	Tom Green	Colorado	317
Loving	Rio Grande	1	Ward	Rio Grande	5
Martin	Colorado	47	Winkler	Rio Grande	2
Mason	Colorado	227			

3.3 Reuse Water Supplies

Reuse water can be defined as any water that has already been used for some purpose and is used again for another purpose instead of being discharged or otherwise disposed. In Region F, treated wastewater effluent has been used for agricultural irrigation and some industrial purposes for many years. It is also becoming a desired source for mining use. The use of wastewater effluent for other purposes, including municipal, has gained a level of public acceptance that allows water managers to implement other reuse strategies. Although there is still some public resistance to the direct reuse of wastewater effluent for potable water supply, acceptance is growing. There is also increasingly widespread use of reuse water for non-potable municipal uses such as irrigation of parks, golf courses, and landscaping. Reuse water supplies (reclaimed water) requires development of the infrastructure necessary to transport the treated effluent to secondary users and may require additional treatment for the end use.

Advantages of Reclaimed Water

- Drought-resistant supply
- Treated effluent is the only source of water that automatically increases as economic and population growth occurs in the community.
- The source of treated effluent is usually located near the intended use, not at some yet-to-be developed, distant reservoir or well field.[1]

The use of reclaimed water can occur directly or indirectly. Direct use is typically defined as use of the effluent before it is discharged to a state water course, under arrangements set up by the generator of the wastewater. Indirect reuse occurs when the effluent is discharged to a stream or reservoir and later diverted from the stream for some purpose, such as municipal, agricultural or industrial supply. Indirect reuse is sometimes difficult to quantify because the effluent becomes mixed with the waters of the receiving body. A water rights permit would be needed to transport the reclaimed water by the bed and banks of the stream or reservoir. At this time, there are no indirect reuse supplies in Region F but some are being considered for future development.

A number of communities in Region F have direct non-potable wastewater reuse programs in place, utilizing municipal wastewater effluent for landscape irrigation or for industrial or agricultural purposes. San Angelo has historically used reuse water to irrigate city-owned farms or has sold the effluent to other irrigators. The Cities of Andrews, Crane, and Eden employ reuse supplies to irrigate golf courses. Colorado City provides reuse water for irrigation purposes. Midland has implemented a direct non-potable reuse project to supply landscape irrigation water to Midland College. Also, mining has become a prominent recipient of direct reuse in Region F. The cities of Midland and Odessa have contracts to supply treated wastewater to mining customers. It is anticipated that over time, mining will utilize the majority of available wastewater from these cities.

The first ever direct potable reuse water supply project was recently developed in Region F by the Colorado River Municipal Water District (CRMWD) in Big Spring. The Big Spring reuse project utilizes advanced treatment systems to reclaim Big Spring's effluent. After advanced treatment, the water is mixed with other raw water supplies and treated again before distribution throughout the CRMWD system.

Reuse supplies developed beyond what is currently being used may be considered as a water management strategy. A summary of the current reuse supplies for Region F is presented in Table 3-10. The county and basin represent the location of where the reuse water is used, not where it is generated.

In addition to municipal wastewater effluent that is reused for mining purposes, recycling of produced water is becoming increasingly popular. This type of reuse collects the water that flows back to the surface during and after the completion of the hydraulic fracturing or oil field flooding. The TWDB has historical estimates of mining reuse by county. For Region F, the existing supply available from this source was set to the maximum estimated use from 2012-2015. A summary of the existing recycled water supply used for mining is provided in Table 3-11.

Table 3-10
Reuse Water Supply in Region F
-Values in Acre-Feet per Year-

County	Basin	2020	2030	2040	2050	2060	2070
Andrews	Colorado	560	560	560	560	560	560
Concho	Colorado	25	25	25	25	25	25
Crane	Rio Grande	73	73	73	73	73	73
Ector	Colorado	9,530	9,530	9,530	9,530	9,530	9,530
Howard	Colorado	1,855	1,855	1,855	1,855	1,855	1,855
Midland	Colorado	11,211	11,211	11,211	11,211	11,211	11,211
Mitchell	Colorado	552	552	552	552	552	552
Runnels	Colorado	22	22	22	22	22	22
Tom Green	Colorado	8,300	8,300	8,300	8,300	8,300	8,300
Ward	Rio Grande	670	670	670	670	670	670

Table 3-11
Recycled Mining Water Supply in Region F
-Values in Acre-Feet per Year-

County	Basin	2020	2030	2040	2050	2060	2070
Andrews	Colorado	44	44	44	44	44	44
Crockett	Rio Grande	1,962	1,962	1,962	1,962	1,962	1,962
Ector	Colorado	29	29	29	29	29	29
Glasscock	Colorado	106	106	106	106	106	106
Howard	Colorado	61	61	61	61	61	61
Irion	Colorado	93	93	93	93	93	93
Martin	Colorado	132	132	132	132	132	132
Midland	Colorado	210	210	210	210	210	210
Reagan	Colorado	178	178	178	178	178	178
Upton	Rio Grande	121	121	121	121	121	121
Ward	Rio Grande	33	33	33	33	33	33

3.4 Water Quality

Water quality can impact a water source's usability. Many groundwater and surface water sources in Region F contain high levels of salts or other constituents that make them unsuitable for drinking water supplies or for non-potable uses sensitive to salinity. Salinity is not easily removed via conventional treatment and often requires advanced treatment such as reverse osmosis which can greatly increase the cost of a project. For purposes of regional water planning, water with TDS levels less than 1,000 mg/l is considered fresh water. This water meets the secondary standard for drinking water. Water with TDS levels greater than 1,000 mg/l and less than 35,000 mg/l is considered brackish. Water with TDS levels greater than 35,000 mg/l is considered saline. The water quality range for brackish water covers many water supplies in Region F, including both surface water and groundwater.

3.4.1 Groundwater Quality

As shown in Table 3-12, many of the major and minor aquifers in Region F contain significant quantities of brackish groundwater, with deeper units having much greater salinity levels. While the Texas Water Development Board defines brackish water supplies with a wide range of salinity levels (from 1,000 to 35,000 mg/l), the economically feasible range for development is much smaller with TDS concentrations ranging between 1,000 and

5,000 mg/l. While some of this water is currently being used for agricultural and industrial purposes, much of it remains unused. It is unlikely that desalination will be sufficiently economical to be a significant supply for end uses such as irrigated agriculture, but these sources may prove feasible for municipal and industrial purposes.

Although extensive brackish and saline water occurs in the deep, typically hydrocarbon-producing formations throughout Region F, for the most part these formations are not practical water supplies for meeting regional water demands. Many of these formations typically produce groundwater with very high salinities and are found at depths too great to be economically feasible as a water supply. It should be noted that most of the deeper, hydrocarbon-producing formations have some potential to produce brackish groundwater at reasonable rates in and near where they outcrop. The outcrops for many of these units are in the eastern third of the region.

Brackish groundwater desalination has increasingly become a focus of state-wide groundwater research. Notable contributions that have occurred within the previous decade include: characterization and quantification of brackish resources (LBG-Guyton Associates, 2003), creation of a state desalination database (Nicot and others, 2005), consideration of concentrate disposal options (Nicot and others, 2004), development of a brackish desalination guidance manual (NRS Consulting Engineers and others, 2008) and creation of the Texas BRACS database (Meyers and others, 2012).

TWDB Report 382 "Pecos Valley Aquifer, West Texas: Structure and Brackish Groundwater" was published in 2012 as the pilot study of the Brackish Resources Aquifer Characterization System (BRACS) Program. The BRACS program was initiated to map and characterize brackish groundwater in order to facilitate desalination projects. The goals of the study were: mapping of the geologic boundaries of the alluvium, mapping of the distribution of total dissolved solids and other parameters crucial to desalination and estimating brackish reservoir volumes. This report is regional in scale, contains a robust data set from numerous sources, and presents relatively detailed structural and water quality data from an aquifer-wide perspective.

As directed by House Bill 30, additional studies have been completed that designate specific brackish production areas for the Rustler, Blaine, and Lipan aquifers. These studies were completed in 2016 and 2017.

Table 3-12
Summary of Water Quality for Groundwater Sources in Region F

Aquifer	Salinity (TDS)[a]	Other constituents of concern
Edwards-Trinity Plateau	Fresh/Brackish	Hardness
Ogallala	Fresh/Brackish	
Hickory	Fresh	Radionuclides
Pecos Valley	Brackish	
Trinity	Fresh/Brackish	
Dockum	Brackish	
Lipan	Brackish	Nitrates
Ellenberger San Saba	Fresh/Brackish	Hardness
Marble Falls	Fresh/Brackish	
Rustler	Brackish	
Capitan Reef	Brackish	
Blaine	Brackish (small pockets of fresh)	Gypsum, halite, and anhydrite
Cross Timbers	Fresh/Brackish	

a. -Fresh <1,000 mg/l; 1,000 mg/l< Brackish> 35,000 mg/l; Saline > 35,000 mg/l

3.4.2 Surface Water Quality

Surface water quality in Region F can often be poor due to high levels of total dissolved solids (TDS). Contamination from natural mineral deposits and anthropogenic sources both contribute to inferior surface water quality throughout the region. Natural sources of dissolved solids include surface water traveling across mineral beds, dissolution of natural underground mineral deposits, and the concentrating effects of evaporation and transpiration from plants. Improper brine disposal from oil and gas well production, leaking oil well casings and the over pressurization of downhole formations, and municipal wastewater treatment plant discharges are among the human sources of TDS. Within reservoirs, concentration of minerals due to evaporation coupled with low runoff often result in diminished water quality as the reservoir levels decline. In addition, lakes located near urban centers can be impacted by non-point source pollution that can affect the treatability and recreational quality of these water sources. The water quality in most of the lakes in Region F are impacted by high TDS levels during drought. These include lakes within the CRMWD system, Red Bluff Reservoir, O.C. Fisher and many of the smaller reservoirs in the upper Colorado River Basin. (More on surface water quality is discussed in Section 1.7.1).

To help improve surface water quality in the region, the Colorado River Municipal Water District (CRMWD) has developed a chloride control project. This project diverts naturally occurring high saline surface water into off channel reservoirs for evaporation. These diversions help to improve the water quality of the main stem of the Colorado River.

3.4.3 Advanced Treatment

Due to limited amounts of high-quality water supply in the region, poorer quality water sources are increasingly being considered viable. Advanced treatment or desalination processes are used to treat water for use as a public water supply, or for non-potable uses sensitive to lower water quality. Most frequently in Region F, the water quality concern is the salt content of the water. However, in some cases, radionuclides are also a significant issue. Reverse osmosis is commonly used as the advanced treatment technology to remove salts or desalinate the water. The Texas secondary drinking water standard for total dissolved solids (TDS) is 1,000 mg/l. Although secondary standards are recommended limits and not required limits, funding may be limited for municipal projects that use a water source with TDS greater than 1,000 mg/l unless desalination is part of the planned treatment process, greatly increasing the cost of new water supplies.

Until recently, advanced treatment of brackish waters was too expensive to be a feasible option for most public water suppliers. However, the costs associated with desalination technology have declined significantly in recent years, making it more affordable for communities to implement. If an available source of brackish water is nearby, desalination can be as cost-effective as transporting better quality water a large distance. In some areas, there is less competition for water from brackish sources because very little brackish water is currently used for other purposes, making it easier to develop new brackish sources.

Two factors significantly impact the cost-effectiveness of desalination: initial water quality and concentrate disposal. Treatment costs are directly correlated to the quality of the source water and can vary significantly depending on the constituents in the water. Use of brackish waters with higher ranges of TDS may not be cost-effective. The presence of other constituents, such as calcium sulfate, may also impact the cost-effectiveness of desalination. The disposal of brine waste from the desalination process can be a significant portion of the costs of a project. The options for concentrate disposal include discharge to surface water, existing sewer, evaporation pond (land application) or to an injection well. Most facilities discharge concentrate to either surface water or sanitary sewer (Shirazi and Arroyo, 2011). The least expensive option is discharge to a receiving body of water or land application. However, a suitable receiving body with acceptable impacts to the environment may not be available. Disposal of concentrate by deep well injection could be a practical and cost-effective method for large-scale desalination projects in Region F.

Two treatment facilities for brackish water currently operating in Region F are in Fort Stockton. The City of Fort Stockton draws water from the Pecos Alluvium and Edwards-Trinity aquifers that must be treated to reduce TDS to acceptable levels. The main Fort Stockton plant consists of microfiltration (MF) and ultraviolet (UV) disinfection pretreatment, followed by RO and chlorination. Feed water with a TDS concentration of approximately 1,400 mg/l is blended with RO permeate at a ratio of 80:20. The maximum capacity of the RO permeate stream is approximately 3.8 MGD. Currently, the Fort Stockton facility produces approximately 7.0 MGD blended water, at 400-700 mg/l TDS. Concentrate streams are disposed of using evaporation ponds. The City of Fort Stockton also owns and operates a second, smaller desalination facility that uses similar technology. The feed water for the secondary plant has a TDS concentration of approximately 2,200 mg/l and is blended with RO permeate at a ratio of 75:25. Currently, the secondary plant produces approximately 1 MGD of blended water at 450 mg/l TDS. Future plans for the Fort Stockton facility include the possible installation of a dedicated treatment train for the city's industrial customers.[5,6]

Other current users of desalination facilities include the City of Brady, Midland Country Club, and Water Runner, Inc in Midland. In addition, the Millersview-Doole Water Supply Corporation (MDWSC) operates a RO desalination plant that uses O.H. Ivie Reservoir as a water source, which has TDS levels ranging from <1,000 to 1,500 mg/l. The City of Eden constructed a reverse osmosis facility to treat water for high radionuclide levels that was completed in 2015. Other users within the region are considering advanced treatment to improve water quality. These will be considered water management strategies.

Other industrial and commercial users in the region also desalinate water for various uses. However, the TWDB database does not report any user with a treatment facility smaller than 0.025 million gallons per day. At this time, it is not feasible to estimate how much of the industrial and commercial desalination utilizes a brackish water source.

Water Quality

Region F has known some water quality challenges in both groundwater and surface water sources. Some of the Region's groundwater sources are brackish and require blending or advanced treatment before use. The Hickory aquifer can have elevated level of radionuclides. The Lipan aquifer can have elevated nitrates and the Blaine aquifer, in addition to being brackish in some parts, can have elevated levels of gypsum, halite, and anhydrite. Some surface water sources can have elevated TDSs from naturally occurring sources and may be exacerbated by low water levels and high evaporation during drought.

3.5 Currently Available Supplies for Water User Groups

Unlike the overall water availability presented in Sections 3.1 and 3.2, currently available supplies are limited by the ability to deliver and/or use water. These limitations may include firm yield of reservoirs, well field capacity, aquifer characteristics, water quality, water rights, permits, contracts, regulatory restrictions, raw water delivery infrastructure and water treatment capacities where appropriate. Currently available supplies in each county are shown in Table 3-13. The total of the currently available supply by use type is shown in Figure 3-10. Summary tables included within Appendix I, *Database (DB22) Tables,* present the currently available water available for each water user group (WUG), arranged by county. (Water user groups are water utilities who provide more than 100 acre-feet per year , “county other” municipal uses, and countywide manufacturing, irrigation, mining, livestock, and steam electric uses.)

Historical water use from TWDB provides the basis for livestock water availability. Surface water supplies for livestock in Region F come primarily from private stock ponds, most of which are exempt under §11.142 of the Texas Water Code and do not require a water right. Supplies to mining include contracted sources (limited by current infrastructure), reuse and recycling, and available groundwater. While oil and gas groundwater use are exempt from groundwater permitting, the groundwater availability as determined by the MAGs are considered for regional planning purposes.

A few users in Region F obtain supplies from outside of Region F including Richland SUD whose supply is located in Region K, Balmorhea (Reeves County-Other) whose supply is located in Region E, and Steam Electric Power in Ector County whose supply is located in Region O. These supplies represent about one half of one percent of Region F’s current supplies. Region F also provides water to users in Brazos G and Region K. These include the Cities of Abilene (G), Rotan (G), Sweetwater (G), Clyde (G), and the portions of Richland SUD (K) and Coleman County SUD (G) not located in Region F. A little over one percent of Region F’s current supplies goes to supply users in other regions.

Figure 3-10
Supplies Currently Available to Water User Groups by Type of Use

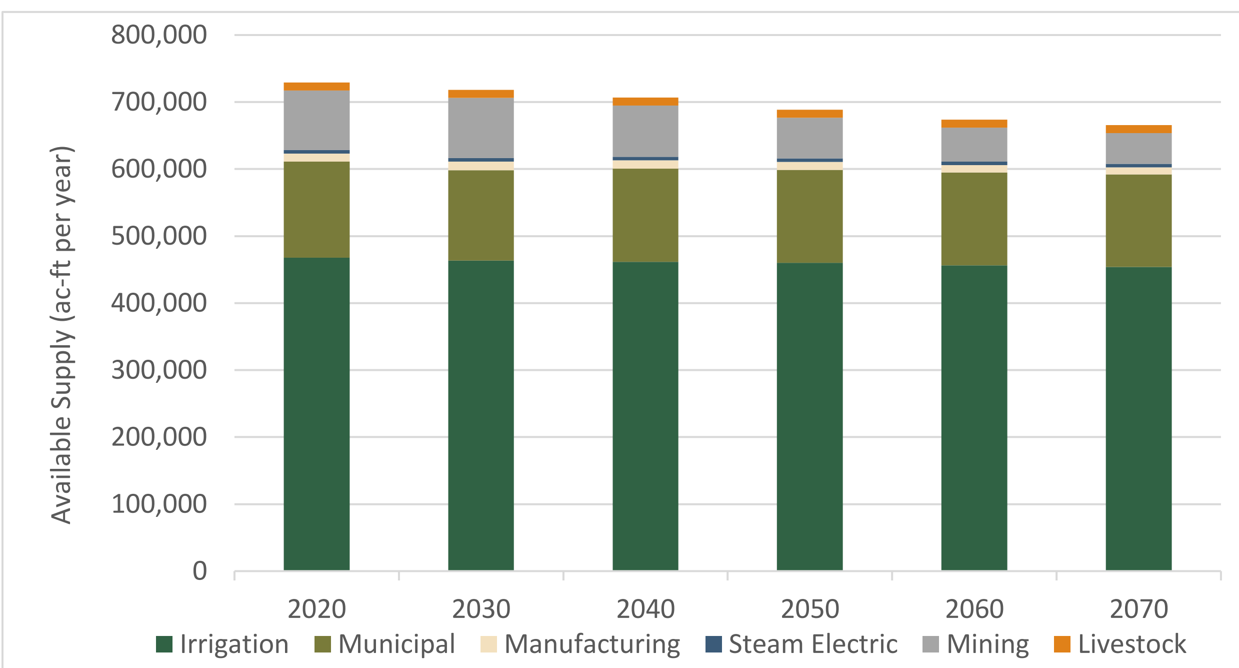


Table 3-13
Summary of Currently Available Supply to Water Users by County [a]
-Values in Acre-Feet per Year-

County	2020	2030	2040	2050	2060	2070
Andrews	26,686	23,139	22,269	21,424	20,833	20,389
Borden	3,981	4,091	3,881	3,553	3,278	3,138
Brown	14,809	14,888	14,765	14,691	14,681	14,677
Coke	1,720	1,704	1,643	1,586	1,538	1,496
Coleman	1,290	1,285	1,265	1,251	1,240	1,232
Concho	6,224	6,225	6,164	6,104	6,051	6,002
Crane	2,575	2,926	3,040	2,967	2,890	2,838
Crockett	7,425	7,425	7,412	6,028	4,833	4,536
Ector	38,705	45,376	48,405	47,604	46,095	45,302
Glasscock	57,487	57,499	56,094	54,794	53,693	53,093
Howard	21,291	22,291	21,301	19,369	17,762	16,713
Irion	3,823	3,823	3,823	3,069	2,069	1,569
Kimble	2,149	2,143	2,136	2,132	2,131	2,131
Loving	3,636	3,636	3,636	3,636	3,341	2,441
Martin	44,705	44,758	42,982	41,524	39,054	37,339
Mason	6,934	6,845	6,606	6,463	6,354	6,266
McCulloch	13,050	12,572	10,863	9,852	9,052	8,401
Menard	5,274	5,256	5,134	5,008	4,897	4,802
Midland	78,018	60,745	57,350	54,638	52,748	52,678
Mitchell	14,315	14,185	14,174	14,158	14,126	14,131
Pecos	154,639	155,059	155,511	155,851	156,181	156,482
Reagan	33,614	33,685	30,827	27,836	27,868	27,892
Reeves	65,781	66,000	66,196	66,337	66,446	66,530
Runnels	5,907	5,936	5,898	5,861	5,820	5,752
Schleicher	3,730	3,866	3,704	3,541	3,396	3,307
Scurry	3,745	4,189	4,308	4,200	4,091	3,971
Sterling	2,221	2,399	2,258	1,967	1,715	1,585
Sutton	3,199	3,538	3,599	3,427	3,255	3,137
Tom Green	61,964	61,831	61,672	61,516	61,354	61,170
Upton	19,597	19,695	18,627	17,569	16,895	16,913
Ward	13,953	13,966	13,800	13,464	12,974	12,717
Winkler	6,816	7,336	7,264	7,167	7,055	6,996
Total	**729,263**	**718,312**	**706,607**	**688,587**	**673,716**	**665,626**

a. Currently available supply reflects the most limiting factor affecting water availability to users in the region. These limitations include firm yield of reservoirs, well field capacity, aquifer characteristics, water quality, water rights, permits, contracts, regulatory restrictions, raw water delivery infrastructure and water treatment capacities.

3.6 Currently Available Supplies for Major Water Providers

There are five designated major water providers in Region F. A major water provider is a water user group or a wholesale water provider of particular significance to the region's water supply as determined by the regional water planning group[4]. Region F considered the quantity of water provided, regional extent, and significance to the region in identifying the major water providers. This identification only provides additional reporting in the regional water plan and does not diminish the planning efforts for other water user groups and wholesale water providers in the region. Similar to the currently available supply for water user groups, the currently available supply for each major water provider is limited by the ability to deliver water to end-users. These limitations include firm yield of reservoirs, well field capacity, aquifer characteristics, water quality, water rights, permits, contracts, regulatory restrictions and infrastructure. A summary of currently available supplies for each major water provider is included in Table 3-14. Brief descriptions of the supply sources are presented below. Attachment 3A contains the water supplies for each of these MWPs broken down by category of use for each decade.

Brown County Water Improvement District No. 1

BCWID owns and operates Lake Brownwood, as well as raw water transmission lines that supply the District's water treatment facilities, irrigation customers and the City of Early. BCWID operates two water treatment facilities in the City of Brownwood which together have a combined capacity of 16 million gallons per day (MGD). Other customers divert water directly from the lake.

Colorado River Municipal Water District (CRMWD)

CRMWD existing supplies operate as two basic systems: the Non-System portion of Lake Ivie and the main CRMWD System. The Lake Ivie Non-System includes yield from Lake Ivie that is contracted to Abilene, Midland, and San Angelo. It also includes contractual supplies to Millersview-Doole WSC, who can only access supplies from Lake Ivie. The main CRMWD System includes the remainder of the yield of Lake Ivie, Lake J.B. Thomas, E.V. Spence Reservoir and well fields in Ward and Martin Counties. CRMWD also supplies reclaimed water from its Big Spring reuse project. CRMWD owns and operates more than 600 miles of water transmission lines to provide water to its member cities and customers.

City of Midland

The City of Midland supplies treated water from four main sources: surface water sales from CRMWD, the T-Bar Ranch and Clearwater Well Fields in Winkler and Loving Counties, the Airport Well Field in Midland County, and the Paul Davis Well Field in Andrews and Martin Counties. The City also has a contract to provide up to 15 MGD of wastewater to the mining industry. The actual amount of reuse supply available to mining is limited to the produced wastewater, which is currently about 10 MGD.

City of Odessa

The City of Odessa is a CRMWD member city. As a member city, Odessa's water supplies will be provided from CRMWD sources. The City of Odessa sells treated water to the Ector County Utility District, as well manufacturing and steam electric power users in Ector County. In addition, the City sells treated effluent to mining users and raw water to irrigation and manufacturing users in Ector and Midland Counties.

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, O.H. Ivie Reservoir (purchased from CRMWD), and E.V. Spence Reservoir (purchased from CRMWD). The City also owns several run-of-the river water rights on the Concho River. San Angelo owns a raw water transmission line from Spence Reservoir (currently in need of rehabilitation) and a 5-mile water transmission line from a pump station on the CRMWD Ivie pipeline just north of the City. The City also owns a well field in McCulloch County in the Hickory aquifer. San Angelo provides treated water to the City of Miles and to rural customers in Tom Green County through an agreement with UCRA. Treated wastewater from the City has historically been used for irrigation in exchange for the irrigation share of water in Twin Buttes Reservoir. However, the City is developing a reuse project for municipal purposes (see discussion of the Concho River Water Project in Chapter 5D).

Table 3-14
Currently Available Supplies for Major Water Providers
-Values in Acre-Feet per Year-

Major Water Provider	Source	2020	2030	2040	2050	2060	2070
BCWID	Lake Brownwood [a]	18,900	18,760	18,620	18,480	18,340	18,200
	Subtotal	*18,900*	*18,760*	*18,620*	*18,480*	*18,340*	*18,200*
CRMWD	Lake Ivie [b]	30,350	29,320	28,290	27,260	26,230	25,200
	Lake Ivie Non-	*16,065*	*15,650*	*15,137*	*14,627*	*14,097*	*13,491*
	System Portion	*14,285*	*13,670*	*13,153*	*12,633*	*12,133*	*11,709*
	Spence Reservoir [a]	0	0	0	0	0	0
	Thomas Reservoir [a]	0	0	0	0	0	0
	Big Spring Reuse	1,855	1,855	1,855	1,855	1,855	1,855
	Ward County Well Field [b]	39,044	30,850	34,551	32,970	31,235	29,500
	Martin County Well Field	1,035	1,035	1,035	1,035	1,035	1,035
	Subtotal	*72,284*	*63,060*	*65,731*	*63,120*	*60,355*	*57,590*
City of Midland	T- Bar Ranch (Winkler/Loving Counties) Well Field	16,815	16,815	16,815	16,815	16,815	16,815
	CRMWD	21,974	4,850	4,679	4,509	4,338	4,168
	Paul Davis Well Field (Andrews County) [c]	1,167	1,114	926	879	844	818
	Paul Davis Well Field (Martin County) [c]	3,485	2,808	2,409	2,185	2,043	1,945
	Airport Well Field	560	560	0	0	0	0
	Direct Reuse (mining, non-potable)	11,210	11,210	11,210	11,210	11,210	11,210
	Subtotal	*55,211*	*37,357*	*36,039*	*35,598*	*35,250*	*34,956*

Major Water Provider	Source	2020	2030	2040	2050	2060	2070
City of Odessa	CRMWD System [a]	28,531	35,267	38,319	37,343	36,255	35,041
	Direct Reuse (non-potable)	9,530	9,530	9,530	9,530	9,530	9,530
	Subtotal	*38,061*	*44,797*	*47,849*	*46,873*	*45,785*	*44,571*
City of San Angelo	Twin Buttes/Nasworthy [a]	0	0	0	0	0	0
	O.C. Fisher Reservoir [a]	0	0	0	0	0	0
	Spence Reservoir [d]	0	0	0	0	0	0
	Lake Ivie [e]	5,020	4,850	4,679	4,509	4,338	4,168
	Concho River	214	214	214	214	214	214
	McCulloch County Well Field (Hickory aquifer)	8,960	8,960	8,960	8,960	8,960	8,960
	Subtotal	*14,194*	*14,024*	*13,853*	*13,683*	*13,512*	*13,342*
	Total	***198,650***	***177,998***	***182,092***	***177,753***	***173,243***	***168,658***

a. Safe yield from the Colorado WAM. See subordination strategy for actual supply used in planning.
b. Limited by MAG in Ward County. CRMWD existing capacity 50,000 AFY.
c. Contract between University Lands and the City of Midland expires in 2035.
d. Supplies from Spence Reservoir currently not available to the City of San Angelo pending rehabilitation of Spence pipeline.
e. For planning purposes supplies limited to 16.54 percent of the safe yield of Ivie Reservoir.

ATTACHMENT 3A

WATER SUPPLIES BY DECADE AND CATEGORY OF USE FOR MAJOR WATER PROVIDERS

Major Water Provider Supplies by Category of Use in Each Decade
(acre-feet per year)

Major Water Provider	Category of Use	2020	2030	2040	2050	2060	2070
BCWID #1	Irrigation	5,000	5,000	5,000	5,000	5,000	5,000
	Livestock	0	0	0	0	0	0
	Manufacturing	548	651	651	651	651	651
	Mining	0	0	0	0	0	0
	Municipal	6,391	6,365	6,229	6,156	6,142	6,143
	Steam Electric Power	0	0	0	0	0	0
	Surplus	6,961	6,744	6,740	6,673	6,547	6,406
	Total	**18,900**	**18,760**	**18,620**	**18,480**	**18,340**	**18,200**
CRMWD	Irrigation	1,460	1,620	1,620	1,456	1,302	1,163
	Livestock	0	0	0	0	0	0
	Manufacturing	3,069	3,452	3,452	3,100	2,778	2,477
	Mining	0	0	0	0	0	0
	Municipal	66,555	56,658	59,329	57,370	55,204	52,995
	Steam Electric Power	1,200	1,330	1,330	1,194	1,071	955
	Total	**72,284**	**63,060**	**65,731**	**63,120**	**60,355**	**57,590**
Midland	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	147	177	177	177	177	177
	Mining	11,210	11,210	11,210	11,210	11,210	11,210
	Municipal	43,854	25,970	24,652	24,211	23,863	23,569
	Steam Electric Power	0	0	0	0	0	0
	Total	**55,211**	**37,357**	**36,039**	**35,598**	**35,250**	**34,956**
Odessa	Irrigation	1,099	1,220	1,220	1,096	981	876
	Livestock	0	0	0	0	0	0
	Manufacturing	1,716	1,952	1,952	1,753	1,571	1,401
	Mining	9,530	9,530	9,530	9,530	9,530	9,530
	Municipal	24,704	30,974	34,026	33,487	32,801	31,959
	Steam Electric Power	1,012	1,121	1,121	1,007	902	805
	Total	**38,061**	**44,797**	**47,849**	**46,873**	**45,785**	**44,571**
San Angelo	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	312	318	302	284	265	247
	Mining	0	0	0	0	0	0
	Municipal	13,882	13,706	13,551	13,398	13,248	13,094
	Steam Electric Power	0	0	0	0	0	0
	Total	**14,194**	**14,024**	**13,853**	**13,682**	**13,513**	**13,341**

LIST OF REFERENCES

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2 Standen and others, 2009. Capitan Reef Complex Structure and Stratigraphy, prepared for Texas Water Development Board Contract No. 0804830794, 63 p.

3 Standen, 2018. Personal communication.

4 Texas Water Development Board. *Exhibit C Second Amended General Guidelines for Fifth Cycle of Regional Water Plan Development*, April 2018.

5 Mickley, Michael C. *Membrane Concentrate Disposal: Practices and Regulations*. Prepared for U.S. Department of Interior, Bureau of Reclamation, Sept. 2001.

4 IDENTIFICATION OF WATER NEEDS

Water needs are identified by finding the difference between currently available supplies developed for water users in Chapter 3 and projected demands developed in Chapter 2. Currently available supplies and demands can be defined in multiple ways yielding different levels of water needs. This chapter outlines First, Second, and Third Tier water needs analyses, as defined below, each utilizing different definitions of supplies and demands. The Texas Water Development Board (TWDB) specifies that the currently available supplies to a water user be defined as the most restrictive of current water rights, contracts, infrastructure capacity and available yields for surface water and historical use and/or modeled available groundwater (MAG) for groundwater, henceforth called "current" supplies.

Under the First Tier water needs analysis, current surface water supplies are analyzed using the Water Availability Model (WAM). Assumptions in the WAM, including the use of strict priority order, underestimate the surface water supplies for some sources in the Colorado River Basin in Region F. These WAM supplies are considered as the most restrictive constraint when developing the First Tier water needs. For groundwater users, the most restrictive constraint is commonly infrastructure limitation and/or the MAG values for a specific aquifer. These current supplies are then compared to the full demand scenario outlined in Chapter 2 to yield the First Tier needs analysis.

The Second Tier needs analysis identifies water needs after consideration of reduced demands due to implemented conservation and direct reuse strategies. In some cases, conservation reduces water needs for a particular water user group (WUG) and enables the conserved water to be applied to the needs of others.

The First and Second Tier analyses are required by TWDB. The Third Tier analysis is unique to Region F. This analysis considers surface water supplies, based on a modification to the Colorado River WAM, which subordinates water rights in the lower portion of the Colorado River Basin to those water rights in Region F. These available supplies with subordination are distributed to the water users and incorporated into the entity's total available supplies. This total supply (called "subordination supplies" for the discussion of the Third Tier water needs) is then compared to the demands after conservation and reuse to provide a more realistic assessment of potential water needs. The Third Tier analysis provides an estimate of the amount of additional water needs that may require the development of infrastructure strategies.

This comparison of current water supply to demands is made for the region, county, basin, major water provider, and water user group. If the projected demands for an entity exceed the current supplies, then a shortage is identified

Region F Has 3 Tiers of Water Needs

- **First Tier Water Needs** compare the currently available supplies to each WUG (limited by contracts and current infrastructure) to the demands.
- **Second Tier Water Needs** compare current supplies with demands after reductions from conservation and direct reuse. This analysis is required by TWDB.
- **Third Tier Water Needs** compare supplies with subordination to demands after reductions from conservation and direct reuse. Third tier water needs are unique to Region F and identify the amount of water supply that need to be met with new strategies.
- Third Tier water needs are 25-35% lower than the First Tier water needs identified in Region F.

(represented by a negative number). For some users, the supplies may exceed the demands (represented by a positive number).

Attachment 4A shows the needs of each Major Water Provider (MWP) in Region F, categorized by water use type, e.g., irrigation, livestock, manufacturing, mining, municipal, steam electric power. Attachment 4B shows a summary of First, Second, and Third Tier needs analyses by each WUG in Region F. Both attachments are provided at the end of this chapter.

4.1 First Tier Water Needs Analysis

The current supply in Region F consists of groundwater, surface water, local supplies and wastewater reuse. There is a small amount of water that comes from outside the region (Regions E, G, and O). The TWDB requires the use of the TCEQ's Water Availability Models (WAM) for regional water planning. Most of the surface water rights in Region F are in the Colorado River Basin. Chapter 3 discusses the use of the WAM models for water supply estimates and the impacts to the available supplies in the upper Colorado River Basin. Under a WAM analysis, water rights are fully allocated based on strict priority order and thus downstream senior water rights holders continuously make priority calls on major municipal water rights in Region F. Although this does not give an accurate assessment of water supplies based on the way the basin has historically been operated, TWDB requires the regional water planning groups to use the WAM to determine supplies. Therefore, by definition, several sources in Region F have no supply, even though in practice, their supply may be greater than indicated by the WAM.

A similar concern is associated with groundwater supplies. The TWDB requires the use of the MAG values as the cap to groundwater supplies in a county. In some situations, this cap has artificially limited the amount of groundwater that is distributed to existing water users for current supplies and may not be representative of the water that is developed and currently being used. As with the surface water supplies, these restrictions may result in artificially higher water needs.

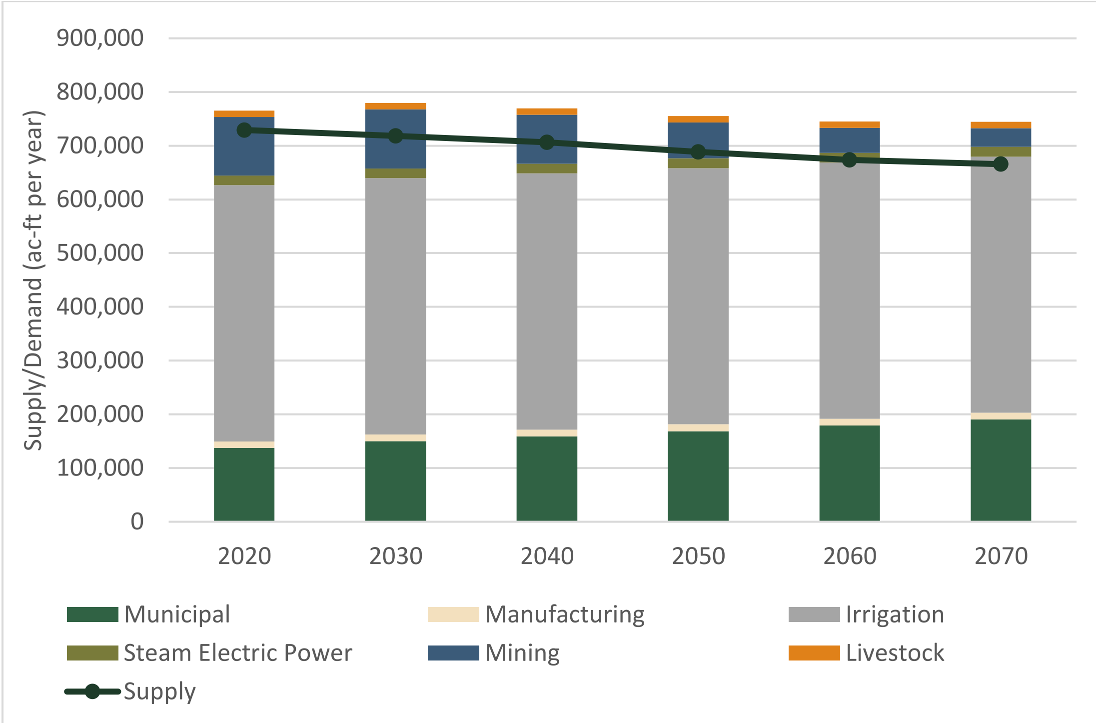
For the First Tier water needs, the current supplies as evaluated in Chapter 3 are compared to the projected demands from Chapter 2 in accordance with TWDB rules. Considering only the current, connected supplies for Region F, on a regional basis there is a projected regional shortage of over 62,000 acre-feet per year in 2020, increasing to a maximum shortage of nearly 103,000 acre-feet per year in 2070. This is shown in Table 4-1 and graphically in Figure 4-1.

On a county basis, there are twenty-two counties that have a shortage at some point over the planning period. These include Andrews, Borden, Brown, Coke, Coleman, Ector, Howard, Irion, Kimble, Loving, Martin, Mason, McCulloch, Menard, Midland, Mitchell, Pecos, Reeves, Runnels, Scurry, Tom Green, and Ward. Based on this analysis, there are significant irrigation, municipal, and mining shortages over the 50-year planning horizon. As previously discussed, some of these shortages are due to limited supply availability either in the surface water modeling (WAM Run 3) or limitations set up by the MAG.

Table 4-1
Comparison of Supplies and Demands for Region F
-Values are in acre-feet per year-

Region F (Acre-feet)	2020	2030	2040	2050	2060	2070
Connected Supply	729,263	718,312	706,607	688,587	673,716	665,626
Demand	765,150	779,505	769,525	755,112	744,947	744,366
Need	-62,592	-71,866	-75,088	-81,200	-90,974	-102,786

Figure 4-1
Region F Supplies and Demands (acre-feet per year)



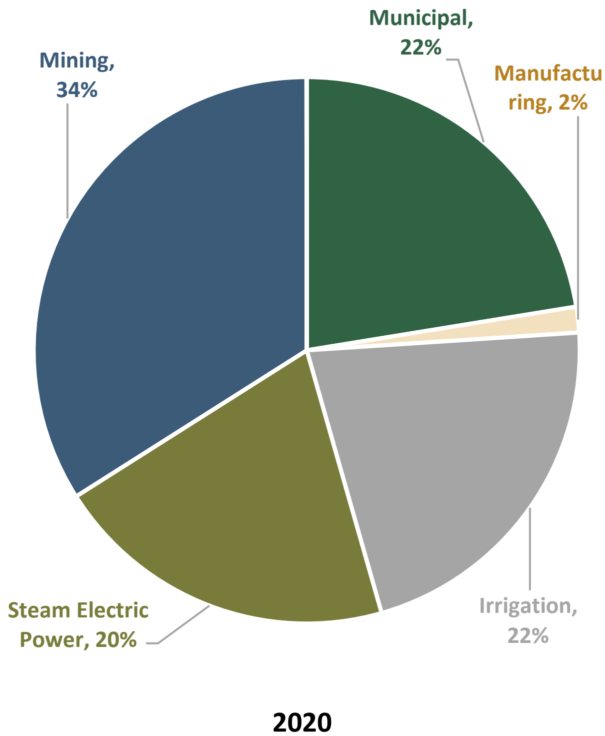
4.1.1 First Tier Water Needs for Water User Groups

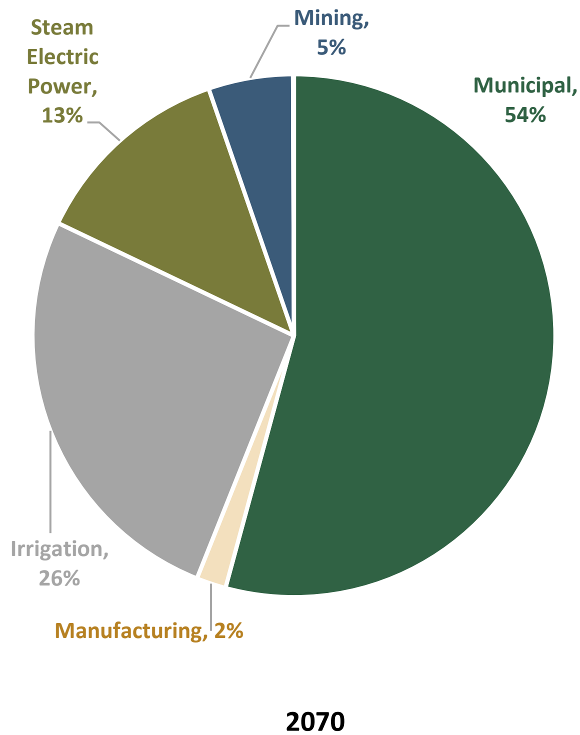
A shortage occurs when current supplies are not sufficient to meet projected demands. In Region F there are 56 water user groups with identified shortages over the planning period. Of these, there are 30 municipal utilities and county-other water users spanning 18 counties that are projected to experience a water shortage before 2070.

Of the six use types, mining accounts for the largest percentage of the shortage in the short term. In 2020, mining represents nearly 36 percent of the water needs. As mining demands decline over time, the percentage of water needs attributed to mining falls to 5 percent in 2070. Municipal users account for the second highest portion of needs in Region F. In 2020, municipal users account for over 20 percent of the region's water needs. By 2070, this percentage grows to 54 percent.

Figure 4-2 graphically illustrates the First Tier water needs in Region F by use type in 2020 and 2070. Table 4-2 and Table 4-3 quantitatively show the water needs by county and use type in 2020 and 2070, respectively.

Figure 4-2
Region F First Tier Needs by Use Type in Year 2020 and 2070





Identified Needs for Municipal Users

Municipal users are shown to have significant water needs throughout the planning period. Thirty municipal water user groups, not accounting for river basin splits, show a shortage at some point during the planning horizon. According to the WAM, the cities of Brady, Coleman, Junction, Mason, and Winters and their customers have no water supply. Mason also has no supplies due to poor quality groundwater that exceeds the maximum contaminant limit for gross alpha particles. The cities of Andrews, Balmorhea, Big Spring, Brady, Bronte, Coahoma, Coleman, Colorado City, Grandfalls, Junction, Mason, Menard, Midland, Miles, Odessa, Robert Lee, San Angelo, Snyder, Stanton, and Winters do not have sufficient water to meet current demands. Other municipal water suppliers that have a water need include Coleman County SUD, Concho Rural Water, Ector County UD, Goodfellow Airforce Base, Greater Gardendale WSC, North Runnels WSC, and County-Other users in Andrews, Coleman, Runnels, and Scurry counties. The counties with the largest municipal needs are Ector, Midland, and Tom Green counties. A significant portion of the needs in these counties are associated with large population centers of Odessa, Midland, and San Angelo.

Identified Needs for Manufacturing Users

There are six counties showing manufacturing needs over the planning period: Andrews, Coleman, Howard, Kimble, Scurry, and Tom Green counties. Manufacturing needs in Ector, Coleman, Howard, and Tom Green counties are associated with needs for the cities of Odessa, Coleman, Big Spring, and San Angelo, respectively, and will be met by strategies developed for these cities.

Identified Needs for Irrigation Users

Irrigation water shortages are identified for nine counties in Region F, including Andrews, Borden, Brown, Coleman, Irion, Kimble, Martin, Mitchell, and Scurry counties.

Table 4-2
Water Needs by County and Use Type in Year 2020
-Values are in acre-feet per year-

County	Irrigation	Manufacturing	Mining	Municipal	Steam Electric Power	Livestock	Total
Andrews	(1,699)	(31)	(1,186)	(222)	0	(9)	**(3,147)**
Borden	0	0	0	0	0	0	**0**
Brown	(1,708)	0	(261)	(12)	0	0	**(1,981)**
Coke	0	0	0	(449)	0	0	**(449)**
Coleman	(396)	(2)	0	(1,026)	0	0	**(1,424)**
Concho	0	0	0	0	0	0	**0**
Crane	0	0	0	0	0	0	**0**
Crockett	0	0	0	0	0	0	**0**
Ector	0	0	0	(2,638)	(109)	0	**(2,747)**
Glasscock	0	0	0	0	0	0	**0**
Howard	0	(147)	0	(662)	(7)	0	**(816)**
Irion	(507)	0	(1,766)	0	0	0	**(2,273)**
Kimble	(1,103)	(603)	0	(626)	0	0	**(2,332)**
Loving	0	0	(3,906)	0	0	0	**(3,906)**
Martin	0	0	0	0	0	0	**0**
Mason	0	0	0	(700)	0	0	**(700)**
McCulloch	0	0	0	(1,391)	0	0	**(1,391)**
Menard	0	0	0	(211)	0	0	**(211)**
Midland	(1)	0	0	(47)	0	0	**(48)**
Mitchell	(1,584)	0	0	0	(10,326)	0	**(11,910)**
Pecos	0	0	(3,500)	0	0	0	**(3,500)**
Reagan	0	0	0	0	0	0	**0**
Reeves	0	0	(10,400)	(107)	0	0	**(10,507)**
Runnels	0	0	0	(440)	0	0	**(440)**
Schleicher	0	0	0	0	0	0	**0**
Scurry	(6,531)	(130)	(242)	(596)	0	0	**(7,499)**
Sterling	0	0	0	0	0	0	**0**
Sutton	0	0	0	0	0	0	**0**
Tom Green	0	(38)	0	(4,921)	0	0	**(4,959)**
Upton	0	0	0	0	0	0	**0**
Ward	0	0	0	0	(2,352)	0	**(2,352)**
Winkler	0	0	0	0	0	0	**0**
Total	**(13,529)**	**(951)**	**(21,261)**	**(14,048)**	**(12,794)**	**(9)**	**(62,592)**

Table 4-3
Water Needs by County and Use Type in Year 2070
-Values are in acre-feet per year-

County	Irrigation	Manufacturing	Mining	Municipal	Steam Electric Power	Livestock	Total
Andrews	(10,134)	(209)	0	(3,075)	0	(60)	**(13,478)**
Borden	(282)	0	0	0	0	0	**(282)**
Brown	(1,711)	0	(263)	(11)	0	0	**(1,985)**
Coke	0	0	0	(437)	0	0	**(437)**
Coleman	(396)	(2)	0	(982)	0	0	**(1,380)**
Concho	0	0	0	0	0	0	**0**
Crane	0	0	0	0	0	0	**0**
Crockett	0	0	0	0	0	0	**0**
Ector	0	0	0	(12,476)	(316)	0	**(12,792)**
Glasscock	0	0	0	0	0	0	**0**
Howard	0	(424)	0	(1,937)	(45)	0	**(2,406)**
Irion	(507)	0	0	0	0	0	**(507)**
Kimble	(1,103)	(704)	0	(604)	0	0	**(2,411)**
Loving	0	0	(1,000)	0	0	0	**(1,000)**
Martin	(4,882)	0	0	(90)	0	0	**(4,972)**
Mason	0	0	0	(676)	0	0	**(676)**
McCulloch	0	0	0	(1,414)	0	0	**(1,414)**
Menard	0	0	0	(196)	0	0	**(196)**
Midland	0	0	0	(19,054)	0	0	**(19,054)**
Mitchell	(1,482)	0	0	(183)	(10,326)	0	**(11,991)**
Pecos	0	0	0	0	0	0	**0**
Reagan	0	0	0	0	0	0	**0**
Reeves	0	0	(4,000)	(147)	0	0	**(4,147)**
Runnels	0	0	0	(436)	0	0	**(436)**
Schleicher	0	0	0	0	0	0	**0**
Scurry	(6,563)	(156)	(144)	(1,506)	0	0	**(8,369)**
Sterling	0	0	0	0	0	0	**0**
Sutton	0	0	0	0	0	0	**0**
Tom Green	0	(215)	0	(12,131)	0	0	**(12,346)**
Upton	0	0	0	0	0	0	**0**
Ward	0	0	0	(155)	(2,352)	0	**(2,507)**
Winkler	0	0	0	0	0	0	**0**
Total	**(27,060)**	**(1,710)**	**(5,407)**	**(55,510)**	**(13,039)**	**(60)**	**(102,786)**

Identified Needs for Livestock Users

Livestock needs have been identified for one county within Region F: Andrews County. Needs in Andrews County are due to limited MAG.

Identified Needs for Mining Users

Recent significant growth in demand for mining water, particularly for oil and gas exploration, has created mining shortages throughout Region F, especially in early decades of the planning horizon. There are seven counties showing mining water shortages over the next fifty years: Andrews, Brown, Irion, Loving, Pecos, Reeves, and Scurry.

Identified Needs for Steam Electric Power Users

Ector, Howard, Mitchell, and Ward counties all show a shortage for steam electric power (SEP) water use. The SEP shortages in Ector County are associated with MAG limitations in Andrews County (one of their sources of supply). The SEP shortage in Mitchell County is attributed to there being no firm yield under WAM Run 3 for Champion Lake, as well as the development of new facilities projected to be brought online by FGE Power. The SEP needs in Howard County are associated with needs of the City of Big Spring and will be met through strategies developed for the Colorado River Municipal Water District (CRMWD), who provides water supplies for Big Spring. Ward County SEP shortage is associated with artificially high water demands. The facility in Ward County recently retired their steam combustion units and replaced them with combined cycle combustion units, which use significantly less water. The demands in Ward County still account for the use of steam generation technology, even though that technology will not be used going forward. To avoid limitations to other users, only the much smaller anticipated future use was allocated water, resulting in a paper shortage for SEP in Ward County.

Identified Needs for Major Water Providers

Table 4-4 is a summary of the needs for the six Major Water Providers (MWPs) in Region F. All MWPs have a water shortage at some point over the next fifty years, with the exception of BCWID. Needs for CRMWD, San Angelo, and Odessa are partially the result of using the Colorado WAM for water availability. A summary of the supply, demand, and needs comparison for each designated major provider is included in Attachment 4A.

Table 4-4
Comparison of Supplies and Demands for Major Water Providers
-Values in Acre-Feet per Year-

Major Water Provider	Category	2020	2030	2040	2050	2060	2070
BCWID #1	Supply	18,900	18,760	18,620	18,480	18,340	18,200
	Demand	11,939	12,016	11,880	11,807	11,793	11,794
	Surplus (Need)	6,961	6,744	6,740	6,673	6,547	6,406
CRMWD	Supply	72,284	63,060	65,731	63,120	60,355	57,590
	Demand	82,768	69,479	73,553	76,502	79,517	83,054
	Surplus (Need)	(10,484)	(6,419)	(7,822)	(13,382)	(19,162)	(25,464)
City of Midland	Supply	55,211	37,357	36,039	35,598	35,250	34,956
	Demand	39,329	43,190	45,643	48,198	50,792	53,619
	Surplus (Need)	15,882	(5,833)	(9,604)	(12,600)	(15,542)	(18,663)
City of Odessa	Supply	38,061	44,797	47,849	46,873	45,785	44,571
	Demand	45,092	50,302	54,724	58,009	61,456	65,247
	Surplus (Need)	(7,031)	(5,505)	(6,875)	(11,136)	(15,671)	(20,676)
City of San Angelo	Supply	14,194	14,024	13,853	13,682	13,513	13,341
	Demand	19,862	21,706	22,571	23,666	24,994	26,438
	Surplus (Need)	(5,668)	(7,682)	(8,718)	(9,984)	(11,481)	(13,097)

a. The demands on San Angelo do not include irrigation demands from Twin Buttes Reservoir

4.1.2 Summary of First Tier Water Needs

The total demands in Region F exceed the total current supply by over 62,000 acre-feet beginning in 2020. The regional need grows to nearly 103,000 acre-feet by 2070. Most of these needs are associated with either mining, municipal, or irrigation demands. Manufacturing, steam electric power, and livestock needs collectively account for only about 20 percent of the needs in Region F in 2020 and 15 percent in

2070. First Tier water needs are largely attributed to assumptions made in the WAM model and limitations by the MAG in certain counties. Other shortages are due to limitations of infrastructure and/or growth. The First Tier needs report provided by the TWDB is provided in Appendix J and is summarized by WUG in Attachment 4B. Further review of the region's options and strategies to meet shortages is explored in more detail in Chapter 5 and the impacts of these strategies on water quality are discussed in Chapter 6. Second Tier Water Needs Analysis

The Second Tier water needs analysis compares current supplies with demands after reductions from conservation and direct reuse. Conservation and direct reuse are both considered water management strategies and are discussed further in Chapter 5B. The Second Tier needs report provided by TWDB is provided in Appendix J and is part of the summary provided in Attachment 4B.

4.2 Summary of Second Tier Water Needs

Under the Second Tier water needs analysis, municipal water needs were reduced through conservation and direct reuse supplies. Conservation was considered for all municipal and irrigation water users. Recycling of water was considered for all mining water user groups. More detail on each of these strategies can be found in Chapter 5B and Appendix C. The plan assumes that a significant reduction in water needs could potentially be achieved through conservation. The realization of these water use reductions is contingent upon the implementation of conservation strategies by individual water users and producers. The plan also includes direct reuse supplies for Bangs, Menard, Mitchell County SEP, and Pecos City.

4.3 Third Tier Water Needs Analysis

The TCEQ WAM does not give an accurate assessment of water supplies based on the way the basin has historically been operated, so Region F has developed a water management strategy called "subordination." Subordination assumes that downstream senior water rights do not make priority calls on Region F water rights in the upper Colorado River Basin, which provides a more realistic assessment of surface water supplies in the upper Colorado River Basin. A full description of the subordination strategy is included in Chapter 5C and Appendix C.

The Third Tier water needs analysis compares the subordination supplies (total current supplies with the subordinated surface water supplies) and the demands after conservation and reuse. The results of the Third Tier water needs analysis is what was used to determine a water user group or major water provider's need for additional water management strategies.

4.3.1 Summary of Third Tier Water Needs

Implementation of the subordination strategy eliminates many of the needs shown in the First and Second Tier needs analyses. Thirteen water user groups (WUGs) show no needs after subordination: Big Spring, Bronte, Coahoma, Coleman, Coleman County SUD, Ector County Utility District, Odessa, Snyder, Stanton, Coleman County-Other, Runnels County-Other, irrigation in Coleman County, and steam electric power in Ector and Howard County. However, there are eleven municipal WUGs that do not have sufficient supplies even after the subordination strategy: Brady, Goodfellow Air Force Base, Junction, Midland, Miles, North Runnels WSC, Robert Lee, San Angelo, Scurry County-Other, and Winters. There are three non-municipal WUGs for whom subordination does not meet their needs: manufacturing in Kimble and Tom Green Counties and steam electric power in Mitchell County. WUGs that do not utilize any surface water sources are not impacted by subordination and continue to show needs throughout the planning period. Figure 4-3 and Table 4-5 compare the First, Second and Third

Tier water needs in Region F throughout the planning cycle. The needs are approximately 20 to 35 percent lower after conservation, direct reuse, and subordination (Third Tier needs) than they are under strict WAM analysis (First Tier needs). Attachment 4B shows the summary of each water user group and major water provider's demands, current supplies, conservation supplies, subordination supplies and Third Tier water needs.

Figure 4-3
Comparison of First, Second, and Third Tier Water Needs in Region F

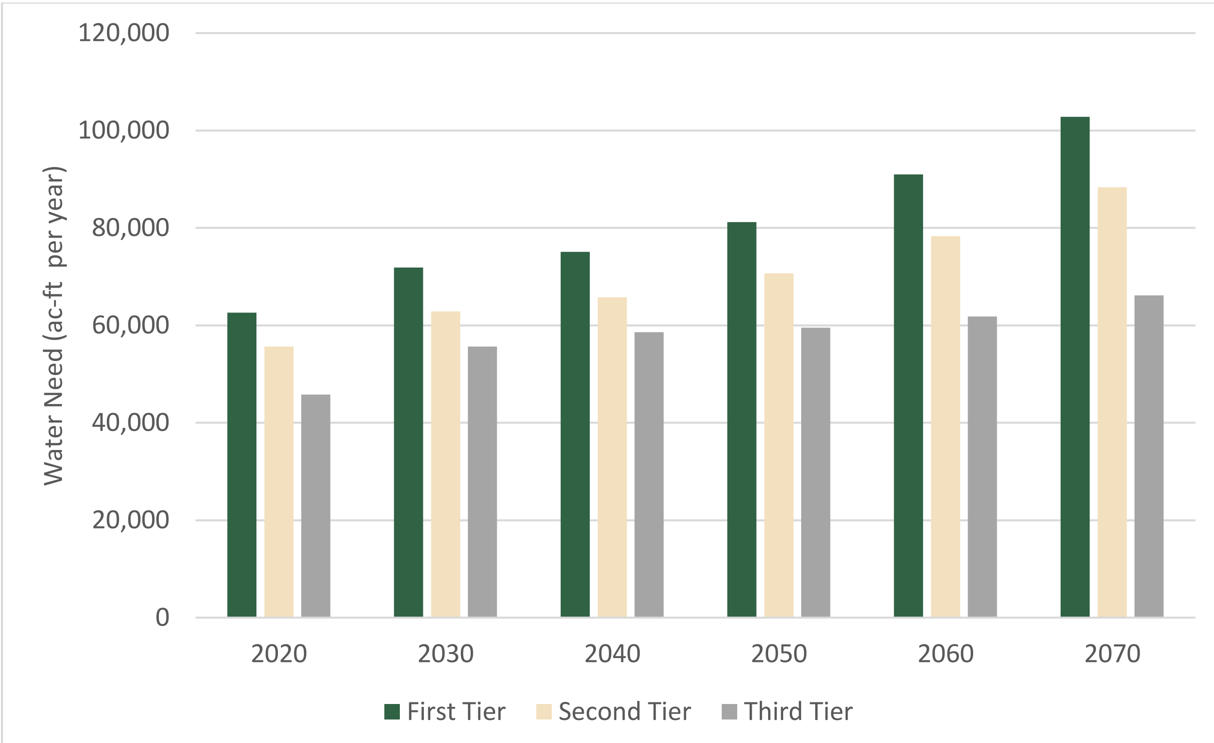


Table 4-5
Comparison of First, Second, and Third Tier Needs in Region F

Tier	2020	2030	2040	2050	2060	2070
First Tier	62,592	71,866	75,088	81,200	90,974	102,786
Second Tier	55,616	62,849	65,764	70,668	78,315	88,372
Third Tier	45,794	55,658	58,587	59,514	61,849	66,160

ATTACHMENT 4A

COMPARISON OF SUPPLY AND DEMAND BY MAJOR WATER PROVIDER

Major Water Provider First Tier Needs by Category of Use in Each Decade (acre-feet per year)

Major Water Provider	Category of Use	2020	2030	2040	2050	2060	2070
BCWID #1	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	0	0	0	0	0
	Steam Electric Power	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**	**0**
CRMWD	Irrigation	(160)	0	0	(164)	(318)	(457)
	Livestock	0	0	0	0	0	0
	Manufacturing	(333)	(500)	(500)	(852)	(1,174)	(1,475)
	Mining	0	0	0	0	0	0
	Municipal	(9,861)	(5,919)	(7,322)	(12,230)	(17,411)	(23,157)
	Steam Electric Power	(130)	0	0	(136)	(259)	(375)
	Total	**(10,484)**	**(6,419)**	**(7,822)**	**(13,382)**	**(19,162)**	**(25,464)**
Midland	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	(5,833)	(9,604)	(12,600)	(15,542)	(18,663)
	Steam Electric Power	0	0	0	0	0	0
	Total	**0**	**(5,833)**	**(9,604)**	**(12,600)**	**(15,542)**	**(18,663)**
Odessa	Irrigation	(121)	0	0	(124)	(239)	(344)
	Livestock	0	0	0	0	0	0
	Manufacturing	(186)	0	0	(199)	(381)	(551)
	Mining	0	0	0	0	0	0
	Municipal	(6,615)	(5,505)	(6,875)	(10,699)	(14,832)	(19,465)
	Steam Electric Power	(109)	0	0	(114)	(219)	(316)
	Total	**(7,031)**	**(5,505)**	**(6,875)**	**(11,136)**	**(15,671)**	**(20,676)**
San Angelo	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	(113)	(163)	(179)	(197)	(216)	(234)
	Mining	0	0	0	0	0	0
	Municipal	(5,555)	(7,519)	(8,539)	(9,787)	(11,265)	(12,863)
	Steam Electric Power	0	0	0	0	0	0
	Total	**(5,668)**	**(7,682)**	**(8,718)**	**(9,984)**	**(11,481)**	**(13,097)**

Major Water Provider Second Tier Needs (After Conservation and Direct Reuse) by Category of Use in Each Decade

Major Water Provider	Category of Use	2020	2030	2040	2050	2060	2070
BCWID #1	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	0	0	0	0	0
	Steam Electric Power	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**	**0**
CRMWD	Irrigation	(160)	0	0	(164)	(318)	(457)
	Livestock	0	0	0	0	0	0
	Manufacturing	(333)	(500)	(500)	(852)	(1,174)	(1,475)
	Mining	0	0	0	0	0	0
	Municipal	(8,962)	(4,869)	(6,185)	(10,981)	(16,070)	(21,683)
	Steam Electric Power	(130)	0	0	(136)	(259)	(375)
	Total	**(9,585)**	**(5,369)**	**(6,685)**	**(12,133)**	**(17,821)**	**(23,990)**
Midland	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	(5,078)	(8,788)	(11,718)	(14,598)	(17,651)
	Steam Electric Power	0	0	0	0	0	0
	Total	**0**	**(5,078)**	**(8,788)**	**(11,718)**	**(14,598)**	**(17,651)**
Odessa	Irrigation	(121)	0	0	(124)	(239)	(344)
	Livestock	0	0	0	0	0	0
	Manufacturing	(186)	0	0	(199)	(381)	(551)
	Mining	0	0	0	0	0	0
	Municipal	(5,987)	(4,741)	(6,029)	(9,745)	(13,790)	(18,326)
	Steam Electric Power	(109)	0	0	(114)	(219)	(316)
	Total	**(6,403)**	**(4,741)**	**(6,029)**	**(10,182)**	**(14,629)**	**(19,537)**
San Angelo	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	(113)	(163)	(179)	(197)	(216)	(234)
	Mining	0	0	0	0	0	0
	Municipal	(5,088)	(6,978)	(7,972)	(9,185)	(10,626)	(12,184)
	Steam Electric Power	0	0	0	0	0	0
	Total	**(5,201)**	**(7,141)**	**(8,151)**	**(9,382)**	**(10,842)**	**(12,418)**

Major Water Provider Third Tier (After Conservation, Direct Reuse, and Subordination) Needs by Category of Use in Each Decade

Major Water Provider	Category of Use	2020	2030	2040	2050	2060	2070
BCWID #1	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	0	0	0	0	0
	Steam Electric Power	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**	**0**
CRMWD	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	0	0	0	0	0
	Steam Electric Power	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**	**0**
Midland	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	(4,719)	(8,397)	(11,297)	(14,145)	(17,168)
	Steam Electric Power	0	0	0	0	0	0
	Total	**0**	**(4,719)**	**(8,397)**	**(11,297)**	**(14,145)**	**(17,168)**
Odessa	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	0	0	0	0	0
	Steam Electric Power	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**	**0**

Major Water Provider	Category of Use	2020	2030	2040	2050	2060	2070
San Angelo	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	(76)	(127)	(147)	(168)	(191)	(212)
	Mining	0	0	0	0	0	0
	Municipal	(3,126)	(5,080)	(6,133)	(7,408)	(8,909)	(10,527)
	Steam Electric Power	0	0	0	0	0	0
	Total	**(3,202)**	**(5,207)**	**(6,280)**	**(7,576)**	**(9,100)**	**(10,739)**

ATTACHMENT 4B

WATER USER GROUP NEEDS BY TIER

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
IRRIGATION, ANDREWS	(1,699)	(5,688)	(7,297)	(8,389)	(9,312)	(10,134)	(681)	(3,651)	(5,260)	(6,352)	(7,275)	(8,097)	(681)	(3,651)	(5,260)	(6,352)	(7,275)	(8,097)
IRRIGATION, BORDEN	0	(138)	(202)	(240)	(265)	(282)	147	157	93	55	30	13	147	157	93	55	30	13
IRRIGATION, BROWN	(1,708)	(1,712)	(1,711)	(1,713)	(1,710)	(1,711)	(1,302)	(1,062)	(1,061)	(1,063)	(1,060)	(1,061)	(1,302)	(1,062)	(1,061)	(1,063)	(1,060)	(1,061)
IRRIGATION, COKE	0	0	0	0	0	0	34	69	83	83	83	83	34	69	83	83	83	83
IRRIGATION, COLEMAN	(396)	(396)	(396)	(396)	(396)	(396)	(373)	(349)	(349)	(349)	(349)	(349)	27	51	51	51	51	51
IRRIGATION, CONCHO	0	0	0	0	0	0	245	490	539	539	539	539	245	490	539	539	539	539
IRRIGATION, CROCKETT	0	0	0	0	0	0	7	14	20	20	20	20	7	14	20	20	20	20
IRRIGATION, ECTOR	879	1,033	1,031	868	717	579	917	1,109	1,144	981	830	692	1,074	1,109	1,144	1,143	1,142	1,141
IRRIGATION, GLASSCOCK	0	0	0	0	0	0	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050
IRRIGATION, HOWARD	0	0	0	0	0	0	344	688	757	757	757	757	344	688	757	757	757	757
IRRIGATION, IRION	(507)	(507)	(507)	(507)	(507)	(507)	(454)	(402)	(349)	(349)	(349)	(349)	(454)	(402)	(349)	(349)	(349)	(349)
IRRIGATION, KIMBLE	(1,103)	(1,103)	(1,103)	(1,103)	(1,103)	(1,103)	(970)	(837)	(784)	(784)	(784)	(784)	(970)	(837)	(784)	(784)	(784)	(784)
IRRIGATION, MARTIN	0	0	0	(685)	(3,165)	(4,882)	1,825	3,649	5,474	4,789	2,309	592	1,825	3,649	5,474	4,789	2,309	592
IRRIGATION, MASON	0	0	0	0	0	0	248	497	745	745	745	745	248	497	745	745	745	745
IRRIGATION, MCCULLOCH	0	0	0	0	0	0	116	232	349	349	349	349	116	232	349	349	349	349
IRRIGATION, MENARD	0	0	0	0	0	0	183	366	549	549	549	549	183	366	549	549	549	549

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
IRRIGATION, MIDLAND	(1)	0	0	0	(1)	0	904	1,811	2,716	2,716	2,715	2,716	907	1,811	2,716	2,718	2,721	2,724
IRRIGATION, MITCHELL	(1,584)	(1,858)	(1,763)	(1,645)	(1,566)	(1,482)	(1,328)	(1,602)	(1,507)	(1,389)	(1,310)	(1,226)	(1,328)	(1,602)	(1,507)	(1,389)	(1,310)	(1,226)
IRRIGATION, PECOS	0	0	0	0	0	0	7,167	14,335	21,502	21,502	21,502	21,502	7,167	14,335	21,502	21,502	21,502	21,502
IRRIGATION, REAGAN	0	0	0	0	0	0	1,102	2,203	3,305	3,305	3,305	3,305	1,102	2,203	3,305	3,305	3,305	3,305
IRRIGATION, REEVES	0	0	0	0	0	0	2,947	5,894	8,841	8,841	8,841	8,841	2,947	5,894	8,841	8,841	8,841	8,841
IRRIGATION, RUNNELS	0	0	0	0	0	0	155	311	373	373	373	373	155	311	373	373	373	373
IRRIGATION, SCHLEICHER	0	0	0	0	0	0	91	109	109	109	109	109	91	109	109	109	109	109
IRRIGATION, SCURRY	(6,531)	(6,555)	(6,565)	(6,562)	(6,560)	(6,563)	(6,153)	(5,799)	(5,582)	(5,579)	(5,577)	(5,580)	(6,153)	(5,799)	(5,582)	(5,579)	(5,577)	(5,580)
IRRIGATION, STERLING	0	0	0	0	0	0	45	90	135	135	135	135	45	90	135	135	135	135
IRRIGATION, SUTTON	0	0	0	0	0	0	56	112	168	168	168	168	56	112	168	168	168	168
IRRIGATION, TOM GREEN	558	509	452	437	386	332	2,683	4,758	5,551	5,536	5,485	5,431	2,683	4,758	5,551	5,536	5,485	5,431
IRRIGATION, UPTON	0	0	0	0	0	0	520	1,040	1,560	1,560	1,560	1,560	520	1,040	1,560	1,560	1,560	1,560
IRRIGATION, WARD	2,898	2,893	2,894	2,901	2,910	2,916	3,056	3,209	3,368	3,375	3,384	3,390	3,056	3,209	3,368	3,375	3,384	3,390
IRRIGATION, WINKLER	0	0	0	0	0	0	175	351	526	526	526	526	175	351	526	526	526	526
LIVESTOCK, ANDREWS	(9)	(17)	(25)	(39)	(50)	(60)	(9)	(17)	(25)	(39)	(50)	(60)	(9)	(17)	(25)	(39)	(50)	(60)
LIVESTOCK, BORDEN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
LIVESTOCK, BROWN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, COKE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, COLEMAN	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64
LIVESTOCK, CONCHO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, CRANE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, CROCKETT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, ECTOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, GLASSCOCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, HOWARD	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
LIVESTOCK, IRION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, KIMBLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, LOVING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, MARTIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, MASON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, MCCULLOCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, MENARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
LIVESTOCK, MIDLAND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, MITCHELL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, PECOS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, REAGAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, REEVES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, RUNNELS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, SCHLEICHER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, SCURRY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, STERLING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, SUTTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, TOM GREEN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, UPTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, WARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIVESTOCK, WINKLER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, ANDREWS	(31)	(59)	(87)	(134)	(174)	(209)	(31)	(59)	(87)	(134)	(174)	(209)	(31)	(59)	(87)	(134)	(174)	(209)
MANUFACTURING, BROWN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
MANUFACTURING, COLEMAN	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	0	0	0	0	0	0
MANUFACTURING, CRANE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, CROCKETT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, ECTOR	1,065	1,061	1,050	831	0	0	1,065	1,061	1,050	831	0	0	1,251	1,061	1,050	1,030	381	551
MANUFACTURING, GLASSCOCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, HOWARD	(147)	0	0	(153)	(293)	(424)	(147)	0	0	(153)	(293)	(424)	0	500	500	500	500	500
MANUFACTURING, IRION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, KIMBLE	(603)	(704)	(704)	(704)	(704)	(704)	(603)	(704)	(704)	(704)	(704)	(704)	(375)	(476)	(476)	(476)	(476)	(476)
MANUFACTURING, MCCULLOCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, MIDLAND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, MITCHELL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, PECOS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, REEVES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, RUNNELS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, SCURRY	(130)	(156)	(156)	(156)	(156)	(156)	(130)	(156)	(156)	(156)	(156)	(156)	(130)	(156)	(156)	(156)	(156)	(156)
MANUFACTURING, SUTTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
MANUFACTURING, TOM GREEN	(38)	(144)	(159)	(178)	(198)	(215)	(38)	(144)	(159)	(178)	(198)	(215)	(1)	(108)	(127)	(149)	(172)	(193)
MANUFACTURING, UPTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, WARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTURING, WINKLER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MINING, ANDREWS	(1,186)	(1,128)	(288)	376	952	1,395	(909)	(868)	(66)	552	1,087	1,499	(909)	(868)	(66)	552	1,087	1,499
MINING, BORDEN	0	0	0	0	0	0	29	39	33	21	10	5	29	39	33	21	10	5
MINING, BROWN	(261)	(266)	(266)	(268)	(264)	(263)	(195)	(200)	(199)	(201)	(198)	(197)	(195)	(200)	(199)	(201)	(198)	(197)
MINING, COKE	0	0	0	0	0	0	20	20	18	16	14	12	20	20	18	16	14	12
MINING, COLEMAN	0	0	0	0	0	0	5	4	4	4	3	3	5	4	4	4	3	3
MINING, CONCHO	0	0	0	0	0	0	20	20	18	15	13	12	20	20	18	15	13	12
MINING, CRANE	0	0	0	0	0	0	26	35	36	29	22	17	26	35	36	29	22	17
MINING, CROCKETT	689	587	1,962	1,962	1,962	1,962	1,004	902	2,005	1,986	1,969	1,965	1,004	902	2,005	1,986	1,969	1,965
MINING, ECTOR	307	225	113	453	745	932	335	255	140	475	763	947	335	255	140	475	763	947
MINING, GLASSCOCK	0	0	0	0	0	0	248	248	189	134	88	63	248	248	189	134	88	63
MINING, HOWARD	0	0	0	0	0	0	143	143	101	59	25	13	143	143	101	59	25	13
MINING, IRION	(1,766)	(1,762)	(456)	93	93	93	(1,444)	(1,440)	(225)	121	107	100	(1,444)	(1,440)	(225)	121	107	100

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
MINING, KIMBLE	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
MINING, LOVING	(3,906)	(3,906)	(3,005)	(1,805)	(1,000)	(1,000)	(3,381)	(3,381)	(2,543)	(1,427)	(699)	(762)	(3,381)	(3,381)	(2,543)	(1,427)	(699)	(762)
MINING, MARTIN	0	0	0	1,117	2,717	3,617	302	302	227	1,166	2,744	3,631	302	302	227	1,166	2,744	3,631
MINING, MASON	0	0	0	0	0	0	43	40	30	24	19	16	43	40	30	24	19	16
MINING, MCCULLOCH	1	1	1	1	0	1	376	352	280	237	203	177	376	352	280	237	203	177
MINING, MENARD	0	0	0	0	0	0	46	45	40	35	30	26	46	45	40	35	30	26
MINING, MIDLAND	0	0	0	0	213	1,013	445	445	344	231	259	1,045	445	445	344	231	259	1,045
MINING, MITCHELL	0	0	0	0	0	0	25	31	27	21	16	12	25	31	27	21	16	12
MINING, PECOS	(3,500)	(3,500)	(3,500)	(2,000)	(600)	500	(2,961)	(2,961)	(2,961)	(1,566)	(533)	552	(2,961)	(2,961)	(2,961)	(1,566)	(533)	552
MINING, REAGAN	0	0	0	263	2,963	4,063	445	445	323	325	2,987	4,071	445	445	323	325	2,987	4,071
MINING, REEVES	(10,400)	(10,400)	(9,900)	(7,700)	(5,600)	(4,000)	(9,518)	(9,518)	(9,053)	(7,007)	(5,054)	(3,566)	(9,518)	(9,518)	(9,053)	(7,007)	(5,054)	(3,566)
MINING, RUNNELS	0	0	0	0	0	0	11	11	10	9	8	7	11	11	10	9	8	7
MINING, SCHLEICHER	0	0	0	0	0	0	26	31	24	16	10	6	26	31	24	16	10	6
MINING, SCURRY	(242)	(395)	(419)	(315)	(213)	(144)	(222)	(363)	(385)	(290)	(196)	(132)	(222)	(363)	(385)	(290)	(196)	(132)
MINING, STERLING	0	0	0	0	0	0	33	40	34	22	11	6	33	40	34	22	11	6
MINING, SUTTON	0	0	0	0	0	0	19	30	32	24	16	11	19	30	32	24	16	11

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
MINING, TOM GREEN	0	0	0	0	0	0	44	45	47	47	48	49	44	45	47	47	48	49
MINING, UPTON	506	506	905	1,705	2,505	3,205	607	607	985	1,758	2,537	3,227	607	607	985	1,758	2,537	3,227
MINING, WARD	0	0	0	0	0	0	80	80	71	55	38	25	80	80	71	55	38	25
MINING, WINKLER	0	0	0	0	0	0	33	49	42	32	22	16	33	49	42	32	22	16
AIRLINE MOBILE HOME PARK LTD	0	0	0	0	0	0	7	7	8	9	10	10	7	7	8	9	10	10
ANDREWS	(192)	(416)	(715)	(1,297)	(1,979)	(2,800)	(147)	(361)	(619)	(1,186)	(1,850)	(2,650)	(147)	(361)	(619)	(1,186)	(1,850)	(2,650)
BALLINGER	830	860	878	880	876	850	842	872	890	892	888	862	1,636	1,623	1,640	1,640	1,641	1,653
BALMORHEA	(107)	(118)	(129)	(137)	(142)	(147)	(105)	(116)	(127)	(135)	(140)	(145)	(105)	(116)	(127)	(135)	(140)	(145)
BANGS	0	0	0	0	0	0	33	33	33	33	33	33	33	33	33	33	33	33
BARSTOW	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
BIG LAKE	0	0	0	0	0	0	10	12	12	13	13	14	10	12	12	13	13	14
BIG SPRING	(611)	0	0	(647)	(1,233)	(1,785)	(480)	138	140	(508)	(1,094)	(1,646)	131	138	140	139	139	139
BRADY	(1,391)	(1,420)	(1,402)	(1,410)	(1,412)	(1,414)	(1,373)	(1,402)	(1,383)	(1,391)	(1,393)	(1,395)	(532)	(561)	(542)	(550)	(552)	(554)
BRONTE	(212)	(210)	(209)	(207)	(207)	(207)	(209)	(207)	(206)	(204)	(204)	(204)	3	3	3	3	3	3
BROOKESMITH SUD	0	0	0	0	1	1	105	105	103	102	103	103	105	105	103	102	103	103
BROWNWOOD	0	0	0	0	0	0	61	91	91	91	91	91	61	91	91	91	91	91

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
COAHOMA	(51)	0	0	(56)	(105)	(152)	(43)	8	8	(48)	(97)	(144)	8	8	8	8	8	8
COLEMAN	(821)	(814)	(795)	(793)	(792)	(792)	(747)	(741)	(723)	(721)	(720)	(720)	572	555	553	534	507	480
COLEMAN COUNTY SUD	(203)	(200)	(193)	(189)	(189)	(189)	(194)	(191)	(184)	(180)	(180)	(180)	9	10	10	10	10	10
COLORADO CITY	0	(133)	(144)	(155)	(168)	(183)	16	(115)	(126)	(137)	(150)	(164)	16	(115)	(126)	(137)	(150)	(164)
CONCHO RURAL WATER	8	0	(3)	(6)	(9)	(13)	28	21	19	17	15	11	36	28	25	22	19	15
COUNTY-OTHER, ANDREWS	(30)	(58)	(91)	(152)	(212)	(275)	(16)	(43)	(74)	(134)	(192)	(254)	(16)	(43)	(74)	(134)	(192)	(254)
COUNTY-OTHER, BORDEN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, BROWN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, COKE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, COLEMAN	(24)	(22)	(22)	(21)	(21)	(21)	(23)	(21)	(21)	(20)	(20)	(20)	1	1	1	1	1	1
COUNTY-OTHER, CONCHO	0	0	0	0	0	0	3	3	3	3	3	3	6	6	6	6	6	6
COUNTY-OTHER, CRANE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, CROCKETT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, ECTOR	0	0	0	0	0	0	0	0	0	0	0	0	0	1,200	2,500	2,500	2,500	2,500
COUNTY-OTHER, GLASSCOCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, HOWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, IRION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, KIMBLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, LOVING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, MARTIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, MASON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, MCCULLOCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, MENARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, MIDLAND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, MITCHELL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, PECOS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, REAGAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, REEVES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, RUNNELS	(23)	(21)	(19)	(18)	(18)	(19)	(21)	(19)	(17)	(16)	(16)	(17)	2	2	2	2	2	2
COUNTY-OTHER, SCHLEICHER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, SCURRY	(402)	(414)	(447)	(522)	(606)	(692)	(382)	(392)	(423)	(496)	(578)	(662)	20	22	24	26	28	30
COUNTY-OTHER, STERLING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, SUTTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, TOM GREEN	264	252	208	173	140	112	264	252	208	173	140	112	356	340	295	258	223	193
COUNTY-OTHER, UPTON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, WARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY-OTHER, WINKLER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRANE	0	0	0	0	0	0	11	12	13	13	14	14	11	12	13	13	14	14
CROCKETT COUNTY WCID 1	0	0	0	0	0	0	12	13	13	13	13	13	12	13	13	13	13	13
DADS SUPPORTED LIVING CENTER	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
EARLY	0	0	0	0	0	0	9	9	9	9	9	9	9	9	9	9	9	9
ECTOR COUNTY UTILITY DISTRICT	(234)	0	0	(332)	(694)	(1,097)	(174)	84	94	(207)	(557)	(948)	60	84	94	125	137	149
EDEN	25	25	25	25	25	25	29	29	29	29	29	29	29	29	29	29	29	29
ELDORADO	0	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6
FORT STOCKTON	0	0	0	0	0	0	36	39	42	44	46	48	36	39	42	44	46	48
GOODFELLOW AIR FORCE BASE	(136)	(191)	(222)	(258)	(298)	(345)	(128)	(182)	(213)	(248)	(288)	(334)	(84)	(140)	(173)	(210)	(253)	(301)
GRANDFALLS	0	0	0	0	(152)	(155)	1	1	1	1	(150)	(153)	1	1	1	1	(150)	(153)
GREATER GARDENDALE WSC	0	(126)	(157)	(194)	(235)	(277)	12	(113)	(142)	(177)	(216)	(257)	12	262	303	268	229	188

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
GREENWOOD WATER	0	0	0	0	0	0	3	3	4	4	4	5	3	3	4	4	4	5
IRAAN	0	0	0	0	0	0	4	4	5	5	5	5	4	4	5	5	5	5
JUNCTION	(626)	(620)	(609)	(605)	(604)	(604)	(618)	(612)	(601)	(597)	(596)	(596)	(368)	(362)	(351)	(347)	(346)	(346)
KERMIT	0	0	0	0	0	0	18	18	19	19	19	19	18	18	19	19	19	19
LORAINE	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2
MADERA VALLEY WSC	0	0	0	0	0	0	5	5	5	6	6	6	5	5	5	6	6	6
MASON	(700)	(690)	(682)	(677)	(676)	(676)	(693)	(683)	(675)	(670)	(669)	(669)	(693)	(683)	(675)	(670)	(669)	(669)
MCCAMEY	0	0	0	0	0	0	7	7	8	8	8	8	7	7	8	8	8	8
MENARD	(211)	(203)	(197)	(196)	(196)	(196)	(139)	(131)	(125)	(124)	(124)	(124)	(139)	(131)	(125)	(124)	(124)	(124)
MERTZON	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3
MIDLAND	15,882	(5,833)	(9,604)	(12,600)	(15,542)	(18,663)	16,513	(5,078)	(8,788)	(11,718)	(14,598)	(17,651)	18,686	(4,719)	(8,397)	(11,297)	(14,145)	(17,168)
MILES	(19)	(34)	(35)	(39)	(42)	(48)	(16)	(31)	(32)	(36)	(39)	(45)	(7)	(22)	(25)	(29)	(33)	(40)
MILLERSVIEW-DOOLE WSC	135	181	184	181	161	99	213	261	263	261	242	182	265	261	263	261	251	244
MITCHELL COUNTY UTILITY	0	0	0	0	0	0	5	5	5	5	5	6	5	5	5	5	5	6
MONAHANS	1,486	1,377	1,320	1,269	1,237	1,211	1,509	1,401	1,345	1,295	1,264	1,238	1,509	1,401	1,345	1,295	1,264	1,238
NORTH RUNNELS WSC	(162)	(159)	(155)	(154)	(154)	(156)	(158)	(155)	(151)	(150)	(150)	(152)	(72)	(69)	(64)	(63)	(63)	(63)

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
ODESSA	(2,451)	0	0	(3,492)	(7,263)	(11,493)	(1,883)	680	752	(2,663)	(6,358)	(10,503)	568	682	752	829	905	990
PECOS	0	0	0	0	0	0	589	1,516	1,518	1,519	1,520	1,520	589	1,516	1,518	1,519	1,520	1,520
PECOS COUNTY FRESH WATER	0	0	0	0	0	0	2	2	3	3	3	3	2	2	3	3	3	3
PECOS COUNTY WCID 1	0	0	0	0	0	0	9	10	11	11	12	12	9	10	11	11	12	12
RANKIN	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3
RICHLAND SUD	78	72	74	77	73	70	81	75	77	80	76	73	81	75	77	80	76	73
ROBERT LEE	(237)	(234)	(231)	(231)	(230)	(230)	(234)	(231)	(228)	(228)	(227)	(227)	2	7	11	11	12	12
SAN ANGELO	(4,785)	(6,658)	(7,632)	(8,824)	(10,243)	(11,773)	(4,326)	(6,126)	(7,074)	(8,232)	(9,614)	(11,105)	(2,450)	(4,307)	(5,308)	(6,523)	(7,958)	(9,505)
SANTA ANNA	0	0	0	0	0	0	3	4	4	4	4	4	3	4	4	4	4	4
SNYDER	(194)	0	0	(256)	(524)	(814)	(153)	47	51	(201)	(465)	(721)	41	47	51	55	59	93
SONORA	0	0	0	0	0	0	115	121	123	126	127	128	115	121	123	126	127	128
SOUTHWEST SANDHILLS WSC	0	0	0	0	0	0	20	22	24	26	28	30	20	22	24	26	28	30
STANTON	23	16	0	(33)	(62)	(90)	31	25	10	(23)	(51)	(79)	62	25	10	10	11	11
STERLING CITY	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3
TOM GREEN COUNTY FWSD 3	0	0	0	0	0	0	3	4	4	4	5	5	3	4	4	4	5	5
WICKETT	967	957	955	959	963	966	969	959	957	961	965	968	969	959	957	961	965	968

Water User Group	Future Unmet Needs/Surplus by Planning Decade (acre-feet per year) – First Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation and Direct Reuse (acre-feet per year) – Second Tier						Future Unmet Needs/Surplus by Planning Decade After Conservation, Direct Reuse, and Subordination (acre-feet per year) – Third Tier					
	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
WINK	0	0	0	0	0	0	3	4	4	4	4	5	3	4	4	4	4	5
WINTERS	(226)	(218)	(206)	(205)	(204)	(204)	(209)	(206)	(197)	(196)	(195)	(195)	(109)	(107)	(99)	(98)	(97)	(98)
ZEPHYR WSC	0	0	0	0	0	0	32	32	31	31	31	31	32	32	31	31	31	31
STEAM ELECTRIC POWER, ECTOR	(109)	0	0	(114)	(219)	(316)	(109)	0	0	(114)	(219)	(316)	0	0	0	0	0	0
STEAM ELECTRIC POWER, HOWARD	(7)	14	14	(8)	(26)	(45)	(7)	14	14	(8)	(26)	(45)	14	14	14	14	14	14
STEAM ELECTRIC POWER, MITCHELL	(10,326)	(10,326)	(10,326)	(10,326)	(10,326)	(10,326)	(9,826)	(9,826)	(9,826)	(9,826)	(9,826)	(9,826)	(8,656)	(8,670)	(8,684)	(8,698)	(8,712)	(8,726)
STEAM ELECTRIC POWER, WARD	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)

5 WATER MANAGEMENT STRATEGIES

Chapter 5 identifies and discusses the water management strategies to meet identified water needs as outlined in Chapter 4. These needs are met through a variety of strategies that have been developed through coordination with the water users in Region F.

Chapter 5 Outline

Chapter 5A: Identification of Water Management Strategies

Chapter 5B: Water Conservation

Chapter 5C: Regional Water Management Strategies

Chapter 5D: Major Water Provider Strategies

Chapter 5E: Water Management Strategies by County

Associated Appendices

Appendix C: Water Management Strategy Evaluation Technical Memorandums

Appendix D: Water Management Strategy Cost Estimates

Appendix E: Strategy Evaluation Matrix and Quantified Environmental Impact Matrix

This chapter is divided into five main parts. Chapter 5A discusses the types of potentially feasible water management strategies, the process used to develop the strategies, and the factors considered in evaluating the strategies. Chapter 5B discusses the water conservation strategies that were considered and recommended for users in Region F. This includes the identification and evaluation for municipal, irrigation, and mining conservation measures. Chapter 5C discusses regional strategies, including subordination, brush control, and weather modification. Chapter 5D presents the recommended water management strategies for the six major water providers in Region F. Chapter 5E addresses the recommended strategies for each water user group with identified shortages and summarizes the water management plans by county.

Over the planning period there may be additional water users that will need to upgrade or modify their water supply systems or develop new supplies but are not specifically identified in this plan. For aggregated water users, such as County-Other, the identification of needs can be challenging due to the nature of the data evaluation. It is the intent of this plan to include all water systems that may demonstrate a need for water supply. This includes established water providers and new water supply corporations formed by individual users that may need to band together to provide a reliable water supply. In addition, Region F considers water supply projects that do not impact other water users but are needed to meet demands or to meet regulatory requirements for consistency with the regional plan even though not specifically recommended in the plan.

This plan gives a potential approach that water suppliers can take to address their needs. Actual implementation of water management strategies is the responsibility of the water suppliers, and the details of strategies will evolve as they are implemented. The Region F Water Planning Group (RWPG) will not be implementing the strategies and does not want this plan to be an obstacle in the development of needed water supplies.

5A IDENTIFICATION AND EVALUATION OF WATER MANAGEMENT STRATEGIES

This section provides a review of the types of water management strategies (WMS) considered for Region F and the approach for identifying the potentially feasible water management strategies for water users with shortages. Once a list of potential feasible strategies has been identified, the most feasible strategies are recommended for implementation. The Region F Plan does not recommend any mutually exclusive strategies. Alternative strategies can also be identified in case the recommended strategies become unfeasible. These strategies are discussed in more detail in later subchapters. This subchapter identifies the potentially feasible strategies for water users that were found to have a projected need in Chapter 4.

Water Management Strategy Categories

- Water Conservation
- Drought Management Measures
- Wastewater Reuse
- Management and/or Expanded Use of Existing Supplies
    - System Operation
    - Conjunctive Use of Groundwater and Surface Water
    - Reallocation of Reservoir Storage
    - Voluntary Redistribution of Water Resources
    - Voluntary Subordination of Existing Water Rights
    - Yield Enhancement
    - Water Quality Improvement
- New Supply Development
    - Surface Water Resources
    - Groundwater Resources
    - Brush Control
    - Desalination
    - Water Right Cancellation
    - Rainwater Harvesting
    - Aquifer Storage and Recovery (ASR)
    - Precipitation Enhancement
- Interbasin Transfers
- Emergency Transfers of Water

5A.1 Identification of Potentially Feasible Strategies

In accordance with TWDB rules, the Region F RWPG has adopted a standard procedure for identifying potentially feasible strategies. This procedure classifies strategies using the TWDB's standard categories developed for regional water planning, which are shown in the box at left.

One of the purposes of this chapter is to provide a big picture discussion on the various strategy types that were identified to potentially reduce or meet the identified needs, the applicability of these strategies for users in Region F, and provide documentation of the strategy types that are not appropriate for Region F.

5A.1.1 Strategies Deemed Infeasible in Region F

While each of these strategy types were considered by the RWPG, not all were determined as viable options for addressing shortages in the region. Region F did not consider drought management as a feasible strategy to meet long-term growth in demands or currently identified needs. This strategy is considered a temporary strategy to conserve available water supplies during times of drought or emergencies and acts as means to minimize the adverse impacts of water supply shortages during drought. Drought management will be employed in the region through the implementation of local drought contingency plans. Region F is supportive of the development and use of these plans during periods of drought or emergency water needs.

The RWPG also did not consider water right cancellation to be a feasible strategy. Instead, Region F recommends that a water right holder consider selling water under their existing water right to the willing buyer or sell the water right outright. Emergency transfers of water are considered in Chapter 7. Similar to drought management, this strategy is an emergency response to drought or loss of water supplies and is not appropriate for long-term growth in demands.

Region F frequently experiences periods of low rainfall that can extend for a long period of time. Most of the area has been in drought-of-record conditions since the mid-1990s. As such, rainwater harvesting was not considered by the RWPG to be a feasible strategy due to the inherent lack of reliability.

The opportunities for reallocation of reservoir storage is very limited in Region F. There are only two federal reservoir projects, O.C. Fisher and Hords Creek, with a dedicated flood pool that could potentially be reallocated. Due to the limited surface water supply in Region F, reallocation would not result in additional reliable supply. As such, this strategy type is not considered in Region F.

5A.1.2 Potentially Feasible Strategies in Region F

The strategy types (and associated subcategories) that were determined as potentially feasible strategies for entities within Region F are water conservation, wastewater reuse, expanded use of existing supplies (system operation, conjunctive use, voluntary redistribution, subordination, and water quality improvements), new supply development (new surface water, new groundwater, brush control, desalination, and ASR), and precipitation enhancement.

The sections below include a brief discussion of each of these strategy types and the specific application to the users in Region F.

Water Conservation

Water conservation is defined as methods and practices that reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses. Water conservation is typically viewed as long-term changes in water use that are incorporated into daily activities.

Water conservation is a valued water management strategy in Region F because it helps extend the limited water resources in the region. It is recommended for all individual municipal and irrigation water users, whether the user has a defined shortage or not. For rural municipal water users, conservation is recommended for County-Other users with an identified water need.

Conservation is also recommended for all mining users. Water conservation measures for manufacturing users are typically process-centered and difficult to develop at the aggregated county level. Region F does not have the level of detail necessary to develop meaningful conservation measures for manufacturing. Therefore, conservation was not considered feasible for manufacturing water users. However, conservation is encouraged for all users and is supported by Region F.

Wastewater Reuse

Wastewater reuse utilizes treated wastewater effluent as either a direct replacement for an existing water supply (direct reuse) or utilizes treated wastewater that has been returned or converted to a water supply resource (indirect reuse). Wastewater reuse is currently utilized by industry and mining users that purchase wastewater effluent from larger municipalities. It is also used for limited irrigation use. CRMWD has a direct potable reuse project that reuses wastewater from the City of Big Spring for municipal use by CRMWD customers. The largest producers of wastewater effluent are the larger cities, including San Angelo, Odessa and Midland. Currently, Odessa and Midland sell most of their treated wastewater for oil field production Others are considering direct and indirect potable reuse for municipal use. There may be potential to expand wastewater reuse in Region F. Entities considering new or additional wastewater reuse include the City of San Angelo, and several smaller cities.

In addition to the traditional application of wastewater reuse, the mining industry produces millions of gallons of "produced water" a day. This water is impaired with chemicals injected during drilling and hydrocarbons (oil and gas). Much of the produced water is either injected in deep geologic formations or recycled for mining use. There is an interest in Region F to treat the produced water for other beneficial uses. This strategy will be considered for Region F.

Expanded Use of Existing Supplies

Expanded use of existing supplies includes seven subcategories ranging from selling developed water that is not currently used to enhancing existing supplies through operations, storage, treatment or other means. In Region F, five of the seven subcategories were determined potentially feasible. These include:

- subordination of senior water rights
- system operation
- conjunctive use of groundwater and surface water
- water quality improvements
- voluntary transfer (sales or contracts for developed water), and
- the recapturing of storage for surface water use through dredging. (Specifically, this strategy was considered for the City of Junction.)

Subordination of Downstream Water Rights

Texas surface water is governed by a priority system, where water rights are issued based on first in time is first in right. In the Colorado River Basin, there are several very large rights that are located in the lower part of the basin that have older (senior) priority dates. These more senior rights can make priority calls on water right holders in Region F. Under a strict priority analysis, the reliable surface water supply in Region F is very low. For many reservoirs, there is no reliable supply. This strategy assumes that senior right holders in the lower Colorado River Basin subordinate their seniority to upper basin water right holders, therefore this strategy is called subordination. Subordination has occurred for several decades in the basin and this strategy is still a reasonable approach to estimate the reliable supply in Region F rather than developing additional new supplies. Subordination typically involves an agreement between water right holders. Due to the sensitive nature of individual agreements, costs are not assigned to this strategy. This strategy is assessed for all reservoirs in the Colorado Basin in Region F and the run-of- river water rights for the City of Junction.

System Operation

System operation involves optimizing the management of two or more water supplies to maximize the supplies from each source and can result in increased water supplies overall. CRMWD and San Angelo both own and operate multiple surface water systems that could potentially benefit from system operation. In previous planning, system operation analyses of these systems found minimal increases in water supplies from system operation. While this strategy is currently employed by CRMWD and San Angelo and supported by Region F, this strategy type was considered and dismissed for purposes of creating additional supply in Region F.

Conjunctive Use of Groundwater and Surface Water

Conjunctive use is the operation of multiple sources of water to optimize the water resources for additional supply. In Region F, CRMWD, San Angelo, and Brady own and operate both surface water and groundwater sources. All three entities intend to conjunctively use the surface water when available to meet demands and use additional groundwater to supplement surface water supplies during drought when surface water resources are depleted. This will help reduce evaporative losses associated with the surface water reservoirs, while still meeting demands with groundwater when surface water is unavailable, or the quality has deteriorated. For Brady, additional treatment of its groundwater will be needed to use this source when surface water is unavailable. The City of Brady has received funding to implement this treatment project which is currently underway.

Water Quality Improvements

Water quality improvements allow for the use of impaired water for municipal or other uses. Generally, this strategy is considered for users with sufficient water quantity but impaired water quality. In Region F, there are considerable amounts of brackish surface water and groundwater. Water quality improvement for these sources are typically accomplished through desalination or blending. This is discussed under the strategy type "Desalination". This strategy type would apply to treatment of other water quality parameters, such as nitrates and radionuclides.

The Hickory aquifer has elevated levels of radionuclides that exceed the drinking water standard. Users of this source include Brady, Eden, Mason, Millersville-Doole WSC, and San Angelo. Additionally, the Lipan aquifer, which serves Concho Rural Water Corporation and rural users in Tom Green County, contains some elevated levels of nitrates.

Voluntary Redistribution

Voluntary redistribution is the transfer of existing water supplies from one user to another through mutually agreeable sales, leases, contracts, options, subordination, or other similar types of agreements. Typically, the entity providing the water has determined that it does not need the water for the duration of the transfer. The transfer of water could be for a set period of years or a permanent transfer. Redistribution of water makes use of existing resources and provides a more immediate source of water. In Region F, there is little to no developed water that is available for redistribution without the development of additional strategies. This strategy is used to represent sales and contracts between a water provider and its customers. It can include current contractual obligations and potential future customers.

New Supply Development

New supply development utilizes water that is not currently being used or generates new supplies through aquifer storage and recovery of water that otherwise would not have been available. This strategy type typically includes substantial infrastructure improvements to develop the new source, transport the water and, if needed, treat the water for its ultimate end use. The subcategories for this strategy type include new surface water development, new groundwater development, brush control, and aquifer storage and recovery.

Surface Water Development

The opportunity for new surface water development is limited in Region F. The Water Availability Model for the Colorado River Basin shows little to no available water for new appropriations. There are existing water rights that are currently not being used but could potentially be further developed. However, there are no identified sponsors for surface water development. New surface water development is not considered in Region F.

Groundwater Development

After the subordination strategy is implemented, groundwater accounts for approximately 75 percent of the total water use in Region F in 2020. In parts of the region, there are considerable amounts of groundwater for future development but most of these sources are located far from the identified needs. In other areas, the groundwater is limited or of poor quality. Even with these limitations, groundwater is a viable and cost-effective supply source for some users. Because surface water supplies are so limited in Region F, the vast majority of municipal water users with a need after subordination during the planning period are expected to expand current groundwater use, develop new groundwater supplies, or purchase water from a provider that develops groundwater. Table 5A-1 shows the amount of groundwater that is available for new groundwater development by aquifer in 2020. Counties that have reached or are near capacity in utilizing the fresh groundwater resources allocated by the MAGs in at least one aquifer are Andrews, Brown, Crockett, Irion, Loving, Martin, Mitchell, Scurry, Tom Green, and Ward counties. In areas where groundwater is not regulated, groundwater development may occur even if the MAG is exceeded. Groundwater production may also exceed the MAGs due to unmetered mining uses such as oil and gas exploration and production and other exempt uses.

Table 5-1
Available Groundwater Supplies for Strategies

Aquifer	Unallocated Supplies[a] (acre-feet/year)
Capitan Reef Complex Aquifer	25,753
Cross Timbers Aquifer	689
Dockum Aquifer	21,481
Edwards-Trinity-Plateau and Pecos Valley Aquifers	250,908
Edwards-Trinity-Plateau Aquifer	242
Edwards-Trinity-Plateau, Pecos Valley, and Trinity Aquifers	129,548
Ellenburger-San Saba Aquifer	3,793
Hickory Aquifer	18,576
Igneous Aquifer	145
Lipan Aquifer	744
Marble Falls Aquifer	215
Ogallala and Edwards-Trinity-High Plains Aquifers	30,064
Ogallala Aquifer	32,961
Other Aquifer	18,798
Pecos Valley Aquifer	0
Rustler Aquifer	6,444
Seymour Aquifer	10
Trinity Aquifer	0

a. This is the total amount of groundwater that is available for strategies in Region F. These amounts may not necessarily be available in a particular county and/or river basin.

Brush Control

In 1985, the Texas Legislature authorized the Texas State Soil and Water Conservation Board (TSSWCB) to conduct a program for the "selective control, removal, or reduction of … brush species that consume water to a degree that is detrimental to water conservation." In 1999 the TSSWCB began the Brush Control Program. In 2011, the 82nd Legislature replaced the Brush Control Program with the Water Supply Enhancement Program (WSEP). The WSEP's purpose is to increase available surface and groundwater supplies through the selective control of brush species that are detrimental to water conservation[1]. As part of their competitive grant, cost sharing program, WSEP considers

- priority watersheds across the state
- the need for conservation within the territory of a proposed projection based on the State Water Plan
- and if the Regional Water Planning Group has identified brush control as a strategy in the State Water Plan.

Three primary species of brush in Region F are eligible for funding from the WSEP. They include juniper, mesquite, and salt cedar. Feasibility studies have been conducted for seven watersheds in Region F. These studies indicate there is potential for water loss reduction from brush, but these losses have been difficult to quantify during periods of drought. However, brush control can still be effective as part of a conjunctive use strategy by increasing inflows into surface water sources during times of normal rainfall. Surface water can be heavily relied on when available, allowing groundwater to be conserved for future times of drought. There are several active brush control programs in Region F, including the City of San Angelo's program for brush removal from Twin Buttes and O.C. Fisher Reservoirs and CRMWD's program for salt cedar removal at Lake Spence. Other water providers have partnered with the TSSWCB on brush removal projects in the past. However, brush management must be an ongoing strategy to continue to realize water savings. This strategy is a potentially feasible strategy for operators and users of the CRMWD system, San Angelo system, Concho River, and Lake Brownwood.

Desalination

Desalination is the removal of excess salts from either surface water or groundwater for beneficial use. In Region F, most of the fresh groundwater supplies have been developed and are currently being used. The region has an abundant source of brackish water that potentially could be desalinated and used for municipal use. This process tends to require considerable energy and has historically been more costly than conventional treatment. It also produces a waste stream that can vary from about 10 percent to nearly 50 percent of the raw water, depending upon the level of and type of dissolved constituents. Since this strategy is fairly expensive, it is not an economically viable option for agricultural use. This strategy is considered for the municipal development of brackish water.

Aquifer Storage and Recovery (ASR)

Aquifer storage and recovery (ASR) involves storing water in aquifers and retrieving this water when needed. The water to be stored can be introduced through enhanced recharge or more commonly injected through a well into the aquifer. If an injection well is used, Texas law requires that the water not degrade the quality of the receiving aquifer. Source water for ASR can include excess surface water, treated wastewater, or groundwater from another aquifer.

To determine the feasibility and applicability of ASR, there are several technical considerations. Specifically,

- ASR requires suitable geological conditions for implementation. Since geologic conditions vary by location, studies must be performed to determine what specific locations would be suitable for ASR.
- Raw surface water and wastewater reuse most likely will require pretreatment prior to injection.
- Operation of an ASR system could significantly impact the amount of water that is retrievable.

Figure 5-1
ASR Screening Process

Recent legislation passed by the 86th Texas Legislature and signed by the Governor on June 10, 2019 requires the regional water plans to consider ASR and provide a specific assessment of this strategy if the region has significant needs. The definition of significant need is deferred to each region. Region F defined the threshold for significant needs to be 5,000 acre-feet per year. There are three entities that meet the significant need threshold: City of Midland, City of San Angelo, and steam electric power generation in Mitchell County.

The steam electric power need is associated with a proposed combined cycle facility for FGE. This facility is no longer being considered at this time, eliminating the projected need for steam electric power. For the other two entities, ASR has been considered but were dismissed for various reason. About 20 years ago, the City of Midland operated an ASR system at a nearby well field. Water from the City's Paul Davis well field was pumped to Midland and stored in the McMillan well field for peaking operations. Operations were ceased after a couple years due to geochemical concerns (perchlorate) and control over the injected water[2] . Midland is not interested in pursuing ASR. The City of San Angelo also considered ASR as part of its Water Supply Engineering Feasibility Study[3] . ASR was ruled out as a potentially feasible strategy due to the lack of suitable geology.

If a sponsor identified ASR as a potentially feasible water management strategy, it was evaluated as part of the Region F Plan. For this plan, ASR is evaluated for the Town of Pecos City.

5A.1.3 Precipitation Enhancement

Precipitation enhancement introduces seeding agents to stimulate clouds to generate more rainfall. This process is also commonly known as cloud seeding or weather modification. In Region F, there are two ongoing weather modification programs: the West Texas Weather Modification Association (WTWMA) project and the Trans Pecos Weather Modification Association (TPWMA) program. Between these two programs, there are active precipitation enhancement activities occurring in 11 counties in Region F. From 2004 to 2016, the WTWMA has helped increase precipitation across its target area by roughly 16 percent, which translates to a 2.25 inches increase in precipitation and an additional 1.27 million acre-feet of water per year[4]. This strategy was considered for irrigated agriculture in those counties.

5A.1.4 Summary of Potentially Feasible Strategies

Potentially feasible water management strategies were identified for water users, wholesale water providers, and major water providers in Region F. These strategies include a wide assortment of strategy types, which were carefully reviewed for entities with identified needs.

While some strategies were determined not to be potentially feasible at this time, the Region F RWPG supports the research and development of new and innovative technologies for water supply. With continued research, new technologies will become more reliable and economical for future users and may be applicable for water suppliers in Region F.

Strategies were only considered potentially feasible if the strategy:

- Is appropriate for regional planning
- Utilizes proven technology and is technically feasible
- Has an identifiable sponsor
- Could meet the intended purpose for the end user considering water quality, economic feasibility, geographic constraints, and other factors, as appropriate
- Meets existing regulations

The process for identifying potentially feasible water management strategies was presented at the Region F meeting in Big Spring on March 15, 2018. There were no public comments and Region F approved the methodology. A list of the potentially feasible water management strategies considered for Region F is included in Attachment 5A. The process for strategy development and evaluation is presented in the following sections.

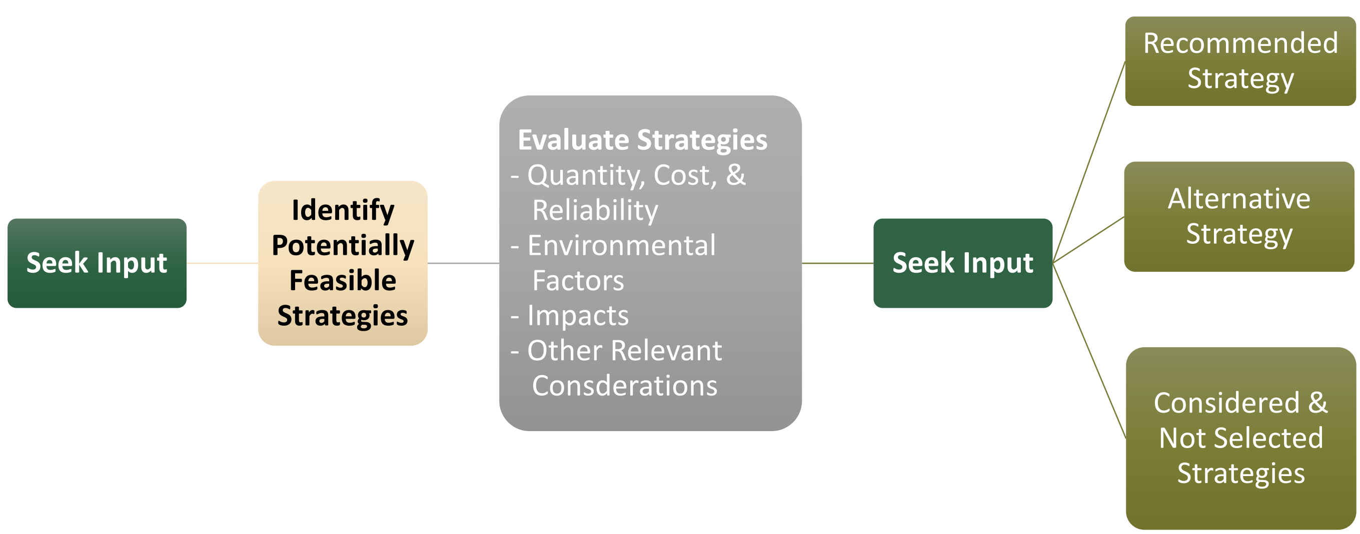
5A.2 Strategy Development

Water management strategies were developed for water user groups to meet projected needs while accounting for their current supply sources, previous supply studies, and available supply within the region. Much of the water supply in Region F is from groundwater, and several of the identified needs could be met by development of new groundwater supplies. Where site-specific data or local aquifer information were available, this information was used. When specific well fields could not be identified, assumptions regarding well capacity, depth of well, lift distance, and associated costs were developed based on county and aquifer estimates. It is important to remember that it is difficult to determine one estimate that is appropriate across an entire county for each aquifer and water user group. The goal was to find average values that were representative for regional planning purposes. In most cases, new surface water supplies are not feasible because of the lack of unappropriated water in the Upper Colorado Basin.

Water transmission lines were assumed to take the shortest route, following existing highways or roads where possible. Profiles were developed using GIS mapping software and Google Earth. Pipes were sized to deliver peak-day flows within reasonable pressure and velocity ranges. Water losses of 25 percent were included for strategies requiring reverse osmosis (RO) treatment (potable reuse or desalination). Water losses associated with transmission were assumed to be negligible for regional planning purposes.

Municipal and manufacturing strategies were developed to provide water of sufficient quantity and quality that is acceptable for its end use. Water quality issues affect water use options and treatment requirements. For the evaluations of the strategies, it was assumed that the final water product would meet existing state water quality requirements for the specified use. For example, a strategy that provided water for municipal supply would

Figure 5-4
Strategy Development and Evaluation Process



meet existing drinking water standards, while water used for mining may have a lower quality.

In addition to the development of specific strategies to meet needs, there are other water management strategies that are general and could potentially increase water for multiple user groups. These include weather modification and brush control. A brief discussion of each of these general strategies and its applicability to Region F is included in Chapter 5C.

5A.3 Strategy Evaluation Criteria

The consideration and selection of water management strategies for water user groups with needs followed TWDB guidelines and were conducted in open meetings with the Region F RWPG. The potentially feasible strategies were evaluated in accordance with state guidance.

Strategy Evaluation Criteria

- Quantity, reliability and cost
- Environmental factors, including effects on environmental water shortages, wildlife habitat and cultural resources
- Impacts on water resources and other water management strategies
- Impacts on agriculture and natural resources
- Other relevant factors

Other relevant factors include regulatory requirements, political and local issues, amount of time required to implement the strategy, recreational impacts of the strategy, and other socio-economic benefits or impacts.

The definition of quantity is the amount of water the strategy would provide to the respective user group in acre-feet per year. This amount is considered with respect to the user's short-term and long-term shortages. Reliability is an assessment of the availability of the specified water quantity to the user over time. If the quantity of water is available to the user all the time, then the strategy has a high reliability. If the quantity of water is contingent on other factors, reliability will be lower. The assessment of cost for each strategy is expressed in dollars per acre-foot per year for water delivered and treated for the end user requirements. Calculations of these costs follow the Texas Water Development Board's guidelines for cost considerations and identify total capital cost and annual costs by decade. Project capital costs are based on September 2018 price levels and include construction costs, engineering, land acquisition, mitigation, right-of-way, contingencies and other project costs associated with the respective strategy. Annual costs include power costs associated with transmission, water treatment costs, water purchase (if applicable), operation and maintenance, and other project-specific costs. Debt service for capital improvements was calculated over 20 years at a 3.5 percent interest rate.

Potential impacts to sensitive environmental factors were considered for each strategy. Sensitive environmental factors may include wetlands, threatened and endangered species, unique wildlife habitats, and cultural resources. In most cases, a detailed evaluation could not be completed because previous studies have not been conducted or the specific location of the new source (such as a groundwater well field) was not identified. Therefore, a more detailed environmental assessment will be required before a strategy is implemented.

The impact on water resources considers the effects of the strategy on water quantity, quality, and use of the water resource. A water management strategy may have a positive or negative effect on a water resource. This review also evaluated whether the strategy would impact the water quantity and quality of other water management strategies identified.

A water management strategy could potentially impact agricultural production or local natural resources. Impacts to agriculture may include reduction in agricultural acreage, reduced water supply for irrigation, or impacts to water quality as it affects crop production. Various strategies may actually improve water quality, while others may have a negative impact. The impacts to natural resources may consider inundation of parklands, impacts to exploitable natural resources (such as mining), recreational use of a natural resource, and other strategy-specific factors.

Strategy evaluations are included in Appendix C and associated infrastructure cost estimates may be found in Appendix D. Appendix E includes a Strategy Evaluation Matrix and Quantified Environmental/Agricultural Impact Matrix.

ATTACHMENT 5A

WATER MANAGEMENT STRATEGIES CONSIDERED AND LIST OF POTENTIALLY FEASIBLE STRATEGIES

Every WUG Entity with an Identified Need			WMSs REQUIRED TO BE CONSIDERED BY STATUTE											ADDITIONAL						
Water User Group Name	County	Maximum Need 2020-2070 (acf/yr)	Conservation	Drought Management	Reuse	Reallocation of Storage	Voluntary Transfers*	Conjunctive Use	Expansion of Existing	New Supplies	Regional Water Supply	Improvement of Water Quality	Emergency Transfer of Water	System Optimization, Subordination	Brush Control	Weather Modification	Desalination	Aquifer Storage and Recovery	Cancellation of Water Rights	Interbasin Transfers
Andrews	Andrews	2,800	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
County-Other	Andrews	275	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Andrews	10,134	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Livestock	Andrews	60	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manufacturing	Andrews	209	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Andrews	1,186	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Borden	282	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Borden	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bangs	Brown	0	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brookesmith SUD	Brown	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brownwood	Brown	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Coleman County SUD	Brown	229	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Early	Brown	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Brown	1,713	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Brown	268	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Santa Anna	Brown	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Zephyr WSC	Brown	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bronte	Coke	212	■	☐	☐	☐	■	☐	■	■	■	☐	☐	■	☐	☐	☐	☐	☐	☐
Irrigation	Coke	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Coke	0	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Robert Lee	Coke	237	■	☐	☐	☐	■	☐	☐	■	■	☐	☐	■	☐	☐	☐	☐	☐	☐
Coleman	Coleman	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
County-Other	Coleman	24	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Irrigation	Coleman	396	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Manufacturing	Coleman	2	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Mining	Coleman	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Eden	Concho	0	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Concho	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Crane	Crane	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Crane	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Crockett County WCID #1	Crockett	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Crockett	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐
Mining	Crockett	0	■	☐	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ector County Utility District	Ector	1,097	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Greater Gardendale WSC	Ector	277	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Ector	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Manufacturing	Ector	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Mining	Ector	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Odessa	Ector	11,493	■	☐	☐	☐	☐	☐	■	■	☐	■	☐	■	☐	☐	☐	☐	☐	☐
Steam Electric Power	Ector	316	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Irrigation	Glasscock	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Glasscock	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Big Spring	Howard	1,785	■	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Coahoma	Howard	152	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Irrigation	Howard	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manufacturing	Howard	424	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐

Every WUG Entity with an Identified Need			WMSs REQUIRED TO BE CONSIDERED BY STATUTE											ADDITIONAL						
Water User Group Name	County	Maximum Need 2020-2070 (acf/yr)	Conservation	Drought Management	Reuse	Reallocation of Storage	Voluntary Transfers*	Conjunctive Use	Expansion of Existing	New Supplies	Regional Water Supply	Improvement of Water Quality	Emergency Transfer of Water	System Optimization, Subordination	Brush Control	Weather Modification	Desalination	Aquifer Storage and Recovery	Cancellation of Water Rights	Interbasin Transfers
Mining	Howard	0	■	□	□	□	■	□	□	■	□	□	□	■	□	□	□	□	□	□
Steam Electric Power	Howard	45	□	□	□	□	□	□	□	□	□	□	□	■	□	□	□	□	□	□
Irrigation	Irion	507	■	□	□	□	□	□	□	□	□	□	□	□	□	■	□	□	□	□
Mertzon	Irion	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Mining	Irion	1,766	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Irrigation	Kimble	1,103	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Junction	Kimble	626	■	□	□	□	□	□	■	■	□	□	□	■	□	□	□	□	□	□
Manufacturing	Kimble	704	□	□	□	□	□	□	□	■	□	□	□	■	□	□	□	□	□	□
Mining	Kimble	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Mining	Loving	3,906	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Irrigation	Martin	4,882	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Mining	Martin	0	■	□	□	□	■	□	□	■	□	□	□	□	□	□	□	□	□	□
Stanton	Martin	90	■	□	□	□	□	□	□	□	□	□	□	■	□	□	□	□	□	□
Irrigation	Mason	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Mason	Mason	700	■	□	□	□	□	□	□	□	□	■	□	□	□	□	□	□	□	□
Mining	Mason	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Brady	McCulloch	1,420	■	□	□	□	□	□	□	□	□	■	□	■	□	□	□	□	□	□
Irrigation	McCulloch	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Millersview-Doole WSC	McCulloch	0	■	□	□	□	□	□	□	□	□	□	□	■	□	□	□	□	□	□
Mining	McCulloch	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Richland SUD	McCulloch	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Irrigation	Menard	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Menard	Menard	211	■	□	■	□	□	□	■	■	□	□	□	□	□	□	□	□	□	□
Mining	Menard	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Airline Mobile Home Park LTD	Midland	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
County-Other	Midland	0	■	□	□	□	□	□	□	■	□	□	□	□	□	□	□	□	□	□
Greenwood Water	Midland	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Irrigation	Midland	1	■	□	□	□	□	□	□	□	□	□	□	■	□	□	□	□	□	□
Midland	Midland	18,663	■	□	□	□	■	□	■	■	■	■	□	■	□	□	□	□	□	□
Mining	Midland	0	■	□	□	□	■	□	□	□	□	□	□	□	□	□	□	□	□	□
Colorado City	Mitchell	183	■	□	□	□	□	□	□	■	□	□	□	□	□	□	□	□	□	□
Irrigation	Mitchell	1,858	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Loraine	Mitchell	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Mitchell County UD	Mitchell	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Mining	Mitchell	0	■	□	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Steam Electric Power	Mitchell	10,326	□	□	■	□	□	□	□	□	□	□	□	■	□	□	□	□	□	□
Fort Stockton	Pecos	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Iraan	Pecos	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Irrigation	Pecos	0	■	□	□	□	□	□	□	□	□	□	□	□	□	■	□	□	□	□
Mining	Pecos	3,500	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Pecos County WCID #1	Pecos	0	■	□	□	□	□	□	□	■	□	□	□	□	□	□	□	□	□	□
Manufacturing	Pecos	161	□	□	□	□	□	□	□	□	□	□	□	■	□	□	□	□	□	□
Big Lake	Reagan	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Irrigation	Reagan	0	■	□	□	□	□	□	□	□	□	□	□	□	□	■	□	□	□	□
Mining	Reagan	0	■	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Balmorhea	Reeves	147	■	□	□	□	□	□	□	■	□	□	□	□	□	□	□	□	□	□

Every WUG Entity with an Identified Need			WMSs REQUIRED TO BE CONSIDERED BY STATUTE											ADDITIONAL						
Water User Group Name	County	Maximum Need 2020-2070 (acf/yr)	Conservation	Drought Management	Reuse	Reallocation of Storage	Voluntary Transfers*	Conjunctive Use	Expansion of Existing	New Supplies	Regional Water Supply	Improvement of Water Quality	Emergency Transfer of Water	System Optimization, Subordination	Brush Control	Weather Modification	Desalination	Aquifer Storage and Recovery	Cancellation of Water Rights	Interbasin Transfers
Irrigation	Reeves	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐
Madera Valley WSC	Reeves	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Reeves	10,400	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pecos City	Reeves	0	■	☐	■	☐	☐	☐	■	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐
Ballinger	Runnels	383	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
County-Other	Runnels	23	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Irigation	Runnels	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Miles	Runnels	48	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Mining	Runnels	0	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
North Runnels WSC	Runnels	194	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Winters	Runnels	226	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
County-Other	Schleicher	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
El Dorado	Schleicher	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Schleicher	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐
Mining	Schleicher	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
County-Other	Scurry	692	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Irrigation	Scurry	6,565	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Manufacturing	Scurry	156	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Scurry	419	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Snyder	Scurry	814	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Irrigation	Sterling	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐
Mining	Sterling	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sterling City	Sterling	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Sutton	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐
Mining	Sutton	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sonora	Sutton	0	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Concho Rural Water	Tom Green	13	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐
County-Other	Tom Green	0	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	■	☐	☐	■	☐	☐	☐
DADS Supported Living Center	Tom Green	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Goodfellow Air Force Base	Tom Green	345	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Irrigation	Tom Green	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐
Manufacturing	Tom Green	215	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
Mining	Tom Green	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
San Angelo	Tom Green	11,773	■	☐	■	☐	☐	☐	☐	■	■	☐	☐	■	■	☐	■	☐	☐	☐
Tom Green County FSD 3	Tom Green	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Upton	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
McCamey	Upton	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Upton	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Rankin	Upton	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
BCWID	Varies	0	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐
CRMWD	Varies	0	■	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	■	☐	☐	■	■	☐	☐
UCRA	Varies	0	☐	☐	☐	☐	■	☐	☐	■	☐	☐	☐	☐	■	☐	☐	☐	☐	☐
Barstow	Ward	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
County-Other	Ward	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Grandfalls	Ward	155	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Ward	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐

Every WUG Entity with an Identified Need			WMSs REQUIRED TO BE CONSIDERED BY STATUTE											ADDITIONAL						
Water User Group Name	County	Maximum Need 2020-2070 (acf/yr)	Conservation	Drought Management	Reuse	Reallocation of Storage	Voluntary Transfers*	Conjunctive Use	Expansion of Existing	New Supplies	Regional Water Supply	Improvement of Water Quality	Emergency Transfer of Water	System Optimization, Subordination	Brush Control	Weather Modification	Desalination	Aquifer Storage and Recovery	Cancellation of Water Rights	Interbasin Transfers
Mining	Ward	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Monahans	Ward	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Southwest Sandhills WSC	Ward	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Steam Electric Power	Ward	2,352	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wickett	Ward	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
County-Other	Winkler	0	■	☐	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Irrigation	Winkler	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kermit	Winkler	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mining	Winkler	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wink	Winkler	0	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

*Does not include existing contractual sales that will be met by strategies developed by the Wholesale Water Provider. Only includes new or increased voluntary transfers.

Region F - Potentially Feasible Water Management Strategies

Sponsor	Potentially Feasible Strategy
Multiple Entities	Municipal conservation
Multiple Entities	Irrigation conservation
Multiple Entities	Mining Conservation (Recycling)
Multiple Entities	Subordination of Downstream Water Rights
Multiple Entities	Reuse (Direct and Indirect, Potable and Non-Potable)
Multiple Entities	Purchase from Provider (Voluntary Transfer)
Multiple Entities	Brush control
Multiple Entities	Weather Modification
Andrews	Develop Ogallala Aquifer Supplies
Andrews	Develop Edwards-Trinity Plateau Aquifer Supplies
Andrews County Livestock	Develop Edwards-Trinity Plateau Aquifer Supplies
Andrews County Manufacturing	Develop Edwards-Trinity Plateau Aquifer Supplies
Andrews County-Other	Develop Edwards-Trinity Plateau Aquifer Supplies
Bangs	Direct Non-Potable Reuse
Balmorhea	Develop Edwards-Trinity-Plateau Aquifer Supplies
Ballinger	Purchase Water Right from Clyde (Fort Phantom Hill Reservoir)
BCWID #1	Develop Groundwater Supplies from Brown County
Big Spring	New Water Treatment Plant
Brady	Advanced Groundwater Treatment
Bronte	Water Treatment Plant Expansion
Bronte	Develop Edwards-Trinity Aquifer Supplies in Nolan County (Region G)
Bronte	Regional System from Lake Brownwood to Runnels and Coke Counties
Bronte	Regional System from Fort Phantom Hill to Runnels and Coke Counties
Bronte	Rehabilitation and Upsizing of Oak Creek Pipeline
Bronte	Develop Other Aquifer Supplies in Runnels County
Bronte	Develop Other Aquifer Supplies in Southwest Coke County
Brown County Mining	Develop Cross Timbers Aquifer Supplies
Colorado City	Develop Dockum Aquifer Supplies
Concho Rural Water	Purchase from Provider
CRMWD	Ward County Well Field Well Replacement
CRMWD	Ward County Well Field Expansion and Development of Winkler County Well Field
CRMWD	Develop Additional Groundwater Supplies in Pecos, Reeves, Ward, and Winkler
Greater Gardendale WSC	Purchase Water from City of Odessa
Greater Gardendale WSC	Purchase Water from Midland FWSD #1
Grandfalls	Develop Pecos Valley Aquifer Supplies
Junction	Dredging River Intake
Junction	Develop Edwards-Trinity Plateau Aquifer Supplies
Kimble County Manufacturing	Develop Edwards-Trinity Plateau Aquifer Supplies
Mason	Additional Water Treatment
Menard	Direct Non-Potable Reuse
Menard	Develop Hickory Aquifer Supplies
Midland	Advanced Treatment with Expanded Use of the Paul Davis Well Field
Midland	Purchase from Provider
Midland	West Texas Water Partnership
Midland County-Other	Development Pecos Valley Aquifer Supplies from Roark Ranch in Winkler County
Mitchell Steam Electric Power	Sale of Wastewater Effluent from Colorado City
Odessa	RO Treatment of Existing Supplies
Odessa	Develop Edwards-Trinity and Capitan Reef Complex Aquifer Supplies in Pecos County

Sponsor	Potentially Feasible Strategy
Odessa	Develop Capitan Reef Complex Aquifer Supplies in Ward County
Pecos County WCID #1	Develop Edwards-Trinity Plateau Aquifer Supplies
Pecos County WCID #1	Transmission Pipeline Replacement
Pecos City	Advanced Water Treatment
Pecos City	Partner with Madera Valley WSC & Expand Well Field
Pecos City	Direct Non-potable Reuse
Pecos City	Direct Potable Reuse
Pecos City	Indirect Potable Reuse with ASR
Reeves County Mining	Develop Additional Pecos Valley Aquifer Supplies
Robert Lee	New Water Treatment Plant
Robert Lee	Develop Groundwater from the Edwards Trinity Plateau in Tom Green County
Robert Lee	Develop Groundwater from the Edwards Trinity Plateau in Nolan County
Robert Lee	Regional System from Fort Phantom Hill to Runnels and Coke Counties
Robert Lee	Purchase Additional Water from Bronte
San Angelo	Desalination of Brackish Groundwater Supplies
San Angelo	Develop Additional Hickory Aquifer Supplies in McCulloch County
San Angelo	Develop Edwards Trinity Plateau Aquifer Supplies in Schleicher County
San Angelo	Develop Pecos Valley/ Edwards-Trinity Aquifer Supplies in Pecos County
San Angelo	Concho River Water Project
San Angelo	West Texas Water Partnership
Scurry County-Other	Purchase Water from Snyder
Scurry Manufacturing	Develop Other Aquifer Supplies
Sonora	Develop Additional Edwards-Trinity-Plateau Aquifer Supplies
Texland Great Plains	Develop Additional Ogallala Aquifer Supplies from Andrews or Gaines County
UCRA	Purchase Water from San Angelo and Expand Transmission System
Winters	Purchase from Provider

LIST OF REFERENCES

[1] Texas State Soil and Water Conservation Board: Water Supply Enhancement Program. Available online at http://www.tsswcb.texas.gov/en/brushcontrol.
[2] Texas Water Development Board. Report 090483094, An Assessment of Aquifer Storage and Recovery in Texas, February 2011.
[3] City of San Angelo. Water Supply Engineering Feasibility Study, October, 2018.
[4] West Texas Weather Modification Association: Analysis and Research. Available online at http://wtwma.com/analysis_and_research.htm.

5B WATER CONSERVATION

Water conservation is a potentially feasible water savings strategy that can be used to preserve the supplies of existing water resources. For municipalities and manufacturers, advanced drought planning and conservation can be used to protect their water supplies and increase reliability during drought conditions. Some of the demand projections developed for SB1 Planning incorporate an expected level of conservation to be implemented over the planning period. For municipal use, the assumed reductions in per capita water use are the result of the implementation of the State Water-Efficiency Plumbing Act[1]. Among other things, the Plumbing Act specifies that only water-efficient fixtures can be sold in the State of Texas. Savings occur because all new construction must use water-efficient fixtures, and other fixtures will be replaced at a fairly steady rate. On a regional basis, the Plumbing Act results in about a ten percent reduction in municipal water use (20,323 acre-feet per year) by year 2070.

Water Conservation in Region F

- Water Conservation is an important part of the Region F Water Supply Portfolio
- Water Conservation is a Recommended Water Management Strategy for
    - Municipal Users
    - Irrigation Users
    - Mining Users
- Conservation is estimated to meet 11% of the water shortages in Region F in 2020 and 14% in 2070.
- More information can be found in Appendix B

Water conservation strategies must be considered for all water users with a need. In Region F, this includes municipal, manufacturing, agricultural, mining, and steam electric power water users. Conservation strategies to reduce industrial (manufacturing, mining, and steam electric power) water use are typically industry and process-specific and cannot be specified to meet county-wide needs. The region recommends that industrial water users be encouraged to develop and implement site-specific water conservation practices. Wastewater reuse is a more general strategy that can be utilized by various industries for process water, and this strategy will be considered where appropriate.

Based on factors developed by the TWDB, irrigation demands are estimated to remain constant over the planning period (2020 to 2070). Reductions in demands due to conservation were not quantified by the TWDB for manufacturing and livestock needs.

Steam electric demands in Region F are estimated to remain constant over the planning period. As an alternative to using water, Region F, in consultation with representatives of the power generators in the area, developed an analysis of alternative cooling technologies that use little or no water. Because these technologies reduce the amount of water needed for power generation, using these technologies can be considered a water conservation strategy and are discussed in this subchapter. Due to the cost of the conversion to this type of technology, this strategy is not considered economically feasible at this time but would be supported by the Region if a power generator chose to pursue the strategy.

Agricultural water shortages include shortages for livestock and irrigation. Most of the livestock demand in Region F is for free-range livestock. Region F encourages individual ranchers to adopt practices that prevent the waste of water for livestock. However, the savings from these practices will be small and difficult to quantify. Therefore, livestock water conservation is not considered in this plan.

For municipal and irrigation users, additional conservation savings can potentially be achieved in the region through the implementation of conservation best management practices (BMPs), as discussed in Section 5B.1.1. These additional conservation measures were considered for all municipal and irrigation water user groups in Region F.

Although water conservation and drought management have proven to be effective strategies in Region F, the RWPG believes that water conservation should not be relied upon exclusively for meeting future needs. The region will need to develop additional surface water, groundwater, and alternative supplies to meet future needs. However, each entity that is considering development of a new water supply should monitor ongoing conservation activities to determine if conservation can delay or eliminate the need for a new water supply project.

The RWPG recognizes that it has no authority to implement, enforce or regulate water conservation and drought management practices. The water conservation practices described in this chapter and elsewhere in this plan are intended only as guidelines. Water conservation strategies determined and implemented by municipalities, water providers, industries or other water users supersede the recommendations in this plan and are considered to be consistent with this plan.

5B.1 Municipal Conservation

Certain public water suppliers are required to update and submit a Water Conservation Plan (WCP) to the Texas Commission on Environmental Quality (TCEQ) every five years. Per Title 30, Part 1, Chapter 288, Subchapter A, Rule 288.2 of the Texas Administrative Code, some specific conservation strategies are required to be included as part of a water conservation plan.

At a minimum each plan must include:

- Utility Profile that describes the entity, water use data, and water supply and wastewater system
- Record management system that is capable of recording water use by different types of users
- Quantified five-year and ten-year water savings goals
- Metering device with a 5 percent accuracy to measure the amount of water diverted from the source of supply
- A program for universal metering
- Measures to determine and control water loss
- A program of continuing public education and information regarding water conservation
- A non-promotional water rate structure
- A reservoir systems operation plan, if applicable
- Means of implementation and enforcement, as evidenced by: a document indicating the adoption of the WCP, and a description of the authority where the water supplier will implement and enforce the WCP
- Documentation of coordination with the regional water planning group

If a public water supplier serves over 5,000 people, they are additionally required to the have a conservation-oriented rate structure and a program of leak detection, repair, and water loss accounting for the water transmission, delivery, and distribution system.

Both the water conservation plans and water loss audit reports for water suppliers in Region F were reviewed to help identify appropriate municipal water conservation measures. The data from the water loss audit reports for Region F water providers are discussed in more detail in Chapter 1 of this plan.

Twenty-four water providers in Region F submitted water loss audits in 2017. Based on these reports, the percentage of real water loss for Region F is approximately 15 percent, which is slightly greater than the accepted range of water loss (less than or equal to 12 percent). This is likely due to the large service areas with low population densities characteristic of rural water supply corporations. For the water suppliers that fall under the water supply corporation category, there may be few cost effective options in reducing water loss.

5B.1.1 Identification of Potentially Feasible Conservation BMPs

To assess the appropriateness of additional conservation BMPs for Region F, 70 potential strategies were identified, and a screening level evaluation was conducted. Due to the differences in the water needs and available resources between the larger municipalities and smaller rural areas, the screening evaluation was performed both for entities with populations less than 20,000 people and entities with populations greater than 20,000.

The evaluation considered six criteria:

- Cost
- Potential Water Savings
- Time to Implement
- Public Acceptance
- Technical Feasibility
- Staff Resources

Each criterion was scored from 1 to 5, with 5 being the most favorable. Scores for all the criteria were then added to create a composite score. The strategies were then ranked and selected based on their composite score.

Selected Strategies for Entities under 20,000

Based on the screening level evaluation and requirements from the TCEQ, the following strategies were selected for consideration for entities in Region F with less than 20,000 people during every decade of the planning period:

- Education and Outreach
- Water Audits and Leak Repair
- Conservation – Oriented Rate Structure
- Water Waste Ordinance

Selected Strategies for Entities over 20,000

Based on the screening level evaluation and requirements from the TCEQ, the following strategies were selected for consideration for entities in Region F with more than 20,000 people during any decade of the planning period:

- Education and Outreach
- Water Audits and Leak Repair
- Conservation – Oriented Rate Structure
- Water Waste Ordinance
- Landscape Ordinance
- Time of Day Watering Limit

Each of the selected strategies above, was considered and evaluated for the appropriate water user groups (greater than or less than 20,000). Details of the strategy evaluation are included in Appendix C.

Municipal Water Conservation

Water conservation is a way life for many in drought prone Region F. Many municipalities have already benefited from the effects of municipal conservation and have a lower per capita water demand in the 2021 Region F Water Plan than previous Region F Water plans.

5B.1.2 Recommended Municipal Conservation Strategies

Published reports and previous studies were used to refine the description for the selected BMPs, including the potential water savings and costs. Water savings for some BMPs are difficult to estimate since there is little data for an extended time period. Also, most entities tend to implement a suite of strategies at the same time, which makes it difficult to estimate the individual water savings. These factors were considered in developing the assumptions defined below for each BMP. As more data becomes available through more rigorous water use tracking, the ability to estimate water conservation savings will improve.

Education and Outreach

Local officials would offer water conservation education to schools, civic associations, include information in water bills, provide pamphlets and other materials as appropriate. It was assumed that the education outreach programs would be needed throughout the planning period to maintain the water savings. It was assumed that education and outreach would save 5,000 gallons per household per year with a 30 percent adoption rate, i.e., assume that 30 percent of the customers respond to this measure by reducing water use. Per person costs were based on data obtained from municipalities and water providers. The costs for entities with populations less than 20,000 are greater on a per person basis than for the larger cities. In this case, education and outreach were assumed to cost $2.75 per person per year with a maximum cost of $15,000 for entities with populations less than 20,000. In contrast, education and outreach were assumed to cost $1.80 per person per year for entities with populations greater than 20,000.

Water Audits and Leak Repairs

Local officials would perform a water audit system wide and create a program of leak detection and repair, including infrastructure replacement as necessary. As part of the this type of program, some entities may choose to install Advanced Metering Infrastructure. It was assumed that 20 percent of an entity's losses could be recovered through a water audit and leak repair program, and that the leak detection and repair program would be an ongoing activity to maintain the level of water loss reductions. This strategy was considered for all cities with greater than or equal to 15 percent losses and WSCs with losses greater than or equal to 25 percent. If no water loss data was available for a WUG, this strategy was not considered. Costs were estimated at $10 per person per year. If an entity's population was less than 20,000 people, then an estimated base cost of $5,000 was added to the total cost.

Rate Structure

Local officials would implement an increasing block rate structure where the unit cost of water increases as consumption increases. Increasing block rate structures discourages the inefficient use or waste of water. Many cities already have a non-promotional rate structure. This strategy assumes that the entity adopts a higher level of a non-promotional rate structure. It is assumed that increasing block rates would save 6,000 gallons per household per year and that 10 percent of the households would respond to this measure by reducing water use. Since it is likely that the entity would conduct the rate structure modifications themselves, this BMP has no additional costs to the water provider.

Water Waste Ordinance

Local officials would implement an ordinance prohibiting water waste such as watering of sidewalks and driveways or runoff into public streets. A water waste ordinance saves about 3,000 gallons per household per year. It is assumed that 50 percent of the households in entities with over 20,000 people and 30 percent of the households in entities with less than 20,000 people would respond to this measure by not wasting water. Costs for this strategy would be those costs associated with enforcement. In this case, the costs associated with enforcement was estimated to be $10,000 in entities with over 20,000 people and $2,500 in entities with less than 20,000 people.

Landscape Ordinance (Population over 20,000)

Local officials would implement an ordinance that would promote residential plantings that conserve water for all new construction. This strategy is assumed to be implemented by 2030 and would only apply to new construction for both residential and commercial properties. This BMP would save 1,000 gallons per increased number of households per year. Costs for this strategy would be those costs associated with enforcement, which were estimated to be $10,000.

Time of Day Watering Limit (Population over 20,000)

Local officials would implement an ordinance prohibiting outdoor watering during the hottest part of the day when most of that water is lost (wasted) through evaporation. Many ordinances limit outdoor watering to between 6 p.m. and 10 a.m. on a year-round basis. It is assumed that time of day watering limits save 1,000 gallons/household/year and 75 percent of the population would realize these savings. (The other 25 percent is either not irrigating or already abide by this practice.) Costs for this strategy would be those costs associated with enforcement, which were estimated to be $10,000.

5B.1.3 GPCD Goals

The Region F planning group recognizes that it has no authority to implement, enforce, or regulate water conservation practices. The municipal conservation measures outlined in this chapter are intended as guidelines. Local, entity specific conservation strategies and BMPs are consistent with this plan and encouraged by the RWPG. Entity specific recommendations supersede the recommendations in this Plan.

As part of House Bill (HB) 807, the regional planning groups are required to "set one or more specific goals for gallons water use per capita per day (gpcd) in each decade of the period covered by the plan for the municipal water user groups in the regional water planning area." It should be noted that these goals are different than the goals set by utilities as part of their TCEQ Water Conservation Plans (WCP). WCP goals are often based on multi-year averages. Gpcd goals in this plan are intended as goals for dry year use, and thus, will generally be higher than the gpcd goal shown in an entity's WCP. Gpcd goals for each municipal user Region F are included as Attachment 5B at the end of this chapter.

5B.1.4 Municipal Conservation Summary

It is estimated that the municipal conservation strategy outlined in this plan will save, on a regional basis, over 2,500 acre-feet in 2020 and over 3,900 acre-feet in 2070. The unit costs vary considerably between water user groups depending on the population size, and implementation of a water audit and leak repair program for entities with high water losses. Generally, conservation programs are funded through a city's annual operating budget and are not capitalized. However, in some cases, an entity may choose to capitalize a portion or all of their program. These kinds of costs are difficult to estimate for each individual entity due to the wide variety of factors at play. For this plan, it is assumed that only water audits and leak repairs are capitalized. It was assumed that the repairs would be financed over 20 years in 2020, 2040, and 2060. However, all capital expenditures for conservation are considered consistent with Region F Plan. The savings and costs associated with water audits and leak repairs are shown separately in Table 5B-3.

Estimates of municipal conservation savings for Region F water users are shown in Table 5B-1. This table shows the amount of water savings that are estimated through conservation water management strategies, which is above the amount assumed to be achieved through the

Plumbing Act. Table 5B-2 shows the estimated costs for municipal conservation.

Although water conservation is part of the culture of the region, the challenge for future water conservation activities in Region F will be the development of water conservation programs that are cost-effective, meet state mandates, and result in permanent real reductions in water use. Development of water conservation programs will be a particular challenge for smaller communities, which lack the financial and technical resources needed to develop and implement the programs. Any water conservation activities should consider the potential adverse impacts of lost revenues from water sales and the ability of communities to find alternative sources for those revenues. State financial and technical assistance will be required to meet state mandates for these communities.

Table 5B-1
Estimated Savings from Municipal Conservation (acre-feet per year)

Water User Group	2020	2030	2040	2050	2060	2070
AIRLINE MOBILE HOME PARK	7	7	8	9	10	10
ANDREWS	45	55	96	111	129	150
ANDREWS COUNTY-OTHER	14	15	17	18	20	21
BALLINGER	12	12	12	12	12	12
BANGS	8	8	8	8	8	8
BALMORHEA	2	2	2	2	2	2
BARSTOW	1	1	1	1	1	1
BIG LAKE	10	12	12	13	13	14
BIG SPRING	131	138	140	139	139	139
BRADY	18	18	19	19	19	19
BRONTE	3	3	3	3	3	3
BROOKESMITH SUD	25	25	25	25	25	25
BROWNWOOD	61	91	91	91	91	91
COAHOMA	8	8	8	8	8	8
COLEMAN	15	15	15	15	15	15
COLEMAN COUNTY-OTHER	1	1	1	1	1	1
COLEMAN COUNTY SUD	10	10	10	10	10	10
COLORADO CITY	16	18	18	18	18	19
CONCHO RURAL WSC	20	21	22	23	24	24
CONCHO COUNTY-OTHER	3	3	3	3	3	3
CROCKETT COUNTY WCID	12	13	13	13	13	13
CRANE	11	12	13	13	14	14
DADS SLC	1	1	1	1	1	1
EARLY	9	9	9	9	9	9
ECTOR COUNTY UD	60	84	94	125	137	149
EDEN	4	4	4	4	4	4
EL DORADO	6	6	6	6	6	6
FORT STOCKTON	36	39	42	44	46	48
GOODFELLOW AFB	8	9	9	10	10	11
GRANDFALLS	1	1	1	1	2	2
GREATER GARDENDALE WSC	12	13	15	17	19	20
GREENWOOD WATER	3	3	4	4	4	5
IRAAN	4	4	5	5	5	5
JUNCTION	8	8	8	8	8	8
KERMIT	18	18	19	19	19	19
LORAINE	2	2	2	2	2	2
MADERA VALLEY WSC	5	5	5	6	6	6
MASON	7	7	7	7	7	7

Water User Group	2020	2030	2040	2050	2060	2070
MCCAMEY	7	7	8	8	8	8
MENARD	5	5	5	5	5	5
MERTZON	3	3	3	3	3	3
MIDLAND	631	755	816	882	944	1,012
MILES	3	3	3	3	3	3
MITCHELL COUNTY UTILITY	5	5	5	5	5	6
MILLERSVIEW-DOOLE WSC	13	14	14	14	14	15
MONAHANS	23	24	25	26	27	27
NORTH RUNNELS WSC	5	5	5	5	5	5
ODESSA	568	680	752	829	905	990
PECOS	29	31	33	34	35	35
PECOS WCID	9	10	11	11	12	12
PECOS COUNTY FRESH WATER	2	2	3	3	3	3
RANKIN	3	3	3	3	3	3
RICHLAND SUD	3	3	3	3	3	3
ROBERT LEE	3	3	3	3	3	3
RUNNELS COUNTY-OTHER	2	2	2	2	2	2
SAN ANGELO	459	532	558	592	629	668
SNYDER	41	47	51	55	59	93
SANTA ANNA	3	4	4	4	4	4
SCURRY COUNTY-OTHER	20	22	24	26	28	30
SONORA	9	9	9	10	10	10
SOUTHWEST SANDHILLS WSC	20	22	24	26	28	30
STANTON	8	9	10	10	11	11
STERLING CITY	3	3	3	3	3	3
TOM GREEN COUNTY FWSD 3	3	4	4	4	5	5
WICKETT	2	2	2	2	2	2
WINK	3	4	4	4	4	5
WINTERS	17	12	9	9	9	9
ZEPHYR WSC	13	13	13	13	13	13
TOTAL	**2,532**	**2,939**	**3,177**	**3,420**	**3,648**	**3,922**

Table 5B-2
Estimated Costs for Municipal Conservation

	2020	2030	2040	2050	2060	2070
Region F Annual Cost	$1,528,000	$1,764,000	$1,870,000	$1,964,000	$2,055,000	$2,161,000
Annual Cost per acre-foot	$606	$600	$589	$574	$563	$551
Annual Cost per 1,000 gal	$1.86	$1.84	$1.81	$1.76	$1.73	$1.69

Table 5B-3
Estimated Savings and Costs from Water Audits and Leak Repairs

Water User Group	Capital Cost			Savings (acre-feet/year)					
	2020	2040	2060	2020	2030	2040	2050	2060	2070
BROOKESMITH SUD	$1,737,000	$1,756,500	$1,756,500	81	81	79	78	78	78
COLEMAN	$1,074,800	$1,085,600	$1,085,600	59	58	57	57	57	57
MILLERSVIEW-DOOLE WSC	$965,800	$991,000	$1,009,100	65	66	65	66	67	68
SONORA	$679,900	$707,400	$720,800	106	112	114	116	117	118
ZEPHYR WSC	$944,700	$954,800	$954,800	19	19	18	18	18	18
TOTAL	**$5,402,200**	**$5,495,300**	**$5,526,800**	**330**	**336**	**333**	**335**	**337**	**339**

5B.2 Irrigation Water Conservation

The agricultural water needs in Region F include livestock and irrigated agriculture. New water supply strategies to meet these needs are limited. For irrigated agriculture, the primary strategies identified to address irrigation shortages are demand reduction strategies (conservation). The agricultural water conservation practices considered include:

- Changes in irrigation equipment
- Crop type changes and crop variety changes
- Conversion from irrigated to dry land farming
- Water loss reduction in irrigation canals

In addition to these practices, the region encourages research into development of drought-tolerant crops, implementation of a region-wide evapotranspiration and soil moisture monitoring network, and, where applicable, water-saving improvements to water transmission systems.

Depending on the method employed to achieve irrigation conservation, the composition of crops grown, sources of water, and method of delivery, will impact the potential savings and costs of this strategy. Since Region F does not have data on county-specific irrigation equipment employed by crop type, a general approach to irrigation conservation savings was taken. For planning purposes, a 5 percent increase in irrigation efficiency was assumed in decades 2020, 2030, and 2040. This efficiency could be achieved through implementation of one or more of the identified practices. The efficiency level was held constant for decades 2050, 2060, and 2070. A maximum efficiency level of 85 percent was assumed. For planning purposes, it was assumed that on average, irrigation conservation would have a capital cost of $760 per acre-foot saved. This is based on the Water Conservation Implementation Task Force Water Conservation Best Management Practices cost per acre for irrigation equipment changes indexed to December 2018 dollars. These costs are based on expenditures for changes in irrigation equipment.

Based on these assumptions, the irrigation conservation strategy is estimated to save around 23,000 acre-feet of supply in 2020 and 60,000 acre-feet in 2070. The projected savings by county are presented in Table 5B-4. The region-wide capital and annual costs are shown in Table 5B-5.

Table 5B-4
Irrigation Conservation Savings (acre-feet per year)

County Name	2020	2030	2040	2050	2060	2070
ANDREWS	1,018	2,037	2,037	2,037	2,037	2,037
BORDEN	147	295	295	295	295	295
BROWN	406	650	650	650	650	650
COKE	34	69	83	83	83	83
COLEMAN	23	47	47	47	47	47
CONCHO	245	490	539	539	539	539
CRANE	0	0	0	0	0	0
CROCKETT	7	14	20	20	20	20
ECTOR	38	76	113	113	113	113
GLASSCOCK	2,050	2,050	2,050	2,050	2,050	2,050
HOWARD	344	688	757	757	757	757
IRION	53	105	158	158	158	158
KIMBLE	133	266	319	319	319	319

County Name	2020	2030	2040	2050	2060	2070
LOVING	0	0	0	0	0	0
MARTIN	1,825	3,649	5,474	5,474	5,474	5,474
MASON	248	497	745	745	745	745
MCCULLOCH	116	232	349	349	349	349
MENARD	183	366	549	549	549	549
MIDLAND	905	1,811	2,716	2,716	2,716	2,716
MITCHELL	256	256	256	256	256	256
PECOS	7,167	14,335	21,502	21,502	21,502	21,502
REAGAN	1,102	2,203	3,305	3,305	3,305	3,305
REEVES	2,947	5,894	8,841	8,841	8,841	8,841
RUNNELS	155	311	373	373	373	373
SCHLEICHER	91	109	109	109	109	109
SCURRY	378	756	983	983	983	983
STERLING	45	90	135	135	135	135
SUTTON	56	112	168	168	168	168
TOM GREEN	2,125	4,249	5,099	5,099	5,099	5,099
UPTON	520	1,040	1,560	1,560	1,560	1,560
WARD	158	316	474	474	474	474
WINKLER	175	351	526	526	526	526
Total	**22,950**	**43,364**	**60,232**	**60,232**	**60,232**	**60,232**

Table 5B-5
Irrigation Conservation Costs

	2020	2030	2040	2050	2060	2070
Region F Capital Cost	$17,442,684	$15,511,646	$12,819,946	$0	$0	$0
Annual Cost per acre-foot	$20.89	$20.89	$12.93	$5.85	$0.00	$0.00
Annual Cost per 1,000 gal	$0.06	$0.06	$0.04	$0.02	$0.00	$0.00

Irrigation conservation is a strategy that proactively causes a decrease in future water needs by increasing the efficiency of current irrigation practices throughout the region. The adoption of irrigation conservation will help preserve the existing water resources for continued agriculture use and provide for other demands. However, without technical and financial assistance it is unlikely that aggressive irrigation conservation programs will be implemented. Also, increased efficiencies may lead to higher water application rates to increase crop yields, which negates the estimated water savings.

Region F recognizes that it has no authority to implement, enforce, or regulate irrigation conservation practices. These water conservation practices are intended to be guidelines. Water conservation strategies determined and implemented by the individual water user group supersede the recommendations in this plan and are considered to meet regulatory requirements for consistency with this plan. Furthermore, all capital expenditures for conservation are considered to be consistent with the Region F plan.

5B.3 Mining Water Conservation

> **Mining Water Conservation**
>
> - Region F highly supports and encourages the use of alternatives to fresh water supply for mining operations.
> - This strategy involves the reuse/recycling of mining flowback water to reduce the demand for fresh water supplies.
> - Several oil and gas companies already employ this strategy and many are expanding and actively pursuing additional ways to further reuse/recycling flowback water.

Most of the mining water use in Region F is used in oil and gas production, and the majority of the increase in projected future use is associated with the current Permian Basin activities. In accordance with §27.0511 of the Texas Water Code, Region F encourages the use of alternatives to fresh water for oil and gas production whenever it is economically and technically feasible to do so. Furthermore, Region F recognizes the regulatory authority of the Railroad Commission and the TCEQ to determine alternatives to fresh water use in the permitting process.

Due to the limited water resources in the Permian Basin, oil and gas companies have been actively pursuing recycling and reuse of the make-up water. These activities are a form of conservation, which is a demand management strategy that decreases future fresh water needs by treating and reusing water used in mining operations. Mining conservation and recycling is possible for both oil and gas mining as well as sand and gravel mining. Mining recycling and conservation was considered for all mining operations in Region F.

The amount of water than can be reused/recycled is dependent on the amount of water that flows back to the surface during and after the completion of the hydraulic fracturing or oil field flooding. For planning purposes, it is assumed that 20 percent of water used for mining purposes would be available through flow back and can be reused/recycled. The flow back water is of low quality and requires treatment or must be blended with fresh water. An estimated 30% of the flow back water will be lost during the treatment process.

On a regional basis, the amount of water saved through mining recycling and conservation is around 5,500 acre-feet in 2020 and nearly 1,500 acre-feet in 2070 when demands will have decreased significantly. Estimated savings by county are shown in Table 5B-6. The actual quantity of water available from this strategy will vary. Since this strategy is largely dependent on each individual operator and on economic factors specific to each mining operation, it is difficult to estimate the actual quantity of water that could be made available through this strategy.

The costs associated with this strategy vary based on the amount of flow back, the geographic location of the flow back, the amount of treatment required, and transportation distances required. For the purposes of this plan, a $20,000 per acre-foot capital investment for the maximum amount of water saved over the planning period was assumed. This investment was amortized over 20 years. However, individual operators may plan to invest the capital with no debt service and would likely implement capital improvements at the level needed for each decade. The costs in Table 5B-7 assume a single capital investment beginning in 2020. A 10 cent per barrel ($775 per acre-foot) annual savings from not having to dispose of the brine was assumed for the decades with capital cost. If an operator continued to employ this strategy in the later decades, they may realize a net savings over treating and disposing of the brine. However, for planning purposes, the annual cost was assumed to be $0 after the capital investment is paid off.

As competition for water grows, and water resources become more scarce, individual mining operators may find it more attractive to implement a reuse/recycling strategy. Reusing/recycling flow back water may also reduce brine disposal costs for the operator to help offset the cost of treatment and transportation. Ultimately, the decision to implement this strategy will be based on the economics of each individual well field. If brackish water is readily available and not in demand by other users, it may be more attractive to use brackish supplies. For planning purposes, it is assumed that the mining industry will adopt this strategy at the following rates:

- If there is a mining water shortage, mining conservation will be adopted 50 percent of the time
- If there is no mining shortage, mining conservation will be adopted 30 percent of the time
- If there is a surplus of mining water, mining conservation will be adopted 10 percent of the time

This assumption is incorporated into the water savings and costs shown in the previous tables. This strategy is recommended for all counties with a mining demand.

Table 5B-6
Mining Conservation (Recycling) Supplies (acre-feet per year)

Mining Conservation (Recycling) Supplies						
County	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
ANDREWS	277	260	222	176	135	104
BORDEN	29	39	33	21	10	5
BROWN	66	66	67	67	66	66
COKE	20	20	18	16	14	12
COLEMAN	5	4	4	4	3	3
CONCHO	20	20	18	15	13	12
CRANE	26	35	36	29	22	17
CROCKETT	315	315	43	24	7	3
ECTOR	28	30	27	22	18	15
GLASSCOCK	248	248	189	134	88	63
HOWARD	143	143	101	59	25	13
IRION	322	322	231	28	14	7
KIMBLE	1	1	1	1	1	1
LOVING	525	525	462	378	301	238
MARTIN	302	302	227	49	27	14
MASON	43	40	30	24	19	16
MCCULLOCH	375	351	279	236	203	176
MENARD	46	45	40	35	30	26
MIDLAND	445	445	344	231	46	32
MITCHELL	25	31	27	21	16	12
PECOS	539	539	539	434	67	52
REAGAN	445	445	323	62	24	8
REEVES	882	882	847	693	546	434
RUNNELS	11	11	10	9	8	7
SCHLEICHER	26	31	24	16	10	6
SCURRY	20	32	34	25	17	12
STERLING	33	40	34	22	11	6
SUTTON	19	30	32	24	16	11

Mining Conservation (Recycling) Supplies						
County	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
TOM GREEN	44	45	47	47	48	49
UPTON	101	101	80	53	32	22
WARD	80	80	71	55	38	25
WINKLER	33	49	42	32	22	16
TOTAL	**5,494**	**5,527**	**4,482**	**3,042**	**1,897**	**1,483**

Table 5B-7
Mining Conservation (Recycling) Costs

Costs	2020	2030	2040	2050	2060	2070
Region F Total Capital Cost	$111,660,000	$0	$0	$0	$0	$0
Region F Annual Cost (ac-ft/yr)	$3,599,000	$3,573,000	$0	$0	$0	$0
Annual Cost per acre-foot	$655	$646	$0	$0	$0	$0
Annual Cost per 1,000 gal	$2.01	$1.98	$0.00	$0.00	$0.00	$0.00

5B.4 Steam Electric Power Conservation

Steam Electric Power is a bit of a misnomer. 'Steam Electric Power' is the official name given by the TWDB for water demands associated with large power generation plants that sell to the open market and use water for cooling, not just facilities that use steam technology. Thus, throughout the Region F Water plan, 'Steam Electric Power' is used to refer to the broader water needs of multiple types of power generation.

By 2070 the region will have water needs for steam electric power generation of nearly 12,000 acre-feet after subordination. However, some these needs may not be realized due to changes in technology at the power generation facility that have already reduced water demands or projected new facilities that may not come online.

The projections for steam electric power water use in Region F are based on the highest county-aggregated historical power water use from 2010-2014. The anticipated water use of future facilities listed in state and federal reports is then added to the demand projections from the anticipated operation date to 2070. Subsequent demand projections after 2020 are held constant throughout the planning period. In Region F there are water demands for power generation in four counties: Ector, Howard, Mitchell, and Ward.

The use of alternative cooling technologies (ACT) that generate the same amount of electricity, but use less water is a form of water conservation. One example of an ACT implemented in power generation facilities is air cooling. This type of technology can be very costly to implement, and the adoption of ACT is largely a business decision on the part of the power industry. At this time, no facilities in Region F are currently considering adoption of this technology and it not considered economically feasible. However, the Region F planning group supports all types of water conservation and would support any power generation facility that chooses to implement a technology change that reduces water needs.

5B.5 Water Conservation Plans

The TCEQ defines water conservation as "a strategy or combination of strategies for reducing the volume of water withdrawn from a water supply source, for reducing the loss or waste of water, for maintaining or improving the efficiency in the use of water, for increasing the recycling and reuse of water, and for preventing the pollution of water."

In §11.1271 of the Texas Water Code, the State of Texas requires water conservation plans for all municipal and industrial/mining water users with surface water rights of 1,000 acre-feet per year or more and irrigation water users with surface water rights of 10,000 acre-feet per year or more. Water conservation plans are also required for all water users applying for a state water right and may also be required for entities seeking state funding for water supply projects. Recent legislation passed in 2003 requires all conservation plans to specify quantifiable five-year and ten-year conservation goals. While achieving these goals is not mandatory, the goals must be identified. 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 to the TWDB. In addition, any entity that is applying for a new water right or an amendment to an existing water right is required to prepare and implement a water conservation plan.

In the Region F area, 16 entities hold municipal or industrial rights in excess of 1,000 acre-feet per year and five entities have irrigation water rights greater than 10,000 acre-feet per year. Each of these entities is required to develop and submit to the TCEQ a water conservation plan. In addition, seven retail public suppliers are required to submit conservation plans to the TWDB. A list of the users in Region F which are required to submit water conservation plans is shown in Table 5B-8. Many more water users have contracts with regional water providers for 1,000 acre-feet per year or more. Presently, these water users are not required to develop water conservation plans unless the user is seeking state funding. However, TCEQ rules require that a wholesale water provider include contract language requiring water conservation plans or other conservation activities from its customers to assist in meeting the goals of the wholesale water provider's plan.[2]

To assist entities in the Region F area with developing water conservation plans, model plans for municipal water users, industrial users and irrigation districts can be accessed online at www.regionfwater.org and clicking on the Documents tab (http://www.regionfwater.org/index.aspx?id=Documents). Each of these model plans address the TCEQ requirements and is intended to be modified by each user to best reflect the activities appropriate to the entity. General model water conservation plan forms are also available from TCEQ in Microsoft Word and PDF formats. A printed copy of the form from TCEQ can be obtained by calling TCEQ at 512-239-4691 or by email to wcp@tceq.texas.gov.

Model Water Conservation Plans

Region F prepares model water conservation plans for municipal water users, industrial users, and irrigation districts. They are available on the Documents tab of the Region F website, www.regionfwater.org.

Table 5B-8
Water Users in Region F Required to Submit Water Conservation Plans

Municipal/Industrial Water Rights Holders		
Brown County WID #1	City of Menard	City of Coleman
City of Ballinger	City of San Angelo[a]	City of Junction
City of Big Spring[a]	City of Sweetwater[b]	CRMWD
City of Brady	City of Winters	Upper Colorado River Authority
Luminant Generation Co.	Texas Parks and Wildlife	Grayden Cedarworks
Retail Public Suppliers		
City of Andrews	City of Midland	City of Pecos
City of Brownwood	City of Odessa	City of Snyder
City of Fort Stockton		
Irrigation Water Rights Holders		
Pecos County WCID #1	Wayne Moore & W H Gilmore	Red Bluff Water Power Control District
Reeves County WID #1	City of San Angelo[a]	

a. These entities are also required to develop a conservation plan as a retail public provider.
b. City of Sweetwater is located in the Brazos G region but holds water rights in Region F.

5B.6 Other Water Conservation Recommendations

Region F encourages all water user groups to practice advanced conservation efforts to reduce water demand, not only during drought conditions, but as a goal in maintaining future supplies. This includes municipal, industrial, mining, and agricultural water users. As appropriate, municipal users should strive to reduce per capita water use to achieve the state-recommended goal of 140 gpcd use. Region F recognizes that some cities and rural communities may not achieve this level of reduction, but many communities have the opportunity to increase their water savings.

With irrigated agriculture being the largest water user in Region F, this sector has the greatest opportunities for water reductions due to conservation. The plan recommends strategies that would reduce the estimated irrigation water use by 63,232 acre-feet per year by 2070. Region F supports the implementation of any and all measures that effectively reduce water for agricultural purposes.

Region F supports and encourages the collaboration of multiple entities across the region to promote water conservation. This could be accomplished with the assistance of regional organizations, such as the GMAs and GCDs. Consistent messaging is important in continuing to maintain and/or increase conservation levels in the region. The TWDB provides a significant amount of information and services pertaining to water conservation that can be accessed at: http://www.twdb.texas.gov/conservation/.

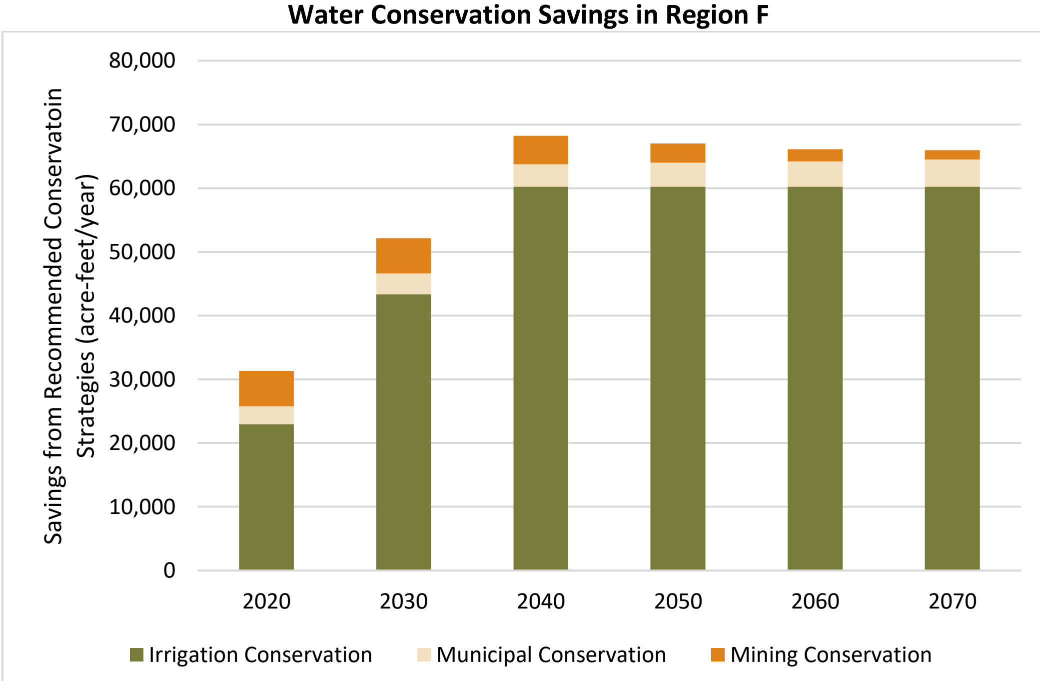
5B.7 Water Conservation Summary

Based on these analyses, it is estimated that implementing water conservation measures for municipal, agricultural, and mining users in Region F could save over 31,000 acre-feet by 2020 and nearly 66,000 acre-feet of water by 2070. Rising water costs and limited additional supplies will require increased water efficiency for all users and is encouraged by Region F.

Table 5B-9
Water Conservation Savings in Region F
-Values in acre-feet per year-

	2020	2030	2040	2050	2060	2070
Municipal Conservation	2,862	3,275	3,510	3,756	3,985	4,261
Irrigation Conservation	22,950	43,364	60,232	60,232	60,232	60,232
Mining Conservation	5,494	5,527	4,482	3,042	1,897	1,483
Total Conservation Savings	**31,306**	**52,166**	**68,224**	**67,030**	**66,114**	**65,976**

Figure 5B-1
Water Conservation Savings in Region F



ATTACHMENT 5B

GPCD GOALS

Water User Group (WUG) Name	GPCD Goals					
	2020	2030	2040	2050	2060	2070
AIRLINE MOBILE HOME PARK LTD	88	85	82	80	80	80
ANDREWS	252	248	244	243	243	243
BALLINGER	156	152	148	148	148	148
BALMORHEA	348	343	342	341	341	341
BANGS	108	103	100	98	98	98
BARSTOW	281	277	274	273	273	273
BIG LAKE	191	186	184	184	184	184
BIG SPRING	185	181	178	177	176	176
BRADY	212	208	204	204	203	203
BRONTE	222	219	215	213	213	213
BROOKESMITH SUD	121	118	116	114	114	114
BROWNWOOD	164	158	155	154	153	153
COAHOMA	185	180	178	178	177	177
COLEMAN	138	134	131	131	130	130
COLEMAN COUNTY SUD	108	104	101	99	99	99
COLORADO CITY	224	220	217	216	216	216
CONCHO RURAL WATER	76	73	71	70	70	70
COUNTY-OTHER, ANDREWS	106	102	99	97	97	96
COUNTY-OTHER, BORDEN	241	236	233	233	233	233
COUNTY-OTHER, BROWN	76	75	74	74	74	74
COUNTY-OTHER, COKE	89	84	81	79	79	79
COUNTY-OTHER, COLEMAN	104	99	96	95	95	95
COUNTY-OTHER, CONCHO	117	113	111	109	109	109
COUNTY-OTHER, CRANE	107	104	102	101	101	100
COUNTY-OTHER, CROCKETT	107	103	102	101	101	101
COUNTY-OTHER, ECTOR	113	111	109	109	108	108
COUNTY-OTHER, GLASSCOCK	107	103	100	100	99	99
COUNTY-OTHER, HOWARD	109	104	101	101	101	101
COUNTY-OTHER, IRION	108	104	100	99	99	99
COUNTY-OTHER, KIMBLE	109	106	103	101	101	101
COUNTY-OTHER, LOVING	110	106	102	101	100	100
COUNTY-OTHER, MARTIN	117	112	109	108	108	108
COUNTY-OTHER, MASON	110	106	104	102	102	102
COUNTY-OTHER, MCCULLOCH	141	138	137	136	136	136
COUNTY-OTHER, MENARD	109	106	102	101	100	100
COUNTY-OTHER, MIDLAND	142	138	135	134	133	133
COUNTY-OTHER, MITCHELL	155	152	150	148	148	148
COUNTY-OTHER, PECOS	119	114	113	113	112	112
COUNTY-OTHER, REAGAN	126	122	120	118	118	118
COUNTY-OTHER, REEVES	130	128	126	126	125	125
COUNTY-OTHER, RUNNELS	86	81	78	77	77	77
COUNTY-OTHER, SCHLEICHER	129	126	124	123	123	123
COUNTY-OTHER, SCURRY	107	102	99	98	97	97
COUNTY-OTHER, STERLING	107	102	102	101	101	101
COUNTY-OTHER, SUTTON	123	119	116	116	115	115
COUNTY-OTHER, TOM GREEN	117	112	112	111	111	111
COUNTY-OTHER, UPTON	108	104	101	100	99	99
COUNTY-OTHER, WARD	168	163	160	159	159	159
COUNTY-OTHER, WINKLER	159	157	157	156	156	156

Water User Group (WUG) Name	GPCD Goals					
	2020	2030	2040	2050	2060	2070
CRANE	306	302	298	297	297	297
CROCKETT COUNTY WCID 1	350	345	342	342	341	341
DADS Supported Living Center	382	379	377	376	376	376
EARLY	87	83	80	79	78	78
ECTOR COUNTY UTILITY DISTRICT	106	104	103	101	101	101
EDEN	143	140	138	137	137	137
ELDORADO	278	274	270	269	268	268
FORT STOCKTON	364	360	357	355	355	355
GOODFELLOW AIR FORCE BASE	180	177	175	174	174	173
GRANDFALLS	280	275	272	272	270	270
GREATER GARDENDALE WSC	71	68	66	65	64	64
GREENWOOD WATER	188	184	181	179	179	179
IRAAN	301	297	293	292	292	292
JUNCTION	210	206	202	201	200	200
KERMIT	270	266	262	262	262	262
LORAINE	100	96	92	92	92	92
MADERA VALLEY WSC	255	251	249	248	248	248
MASON	290	286	282	280	280	280
MCCAMEY	331	326	323	323	323	323
MENARD	206	202	198	198	197	197
MERTZON	106	103	100	98	98	98
MIDLAND	172	169	166	165	164	164
MILES	101	96	94	92	92	92
MILLERSVIEW-DOOLE WSC	113	109	107	105	105	105
MITCHELL COUNTY UTILITY	115	111	107	107	107	106
MONAHANS	298	293	290	290	289	289
NORTH RUNNELS WSC	92	88	85	84	83	83
ODESSA	171	167	164	163	162	162
PECOS	274	269	268	268	267	267
PECOS COUNTY FRESH WATER	238	234	230	228	228	228
PECOS COUNTY WCID 1	111	107	104	103	102	102
RANKIN	285	281	278	278	278	278
RICHLAND SUD	208	204	202	201	201	200
ROBERT LEE	249	244	241	240	240	240
SAN ANGELO	151	147	144	143	142	142
SANTA ANNA	122	116	113	113	112	112
SNYDER	130	126	123	122	122	121
SONORA	297	293	290	289	289	288
SOUTHWEST SANDHILLS WSC	77	72	68	67	66	65
STANTON	168	163	160	159	159	159
STERLING CITY	258	254	250	250	250	250
TOM GREEN COUNTY FWSD 3	101	97	95	94	93	93
WICKETT	359	355	352	351	351	351
WINK	300	294	292	292	292	291
WINTERS	71	66	62	62	62	62
ZEPHYR WSC	67	64	63	62	61	61

LIST OF REFERENCES

[1] Texas Health and Safety Code. *Water Saving Performance Standards*, Title 5, Subtitle B § 372.002, 2019.

[2] Texas Administrative Code (TAC). 2018. Title 30, Part 1, Chapter 288, Subchapter A, Subchapter B, and Subchapter C, April 2019, downloaded from: http://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=288

5C REGIONAL WATER MANAGEMENT STRATEGIES

Several strategies have been identified that will benefit multiple user groups across the region. These strategies include: subordination of downstream water rights, brush control, and precipitation enhancement. This subchapter discusses each of these strategies and outlines the recommendations, quantities and costs associated for each user of the strategy. Detailed strategy evaluations are included in Appendix C.

5C.1 Subordination of Downstream Water Rights

The TWDB requires the use of the TCEQ Water Availability Models (WAM) for regional water planning. Most of the water rights in Region F are in the Colorado River Basin. Chapter 3 discusses the use of the WAM models for water supply estimates and the impacts to the available supplies in the Upper Colorado River Basin. The Colorado WAM assumes that senior lower basin water rights would continuously make priority calls on Region F water rights. That assumption is not consistent with the historical operation of the Colorado River Basin and likely underestimates the amount surface water supplies available in Region F.

Although the Colorado WAM does not give an accurate assessment of water supplies based on the way the basin has historically been operated, TWDB requires the regional water planning groups to use the WAM to determine supplies. Using WAM supplies causes several sources in Region F to have no supply by definition, even though in practice their supply may be greater than indicated by the WAM. According to the WAM, the Cities of Ballinger, Brady, Coleman, Junction, and Winters and their customers have no water supply. The Morgan Creek power plant has no supply to generate power. The Cities of Big Spring, Bronte, Coahoma, Midland, Miles, Odessa, Robert Lee, San Angelo, Snyder and Stanton do not have sufficient water to meet current demands. Overall, the Colorado WAM supplies show shortages that are the result of modeling assumptions and regional water planning rules and are inconsistent with the historical operation of the Colorado Basin. This would indicate Region F needs to immediately spend significant funds on new water supplies, when in reality the magnitude of the indicated water shortages are not justified. Conversely, the WAM model shows more water in Region K (Lower Colorado Basin) than may actually be available.

One way for the planning process to reserve water supplies for these communities and their customers is to assume that downstream senior water rights holders subordinate their priority rights to major Region F municipal water rights, a strategy referred to as subordination in this plan.

Since the subordination strategy impacts water supplies outside of Region F, coordination with the Lower Colorado Regional Water Planning Group (Region K) was conducted. For the development of the 2006 regional water plans, a joint modeling effort was conducted with Region K and an agreement was reached for planning purposes. In subsequent planning cycles, Region K developed its own version of this subordination strategy, called the “cutoff model” that modified the priority dates for all water rights above Lakes Ivie and Brownwood. Region F has adopted the premise of the Region K’s cutoff model with only minor variations for purposes of the subordination strategy in this plan. The Region F model makes two major assumptions: 1) senior water rights in the Lower Colorado Basin (Region K) do not make priority calls on the upper basin, and 2) these upper basin water rights do not make calls on each other. Figure 5C-1 shows the divide between the upper and lower basin and depict which reservoirs were included in the subordination modeling. For the 2021 Region F Plan, the Region K model developed for LCRA with hydrology through December 2016 was used for the subordination modeling.

The Region F model differs from the Region K model by including the City of Junction's run-of-river rights in the upper basin. Other refinements to the subordination modeling include modifications for the Pecan Bayou. As discussed above, the assumption that upper basin water rights do not make calls on each other is consistent with general operations in the basin, but it may not be appropriate for determining water supplies during drought in the Pecan Bayou watershed. To better reflect reality, an assumption was made that the upstream reservoirs hold inflows that would have been passed to Lake Brownwood under strict priority analysis if Lake Brownwood is above 50 percent of the conservation capacity. This scenario provides additional supplies in the upper watershed while allowing Lake Brownwood to make priority calls at certain times during drought (i.e. when Lake Brownwood is below 50 percent of the conservation pool).

Two reservoirs providing water to the Brazos G planning region were included in the subordination analysis. Lake Clyde is located in Callahan County and provides water to the City of Clyde. Oak Creek Reservoir is located in Region F and supplies a small amount of water to water user groups within Regions F and G. Oak Creek Reservoir is owned and operated by the City of Sweetwater, which is in the Brazos G Region. Both Clyde and Sweetwater have other sources of water in addition to the supplies in the Colorado Basin.

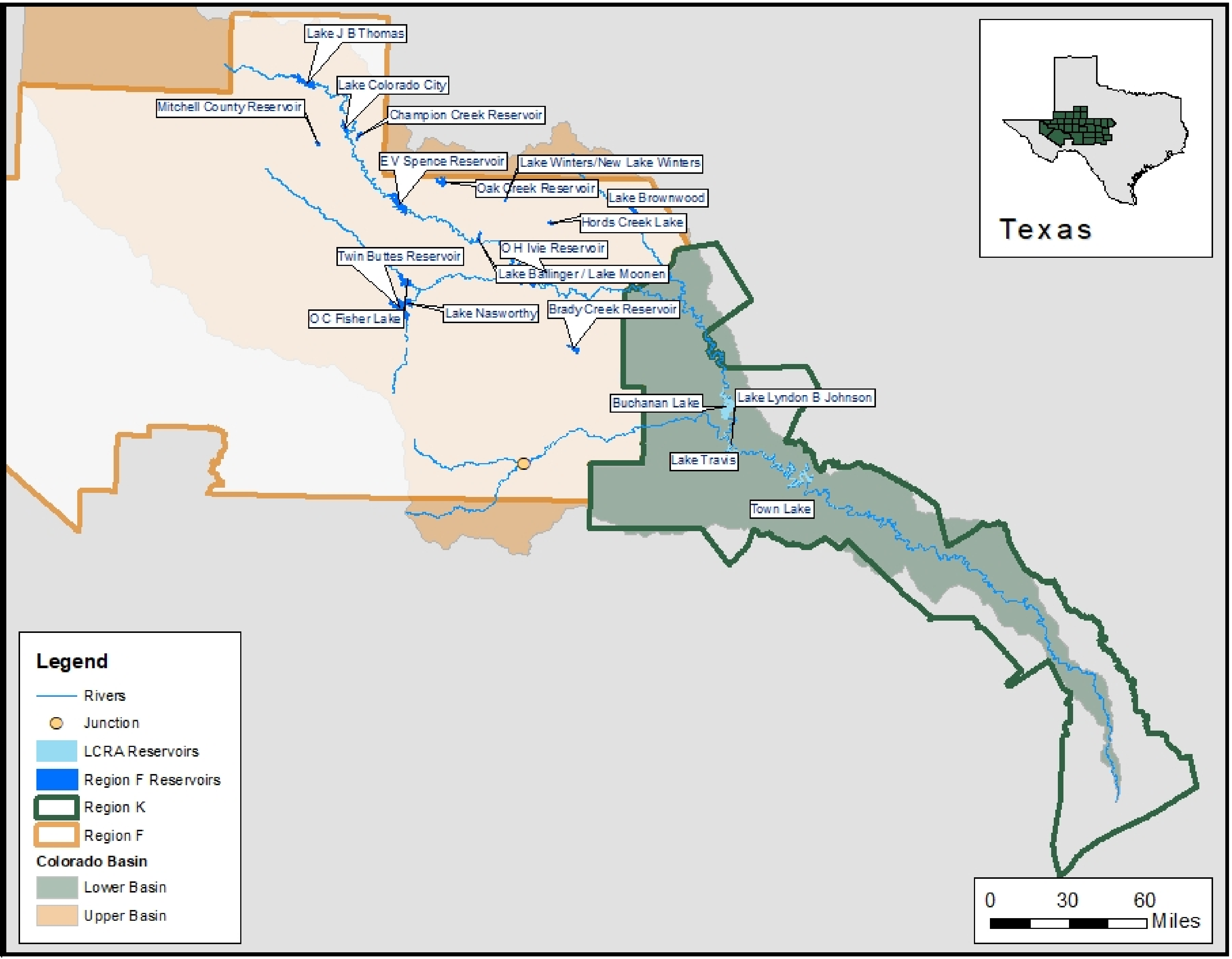
The subordination strategy modeling was conducted for regional water planning purposes only. By adopting this strategy, the Region F RWPG does not imply that the water rights holders have agreed to relinquish the ability to make priority calls on junior water rights. The Region F RWPG does not have the authority to create or enforce subordination agreements. Such agreements must be developed by the water rights holders themselves. Region F recommends and supports ongoing discussions on water rights issues in the Colorado Basin that may eventually lead to formal agreements that reserve water for Region F water rights.

The modeling shows that over 43,800 acre-feet of additional supply is available through the subordination strategy in 2020 and over 43,200 acre-feet in 2070. Table 5C-1 compares the 2020 and 2070 Region F water supply sources with and without subordination.

The reliability of this strategy is considered to be medium based on the uncertainty of implementing this strategy. The subordination strategy defined for the Region F Water Plan is for planning purposes. If an entity chooses to enter into a subordination agreement with a senior downstream water right holder, the details of the agreement (including costs, if any) will be between the participating parties. Therefore, strategy costs were not determined for the subordination strategy. For planning purposes, capital and annual costs for the subordination strategy are assumed to be $0.

Subordination

- Subordination changes the water availability modeling assumptions to more accurately reflect the historical operation of the Upper and Lower Colorado River Basins.
- This strategy is coordinated with Region K (Lower Colorado River Basin) to avoid double counting water supplies.
- Subordination provides over 40,000 additional acre-feet of water supply to Region F.



Region F

Subordination Strategy

FIGURE 5C-1

Table 5C-1
Region F Surface Water Supplies with and without Subordination

Reservoir Name	2020 Supply WAM Run 3	2020 Supply Subordination	2070 Supply WAM Run 3	2070 Supply Subordination
Lake Colorado City	0	1800	0	1550
Champion Creek Reservoir	0	1,170	0	1,100
Colorado City/Champion System	0	2,970	0	2,650
Lake Coleman	0	1,792	0	1,692
Hords Creek Lake	0	180	0	146
Coleman System	0	1,972	0	1,838
O. C. Fisher Lake[a]	0	0	0	0
Twin Buttes Reservoir[a]	0	1,670	0	1,195
Lake Nasworthy	0	See Twin Buttes	0	See Twin Buttes
San Angelo System	0	1,670	0	1,195
Lake J. B. Thomas (CRMWD System)	0	3,725	0	3,610
E.V. Spence Reservoir (CRMWD System)	0	21,575	0	21,355
O.H. Ivie Reservoir (CRMWD System)	14,285	15,193	11,709	13,067
O.H. Ivie Reservoir (Non-System)	16,065	17,147	13,491	15,053
O.H. Ivie Reservoir Total	30,350	32,340	25,200	28,120
CRMWD System Total (Thomas, Spence & Ivie)	14,285	40,493	11,709	38,032
Lake Ballinger / Lake Moonen	0	785	0	770
Lake Balmorhea	18,800	18,800	18,800	18,800
Brady Creek Reservoir	0	1,950	0	1,750
Lake Brownwood	18,900	24,340	18,200	23,770
Mountain Creek Reservoir	0	70	0	70
Oak Creek Reservoir	0	1,025	0	840
Red Bluff Reservoir	30,050	30,050	29,700	29,700
Lake Winters/ New Lake Winters	0	175	0	175
Kimble County ROR	0	250	0	250
TOTAL	***98,100***	***141,925***	***91,900***	***135,121***
Increase with Subordination	***43,825***		***43,221***	

[a] Supplies are less than theoretically available from the subordination model.

A list of the water user groups that could potentially benefit from subordination and the amount assumed for planning are shown in Table 5C-2.

Table 5C-2
Subordination Supplies by WUG

WUG Name	Additional Supplies Made Available through the Subordination Strategy					
	2020	2030	2040	2050	2060	2070
Allocated Subordination Supplies						
Ballinger [a]	794	751	750	748	753	791
County-Other, Runnels	23	21	19	18	18	19
North Runnels WSC	86	86	87	87	87	89
Brady	841	841	841	841	841	841
Steam Electric Power, Mitchell	1,170	1,156	1,142	1,128	1,114	1,100
Junction	250	250	250	250	250	250
Manufacturing, Kimble	228	228	228	228	228	228
Abilene	329	359	391	421	453	483
Midland [a]	2,173	359	391	421	453	483
Millersview-Doole WSC	52	0	0	0	9	62
Odessa	2,451	2	0	3,492	7,263	11,493
Ector County Utility District	234	0	0	332	694	1,097
Irrigation, Ector [a]	157	0	0	162	312	449
Irrigation, Midland	3	0	0	2	6	8
Manufacturing, Ector	186	0	0	199	381	551
Steam Electric Power, Ector	109	0	0	114	219	316
Big Spring	611	0	0	647	1,233	1,785
Coahoma	51	0	0	56	105	152
Manufacturing, Howard	147	0	0	153	293	424
Steam Electric Power, Howard	21	0	0	22	40	59
Snyder	194	0	0	256	524	814
County-Other, Scurry	29	0	0	31	59	85
Rotan	18	0	0	17	32	46
Stanton	31	0	0	33	62	90
Irrigation, Coleman	400	400	400	400	400	400
Coleman	1,319	1,296	1,276	1,255	1,227	1,200
Coleman County SUD	227	225	218	214	215	215
County-Other, Coleman	24	22	22	21	21	21
Manufacturing, Coleman	2	2	2	2	2	2
County-Other, Tom Green	70	70	70	70	70	70
Bronte	212	210	209	207	207	207
Robert Lee	236	238	239	239	239	239
San Angelo [a]	1,875	1,819	1,766	1,709	1,656	1,600
Upper Colorado River Authority	42	37	33	30	26	23
Goodfellow Air Force Base	44	42	40	38	35	33
Manufacturing, Tom Green	37	36	32	29	26	22
Winters	100	99	98	98	98	97
Non-Allocated Subordination Supplies						
Brady Creek (non-allocated)	1,109	1,069	1,029	989	949	909
BCWID (non-allocated)	5,440	5,466	5,492	5,518	5,544	5,570
CRMWD (non-allocated)	15,819	19,911	18,533	13,002	7,245	972
Oak Creek (non-allocated)	577	540	503	468	431	394
Lake Colorado City (non-allocated)	1,800	1,750	1,700	1,650	1,600	1,550
Subordination Supplies for Future Use						
Odessa	3,930	3,930	3,930	3,930	3,930	3,930
Manufacturing, Howard		500	500	500	500	500
Greater Gardendale WSC		375	445	445	445	445
County-Other, Ector		1,200	2,500	2,500	2,500	2,500
County-Other Scurry	373	414	447	491	547	607

a Includes subordination supplies from multiple sources and/or providers.

5C.2 General Water Management Strategies

5C.2.1 Brush Control

Brush control has been identified as a potentially feasible water management strategy for Region F. It has the potential to enhance the existing supply from the region's reservoirs.

In 1999, the Texas State Soil and Water Conservation Board began the Brush Control Program. In 2011, the 82nd Legislature replaced the Brush Control Program with the Water Supply Enhancement Program (WSEP). The WSEP's purpose is to increase available surface and groundwater supplies through the selective control of brush species that are detrimental to water conservation. The WSEP considers priority watersheds across the State, the need for conservation within the territory of a proposed projection based on the State Water Plan and if the Regional Water Planning Group has identified brush control as a strategy in the State Water Plan as part of their competitive grant, cost sharing program. Three primary species are eligible for funding from the WSEP: juniper, mesquite and salt cedar.

For a watershed to be eligible for cost-share funds from the WSEP, a feasibility study must demonstrate increases in projected post-treatment water yield as compared to the pre-treatment conditions. Feasibility studies have been conducted and published for the following watersheds in Region F and are shown on Figure 5C-2:

- Lake Brownwood
- North Concho River (O.C. Fisher Lake)
- O.H. Ivie Reservoir (Lake Basin)
- O.H. Ivie Reservoir (Watershed, Upper Colorado River and Concho River)
- E.V. Spence (Upper Colorado River)
- Lake J.B. Thomas (Upper Colorado River)
- Twin Buttes Reservoir (including Lake Nasworthy)
- Upper Llano River, including South and North Llano Rivers and Junction City Lake

Active brush removal has been implemented in several watersheds, but to be an effective and reliable long-term water production strategy, areas where brush removal has been performed, must be maintained. These maintenance activities qualify as brush control for purposes of this plan.

Although many studies have illustrated the benefits of brush control, it is difficult to quantify the amount of water supply created by the strategy for regional water planning. This quantification is important because in most areas where the program is being implemented, hydrologic records indicate long term declines in reservoir watershed yields (some as much as 80%). Region F has been in serious drought conditions during most of the time that the region's brush removal programs have been in place, so the monitoring programs associated with these projects may not have shown significant gains due to the lack of rainfall events. Also, the benefits from brush control are long term; it takes time for aquifers to recharge and it may take some time for watersheds to return to pre-brush conditions.

For purposes of this plan, brush control is recommended for the following sponsors and watersheds. The quantity of water directly associated with brush removal under drought conditions is limited since it is reliant on rainfall, but it is assumed that this strategy will increase the reliability of the surface water supplies made available through subordination. It may also help increase supplies when employed as part of a conjunctive strategy. By heavily using surface water when it is available, groundwater is preserved for times of future drought.

Figure 5C-2
Brush Control Watershed Feasibility Studies

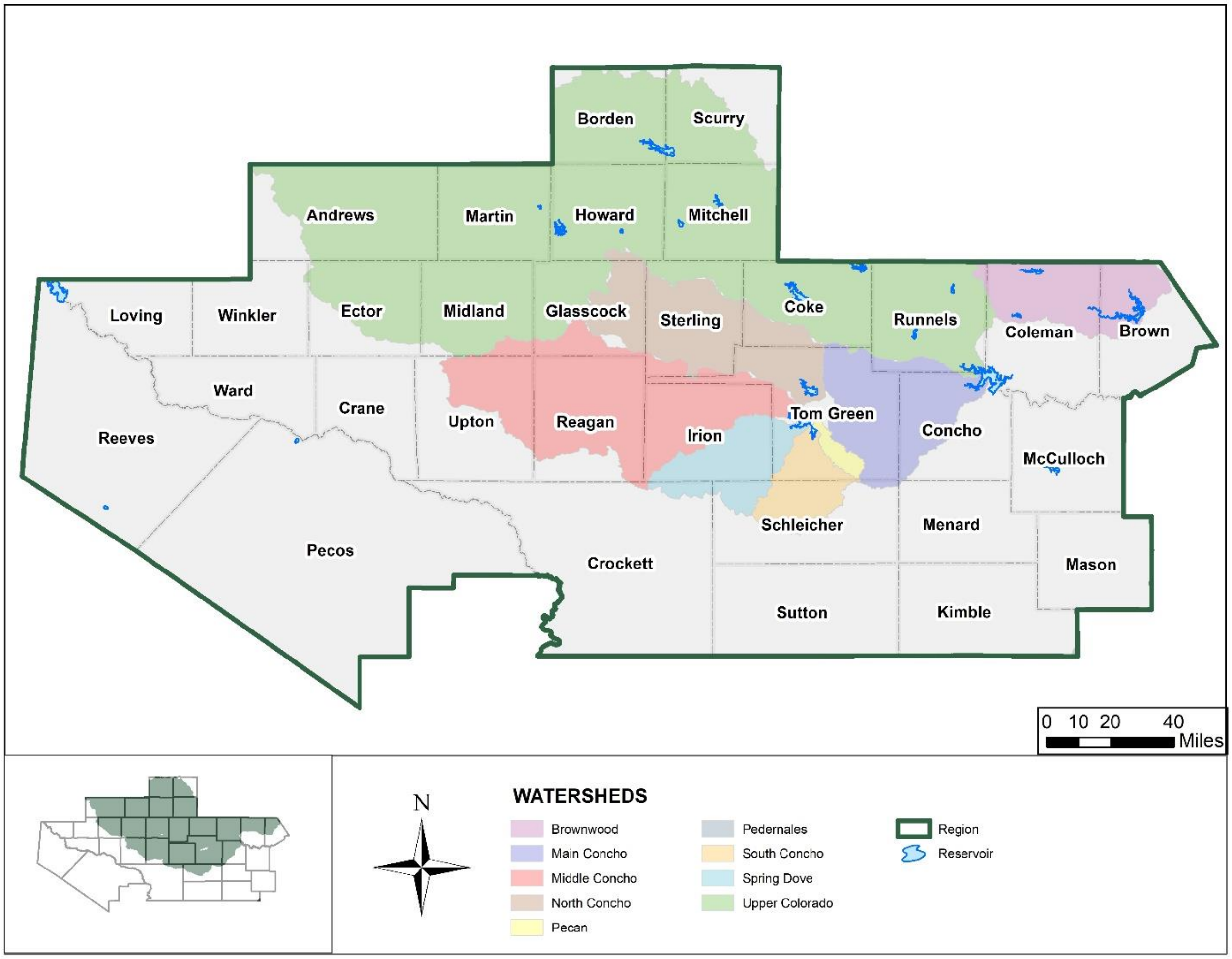


Table 5C-3
Region F Brush Control

Sponsor	Watershed	Annual Cost	Quantity (acre-feet per year)
UCRA	O.H. Ivie	$51,000	60
San Angelo	Twin Buttes Reservoir	$44,000	90
BCWID	Lake Brownwood	$156,000	400

5C.2.2 Weather Modification

Weather modification is a water management strategy currently used in Texas to increase precipitation released from clouds over a specified area. Typically, weather modification is practiced during the dry summer months when conditions are most favorable. The most common form of weather modification or rainfall enhancement is cloud seeding. Early forms of weather modification began in Texas in the 1880s by firing cannons to induce convective cloud formation. Current cloud seeding techniques are used to enhance the natural process for the formation of precipitation in a select group of convective clouds.

Weather modification is most often utilized as a water management strategy during the dry summers in West Texas, with the season beginning in March and ending in October. The water produced by weather modification augments existing surface and groundwater supplies. It also reduces the reliance on other supplies for irrigation during times of normal and slightly below normal rainfall. However, not all of this water is available for water demands. Some of this precipitation is lost to evaporation, evapotranspiration, and local ponds. During drought years the amount of additional rainfall produced by weather modification may not be significant. However, by using this strategy during normal rainfall years, groundwater is preserved for use during future times of drought.

The amount of water made available to a specific entity from this strategy is difficult to quantify, yet there are regional benefits. Four major benefits associated with weather modification include:

- Improved rangeland and agriculture due to increased precipitation
- Greater runoff to streams and rivers due to higher soil moisture
- Groundwater recharge
- Hail suppression

In Region F, there are two ongoing weather modification programs: the West Texas Weather Modification Association (WTWMA) project and the Trans Pecos Weather Modification Association (TPWMA) program. Figure 5C-3 shows the counties that are currently participating in weather modification programs.

Based on data collected from the WTWMA program, precipitation increases across participating counties in 2016 varied from slightly less than 0.5 inches to over 2 inches in the year, averaging 2.02 inches of increased rainfall. [1] This represented over a 10 percent increase in rainfall. In the Trans Pecos area, the rainfall increases were less, averaging 0.43 inches of increased rainfall.[2]

While it is difficult to quantify the benefits to individual water user groups, weather modification is a recommended strategy for irrigated agriculture for counties that currently participate in an active program. It is assumed that the increase in rainfall will offset irrigation water use. To determine the water savings associated with this strategy, an estimate of the increase in annual rainfall over the typical growing season is applied directly to the irrigated acreages. [3] These savings are shown by county in Table 5C-4.

The reliability of water supplies from precipitation enhancement is considered to be low for two reasons. First, it is uncertain how much water is made directly available per water user. Second, during drought conditions precipitation enhancement may not result in a significant increase in water supply. However, water saved due to precipitation enhancement will preserve local groundwater for future use.

The cost of operating Texas weather modification programs are approximately 4 to 6 cents per acre. For planning purposes, it was assumed that it would cost 4.5 cents per acre. These costs are supported by local municipalities, groundwater districts, irrigation districts, and landowners. The costs shown in Table

5C-4 are based on the program cost for the irrigated acres. Actual costs would be higher when considering the entire program areas.

Figure 5C-3
Current Weather Modification Programs

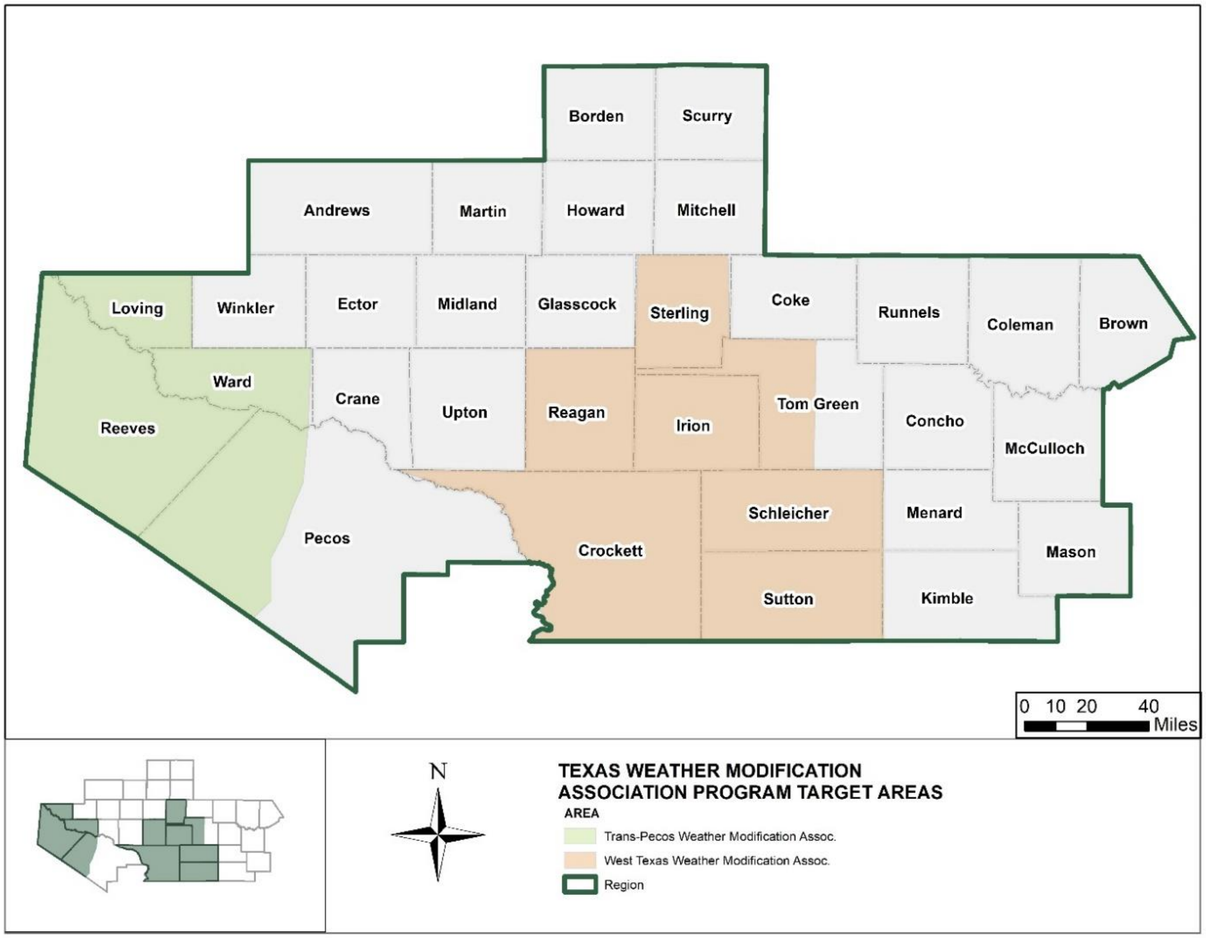


Table 5C-4
Weather Modification Water Savings and Cost

Weather Modification Program	County	Water Savings (ac-ft/yr)	Cost ($)	Cost per Ac-Ft ($/ac-ft)
TPWMA	Pecos	106	$580	$5.45
TPWMA	Reeves	326	$366	$1.13
TPWMA	Ward	259	$147	$0.57
WTWMA	Crockett	1	$1	$0.47
WTWMA	Irion	202	$42	$0.21
WTWMA	Reagan	1,869	$364	$0.19
WTWMA	Schleicher	275	$64	$0.23
WTWMA	Sterling	48	$18	$0.39
WTWMA	Sutton	34	$15	$0.45
WTWMA	Tom Green	2,007	$882	$0.44
TOTAL		**5,128**		**$0.48**

Source: Texas Weather Modification Association[4]

LIST OF REFERENCES

[1] West Texas Weather Modification Association. *2017 Annual Report for West Texas Weather Modification Association*.

[2] Texas Weather Modification Courier, February 2014. <http://www.texasweathermodification.com>.

[3] United States Department of Agriculture, National Agricultural Statistics Service. "2017 Census of Agriculture, Texas State and County Profiles." Rep. <http://www.agcensus.usda.gov/Publications/2017/>

[4] Arquimedes Ruiz Columbie. Active Influence & Scientific Management, *Annual Evaluation Report 2016 State of Texas*. Prepared for the Texas Weather Modification Association. <http://www.texasweathermodification.com>.

5D MAJOR WATER PROVIDER WATER MANAGEMENT STRATEGIES

Region F has five major water providers. Among these providers, four are shown to have water supply shortages (see Chapter 4). To better understand the quantity of water that will need to be developed through infrastructure strategies, the needs presented for the major water providers consider supply reductions from municipal conservation and supplies made available through subordination. Both of these strategies are developed and discussed in Chapters 5B and 5C, respectively, and are presented in this chapter for completeness in identifying recommended water management strategies. Discussion of the water needs and recommended water management strategies for each of the major water providers is presented in the following sections. Full strategy evaluations are included in Appendix C.

Region F Major Water Providers

- Brown County Water Improvement District No. 1 (BCWID No. 1)
- Colorado River Municipal Water District (CRMWD)
- Midland
- Odessa
- San Angelo

5D.1 Brown County Water Improvement District No. 1

The Brown County Water Improvement District (BCWID) #1 supplies water to members in Brown, Coleman, Mills and Runnels counties. Major customers include Bangs, Brookesmith SUD, Brownwood, Early, Zephyr WSC, and manufacturers and irrigators in Brown County. The BCWID currently receives all of its supply from Lake Brownwood. Lake Brownwood has sufficient yield to meet BCWID's needs even without subordination. With subordination and conservation, BCWID shows a supply surplus throughout the planning horizon. BCWID has investigated groundwater development as a way to ensure a reliable water supplies during times of extreme drought. However, test wells found that the water quality was poor and would be very costly to treat. BCWID does not intend to develop a groundwater source at this time but would consider pursuit of this source if needed under extreme drought conditions. Table 5D- 1 shows the comparison of supply and demand for BCWID with subordination and conservation supplies.

Potentially feasible water management strategies for Brown County WID #1 include:

- Municipal Conservation
- Subordination
- Brush Control
- Develop Groundwater Supplies

Full strategy evaluations are included in Appendix C. The following strategies were recommended for BCWID #1. Both conservation and subordination are discussed in detail in previous chapters, but they are also discussed below as a recommended strategy for completeness.

Table 5D-1
Comparison of Supply and Demand for BCWID

Supplies	**Supply 2020**	**Supply 2030**	**Supply 2040**	**Supply 2050**	**Supply 2060**	**Supply 2070**
Lake Brownwood Safe Supply (with subordination)	24,340	24,226	24,112	23,998	23,884	23,770
Customer Conservation	254	285	282	281	281	281
Total Availability	**24,594**	**24,511**	**24,394**	**24,279**	**24,165**	**24,051**
Treated Water Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
City of Bangs	310	305	296	291	290	290
Brookesmith SUD	1,212	1,208	1,183	1,169	1,167	1,167
Coleman County SUD	229	227	222	219	218	218
City of Santa Anna	156	154	149	149	148	148
Brownwood	3,717	3,713	3,640	3,600	3,593	3,593
County-Other, Brown	129	129	129	129	129	129
Early	292	287	277	271	270	270
Zephyr WSC	346	342	333	328	327	328
Manufacturing, Brown	548	651	651	651	651	651
Total Treated Water Demand [a]	**6,939**	**7,016**	**6,880**	**6,807**	**6,793**	**6,794**
Irrigation, Brown	5,000	5,000	5,000	5,000	5,000	5,000
Total Raw Water Demand	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**	**5,000**
Total Demand	**11,939**	**12,016**	**11,880**	**11,807**	**11,793**	**11,794**
Surplus (Shortage)	**Surplus (Shortage) 2020**	**Surplus (Shortage) 2030**	**Surplus (Shortage) 2040**	**Surplus (Shortage) 2050**	**Surplus (Shortage) 2060**	**Surplus (Shortage) 2070**
Surplus (Shortage)	***12,655***	***12,495***	***12,514***	***12,472***	***12,372***	***12,257***

a. Existing treatment capacity limits treated water supply to 11,050 acre-feet per year.

5D.1.1 BCWID No. 1 Recommended Water Management Strategies

Municipal Conservation

This strategy pro-actively reduces municipal retail water demands through public education and outreach, an inclining rate structure to discourage high water use, a water waste ordinance, a landscape ordinance for new construction, and time of day outdoor watering limits. As a wholesale water provider, BCWID #1 cannot carry out this strategy. This strategy will be implemented by each individual member and customer city. These combined efforts are expected to reduce BCWID's demands by about 2 percent throughout the planning horizon. The costs for this strategy are associated with each retail water provider.

Subordination

The subordination strategy increases the supply to Lake Brownwood by changing the strict priority modeling assumptions utilized in WAM Run 3. Under the subordination strategy, Lake Brownwood's supplies increase to over 24,300 acre-feet in 2020. The supplies decrease to nearly 23,700 acre-feet by 2070 due to sedimentation in the reservoir. The subordination strategy is discussed in detail in Chapter 5C and in Appendix C. Region F recognizes that a subordination agreement is not within the authority of the RWPG. Such an agreement must be developed by the water rights holders themselves, including BCWID.

Brush Control

Certain species of brush can drastically reduce the water yield in a watershed. By replacing water intensive brush species with less water intensive native plants, increased runoff to the reservoirs is possible. Funding for this type of project is typically available through the Water Supply Enhancement Program of the Texas State Soil and Water Conservation Board (TSSWCB), though there was no funding statewide in 2019. The TSSWCB has already completed feasibility studies for the Lake Brownwood watershed. Some of this land has already been treated for brush. However, in order to continue to realize these water savings, brush must be continually retreated. The reservoir yields shown under subordination include hydrology through the end of 2016. Therefore, all savings gained by previous treatment of brush are shown in the modeled yield of these reservoirs. However, any future brush treatments could yield small amounts of additional savings. According to the TSSWCB annual reports, on average, about 1,000 acres of brush per year are treated in this area. Based on this level of brush treatment, around 400 acre-feet of increased supply is estimated.

5D.1.2 BCWID No. 1 Water Management Plan Summary

BCWID No. 1 Recommended Water Management Strategies

- Municipal Conservation
- Subordination
- Brush Control

Table 5D- 2 shows a comparison of supply and demand after recommended strategies are implemented for BCWID No. 1. Subordination and conservation are shown in this table as strategies for completeness. Table 5D- 3 shows the capital and annual costs for the recommended plan for BCWID #1.

Figure 5-1 illustrates the recommended water management plan for BCWID. BCWID currently has a surplus of water available. The only recommended strategy is brush control.

Table 5D-2
Recommended Water Management Strategies for BCWID #1
-Values are in Acre-Feet per Year-

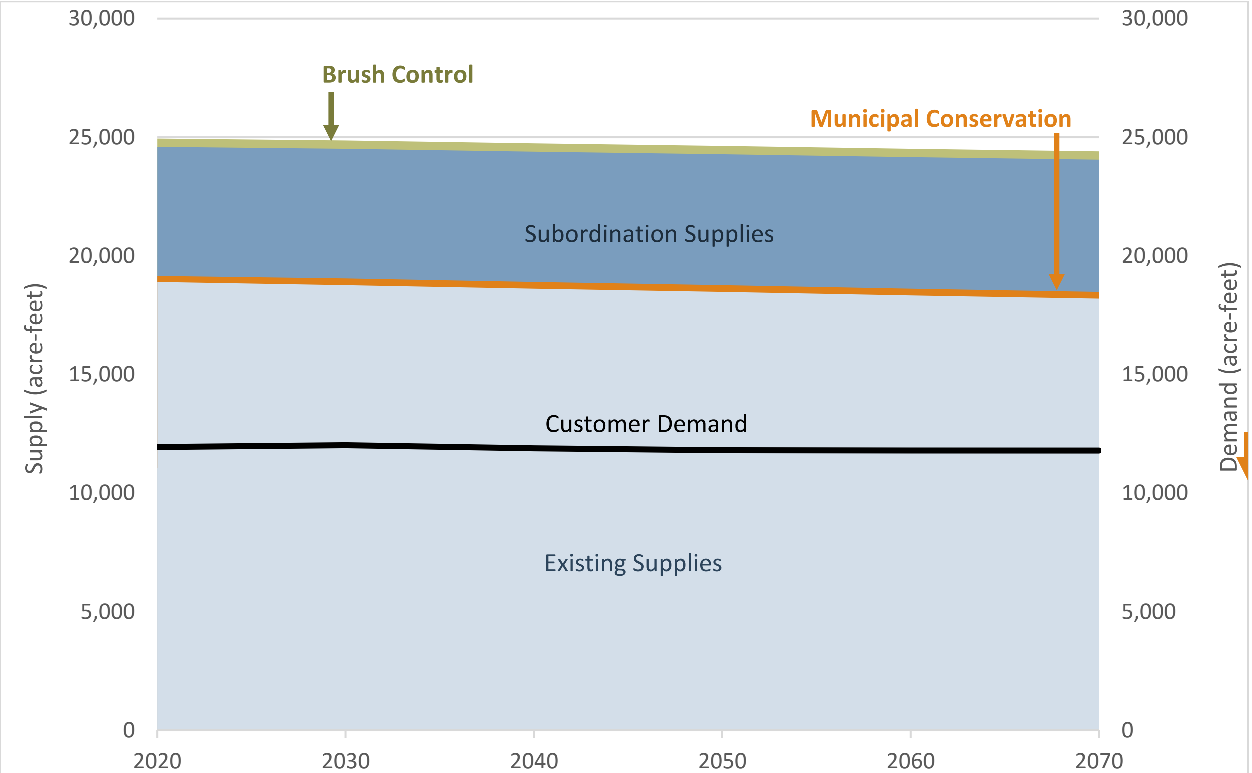
	2020	2030	2040	2050	2060	2070
Surplus (Shortage) before Recommended Strategies	**12,401**	**12,210**	**12,232**	**12,191**	**12,091**	**11,976**
Recommended Strategies (acre-feet per year)	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Subordination	*5,440*	*5,466*	*5,492*	*5,518*	*5,544*	*5,570*
Customer Conservation	*254*	*285*	*282*	*281*	*281*	*281*
Brush Control	400	400	400	400	400	400
Surplus (Shortage) after Recommended Strategies	***13,055***	***12,895***	***12,914***	***12,872***	***12,772***	***12,657***
Management Supply Factor	*2.1*	*2.1*	*2.1*	*2.1*	*2.1*	*2.1*

Strategies in grey italics were included in the previous calculation of surplus (shortages). They are included in this table for completeness but are not included in the total to avoid double counting.

Table 5D-3
Cost for Strategies for BCWID #1

Strategy	Capital Cost (Thousand $)	Unit Cost ($/1,000 gal)	
		With Debt Service	After Debt Service
Municipal Conservation of Customers	---	NA	NA
Subordination	---	$0	$0
Brush Control	---	NA	$1.20

Figure 5D-1
BCWID No. 1 Water Management Plan



BCWID No. 1 Alternative Water Management Strategies

BCWID No. 1 investigated groundwater development to bolster the security of their water supplies and to serve as a potential backup supply to Lake Brownwood. Based on analysis from their test wells, wells in Brown County can yield supply from deep formations, however, water quality is poor and contains high total dissolved solids (TDS), requiring advanced treatment. Due to the high cost and currently adequate supplies from Lake Brownwood, BCWID does not intend to pursue a groundwater strategy at this time. However, it is included as an alternative water management strategy should conditions change. Additional information on this strategy is included in Appendix C.

5D.2 Colorado River Municipal Water District (CRMWD)

The Colorado River Municipal Water District (CRMWD), the largest water supplier in Region F, provides raw water from both groundwater and surface water sources to its member cities and customers. CRMWD owns and operates three major reservoirs, Lake J.B. Thomas, E.V. Spence Reservoir, and O.H. Ivie Reservoir, as well as several chloride control reservoirs (diverted water system) for water quality control. Groundwater sources include well fields in Ward and Martin Counties. CRMWD member cities include Big Spring, Odessa and Snyder. CRMWD also supplies water to Midland, San Angelo and Abilene, as well as several smaller water utilities and cities that serve customers in Concho, Howard, Martin, Runnels, and Ward counties.

CRMWD can be thought of as two systems: customers who have contracts only from Lake Ivie (Lake Ivie-non system) and CRMWD member cities and system customers which are supplied from the remaining yield in Ivie, as well as all of CRMWD's other sources of supply. Because the nature of these contractual relationships are different, the needs of each system are evaluated separately. Table 5D- 1 summarizes the supplies and demands for CRMWD's system, which includes subordinated supplies from Lake O.H. Ivie, E.V. Spence Reservoir, Lake J.B. Thomas, potable reuse water from Big Spring, and groundwater. Potential future customers include demands that CRMWD's member cities intend to serve. Table 5D- 2 summarizes the supplies and demands for CRMWD's Lake Ivie non-system portion. Supply from the diverted water system is brackish and cannot be used for municipal purposes in its typical state. Currently, there are no potable or non-potable demands on this water source.

Following the most recent significant drought years (2011-2015), the demands on CRMWD decreased significantly. This was partly due to drought restrictions and partly due to the development of additional supplies by several of CRMWD's customers (Midland and San Angelo). The water demands adopted by Region F and the TWDB are based on dry year use in 2011, prior to this observed decline. To better understand CRMWD's needs analysis with the reduced demands, a secondary demand scenario was developed. (More detail on the secondary demand scenario is in Chapter 2.) These demands are between 60 and 70 percent of the TWDB-adopted demands, and are shown on Table 5-1, beneath the TWDB-adopted demands. There is no secondary demand analysis developed for the Lake Ivie non-system demands because the demands are contractual.

Table 5D-4

Comparison of Supply and Demand for CRMWD System

-Values are in Acre-Feet per Year-

CRMWD System Supplies	Supply 2020	Supply 2030	Supply 2040	Supply 2050	Supply 2060	Supply 2070
Lake Ivie (with subordination)	15,193	14,769	14,342	13,918	13,491	13,067
Spence Reservoir (with subordination)	21,575	21,531	21,487	21,443	21,399	21,355
Thomas Reservoir (with subordination)	3,725	3,702	3,679	3,656	3,633	3,610
Big Spring Potable Reuse	1,855	1,855	1,855	1,855	1,855	1,855
Ward County Well Field	39,044	38,176	36,441	32,970	31,235	29,500
Martin County Well Field	1,035	1,035	1,035	1,035	1,035	1,035
Customer Conservation	899	1,050	1,137	1,249	1,341	1,474
Total Supply Availability	**83,326**	**82,118**	**79,976**	**76,126**	**73,989**	**71,896**

CRMWD System Current Demands	Demand 2020	Demand 2030	Demand 2040	Demand 2050	Demand 2060	Demand 2070
Odessa and Customers	31,632	35,267	38,319	41,604	45,051	48,842
Odessa	25,004	28,329	31,091	34,071	37,202	40,669
Ector County UD	2,385	2,645	2,935	3,240	3,556	3,880
Manufacturing, Ector County	1,902	1,952	1,952	1,952	1,952	1,952
Irrigation, Ector County	1,197	1,194	1,192	1,191	1,190	1,189
Irrigation, Midland County	23	26	28	29	30	31
SEP, Ector County	1,121	1,121	1,121	1,121	1,121	1,121
Big Spring and Customers	8,462	8,611	8,625	8,573	8,561	8,561
Big Spring	6,227	6,368	6,379	6,327	6,316	6,316
Coahoma	526	534	537	537	536	536
Manufacturing, Howard Co.	1,500	1,500	1,500	1,500	1,500	1,500
SEP, Howard Co.	209	209	209	209	209	209
Snyder and Customers	2,458	2,671	2,785	2,963	3,149	3,345
Snyder	1,980	2,201	2,320	2,499	2,686	2,882
Scurry County-Other	300	300	300	300	300	300
Rotan	178	170	165	164	163	163
Other Customers	19,753	861	865	869	720	720
Midland [a]	18,798	0	0	0	0	0
Stanton	320	320	320	320	320	320
Irrigation	400	400	400	400	400	400
Ward County Other	100	-	-	-	-	-
Grandfalls	135	141	145	-	-	-
Total Current 2021 RWP Demands	***62,305***	***47,410***	***50,594***	***53,860***	***57,481***	***61,468***
Total Current Secondary Scenario Demands	***44,124***	***30,199***	***32,373***	***34,710***	***37,091***	***39,682***
CRMWD System Potential Future Customer Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
Additional Supply for Odessa Advanced Treatment Losses	3,930	3,930	3,930	3,930	3,930	3,930
Howard County Manufacturing (Sales from Big Spring)		500	500	500	500	500
Greater Gardendale WSC (Sales from Odessa)		375	445	445	445	445
Ector County - Other (ECUD Expanded Service Area, Sales from Odessa)		1,200	2,500	2,500	2,500	2,500
Scurry County-Other (Sales from Snyder)	373	414	447	491	547	607
Total Future Customer Demand	**4,303**	**6,419**	**7,822**	**7,866**	**7,922**	**7,982**
CRMWD System Surplus (Shortage)	**Surplus (Shortage) 2020**	**Surplus (Shortage) 2030**	**Surplus (Shortage) 2040**	**Surplus (Shortage) 2050**	**Surplus (Shortage) 2060**	**Surplus (Shortage) 2070**
Surplus (Shortage) with 2021 RWP Demands	***16,738***	***28,312***	***21,585***	***14,426***	***8,613***	***2,474***
Surplus (Shortage) with Secondary Scenario Demands	***34,919***	***45,523***	***39,806***	***33,576***	***29,004***	***24,260***

[a] Midland 1966 Contract expires in 2029.

Table 5D-5
Comparison of Supply and Demand for Lake Ivie Non-System

Lake Ivie Non-System Supplies	**Supply 2020**	**Supply 2030**	**Supply 2040**	**Supply 2050**	**Supply 2060**	**Supply 2070**
Lake Ivie (with subordination)	17,147	16,727	16,310	15,890	15,473	15,053
Total Availability	**17,147**	**16,727**	**16,310**	**15,890**	**15,473**	**15,053**
Lake Ivie Non-System Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
Abilene [a]	5,349	5,209	5,070	4,930	4,791	4,651
Midland [a]	5,349	5,209	5,070	4,930	4,791	4,651
San Angelo [a]	5,349	5,209	5,070	4,930	4,791	4,651
Millersview-Doole WSC	600	600	600	600	600	600
Ballinger	500	500	500	500	500	500
Total Current Demand	**17,147**	**16,727**	**16,310**	**15,890**	**15,473**	**15,053**
Lake Ivie Non-System Surplus (Shortage)	**Surplus (Shortage) 2020**	**Surplus (Shortage) 2030**	**Surplus (Shortage) 2040**	**Surplus (Shortage) 2050**	**Surplus (Shortage) 2060**	**Surplus (Shortage) 2070**
Available Surplus Supply	***0***	***0***	***0***	***0***	***0***	***0***

[a] Contract is for 16.54% of the safe yield of Ivie. So this demand changes with the implementation of the subordination strategy.

With subordinated supplies, CRMWD can fully meet its current customer demands without developing additional supplies. After the expiration of its contract with Midland in 2029, CRMWD is shown to have a surplus. CRMWD has a reserve of water for their existing customers and has the potential to serve additional future customers beyond those shown in this plan, if they choose. When the lower secondary demand scenario is considered, the surplus of water in 2030 increases.

While CRMWD is shown to have sufficient water supplies, there is some uncertainty associated with the reliability of surface water supplies in the Upper Colorado Basin. CRMWD lakes are still in drought of record conditions and on-going drought will likely continue to decrease the reliable supply from these sources. It is important for CRMWD to develop and maintain their portfolio of water supplies that can be used during drought to increase the reliability of the CRMWD system. Also, as the region continues to respond to the increased oil and gas activities, the demands on CRMWD may increase as new customers request water. Given these unknowns, CRMWD is pursuing water management strategies to meet these future demands and bolster the reliability of their water supply.

The following strategies were identified as potentially feasible for CRMWD:

- Conservation of Wholesale Customers
- Subordination of Senior Downstream Water Rights
- Ward County Well Field Well Replacement
- Ward County Well Field Expansion and the Development of Winkler County Well Field
- Develop Additional Groundwater Supplies in Pecos, Reeves, Ward and Winkler Counties

Full strategy evaluations are included in Appendix C. The following strategies were recommended for CRMWD. Both conservation and subordination are discussed in detail in previous chapters, but they are also discussed below as a recommended strategy for completeness.

5D.2.1 CRMWD Recommended Water Management Strategies

Municipal Conservation

This strategy pro-actively reduces municipal retail water demands through public education and outreach, an inclining rate structure to discourage high water use, a water waste ordinance, a landscape ordinance for new construction, and time of day outdoor watering limits. As a wholesale water provider, CRMWD cannot carry out this strategy. This strategy will be carried out by each individual member and customer city. These combined efforts are expected to reduce CRMWD customer demands by about 2 to 4 percent throughout the planning horizon. The costs for this strategy are associated with each retail water provider. CRMWD fully supports the efforts of the cities to implement water education and conservation measures.

Subordination

The subordination strategy increases the supply to CRMWD's reservoirs by changing the strict priority modeling assumptions utilized in WAM Run 3 such that downstream senior water right holders do not make priority calls on upstream users in Region F. Under the subordination strategy, the District's surface water system's supplies increase from about 30,000 acre-feet to over 57,600 acre-feet in 2020. By 2070, the subordination supplies decrease to about 53,000 acre-feet due to sedimentation in the reservoirs. The subordination strategy is discussed in detail in Chapter 5C and in Appendix C. Region F recognizes that a subordination agreement is not within the authority of the RWPG. Such an agreement must be developed by the water rights holders themselves, including CRMWD. CRMWD already has agreements in place with LCRA for Lake Ivie and other surface water sources.

Ward County Well Replacement

CRMWD currently owns and operates a well field in Ward County that produces water from the Pecos Valley aquifer. The integrity of the wells and pipelines that comprise this well field are expected to deteriorate over time, reducing the available supply of the well field. As a result, CRMWD plans to actively rehabilitate and/or replace out-of-service wells to restore the yield of the well field throughout the planning horizon (2020 – 2070). In this strategy, it was assumed that new water wells and well field piping would be constructed to replace old infrastructure, which would enable CRMWD to withdraw additional groundwater from their Ward County well field that would otherwise be inaccessible. All other infrastructure is in place to transmit and treat the supply from this well field.

Ward County Well Field Expansion and Development of Winkler County Well Field

CRMWD owns and operates a well field in Ward County and owns the rights to an undeveloped well field in southern Winkler County. Both areas produce water from the Pecos Valley aquifer. This strategy involves the development of the Winkler County rights as well as an expansion of their existing Ward County well field. A newly developed pipeline and pump station will deliver supply from the Winkler County well field to the existing Ward County well field. From there, supply from both sources will be transferred to CRMWD's service area using existing transmission lines, as well as new and/or upgraded pump stations along the route. The capacity of the existing transmission system will be upgraded from 46 MGD to 65 MGD to accommodate the additional 20 MGD peak supply estimated from this project. This project is expected to come online in 2050.

5D.2.2 CRMWD Water Management Plan Summary

CRMWD Recommended Water Management Strategies

- Municipal Conservation
- Subordination
- Ward County Well Field Well Replacement
- Ward County Well Field Expansion and the Development of Winkler County Well Field

Figure 5D-2 illustrates the recommended water management plan for CRMWD. Major recommended strategies include expansion of the Ward County Well Field and development of the Winkler County Well field, in addition to well replacement at the Winkler County Well Field. CRMWD has no identified water needs and the development of the recommended strategies will increase their reserve supplies. The surplus of supply for CRMWD after the implementation of recommended strategies are shown in Table 5D- 3.

The costs for these strategies are summarized in Table 5D-4. The recommended water plan for CRMWD will provide water to meet all current and future customer demands with a reserve.

Figure 5D-2
CRMWD Water Management Plan

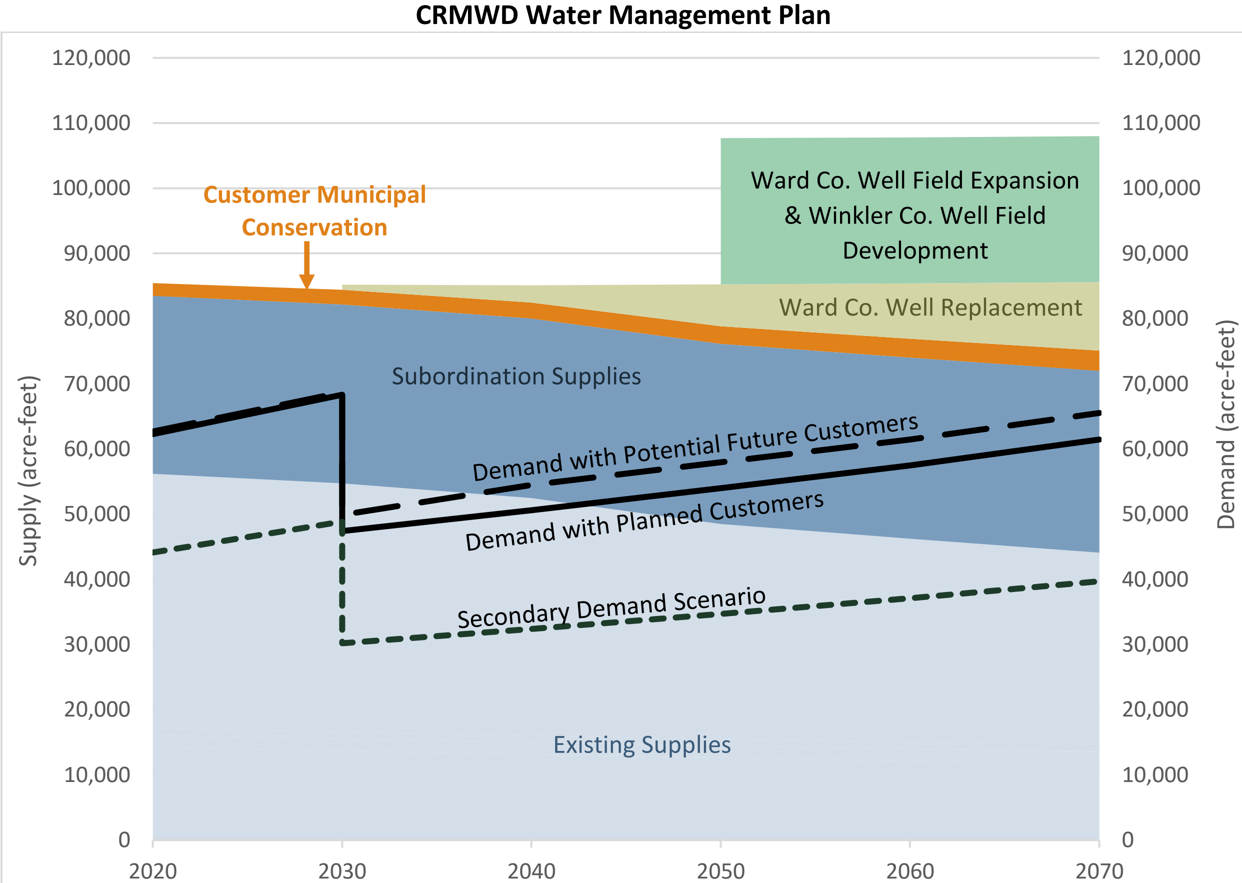


Table 5D-6
Recommended Water Management Strategies for CRMWD
Values are in Acre-Feet per Year-

CRMWD Strategies Summary						
	2020	**2030**	**2040**	**2050**	**2060**	**2070**
Surplus (Shortage) with 2021 RWP Demands before Recommended Water Management Strategies	***16,738***	***28,312***	***21,585***	***14,426***	***8,613***	***2,474***
Surplus (Shortage) with Secondary Scenario Demands before Recommended Water Management Strategies	***34,919***	***45,523***	***39,806***	***33,576***	***29,004***	***24,260***
Recommended Strategies	**Supply 2020**	**Supply 2030**	**Supply 2040**	**Supply 2050**	**Supply 2060**	**Supply 2070**
Subordination	*27,290*	*27,409*	*27,528*	*27,647*	*27,766*	*27,885*
Customer Conservation	*899*	*1,050*	*1,137*	*1,249*	*1,341*	*1,474*
Ward County Well Replacement	0	755	2,650	6,295	8,361	10,343
Ward and Winkler County Well Field Expansion				22,400	22,400	22,400
Total Strategy Supply (Excluding Conservation and Subordination)	**0**	**755**	**2,650**	**28,695**	**30,761**	**32,743**
Surplus (Shortage) after Recommended Strategies	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Surplus (Shortage) Supply with 2021 RWP Demands	*16,718*	*29,044*	*24,210*	*43,095*	*39,347*	*35,189*
Surplus (Shortage) Supply with Secondary Scenario Demands	*34,899*	*46,255*	*42,431*	*62,245*	*59,737*	*56,975*
Management Supply Factor	*1.3*	*1.5*	*1.4*	*1.7*	*1.6*	*1.5*

Strategies in grey italics were included in the previous calculation of surplus (shortages). They are included in this table for completeness but are not included in the total to avoid double counting.

Table 5D-7
Cost of Recommended Water Management Strategies for CRMWD

Strategy	**Capital Cost (Million $)**	**Unit Cost ($/1,000 gal)**	
		With Debt Service	**After Debt Service**
Subordination	$0	$0	$0
Customer Conservation	NA	NA	NA
Ward County Well Replacement	$10.4	$0.31	$0.23
Ward and Winkler County Well Field Expansion	$168.3	$2.61	$0.99

CRMWD Alternative Water Management Strategies

Alternative water management strategies are identified and may be implemented if a recommended strategy is no longer viable or if there is a new need that cannot be met by the recommended water management plan. CRMWD has identified one alternate water management strategy to develop additional groundwater supplies from Pecos, Reeves, Ward and/or Winkler Counties. This strategy is for new groundwater supplies and does not include water rights currently held by CRMWD. Some of these groundwater supplies may require advanced treatment, such as desalination but the development of the treatment facilities would not occur until after 2070. Therefore, costs for advanced treatment were not included. This strategy is described in full and evaluated in Appendix C.

5D.3 Midland

The City of Midland, located in Midland County, is the largest city in Region F and serves as a prominent center for economic, trade, and cultural activities. The City of Midland has experienced rapid population growth in recent years, primarily due to increased oil and gas exploration in the underlying Permian Basin. Over the planning horizon (2020 – 2070), this rapid growth is expected to continue as the City's population is projected to grow by nearly 60 percent and its municipal demands are projected to increase by over 50 percent. In addition to the increase in the number of residents in Midland, many workers commute from other areas of the State during the work week. These working commuters are officially counted as residents elsewhere, so they are not considered in the population and water demands in this Plan; however, they still contribute to the water demand the City must provide.

The City of Midland draws its supply from four main sources: sales from CRMWD, the Airport well field in Midland County, the Paul Davis well field in Andrews and Martin Counties, and the T-Bar Ranch and Clearwater Well Fields in Winkler and Loving Counties. The City provides water to their municipal customers as well as manufacturing demand within the City. Based on these projections, the City begins to experience shortages in 2030 after the expiration of one its contracts with CRMWD in 2030. The Airport well field is expected to be depleted by 2035 and the Paul Davis well field is limited by the MAG from 2040 onward, deepening the shortage after 2040. Table 5D- 8 shows the City's supplies and demands.

Table 5D-8
City of Midland Water Supplies and Demands

Supplies	**Supply 2020**	**Supply 2030**	**Supply 2040**	**Supply 2050**	**Supply 2060**	**Supply 2070**
CRMWD Contracts with Midland (w/ Subordination)	24,147	5,209	5,070	4,930	4,791	4,651
CRMWD (Ivie)	5,020	4,850	4,679	4,509	4,338	4,168
CRMWD (1966 Contract)	16,954	0	0	0	0	0
CRMWD Subordination	2,173	359	391	421	453	483
T-Bar Ranch/Clearwater Well Field	16,815	16,815	16,815	16,815	16,815	16,815
Paul Davis Well Field (Ogallala Aquifer)	4,652	3,807	3,334	3,065	2,887	2,764
Airport Well Field	560	560	0	0	0	0
Municipal Conservation	631	755	816	882	944	1,012
Total Availability	**46,805**	**27,261**	**26,035**	**25,692**	**25,437**	**25,242**
Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
City of Midland	27,972	31,803	34,256	36,811	39,405	42,232
Manufacturing, Midland County	147	177	177	177	177	177
Total Raw Water Demands	**28,119**	**31,980**	**34,433**	**36,988**	**39,582**	**42,409**
Surplus (Shortage)	**Surplus (Shortage) 2020**	**Surplus (Shortage) 2030**	**Surplus (Shortage) 2040**	**Surplus (Shortage) 2050**	**Surplus (Shortage) 2060**	**Surplus (Shortage) 2070**
Surplus (Shortage)	**18,686**	**(4,719)**	**(8,398)**	**(11,296)**	**(14,145)**	**(17,167)**

The City of Midland also has a contract to sell their treated wastewater effluent for mining use. No potable water supplies are used to meet this demand. The treated wastewater is expected to be primarily used for mining in Midland, Martin, Reagan, and Upton Counties. The contract is for up to 15 MGD (16,800 acre-feet per year) but will be limited by actual wastewater flow. Current flows are around 10 MGD (11,200 acre-feet per year). Improvements are currently being designed to the wastewater plant to make this volume feasible, with improvements expected to be completed by 2020. As shown in Table 5D- 9, there are no shortages to meet the demand for wastewater for the mining industry over the planning horizon and thus, no strategies were considered for this purpose.

Table 5D-9
City of Midland Wastewater Supplies and Demands

Supplies	**Supply 2020**	**Supply 2030**	**Supply 2040**	**Supply 2050**	**Supply 2060**	**Supply 2070**
Direct Reuse (WW Effluent Sales to Mining)	11,210	11,210	11,210	11,210	11,210	11,210
Total Availability	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**
Wastewater Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
Mining, Pioneer Resources Contract	11,210	11,210	11,210	11,210	11,210	11,210
Mining, Midland County	2,803	2,803	2,803	2,803	2,803	2,803
Mining, Martin County	2,803	2,803	2,803	2,803	2,803	2,803
Mining, Reagan County	2,803	2,803	2,803	2,803	2,803	2,803
Mining, Upton County	2,801	2,801	2,801	2,801	2,801	2,801
Total Demand	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**
Surplus (Shortage)	**Surplus (Shortage) 2020**	**Surplus (Shortage) 2030**	**Surplus (Shortage) 2040**	**Surplus (Shortage) 2050**	**Surplus (Shortage) 2060**	**Surplus (Shortage) 2070**
Surplus (Shortage)	0	0	0	0	0	0

However, several water management strategies were considered for Midland to meet the municipal needs of their retail customers.

Potentially Feasible Water Management Strategies Considered for Midland:

- Municipal Conservation
- Subordination
- West Texas Water Partnership
- Advanced Water Treatment and Expanded Use of the Paul Davis Well Field
- Purchase from CRMWD

Full strategy evaluations are included in Appendix C. Both conservation and subordination are discussed in detail in previous sections, but they are also discussed below as a recommended strategy for completeness.

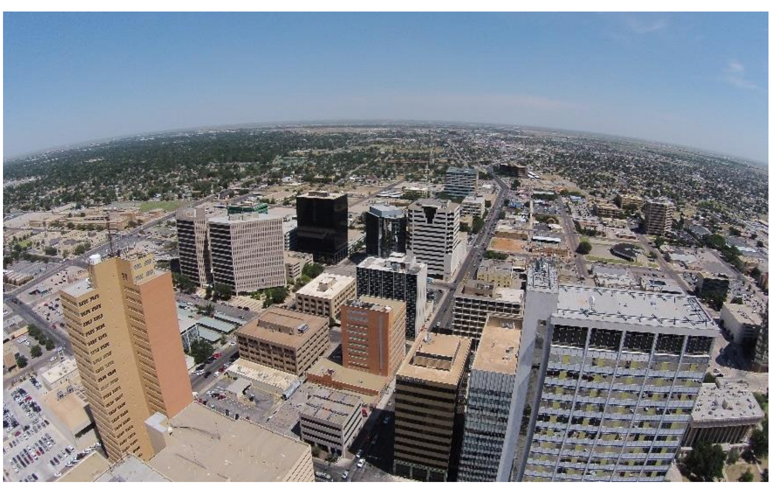
5D.3.1 Midland Recommended Water Management Strategies

Municipal Conservation

Municipal conservation pro-actively reduces municipal water demands through public education and outreach, an inclining rate structure to discourage high water use, a water waste ordinance, a landscape ordinance for new construction, and time of day outdoor watering limits. These efforts are projected to reduce the City of Midland's demands by about 631 to 1,012 acre-feet per year throughout the planning horizon (2020 – 2070).

Subordination

The subordination strategy increases the supply to CRMWD's reservoirs by changing the strict priority modeling assumptions utilized in WAM Run 3 such that downstream senior water right holders do not make priority calls on upstream users in Region F. Some of the subordinated supply goes to supply Midland as a customer city to meet the City's demands on CRMWD. The subordination strategy is discussed in detail in Chapter 5C and in Appendix C.



Advanced (RO) Water Treatment and Expanded Use of Paul Davis Well Field

Groundwater from the Paul Davis Well Field typically contains high TDS levels. Consequently, the City is interested in pursuing the development of an advanced treatment (RO) facility to treat this groundwater to a higher quality. For planning purposes, it was assumed that the project would generally operate to produce 6,300-6,500 acre-feet per year to bring the total supply pumped from the Paul Davis Well Field to 10 MGD. Current transmission infrastructure is in place to transport this water to the City for treatment and distribution. Treatment losses were estimated at 25 percent. It was assumed that the reject stream from this facility would be treated at the City's wastewater treatment plant (WWTP). The treated water from this facility water would be blended with the rest of their supplies to improve overall drinking water quality. Overall, this project is estimated to require a capital investment of $56 million and is projected to come online by 2040.

West Texas Water Partnership

The Cities of Midland, San Angelo, and Abilene have formed the West Texas Water Partnership (the Partnership) to evaluate long-term water supplies the Partnership could develop jointly. The Partnership is conducting a separate study to determine the most feasible water management strategies for these cities, but the results were not available at the writing of this Initially Prepared Plan. Additional information is anticipated before the publication of the Final Region F Water Plan.

5D.3.2 Midland Water Management Plan Summary

Midland Recommended Water Management Strategies

- Municipal Conservation
- Subordination
- West Texas Water Partnership
- Advanced Treatment (RO) of Paul Davis Well Field Supplies

Figure 5-3 depicts the recommended water management plan for Midland. Main strategies include the West Texas Water Partnership and Advanced Treatment of Paul Davis Well Field Supplies.

The needs for the City of Midland after the implementation of recommended strategies are shown in Table 5-3. Table 5D-4 shows the capital and annual costs for these strategies. With the recommended water plan, Midland shows no water supply shortages throughout the planning horizon.

Figure 5D-3
Midland Water Management Plan

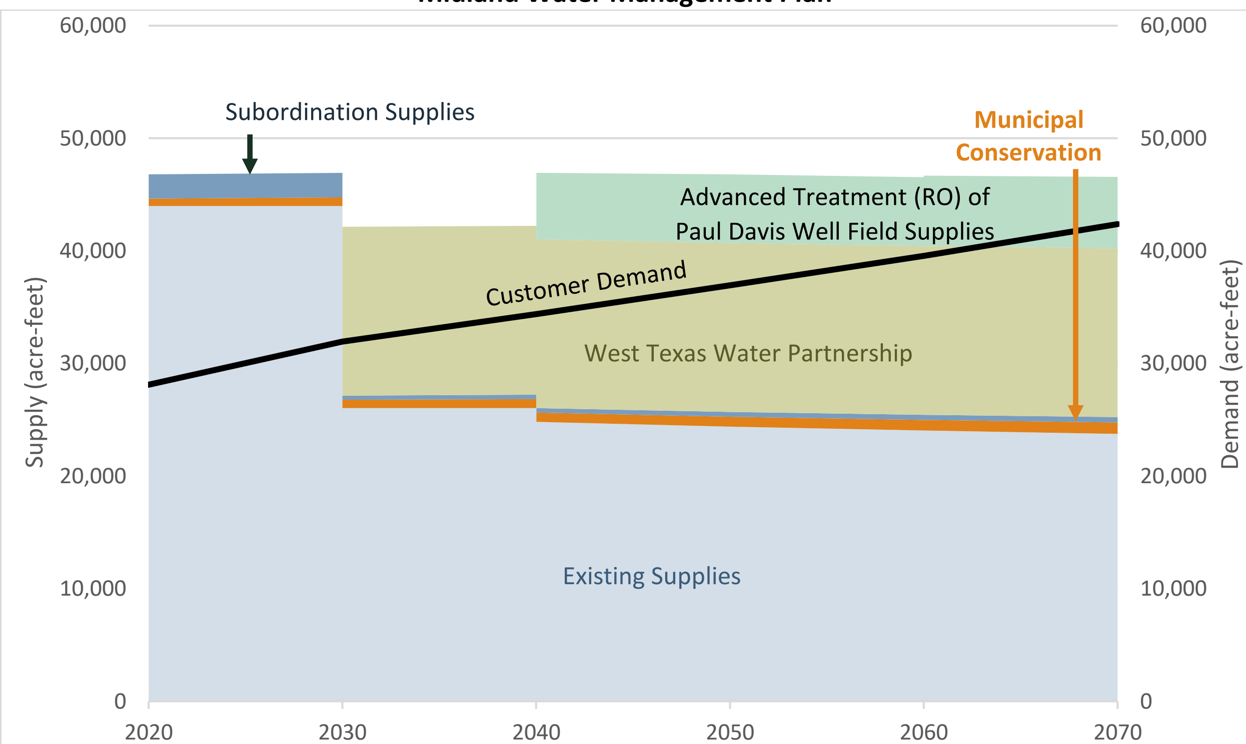


Table 5D-10
Recommended Water Strategies for the City of Midland

Summary before Recommended Strategies	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Supplies	46,805	27,261	26,035	25,692	25,437	25,242
Demand	28,119	31,980	34,433	36,988	39,582	42,409
Surplus (Shortage) with Conservation and Subordination	**18,686**	**(4,719)**	**(8,398)**	**(11,296)**	**(14,145)**	**(17,167)**
Recommended Strategies (acre-feet per year)	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Subordination	*2,173*	*359*	*391*	*421*	*453*	*483*
Municipal Conservation	*631*	*755*	*816*	*882*	*944*	*1,012*
West Texas Water Partnership		15,000	15,000	15,000	15,000	15,000
Additional Paul Davis Groundwater w/ Treatment			5,899	6,101	6,235	6,327
Total Supply from Recommended Strategies	**0**	**15,000**	**20,899**	**21,101**	**21,235**	**21,327**
Surplus (Shortage) after Recommended Strategies	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Surplus (Shortage)	**18,686**	**10,281**	**12,501**	**9,805**	**7,090**	**4,160**
Management Supply Factor	*1.7*	*1.3*	*1.4*	*1.3*	*1.2*	*1.1*

Strategies in grey italics were included in the previous calculation of surplus (shortages). They are included in this table for completeness but are not included in the total to avoid double counting.

Table 5D-11
Costs for Recommended Strategies for the City of Midland

Strategy	**Capital Cost (Million $)**	**Unit Cost ($/1,000 gal)**	
		With Debt Service	**After Debt Service**
Municipal Conservation	---	NA	NA
Subordination	---	NA	NA
West Texas Water Partnership	TBD	TBD	TBD
Advanced Treatment Facility	$60.8	$5.08	$3.06

Midland Alternative Water Management Strategies

Alternative strategies are included in the plan as additional options that the City may pursue. One alternative strategy has been identified for the City of Midland to purchase supplies from CRMWD. The City of Midland currently receives water from CRMWD through two separate contracts: the Ivie Contract and the 1966 Contract. The 1966 Contract provides around 18,000 acre-feet of supply from any of CRMWDs sources to Midland. This contract will expire by 2029. An alternative strategy involves the City of Midland entering into a new contract agreement with CRMWD to replace the 1966 Contract. Contract negotiations are beyond the scope of regional water planning and are dependent upon the two parties reaching mutually agreeable terms that may differ from what is outlined in this plan.

5D.4 Odessa

The City of Odessa is located in Ector County. As one of the largest cities in Region F, it is a major center of employment, trade and cultural activities. The City of Odessa is a member city of CRMWD and receives all of its supply from CRMWD. The City currently sells treated supplies to Ector County Utility District, and some manufacturing operations. The City's raw water is currently contracted for use by manufacturing and irrigation users. Additionally, Odessa produces about 8.5 MGD of wastewater; 2.5 MGD is diverted to the Gulf Coast Authority (GCA), while the other 6 MGD is sold to Pioneer for mining use.

Table 5D- 12 shows a comparison of the Region F supply and demand for the City of Odessa, considering subordination of CRMWD's surface water sources. Under these assumptions, the City of Odessa does not show a shortage over the planning horizon for current users. However, the City is planning to develop advanced treatment which will increase losses and effectively increase the City's demand. This additional demand will be met by additional supplies from CRMWD.

Table 5D-12
Comparison of Supply and Demand for Treated and Water for Odessa
-Values are in Acre-Feet per Year-

Supplies	**Supply 2020**	**Supply 2030**	**Supply 2040**	**Supply 2050**	**Supply 2060**	**Supply 2070**
CRMWD System Total (without subordination)	28,531	35,267	38,319	37,343	36,255	35,041
Subordination of CRMWD Supplies	3,101	0	0	4,261	8,796	13,801
Total Availability	**31,632**	**35,267**	**38,319**	**41,604**	**45,051**	**48,842**
Current Potable Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
City of Odessa	25,004	28,329	31,091	34,071	37,202	40,669
Ector County UD	2,385	2,645	2,935	3,240	3,556	3,880
Manufacturing, Ector County	450	500	500	500	500	500
Quail Run Power Generation Facility	1,121	1,121	1,121	1,121	1,121	1,121
Total Current Potable Demand	**28,960**	**32,595**	**35,647**	**38,932**	**42,379**	**46,170**
Potential Future Potable Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
Greater Gardendale WSC	0	375	445	445	445	445
Ector County - Other (ECUD Expanded Service Area)	0	1,200	2,500	2,500	2,500	2,500
Total Future Potable Demand	**0**	**1,575**	**2,945**	**2,945**	**2,945**	**2,945**
Raw Water Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
Irrigation, Ector County	1,197	1,194	1,192	1,191	1,190	1,189
Irrigation, Midland County	23	26	28	29	30	31
Manufacturing, Ector County (Rextac)	1,452	1,452	1,452	1,452	1,452	1,452
Total Current Demand	**2,672**	**2,672**	**2,672**	**2,672**	**2,672**	**2,672**
Surplus (Shortage)	**Surplus (Shortage) 2020**	**Surplus (Shortage) 2030**	**Surplus (Shortage) 2040**	**Surplus (Shortage) 2050**	**Surplus (Shortage) 2060**	**Surplus (Shortage) 2070**
Current Surplus (Shortage)	**0**	**0**	**0**	**0**	**0**	**0**
Future Surplus (Shortage)	**0**	**(1,575)**	**(2,945)**	**(2,945)**	**(2,945)**	**(2,945)**

Table 5D-13
Comparison of Supply and Demand for Reuse Water for Odessa
-Values are in Acre-Feet per Year-

Supplies	**Supply 2020**	**Supply 2030**	**Supply 2040**	**Supply 2050**	**Supply 2060**	**Supply 2070**
Direct Reuse - Ector County	9,530	9,530	9,530	9,530	9,530	9,530
Total Availability	**9,530**	**9,530**	**9,530**	**9,530**	**9,530**	**9,530**
Reuse Water Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
Mining, Ector (Pioneer)	6,727	6,727	6,727	6,727	6,727	6,727
Mining, Ector (GCA)	2,803	2,803	2,803	2,803	2,803	2,803
Total Demand	**9,530**	**9,530**	**9,530**	**9,530**	**9,530**	**9,530**
Surplus (Shortage)	**Surplus (Shortage) 2020**	**Surplus (Shortage) 2030**	**Surplus (Shortage) 2040**	**Surplus (Shortage) 2050**	**Surplus (Shortage) 2060**	**Surplus (Shortage) 2070**
Surplus (Shortage)	**0**	**0**	**0**	**0**	**0**	**0**

As a member city of CRMWD, CRMWD plans to provide all of Odessa's water needs through development of additional strategies. CRMWD has sufficient water to meet Odessa's current and future demands. However, should the City of Odessa pursue the development of supplies independently of CRMWD, the following strategies were identified as potentially feasible for the City of Odessa:

- Municipal Conservation
- Subordination (associated with CRMWD sources)
- Additional Supplies from CRMWD
- New Reverse Osmosis Treatment Facility
- Development of Brackish Groundwater in Ward County
- Development of Groundwater near Fort Stockton

Full strategy evaluations are included in Appendix C. Both conservation and subordination are discussed in detail in previous sections, but they are also discussed below as a recommended strategy for completeness.

5D.4.1 Odessa Recommended Water Management Strategies

Municipal Conservation

This strategy pro-actively reduces municipal water demands through public education and outreach, an inclining rate structure to discourage high water use, a water waste ordinance, a landscape ordinance for new construction, and time of day outdoor watering limits. These efforts are expected to reduce the City of Odessa's demands by about 1.5 to 2 percent throughout the planning horizon.

Subordination

The subordination strategy increases the supply to CRMWD's reservoirs by changing the strict priority modeling assumptions utilized in WAM Run 3 such that downstream senior water right holders do not make priority calls on upstream users in Region F. Some of the subordinated supply goes to supply Odessa as a member city to meet the City's demands. The subordination strategy is discussed in detail in Chapter 5C and in Appendix C. Region F recognizes that a subordination agreement is not within the authority of the RWPG. Such an agreement must be developed by the water rights holders themselves, including CRMWD. CRMWD already has such an agreement in place with LCRA for Lake Ivie and other surface water sources.

Additional Supplies from CRMWD

To meet the additional demands of the City, Ector County UD, manufacturing, irrigation users, or other future customers, Odessa would obtain additional supplies from CRMWD. These supplies would likely come from one or more of the multiple strategies that CRMWD is developing for its member cities and customers. With the development of these strategies, CRMWD is planning to take the new supplies to the Odessa Terminal Storage Reservoir, where Odessa would transport the water to its treatment facilities. It is assumed that all improvements and costs for these additional supplies are included with the development of the CRMWD strategies. Therefore, the capital cost of this water is shown on CRMWD.

Advanced Treatment (RO) Facility

To address water quality concerns associated with existing high TDS levels in CRMWD's surface water system, the City of Odessa is planning to pursue the development of an advanced treatment (RO) facility. For planning purposes, it was assumed that this project would have a peak capacity 20 MGD but would generally operate at around 14 MGD on an average annual basis. This facility is estimated to produce 15,700 acre-feet of finished water per year, based on estimated treatment losses of 20 percent. Finished water would be blended with the rest of the City's supplies to improve the overall drinking water quality. This project is estimated to require a capital investment of $83.1 million.

5D.4.2 Odessa Water Management Plan Summary

Odessa Recommended Water Management Strategies

- Municipal Conservation
- Subordination
- Additional Supplies from CRMWD
- New Reverse Osmosis Treatment Facility

The needs for Odessa after the implementation of recommended strategies are shown in Table 5D- 3. Table 5D- 4 shows the capital and annual costs for these strategies.

Figure 5D-4 demonstrates the recommended water management plan for the City of Odessa. The primary recommended strategy for the City is to improve the water quality of the subordinated surface water supplies with the addition of advanced treatment. This plan indicates the recommended strategies are sufficient to meet Odessa's projected needs.

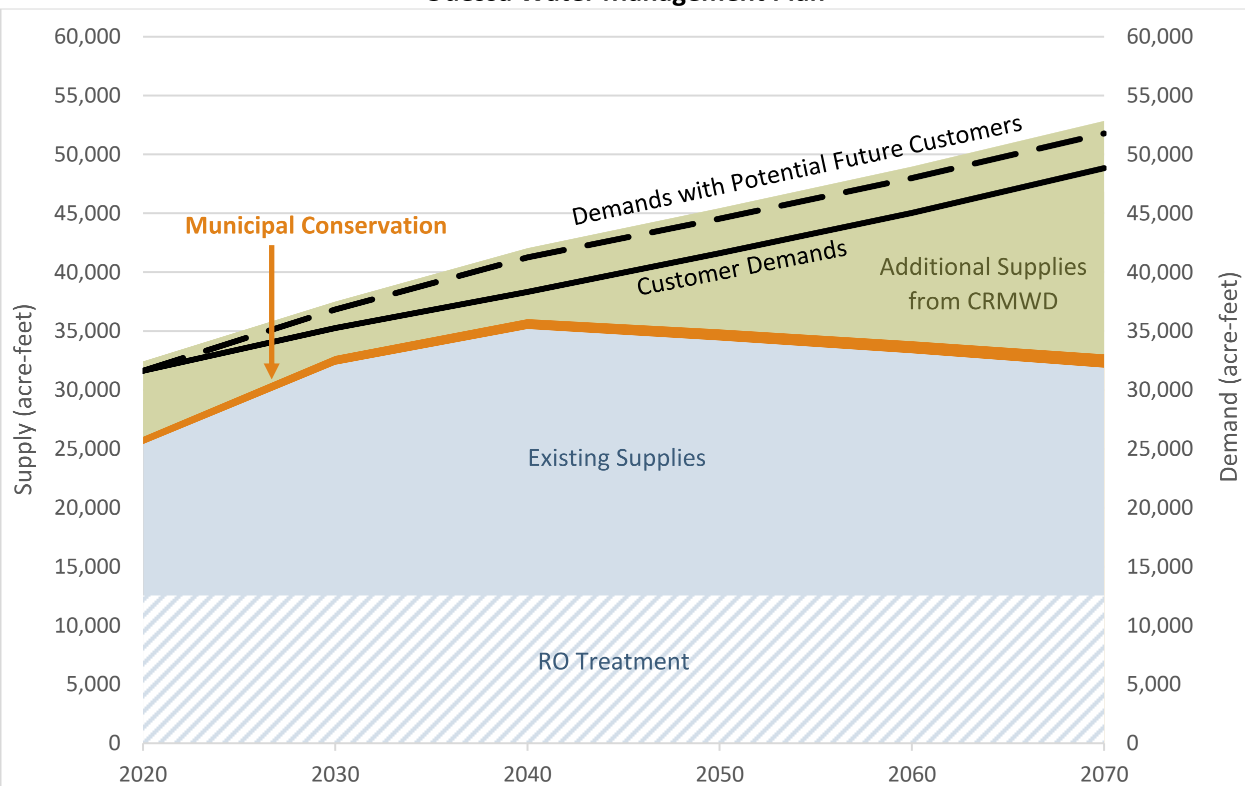
Table 5D-14
Recommended Strategies for the City of Odessa
-Values are in Acre-Feet per Year-

Summary before Recommended Strategies	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Current Surplus (Shortage) with Subordination	**0**	**0**	**0**	**0**	**0**	**0**
Future Surplus (Shortage)	**0**	**(1,575)**	**(2,945)**	**(2,945)**	**(2,945)**	**(2,945)**
Recommended Strategies (acre-feet per year)	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Subordination of CRMWD Supplies	*3,101*	*0*	*0*	*4,261*	*8,796*	*13,801*
Municipal Conservation	628	764	846	954	1,042	1,139
RO Treatment	*15,700*	*15,700*	*15,700*	*15,700*	*15,700*	*15,700*
Treatment Losses	-3,930	-3,930	-3,930	-3,930	-3,930	-3,930
Additional Supply from CRMWD	3,930	5,505	6,875	6,875	6,875	6,875
Surplus (Shortage) after Recommended Strategies	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Current Surplus (Shortage)	***628***	***764***	***846***	***954***	***1,042***	***1,139***
Future Surplus (Shortage)	***0***	***0***	***0***	***0***	***0***	***0***
Management Supply Factor	***1***	***1***	***1***	***1***	***1***	***1***

Table 5D-15
Costs for the Recommended Strategies for the City of Odessa

Strategy	Capital Cost (Thousand $)	Unit Cost ($/1,000 gal)	
		With Debt Service	After Debt Service
Municipal Conservation	---	NA	NA
Subordination	---	NA	NA
Advanced Treatment (RO) Facility	$83,072	$3.41	$2.27

Figure 5D-4
Odessa Water Management Plan



Odessa Alternative Water Management Strategies

Odessa has identified two alternative strategies, which may be implemented if additional supplies are needed or one of the City's strategies cannot be implemented. The Alternate Water Management Strategies for Odessa include:

- Development of Brackish Groundwater in Ward County
- Development of Groundwater near Fort Stockton

Both of these strategies are described in full and evaluated in Appendix C.

5D.5 City of San Angelo

The City of San Angelo is located in Tom Green County near the center of Region F. As one of the largest cities in the region, it is a major center of employment, trade and cultural activities in the region. The City currently receives water from six sources: Lake Nasworthy, Twin Buttes Reservoir, the Concho River, O.C. Fisher Reservoir, Ivie Reservoir and a well field in McCulloch County (Hickory aquifer). The city also has a contract with CRMWD for water from the Spence Reservoir, but the pipeline needs rehabilitation and is not currently being used. Tom Green County WCID #1 currently utilizes the City of San Angelo's effluent water prior to taking their water supplies (when available) in Twin Buttes. The City plans to convert this to municipal supply as part of the Concho River Water Project. San Angelo will continue to provide wastewater to the irrigators when it is not needed as municipal supply.

Table 5D- 1 is a comparison of the Region F supply and water demand for the City of San Angelo and its customers. San Angelo supplies all the treated water to Goodfellow Air Force Base and about half of the manufacturing demand in Tom Green County. The City also has a contract with the Upper Colorado River Authority (UCRA) to supply up to 1,000 acre-feet per year.

There is a small reliable supply from three of the City's run-of- river permits but under strict priority analysis there is no reliable supply from the San Angelo Reservoir system. However, these reservoirs are used by the City during most years but may not be reliable during extreme drought years. As such only, a portion of the supply theoretically available from the subordination model is shown as available to City of San Angelo. This supply is expected to decrease over time due to reduction in yield from sedimentation. The City of San Angelo is actively pursuing other strategies to replace supplies from their surface water system. The contracts between the City and CRMWD specify that San Angelo is entitled to 6 percent of the safe yield of Spence Reservoir and 16.54 percent of the safe yield of Ivie. Since the City cannot physically take water from Spence due to the poor condition of the pipeline, San Angelo has no current supply from this source. Due to cost, quality, and reliability concerns, the City of San Angelo does not plan to rehabilitate the Spence Pipeline at this time.

The City of San Angelo is currently authorized to divert 2,750 plus any banked water from their Hickory well field which increases their supply to 12,000 acre-feet per year over time. Currently, the City can treat up to 8 MGD (8,960 AFY) of this supply. Increases in well field and treatment capacity are considered in this plan as a strategy.

Table 5D-16
Comparison of Supply and Demand for the City of San Angelo
-Values are in Acre-Feet per Year-

Supplies	**Supply 2020**	**Supply 2030**	**Supply 2040**	**Supply 2050**	**Supply 2060**	**Supply 2070**
Concho River	214	214	214	214	214	214
San Angelo System (with subordination) [a]	1,670	1,575	1,480	1,385	1,290	1,195
Ivie Reservoir (with subordination) [b]	5,349	5,209	5,070	4,930	4,791	4,651
McCulloch County Well Field (Hickory Aquifer)	8,960	8,960	8,960	8,960	8,960	8,960
Municipal Conservation	467	541	567	602	639	679
Total Availability	**16,660**	**16,499**	**16,291**	**16,091**	**15,894**	**15,699**
Demands	**Demand 2020**	**Demand 2030**	**Demand 2040**	**Demand 2050**	**Demand 2060**	**Demand 2070**
City of San Angelo	17,924	19,657	20,494	21,556	22,847	24,250
UCRA	1,000	1,000	1,000	1,000	1,000	1,000
Goodfellow Air Force Base	513	568	596	629	666	707
Manufacturing, Tom Green County	425	481	481	481	481	481
Total Demand	**19,862**	**21,706**	**22,571**	**23,666**	**24,994**	**26,438**
Surplus (Shortage)	**Surplus (Shortage) 2020**	**Surplus (Shortage) 2030**	**Surplus (Shortage) 2040**	**Surplus (Shortage) 2050**	**Surplus (Shortage) 2060**	**Surplus (Shortage) 2070**
Surplus (Shortage)	**(3,202)**	**(5,207)**	**(6,280)**	**(7,575)**	**(9,100)**	**(10,739)**

[a] Includes Twin Buttes, Lake Nasworthy, and O.C. Fisher; includes contracted portion to UCRA and future contractual increases. Shown as less than what is theoretically available from the WMS.
[b] 16.54% of the safe yield of Ivie with subordination

Through the standard procedure and discussions with the City of San Angelo, potentially feasible water management strategies were developed for further evaluation. A few strategies were discussed but not considered feasible at this time. These include system optimization and voluntary redistribution through lease or purchase of existing water rights. The system optimization strategy looks at the potential benefit from operating the Twin Buttes, Nasworthy, and O.C. Fisher's reservoirs as a system. The City of San Angelo currently operates its reservoirs in this fashion and likely experiences a small benefit. However, since the yield of the reservoirs under the extended Colorado WAM is negligible, this strategy was not further evaluated. It is recommended however that San Angelo continue to operate their reservoirs as a system to obtain optimal supply. Voluntary redistribution of existing water rights is a strategy where the City would enter into purchase or lease agreements for existing water rights currently held by other users. The City of San Angelo has purchased existing water rights in the past and may continue to purchase other water rights on a willing-buyer willing-seller basis if the cost is not prohibitive. Diversions for these rights could be moved to one of San Angelo's existing diversion points, or the rights could simply not be exercised, eliminating the possibility of a priority call. The City has been approached by individuals wishing to sell their water rights, but the high costs have made this option unfeasible. If there was a cost-effective opportunity to purchase or lease water rights in the future, the City of San Angelo may want to move forward with this strategy. Region F has not identified any specific rights for purchase at this time, so no quantity, costs or impacts can be developed at this time.

The following strategies were identified as potentially feasible for the City of San Angelo:

- Municipal Conservation
- Subordination
- Brush Control
- Indirect reuse for municipal use (Concho River Water Project)
- Hickory Well Field Expansion in McCulloch County
- Development of Pecos Valley and Edwards-Trinity aquifer supplies in Southwest Pecos County
- Development of Edwards-Trinity aquifer supplies in Schleicher County
- Desalination of Additional Groundwater Supplies
- West Texas Water Partnership

Full strategy evaluations are included in Appendix C.

5D.5.1 San Angelo Recommended Water Management Strategies

Municipal Conservation

This strategy pro-actively reduces municipal water demands through public education and outreach, inclining rate structure to discourage high water use, a water waste ordinance, a landscape ordinance for new construction, and time of day outdoor watering limits. These efforts are expected to reduce the City of San Angelo's demands by about 2 percent throughout the planning horizon.

Brush Control

Certain species of brush can drastically reduce the water yield in a watershed. By replacing water intensive brush species with less water intensive native plants, increased runoff to the reservoirs is possible during normal and wet periods. Funding for this type of project may be available through the Water Supply Enhancement Program of the Texas State Soil and Water Conservation Board (TSSWCB), though none was allocated in 2019. The TSSWCB has already completed feasibility studies for the O.C. Fisher, Twin Buttes and Lake Nasworthy watersheds. To date, nearly half of this land has already been treated for brush. However, in order to continue to realize these water savings, brush must be continually retreated. The reservoir yields shown under subordination include hydrology through the end of 2016. Therefore, all savings gained by previous treatment of brush are shown in the modeled yield of these reservoirs under subordination. However, any future brush treatments could yield small amounts of additional savings. According to the TSSWCB annual reports, on average, about 500 to 3,000 acres of brush per year are treated in this area.

Subordination

The subordination strategy increases the supply to San Angelo's reservoirs by changing the strict priority modeling assumptions utilized in WAM Run 3 such that downstream senior water right holders do not make priority calls on upstream users in Region F. As discussed previously, supplies from the subordination strategy will be available in most years but may not be reliable in extreme drought years. Because of this, the supplies from this strategy were limited from what is theoretically available from the subordination model for San Angelo. For the purposes of this plan, the subordination strategy for San Angelo increases the City's surface water system (Twin Buttes, Lake Nasworthy, and O.C. Fisher Reservoirs) supplies increase from 0 acre-feet to 1,670 acre-feet in 2020 and decrease to about 1,200 acre-feet by 2070 due to sedimentation in the reservoirs. The subordination strategy is discussed in detail in Chapter 5C and in Appendix C. Region F recognizes that a subordination agreement is not within the authority of the Regional Water Planning Group. Such an agreement must be developed by the water rights holders themselves, including the City of San Angelo.

Concho River Water Project

The City of San Angelo recently completed a long-range water supply study which identified the Concho River Water Project as the next major water supply for the City. The project is an indirect reuse project that will provide approximately 8,400 acre-feet of water as municipal supply. The project will release highly treated wastewater into the Concho River where it will be diverted approximately 8 miles downstream and treated for municipal use. The project includes permitting, and water and wastewater treatment plant upgrades. The capital costs associated with these upgrades are estimated at nearly $117 million.

Hickory Aquifer Well Field Expansion in McCulloch County

The City of San Angelo operates a well field project in McCulloch County that pumps groundwater from the Hickory aquifer. This project consists of 15 wells and a transmission system that transports water to the City. This system has the capability to pump about 12,000 acre-feet per year (10.8 MGD) and has infrastructure in place to treat 8,960 acre-feet per year (8 MGD). Based on the current treatment capacity, this project can provide up to 8,960 acre-feet per year according to their agreement with the Hickory Underground Water District and utilizing banked water. Starting in 2026, the City's permitted supply increases to an annual amount of 10,000 acre-feet. The project's permitted supply will reach its ultimate capacity of 12,000 acre-feet by 2036. In order to reach this full capacity, the City will need to add additional wells, increase their radium treatment capacity, and upgrade some pump stations along the pipeline route. No additional pipelines or increases in pipeline capacity are required. The capital costs associated with these upgrades are estimated at $66 million.

5D.5.2 San Angelo Water Management Plan Summary

San Angelo Recommended Water Management Strategies

- Municipal Conservation
- Subordination
- Brush Control
- Concho River Water Project (Indirect Reuse)
- Hickory Well Field Expansion in McCulloch County

Table 5D- 17 shows the supply amounts from each strategy and the needs after implementation of the recommended strategies for San Angelo. The costs for each recommended strategy are summarized in Table 5D- 18.

Primary strategies for San Angelo include the Concho River Water Project and expansion of the City's Hickory Well Field. Figure 5D-5 illustrates the recommended water management plan for San Angelo. This plan indicates that the recommended strategies will be able to meet all of San Angelo's projected needs throughout the planning horizon.

Table 5D-17
Recommended Water Management Strategies for the City of San Angelo

-Values are in Acre-Feet per Year-

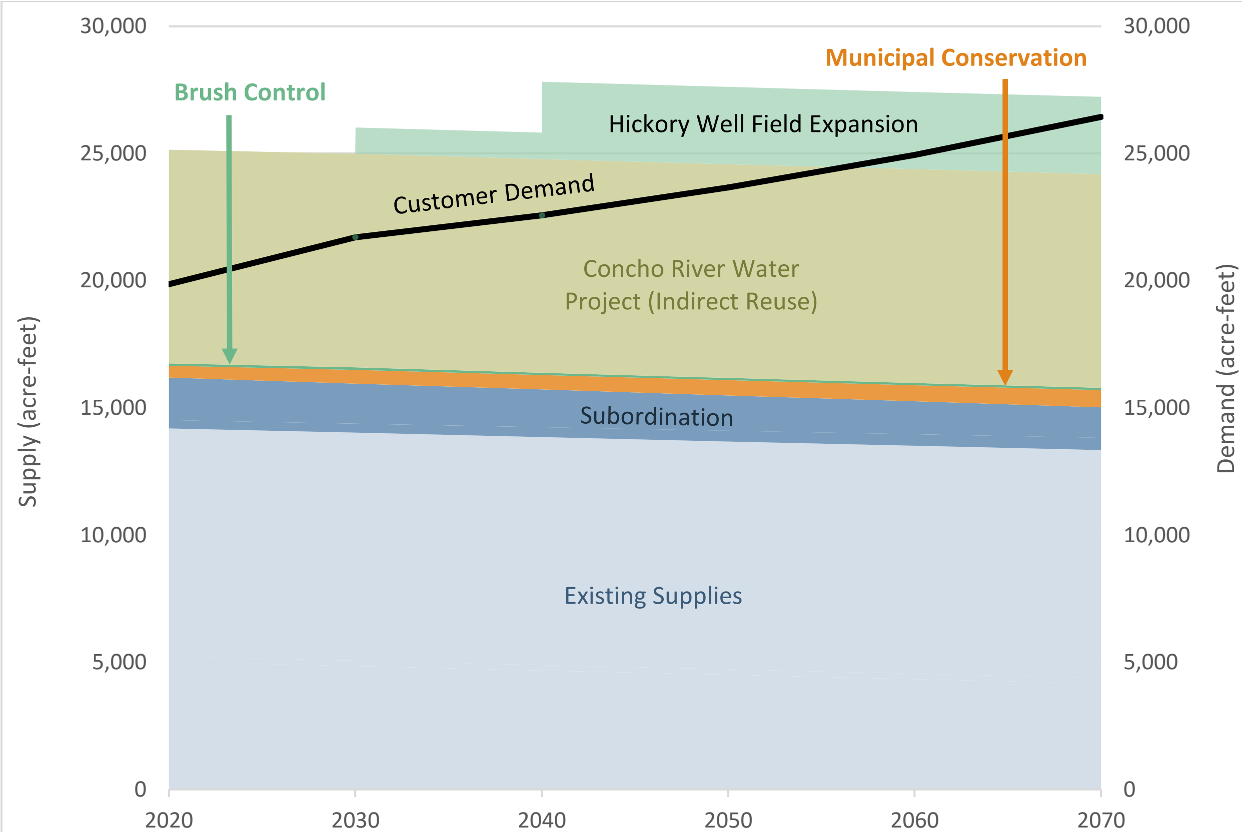
	2020	2030	2040	2050	2060	2070
Surplus (Shortage) before Recommend Strategies	**(3,202)**	**(5,207)**	**(6,280)**	**(7,575)**	**(9,100)**	**(10,739)**
Recommended Strategies	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Subordination - Ivie Contract	*329*	*359*	*391*	*421*	*453*	*483*
Subordination - San Angelo System	*1,670*	*1,575*	*1,480*	*1,385*	*1,290*	*1,195*
Municipal Conservation	*467*	*541*	*567*	*602*	*639*	*679*
Brush Control	90	90	90	90	90	90
Concho River Project (Indirect Reuse)	8,400	8,400	8,400	8,400	8,400	8,400
Hickory Well Field Expansion	0	1,040	3,040	3,040	3,040	3,040
Total Supply from Recommended Strategies	**8,490**	**9,530**	**11,530**	**11,530**	**11,530**	**11,530**
	2020	**2030**	**2040**	**2050**	**2060**	**2070**
Surplus (Shortage) after Recommended Strategies	**3,028**	**4,323**	**5,250**	**3,955**	**2,430**	**791**
Management Supply Factor	*1.3*	*1.2*	*1.2*	*1.2*	*1.1*	*1*

Strategies in grey italics were included in the previous calculation of surplus (shortages). They are included in this table for completeness but are not included in the total to avoid double counting.

Table 5D-18
Costs for the Recommended Strategies for the City of San Angelo

Strategy	Capital Cost (Million $)	Unit Cost ($/1,000 gal)	
		With Debt Service	After Debt Service
Municipal Conservation	---	NA	NA
Subordination	---	NA	NA
Brush Control	---	NA	$1.50
Concho River Water Project	$117	$3.84	$0.83
Hickory Well Field Expansion	$66	$7.12	$3.18

Figure 5D-5
San Angelo Water Management Plan



San Angelo Alternative Water Management Strategies

The City of San Angelo is considering additional strategies which may be implemented if additional supplies are needed or if one or more of the recommended strategies is determined to be no longer feasible. Alternative water management strategies for San Angelo include:

- Development of Edwards-Trinity aquifer supplies in Schleicher County
- Development of Pecos Valley and Edwards-Trinity aquifer supplies in Southwest Pecos County
- Desalination of Additional Groundwater Supplies

5E COUNTY WATER MANAGEMENT PLANS

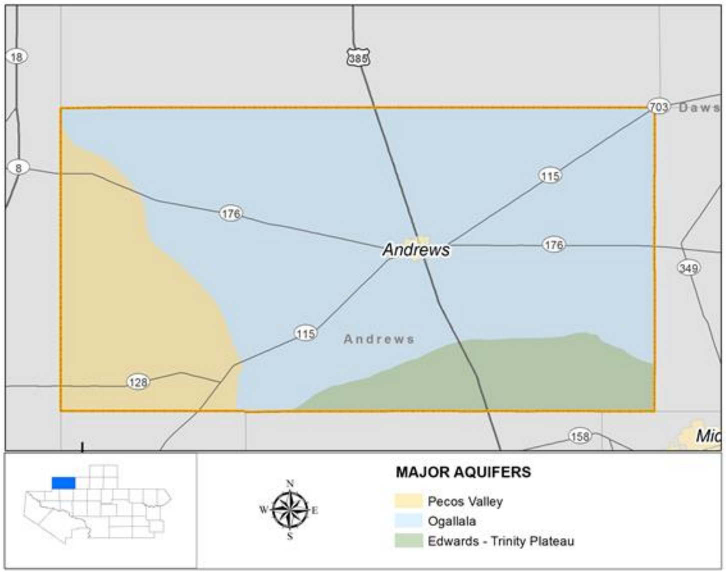
There are 32 counties in Region F, of which eleven show no shortages after conservation and subordination. Twenty-one of the 32 counties in Region F were identified with a water shortage over the planning horizon (2020 to 2070). This subchapter discusses the water issues of each county and outlines the proposed water management strategies to meet these identified shortages. For some counties, there are projected shortages that cannot be met through an economically viable project. It is important to remember that economic viability of a project is based on the current understanding of the value of water and that maximum cost that can be paid for water in certain industries such as irrigated agriculture. These assumptions of economic viability may change over time and will be reevaluated in the next plan. These "unmet needs" are also identified, if present, by county. Descriptions of water management strategies that are developed by a major water provider are discussed in Chapter 5D and included in the county summary tables for completeness, as appropriate. Detailed evaluations of the potentially feasible water management strategies are included in Appendix C and the detailed costs are presented in Appendix D. A summary evaluation matrix is included in Appendix E.

Region F Counties

- 32 total counties in the region
- 11 counties have no shortages after subordination and conservation
- 21 counties have shortages over the planning horizon
- 8 counties have unmet needs over the planning horizon

5E.1 Andrews County

Andrews County has limited surface water and groundwater supplies. Some local surface water is used by livestock, but the majority of water within Andrews County is supplied from the Dockum and Ogallala aquifers. Much of the supply from these sources is nearly fully developed for current use. As a result, there are identified shortages that may not be able to be met by supplies within the county.



The majority of Andrews County's shortages are associated with irrigation, municipal, and mining water needs. Irrigation is the largest water user group within Andrews County, with a water demand at approximately 20,365 acre-feet and current supplies available to meet this need of approximately 18,666 acre-feet in 2020. The only strategy identified for irrigation is conservation. The mining demand in Andrews County is 2,657 acre-feet in 2020, which cannot be met with existing supplies. Strategies identified for mining include utilizing recycled water (conservation) or non-potable reuse. Conservation strategies are discussed in more detail in Chapter 5B.

Most of the municipal shortage within Andrews County is affiliated with the City of Andrews, which has the second largest shortage identified within the county. The City obtains their water from the Ogallala aquifer and plans on expanding their well fields in order to better support their existing supply. Similarly, the Texland Great Plains Water Supply Company (Great Plains), a wholesale water provider (WWP) that operates in Andrews County and Gaines County (Region O), is also identified to have a need and plans to expand their well field. Most strategies for water user groups that have needs in Andrews County are to develop additional groundwater supplies, however, the current MAG volume available in the local aquifers will not support these desired projects. For planning purposes, if a strategy exceeds the MAG availability it does not qualify for state funding and cannot be a recommended strategy, whether or not a GCD is in place. For the purpose of this plan, groundwater strategies developed for water users in Andrews County are not recommended, but are alternative strategies put in place to be recommended only if the DFC and associated MAG were to change in future planning cycles.

5E.1.1 Andrews

Andrews Recommended Strategies

- Municipal Conservation
- Groundwater development strategies for Andrews are considered Alternative due to MAG limitations.

The City of Andrews obtains its water from city well fields in the Ogallala aquifer and purchased groundwater from University Lands. The City's contract with University Lands expires in 2035. It is assumed that the City will renew this contract for supplies through the planning period. Strategies to develop additional groundwater in the Ogallala aquifer as part of the City's well field expansion project exceed the current MAG availability, and therefore, these strategies are not recommended. However, they can be included as alternative strategies designed to be recommended upon a change in DFC and MAG availabilities in future planning cycles. More information pertaining to these projects are located in Appendix B. For the purpose of this plan, municipal conservation is expected to yield approximately 45 acre-feet in 2020. The preservation of existing supplies through municipal conservation is a recommended strategy.

The City of Andrews has also discussed the possibility of importing additional water from Val Verde County and from the T-Bar well field. However, the small amount of water obtained from these strategies does not outweigh the considerable costs for the necessary infrastructure. These strategies were identified as not being potentially feasible and therefore were not fully evaluated as part of this planning cycle. If part of the infrastructure cost can be shared with others, these strategies may be more feasible in the future.

Potentially Feasible Water Management Strategies Considered for the City of Andrews:

- Municipal Conservation
- Develop Ogallala Aquifer Supplies
- Develop Edwards-Trinity Plateau Aquifer Supplies (Antlers Formation)

Develop Ogallala Aquifer Supplies

This strategy proposes additional groundwater development from the Ogallala aquifer. A total of 14 new wells would be drilled along with associated well field piping. The amount of supply expected is 2,810 acre-feet per year, but there is no water available under the current MAG, causing this strategy to officially be listed as an Alternative strategy. However, there is currently no GCD in Andrews County to manage to the DFC and it is anticipated that users in Andrews County will continue groundwater development and use. Capital costs are estimated at $15.6 million.

Develop Edwards-Trinity Plateau Aquifer Supplies (Antlers Formation)

This strategy assumes that 38 new wells will need to be constructed at a 150-ft depth to access the additional aquifer supplies needed. Each well is assumed to be operating at a capacity of 50 gpm. A transmission pipe will be constructed to transfer the groundwater. This strategy will cost approximately $24.9 million to implement and is estimated to yield an additional 2,600 acre-feet of water per year.

Table 5E- 1
Recommended and Alternative Water Strategies for Andrews

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		4,202	5,046	5,805	6,712	7,787	9,041
Existing Supply (Groundwater)		4,010	4,630	5,090	5,415	5,808	6,241
Shortage		192	416	715	1,297	1,979	2,800
Recommended Strategies							
Municipal Conservation	$0	45	55	96	111	129	150
Alternative Strategies							
Develop Ogallala Aquifer Supplies	$15,663,000	2,810	2,810	2,810	2,810	2,810	2,810
Develop Edwards-Trinity Plateau Aquifer Supplies (Antlers Formation)	$24,927,000	2,600	2,600	2,600	2,600	2,600	2,600

5E.1.2 Texland Great Plains Water Supply Co. LLC

The Texland Great Plains Water Supply Company (Great Plains) is a wholesale water provider (WWP) that provides water to customers in Region F and the Llano Estacado Region (Region O). The water supply system operates well fields in the Ogallala aquifer in Andrews County in Region F and Gaines County in Region O. Great Plains owns an extensive pipeline system that has historically provided water primarily for oil and gas operations. In Region F, Great Plains also provides a small amount of municipal water to the City of Goldsmith, manufacturing users and a steam electric operation in Ector County. Due to the limited supplies from the Ogallala aquifer in Andrews and Gaines Counties, Great Plains is shown to have a projected shortage of approximately 40 acre-feet per year in 2020 and 180 acre-feet by 2070, as presented in Table 5E- 2.

Table 5E- 2
Comparison of Supply and Demand for the Great Plains Water Supply System
-Values are in Acre-Feet per Year-

Supplies	2020	2030	2040	2050	2060	2070
Andrews Co. Well Field	1,782	1,631	1416	1283	1171	1072
Gaines Co. Well Field	4,731	4,781	4,838	4,929	5,007	5,075
Total Supplies	**6,513**	**6,412**	**6,254**	**6,212**	**6,178**	**6,147**
Demands	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
County-Other, Ector (City of Goldsmith)	68	68	68	68	68	68
Steam Electric Power, Ector County	3,716	3,716	3,716	3,716	3,716	3,716
Manufacturing, Ector County	245	245	245	245	245	245
Mining, Andrews County	50	50	50	50	50	50
Mining, Ector County	375	300	150	150	150	150
Mining, Gaines County	2,100	2,100	2,100	2,100	2,100	2,100
Total Demand	**6,554**	**6,479**	**6,329**	**6,329**	**6,329**	**6,329**
Shortage	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Shortage	41	67	75	117	151	182

These shortages are associated with the limitations of the MAGs. The existing well fields can produce the required supply but there is competition for water from the Ogallala aquifer. In Andrews County there is no groundwater district to enforce the MAG withdrawal limits, but there is a district in Gaines County. For planning purposes there is no available water from the Ogallala aquifer in Andrews and/or Gaines County for water management strategies. There is a small amount of MAG available in Andrews County from the Dockum aquifer, but the water quality of this supply is poor, and productivity is limited.

In order to meet any potential future needs, Great Plains is planning to expand their well field and drill new wells in northern Andrews County and/or southern Gaines County. Due to limitations of the MAG in both Andrews and Gaines County, this is shown as an alternative strategy in the plan.

Potentially Feasible Water Management Strategies Considered for Texland Great Plains:

- Develop Additional Ogallala Aquifer Supplies in Andrews or Gaines County

Texland Great Plains Recommended Strategies

- None. Texland Great Plains groundwater development is considered Alternative due to MAG limitations.

Develop Additional Ogallala Aquifer Supplies from Andrews or Gaines County

This strategy is for a small well field expansion at Texland Great Plains existing facilities in Andrews and Gaines counties. This strategy assumes one new well in the Ogallala Aquifer. Due to MAG limitations in these counties, this strategy is classified as alternative.

Table 5E- 3
Alternative Water Strategies for Great Plains

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		6,554	6,479	6,329	6,329	6,329	6,329
Existing Supply (Groundwater)		6,513	6,412	6,254	6,212	6,178	6,147
Shortage		41	67	75	117	151	182
Alternative Strategies							
Develop Additional Supplies in Ogallala Aquifer	$380,000	200	200	200	200	200	200

5E.1.3 Andrews County-Other

Andrews County-Other has less than 4,428 in population, which consists of individuals living outside of a named water user group. This compilation of users known as County-Other is self-supplied. The shortages for this population stem from limited MAG availability in the county and therefore additional groundwater development is considered as an alternative water management strategy. Since Andrews County has no GCD, there is no one to issue permits or manage production to meet the DFC. Municipal conservation was also considered and recommended as a strategy for Andrew County-Other. Conservation strategies are discussed in Chapter 5B.

Potentially Feasible Water Management Strategies Considered for Andrews County-Other:

- Municipal Conservation
- Develop Edwards-Trinity Plateau Aquifer Supplies

Develop Edwards-Trinity Plateau Aquifer Supplies

This strategy assumes that 5 new wells will need to be constructed at a 150-ft depth in order to access the additional aquifer supplies needed. Each well is assumed to be operating at a capacity of 50 gpm. This strategy will cost approximately $751,000 to implement and is estimated to yield an additional 250 acre-feet of water per year.

Andrews County-Other Recommended Strategies

- Municipal Conservation
- Groundwater development for Andrews County-Other is considered Alternative due to MAG limitations.

Table 5E- 4
Recommended and Alternative Water Strategies for Andrews County-Other

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		537	577	618	666	720	776
Existing Supply (Groundwater)		507	519	527	514	508	501
Shortage		30	58	91	152	212	275
Recommended Strategies							
Municipal Conservation	**$0**	14	15	17	18	20	25
Alternative Strategies							
Develop Edwards-Trinity Plateau Aquifer Supplies	$751,000	250	250	250	250	250	250

5E.1.4 Andrews County Livestock

Andrews County has approximately 10 to 60 acre-feet of livestock shortages over the planning horizon due to MAG limitations in the county. An alternative water management strategy is included to provide additional water from the Edwards-Trinity Plateau aquifer.

Potentially Feasible Water Management Strategies Considered for Andrews County Livestock:

- Develop Edwards-Trinity Plateau Supplies

Andrews County Livestock Recommended Strategies

- None. Groundwater development for Andrews County Livestock is considered Alternative due to MAG limitations.

Develop Edwards-Trinity Plateau Aquifer Supplies

This strategy assumes that 3 new wells will need to be constructed at a 150-ft depth in order to access the additional aquifer supplies needed. Each well is assumed to be operating at a capacity of 20 gpm. This strategy will cost approximately $327,000 to implement and is estimated to yield an additional 60 acre-feet of water per year.

Table 5E- 5
Alternative Water Strategies for Andrews County Livestock

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		210	210	210	210	210	210
Existing Supply (Groundwater)		201	193	185	171	160	150
Shortage		9	17	25	39	50	60
Alternative Strategies							
Develop Edwards-Trinity Plateau Aquifer Supplies	$327,000	60	60	60	60	60	60

5E.1.5 Andrews County Manufacturing

A small portion of the Andrews County manufacturing demand is supplied through sales from the City of Andrews. The remainder of the manufacturing in the county is self-supplied from the Dockum and Ogallala aquifers. Due to limited supplies under the MAG, manufacturing in Andrews County also shows a shortage over the planning horizon that cannot be met. An alternative water management strategy for additional groundwater from the Edwards-Trinity Plateau aquifer was developed.

Potentially Feasible Water Management Strategies Considered for Andrews County Manufacturing:

- Develop Edwards-Trinity Plateau Supplies

Develop Edwards-Trinity Plateau Aquifer Supplies

This strategy assumes that 4 new wells operating at 50 gpm constructed at a 150-ft depth to access the additional aquifer supplies needed. This strategy will cost approximately $591,000 to implement and is estimated to yield an additional 210 acre-feet of water per year.

Andrews County Manufacturing Recommended Strategies

- None. Groundwater development for Andrews County Livestock is considered Alternative due to MAG limitations.

Table 5E- 6
Alternative Water Strategies for Andrews County Manufacturing

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		580	617	617	617	617	617
Existing Supply (Groundwater, Purchased from Andrews)		549	558	530	483	443	408
Shortage		31	59	87	134	174	209
Alternative Strategies							
Develop Edwards-Trinity Plateau Aquifer Supplies	$591,000	210	210	210	210	210	210

5E.1.6 Andrews County Mining

Andrews County Mining has a projected shortage from 2020 to 2040, with a shortage of nearly 1,200 acre-feet per year in 2020. Region F has identified mining conservation (recycling) as recommended strategy. Additional information on conservation strategies is included in Chapter 5B. The remainder of the need is unmet since the groundwater available under the MAG is limited and mining is an exempt use. However, it is anticipated that the mining industry, as an exempt user, will continue to use groundwater as needed to meet any of their demands.

5E.1.7 Andrews County Summary

Before strategies, Andrews County has a projected shortage of over 12,000 acre-feet per year by 2070 and has limited options under regional planning guidelines to meet these shortages. The MAG in Andrews County is limiting and results in water needs for all users in the county. Most of these needs remain unmet. However, since there is no GCD in Andrews County, users may functionally develop supplies in larger quantities than regional planning recognizes. While the unmet needs are large, some of the need is currently being met by groundwater use above the MAG limits. It is anticipated that the water users in Andrews County will continue to use groundwater at the current levels and possibly expand groundwater use over time. These strategies are included as alternative water management strategies.

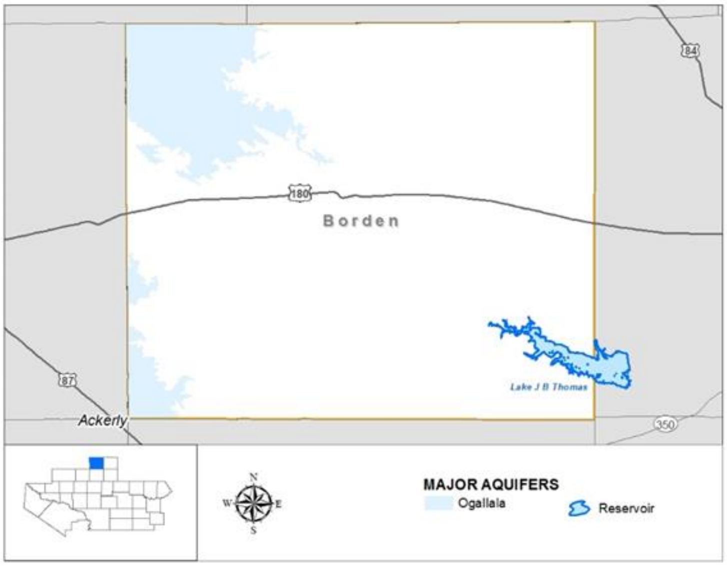
Table 5E- 7
Andrews County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Andrews	Ogallala Aquifer	192	2,800	Municipal Conservation Develop Edwards-Trinity Plateau Supplies (Alternative)
County-Other	Ogallala Aquifer	30	275	Municipal Conservation Develop Edwards-Trinity Plateau Supplies (Alternative)
Texland Great Plains	Ogallala Aquifer	42	182	Develop Ogallala Aquifer Supplies (Alternative)
Irrigation	Ogallala Aquifer, Edwards-Trinity High Plains Aquifer, Reuse (Andrews)	1,699	9,317	Irrigation Conservation
Livestock	Dockum Aquifer, Stock Ponds, Ogallala Aquifer	9	60	Develop Edwards-Trinity Plateau Supplies (Alternative)
Manufacturing	Sales from Andrews, Dockum Aquifer, Ogallala Aquifer	31	209	Develop Edwards-Trinity Plateau Supplies (Alternative)
Mining	Ogallala Aquifer, Dockum Aquifer	2,934	473	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

Table 5E- 8
Unmet Needs in Andrews County
-Values are in Acre Feet per Year-

Water User Group	2020	2030	2040	2050	2060	2070
Andrews	147	361	619	1,186	1,850	2,650
County-Other	16	43	74	134	192	254
Livestock	9	17	25	39	50	60
Manufacturing	31	59	87	134	174	209
Irrigation	681	3,651	5,260	6,352	7,275	8,097
Mining	909	868	66	0	0	0
TOTAL	**1,793**	**4,999**	**6,132**	**7,845**	**9,541**	**11,270**

5E.2 Borden County



Borden County has limited surface water and groundwater supplies. Some local surface water is used by livestock, but the majority of water within Borden County is supplied from the Ogallala aquifer and Other aquifer. Much of the supply from these sources is nearly fully developed for current use. Irrigation is the largest water user within the county with a water demand of roughly 2,950 acre-feet per year. All of the shortages in Borden County are for irrigation; however, it is estimated that these shortages can be met by conservation. Conservation strategies are discussed in more detail in Chapter 5B. All other water use categories in Borden County, including county-other, livestock, and mining, were identified to not have shortages and therefore no strategies were required.

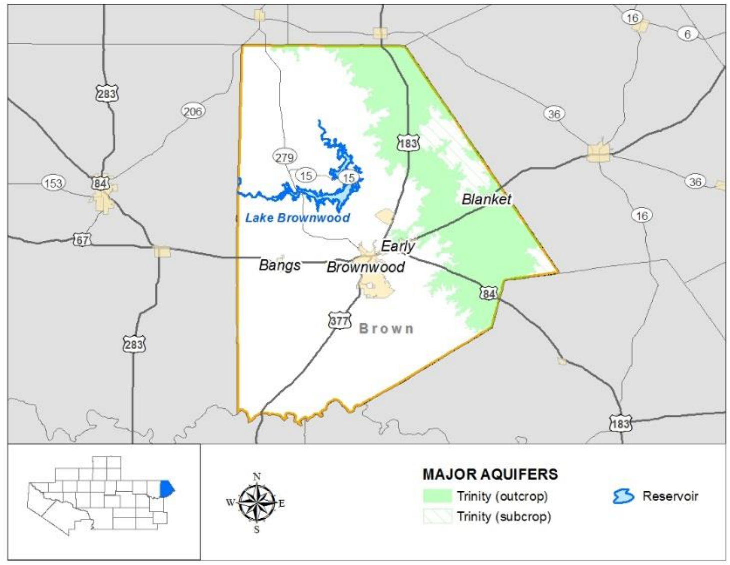
5E.2.1 Borden County Summary

Borden County is projected to have no water shortages throughout the planning horizon. However, irrigation conservation and mining conservation (recycling) are recommended. Borden County-Other does not have a shortage, so municipal conservation was not recommended as a strategy.

Table 5E- 9
Borden County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
County-Other	Ogallala Aquifer, Local Alluvium Aquifer	None	None	None
Irrigation	Ogallala Aquifer, Local Alluvium Aquifer	0	282	Irrigation Conservation
Livestock	Stock Ponds	None	None	None
Manufacturing	----	----	----	----
Mining	Local Alluvium Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.3 Brown County



Most of the water supply in Brown County is supplied by Brown County Water Improvement District #1 (BCWID) from Lake Brownwood. None of the entities supplied by BCWID #1 show a water shortage over the planning horizon. BCWID #1 is classified as a major water provider and is discussed further in Chapter 5D. Coleman County SUD, as well as irrigation and mining users, show a water shortage over the planning horizon. The identified shortage for Coleman County SUD is attributed to a lack of firm yield in Lake Coleman. When considering subordination supply from Lake Coleman, the shortages for Coleman County SUD are met. Mining customers are supplied entirely by groundwater and their shortages can be met through the development of additional groundwater supplies. Irrigation users receive their supply through various sources, however, the only recommended strategy in the plan is conservation.

Conservation is recommended as strategy in Brown County for municipal, irrigation, and mining. All conservation strategies are further discussed in Chapter 5B. The City of Bangs, which does not have a need, plans to pursue a direct non-potable reuse strategy. County-Other, Livestock and Manufacturing all have no shortages and no recommended strategies.

5E.3.1 Bangs

Bangs is a customer of BCWID and has no shortages over the planning horizon. However, Bangs plans to pursue a small scale direct non-potable reuse project for irrigation at a golf course.

Potentially Feasible Water Management Strategies Considered for Bangs:

- Municipal Conservation
- Direct Non-Potable Reuse

Bangs Recommended Strategies

- Municipal Conservation
- Direct Non-Potable Reuse

Direct Non-Potable Reuse

For the purposes of this plan, it was assumed that minor improvements would need to be made at the wastewater treatment facility as well as additional piping to transport the water from the plant to the golf course. This strategy will provide approximately 25 acre-feet per year and is estimated to cost approximately $581,000.

Table 5E- 10
Recommended Water Strategies for Bangs

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		310	305	296	291	290	290
Existing Supply (Purchased from BCWID #1)		310	305	296	291	290	290
Shortage		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	$0	8	8	8	8	8	8
Reuse	$581,000	25	25	25	25	25	25
TOTAL	**$0**	**33**	**33**	**33**	**33**	**33**	**33**

5E.3.2 Brown County Mining

Brown County Mining Recommended Strategies

- Mining Conservation (Recycling)
- Develop Cross Timbers Aquifer Supplies

Brown County Mining is projected to have water shortages ranging from 261 to 268 acre feet per year throughout the planning horizon. Currently, mining customers in Brown County are supplied entirely by groundwater from the Trinity Aquifer and Cross Timbers Aquifer. Region F identified further development of these groundwater supplies to meet the projected shortages.

Potentially Feasible Water Management Strategies Considered for Brown County Mining:

- Mining Conservation (Recycling)
- Develop Cross Timbers Aquifer Supplies

Develop Cross Timbers Aquifer Supplies

This strategy assumes that 45 new wells will need to be constructed at a 320-ft depth in order to access the additional aquifer supplies needed. Each well is assumed to be operating at a capacity of 5 gpm. This strategy will cost approximately $3.3 million to implement and is estimated to yield an additional 210 acre-feet of water per year.

Table 5E- 11
Recommended Water Strategies for Brown County Mining

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		943	948	951	952	948	944
Existing Supply (Groundwater)		682	682	685	684	684	681
Shortage		261	266	266	268	264	263
Recommended Strategies							
Mining Conservation (Recycling)	$1,340,000	66	66	67	67	66	66
Develop Cross Timbers Aquifer Supplies	$2,440,000	210	210	210	210	210	210
TOTAL	**$3,780,000**	**276**	**276**	**277**	**277**	**276**	**276**

5E.3.3 Brown County Summary

Lake Brownwood (BCWID #1) has sufficient supplies to meet most of the county's demands. Development of additional groundwater supplies is necessary to meet shortages for mining. Conservation is recommended for all municipal, irrigation, and mining users. Irrigation is the only entity that has unmet needs over the planning horizon.

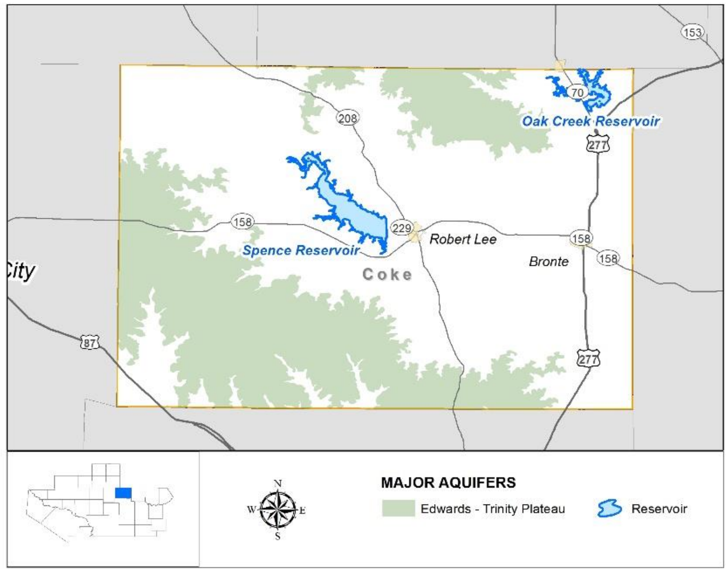
Table 5E- 12
Brown County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Bangs	Sales from BCWID #1	None	None	Municipal Conservation Direct Non-Potable Reuse
Brookesmith SUD	Sales from BCWID #1	None	None	Municipal Conservation
Brownwood	Sales from BCWID #1	None	None	Municipal Conservation
Coleman County SUD	Sales from BCWID #1 and City of Coleman	227	215	Municipal Conservation Subordination (through the City of Coleman)
Early	Sales from BCWID #1	None	None	Municipal Conservation
Santa Anna	Sales from BCWID #1	None	None	Municipal Conservation
Zephyr WSC	Sales from BCWID #1	None	None	Municipal Conservation
County-Other	Sales from Brownwood, Trinity Aquifer	None	None	None
Irrigation	Sales from BCWID #1, Run-of-River, Trinity Aquifer	1,708	1,711	Irrigation Conservation
Livestock	Livestock Local Supplies, Other Aquifer	None	None	None
Manufacturing	Sales from BCWID #1	None	None	None
Mining	Trinity and Other Aquifers	195	197	Mining Conservation (Recycling) Develop Cross Timbers Aquifer Supplies
Steam Electric	----	----		----

Table 5E- 13
Unmet Needs in Brown County
-Values are in Acre Feet per Year-

Water User Group	2020	2030	2040	2050	2060	2070
Irrigation	1,302	1,062	1,061	1,063	1,060	1,061

5E.4 Coke County



Coke County has very limited groundwater and surface water supplies. Without subordination both E.V. Spence and Oak Creek Reservoir show zero reliable supply. Lake Spence is owned and operated by CRMWD. The subordination supplies from this reservoir go to supply CRMWD customers outside Coke County. Robert Lee previously had a contract with CRMWD and previously received supply from the Spence Reservoir. However, their water treatment plant has been shuttered and their contract has expired. Robert Lee no longer uses this source. Oak Creek Reservoir is owned and operated by the City of Sweetwater (Region G) and is used in conjunction with their other supplies to provide water to Sweetwater and their customers, including Bronte. Groundwater supply in the county is also limited. There are some small alluvium deposits of freshwater, but they are limited and generally not prolific. The Edwards-Trinity Plateau aquifer does have unused availability in the county, but the quality tends to be poor and may require advanced treatment for municipal use. For many of the smaller, rural communities in Coke County, the development of this supply is economically infeasible.

5E.4.1 Bronte

In the past, the City of Bronte relied solely on water from the Oak Creek Reservoir (sales from the City of Sweetwater located in Region G). However, prolonged drought has greatly impacted the supply available from Oak Creek and without subordination, the source shows no supply. As a result, Bronte developed a groundwater supply from ten wells in the vicinity of Oak Creek Reservoir. The groundwater is delivered to the City in the Oak Creek pipeline. The groundwater supply is from an unclassified aquifer and the reliability is not well known. For the purpose of this plan, it is assumed that this source could provide about 130 acre-feet of supply per year. Assuming the City of Sweetwater is able to meet their full obligation to Bronte, they show no shortages over the planning horizon. However, if Sweetwater is not able to meet this amount, Bronte would show significant shortages. To ensure the security of their water supply, the City of Bronte is diligently pursuing all options. Several strategies for Bronte in previous plans were evaluated and some were considered economically infeasible. These were not reevaluated for this plan and are listed below.

Previously Evaluated and Dismissed Water Management Strategy:

- Brackish groundwater development with advanced treatment
- Direct Potable Reuse

For this plan, several potentially feasible strategies were considered for Bronte including:

- Municipal Conservation
- Subordination (Oak Creek Supplies from Sweetwater)
- Rehabilitation and Upsizing of the Oak Creek Pipeline
- Water Treatment Plant Expansion
- Regional System from Lake Brownwood to Runnels and Coke Counties
- Regional System from Fort Phantom Hill to Runnels and Coke Counties
- Develop Other Aquifer Supplies in Southwest Coke County
- Develop Edwards-Trinity Plateau Supplies in Nolan County
- Develop Other Aquifer Supplies in Runnels County

Bronte Recommended Strategies

- Municipal Conservation
- Subordination (Oak Creek Reservoir)
- Rehabilitation and Upsizing of Oak Creek Pipeline
- Water Treatment Plant Expansion
- Develop Other Aquifer Supplies in Southwest Coke County

Recommended strategies for the City of Bronte are discussed below. Alternate strategies are described further in Appendix C.

Rehabilitation and Upsizing of the Oak Creek Pipeline

The City of Bronte has a 13-mile pipeline to Oak Creek Reservoir. This pipeline is approximately 60 years old and in need of replacement and upsizing to provide adequate capacity. The proposed strategy includes a new 50,000-gallon/ground storage tank, upgrades to the pump station at the intake, and 13 miles of 14-inch pipeline. The additional yield from this strategy represents the additional supplies (subordination sales from Sweetwater) that were previously constrained by the pipeline's capacity. The strategy is estimated to cost nearly $9.8 million dollars.

Water Treatment Plant Expansion

In order to continue supplying Bronte's municipal needs and treated water sales to Robert Lee, the City of Bronte will need a 1.5 MGD water treatment plant expansion in 2020. This is estimated to cost $10.3 million.

Develop Other Aquifer Supplies in Southwest Coke County

The Coke County Underground Water District has done some groundwater exploration in Southwest Coke County. Bronte is considering developing 5 new wells in this area. It is estimated that the wells would produce around 100 gpm from a 300 ft depth and be of adequate quality for municipal use without advanced treatment. A 31-mile transmission pipeline would be needed to deliver these supplies to the City. Capital costs are estimated at $23.7 million.

Table 5E- 14
Recommended Water Strategies for Bronte

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		577	573	569	566	566	566
Existing Supply (Groundwater)		129	125	121	120	120	120
Shortage		448	448	448	446	446	446
Recommended Strategies							
Subordination (Oak Creek Reservoir)	$0	448	448	448	446	446	446
Municipal Conservation		3	3	3	3	3	3
*Oak Creek Pipeline Rehabilitation**	*$9,896,000*	*448*	*448*	*448*	*446*	*446*	*446*
*Water Treatment Plant Expansion**	*$10,270,000*	*448*	*448*	*448*	*446*	*446*	*446*
Develop Other Aquifer Supplies in Southwest Coke County	$23,694,000	800	800	800	800	800	800
TOTAL	**$43,860,000**	**1,251**	**1,251**	**1,251**	**1,249**	**1,249**	**1,249**

**This strategy is for infrastructure projects required to access the subordination supplies Oak Creek pipeline supplies and is not included in the total to avoid double counting.*

Alternative Water Management Strategies for Bronte include:

- Regional System from Lake Brownwood to Runnels and Coke Counties
- Regional System from Fort Phantom Hill to Runnels and Coke Counties
- Develop Edwards-Trinity Plateau Supplies in Nolan County
- Develop Other Aquifer Supplies in Runnels County

5E.4.2 Robert Lee

The City of Robert Lee provides water to its current customers and about 10 acre-feet to Coke County WSC (Coke County-Other). It currently purchases all of its supply from the City of Bronte. The City previously owned and operated a surface water treatment plant for water supplied by Spence and Mountain Creek Reservoirs. However, due to prolonged drought, these water sources became unreliable and the water treatment plant was shuttered. The City is currently pursuing several different water supply options. Additionally, several other strategies have previously been evaluated for Robert Lee that were found to be economically infeasible and are listed below.

Previously Evaluated and Dismissed Water Management Strategies:

- Desalination of Spence Reservoir Water
- Floating pump in Mountain Creek Reservoir
- Direct Potable Reuse

Potentially Feasible Water Management Strategies Considered for Robert Lee:

- Municipal Conservation
- Purchase additional water from Bronte
- Regional System from Fort Phantom Hill to Runnels and Coke Counties

- Regional System from Lake Brownwood to Runnels and Coke Counties
- New water treatment plant to utilize supply from Spence and Mountain Creek Reservoirs
- Develop groundwater from Edwards-Trinity Plateau in Nolan County
- Develop groundwater from Edwards-Trinity Plateau in Tom Green County

Purchase Additional Water from Bronte

The City of Robert Lee currently has a contract to purchase 224 acre-feet per year of supply from Bronte. It is recommended that Robert Lee increase this amount to meet their water supply needs. This strategy assumes this is done on willing buyer, willing seller basis. The recommended strategies for Robert Lee are shown in the table below. The shortages reported in this table include shortages to County-Other that Robert Lee currently supplies. Water made available to Robert Lee from these strategies will be used to meet the County-Other demands.

Robert Lee Recommended Strategies

- Municipal Conservation
- Subordination (Bronte Supplies)
- Purchase Additional Supply from Bronte

Table 5E- 15
Recommended Water Strategies for Robert Lee

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		305	300	296	296	295	295
Existing Supply (Purchased)		68	66	65	65	65	65
Shortage		237	234	231	231	230	230
Recommended Strategies							
Municipal Conservation	$0	3	3	3	3	3	3
Subordination (existing contract with Bronte)	$0	156	158	159	159	159	159
Purchase Additional Supply from Bronte	$0	80	80	80	80	80	80
TOTAL	**$0**	**239**	**241**	**242**	**242**	**242**	**242**

Alternative Water Management Strategies Considered for Robert Lee:

- New water treatment plant to utilize supply from Spence and Mountain Creek Reservoirs
- Regional Systems from Fort Phantom Hill to Runnels and Coke Counties
- Develop Edwards-Trinity Plateau Aquifer in Nolan County
- Develop Edwards-Trinity Plateau Aquifer in Tom Green County
- Regional System from Lake Brownwood to Runnels and Coke Counties

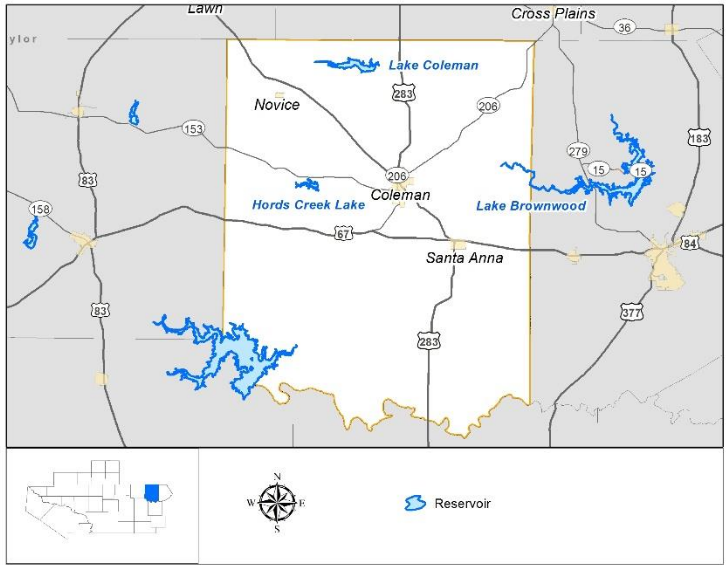
5E.4.3 Coke County Summary

After subordination of downstream water rights associated with Oak Creek Reservoir and Robert Lee purchasing additional water, Coke County has a no official water needs. However, the ability to meet this need is dependent on Sweetwater continuing to provide adequate supplies from Oak Creek Reservoir. The ability to develop additional water supplies through economically feasible strategies is limited. Both the local groundwater and surface water have known water quantity and quality limitations. The ability to use these sources for municipal purposes would likely require advanced treatment. The entities in Coke County continue to explore their options.

Table 5E- 16
Coke County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Bronte	Sales from Sweetwater, Other Undifferentiated Aquifer	368	366	Municipal Conservation, Subordination, Rehabilitation of Oak Creek Pipeline, New Groundwater in Southwest Coke County
Robert Lee	CRMWD, Run-of-River, Sales from Bronte	247	240	Municipal Conservation, Subordination (through Bronte), Purchase Additional Supplies from Bronte
County-Other	Edwards-Trinity Plateau Aquifer, Other Undifferentiated Aquifer	None	None	None
Irrigation	Run-of-River, Edwards-Trinity Plateau Aquifer, Other Undifferentiated Aquifer	None	None	Irrigation Conservation
Livestock	Stock Ponds, Edwards-Trinity Plateau Aquifer, Other Undifferentiated Aquifer	None	None	None
Manufacturing	----	----	----	----
Mining	Edwards-Trinity Plateau Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	Oak Creek Reservoir	None	None	None

5E.5 Coleman County



Users in Coleman County largely rely on surface water. Many water user groups including Brookesmith SUD, Coleman County SUD, and Santa Anna are supplied by Brown County WID #1 from Lake Brownwood. These entities are discussed further under Brown County. The City of Coleman is supplied by Lake Coleman and Hords Creek. Irrigators in Coleman County rely primarily on Lake Coleman and run-of-river rights for their supply, but also pump some groundwater from the Cross Timbers aquifer. Mining users are supplied entirely by groundwater from other undifferentiated aquifers, while livestock users utilize local water supplies to meet their demands.

Without subordination, Lake Coleman and Hords Creek show no supply, leaving irrigators, the City of Coleman and the City's customers including Coleman County SUD, County-Other, and manufacturing with shortages. However, when considering conservation and subordination, supplies are adequate to meet all these shortages and no additional infrastructure strategies are needed. Conservation and subordination are discussed further in Chapters 5B and 5C, respectively.

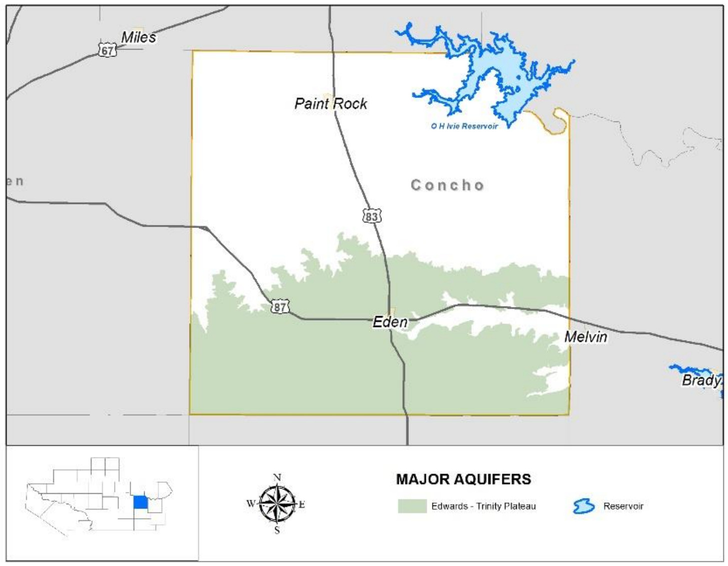
5E.5.1 Coleman County Summary

After subordination of downstream water rights, Coleman County has no water shortages. Although there is no need, conservation is recommended for irrigation and mining users, as well as for municipal users (City of Coleman, Brookesmith SUD, Coleman County SUD, Santa Anna, County-Other).

Table 5E- 17
Coleman County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Brookesmith SUD		See Brown County		
Coleman	Lake Coleman, Hords Creek	1,074	1,030	Municipal Conservation, Subordination
Coleman County SUD		See Brown County		
Santa Anna		See Brown County		
County-Other	Sales from Coleman	24	21	Municipal Conservation
Irrigation	Run-of-River, Lake Coleman, Cross Timbers Aquifer	396	396	Irrigation Conservation, Subordination
Livestock	Livestock Local Supplies, Other Aquifer	None	None	None
Manufacturing	Sales from Coleman	None	None	None
Mining	Other Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----		----

5E.6 Concho County



Concho County is primarily dependent on groundwater supplies from the Hickory, Edwards-Trinity Plateau, Lipan, and other undifferentiated aquifers. The City of Eden uses a small amount of reuse supplies for local golf course. The amount of supply available from these sources is shown to be adequate for most users in Concho County. Other sources of water supply in Concho County include run-of-river supplies for irrigators and County-Other users, as well as sales from the Upper Colorado River Authority (UCRA) to Concho County-Other users. Chapter 5D contains more details regarding sales from UCRA. Overall, Concho County is shown to have no water shortages throughout the planning horizon.

Conservation is recommended for municipal, irrigation, and mining users. Conservation is discussed further in Chapter 5B. Millersview-Doole WSC is split between Concho and McCulloch Counties. Further discussion on Millersview-Doole is discussed under McCulloch County.

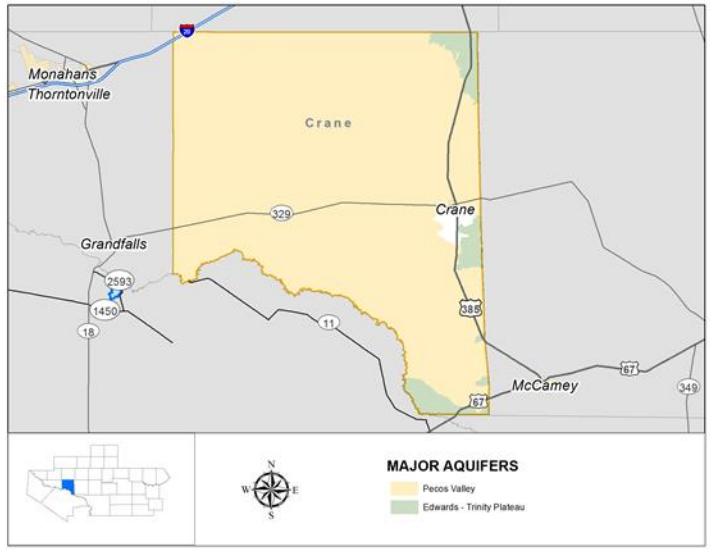
5E.6.1 Concho County Summary

No water user groups in Concho County are projected to have a water need throughout the planning horizon. Although there are no water shortages, conservation is recommended for irrigation, mining, and municipal users in the county, including the City of Eden.

Table 5E- 18
Concho County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
County-Other	Sales from Eden, Edwards-Trinity Plateau Aquifer, Other Aquifer, Run-of-River, Sales from UCRA	None	None	Municipal Conservation
Eden	Edwards-Trinity Plateau, Pecos Valley & Trinity Aquifer, Other Aquifers, Reuse	None	None	Municipal Conservation
Millersview-Doole WSC	See McCulloch County			
Irrigation	Run-of-River, Lipan Aquifer, Other Aquifers	None	None	Irrigation Conservation
Livestock	Livestock Local Supplies, Edwards-Trinity Plateau Aquifer	None	None	None
Manufacturing	----	----	----	----
Mining	Other Aquifers	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.7 Crane County



Crane County has limited surface water and groundwater supplies. Some local surface water is used by livestock, but the majority of water within Crane County is supplied from the Pecos Valley and Edwards-Trinity Plateau aquifers. The largest water demand in Crane County is affiliated with the City of Crane and the surrounding rural communities that are classified as County-Other. The City of Crane and County-Other currently obtain water from the Pecos Valley and Edwards-Trinity Plateau aquifers in Crane and Ward counties. In addition, the City of Crane utilizes a small amount of reuse water for golf course irrigation.

Municipal users and all other users (livestock, mining) in Crane County were identified to have no water shortages throughout the planning horizon. Municipal and mining conservation (recycling) were identified as viable means of preserving existing supplies and are recommended strategies. These conservation strategies will provide the opportunity to reduce the use of groundwater and local supplies within Crane County and are discussed in more detail in Chapter 5B.

5E.7.1 Crane County Summary

No water shortages were identified for water user groups in Crane County; however, conservation is recommended for irrigation and mining users, as well as municipal users (City of Crane).

Table 5E- 19
Crane County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Crane	Pecos Valley Aquifer, Edwards-Trinity Plateau Aquifer, Reuse	None	None	Municipal Conservation
County-Other	City of Crane	None	None	None
Irrigation	----	----	----	----
Livestock	Pecos Valley Aquifer, Edwards-Trinity Plateau Aquifer, Stock Ponds	None	None	None
Manufacturing	Pecos Valley Aquifer, Edwards-Trinity Plateau Aquifer, Dockum Aquifer	None	None	None
Mining	Pecos Valley Aquifer, Edwards-Trinity Plateau Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.8 Crockett County

Almost all of the current water supply in Crockett County is derived from the Edwards-Trinity Plateau aquifer. Mining currently uses an estimated 1,900 acre-feet per year of reuse/recycling supplies. No users in Crockett County are shown to have a shortage over the planning horizon.

5E.8.1 Crockett County Irrigation

Although Crockett County Irrigation shows no shortage, both conservation and weather modification are recommended strategies. Crockett County lies in the West Texas Weather Modification Association program area, where precipitation enhancement is currently active.

Crockett County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Potentially Feasible Water Management Strategies Considered for Crockett County Irrigation:

- Irrigation Conservation
- Weather Modification

Weather Modification

The West Texas Weather Modification Association attributes an annual increase of 1.14 inches of precipitation over Crockett County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 13 irrigated acres in Crockett County, implementation of this strategy is expected to save 1 acre-foot of water per year at a unit cost of $0.47 per acre-foot.

Table 5E- 20
Recommended Water Strategies for Crockett County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		135	135	135	135	135	135
Supply (Groundwater)		135	135	135	135	135	135
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Irrigation Conservation	$15,000	7	14	20	20	20	20
Weather Modification	$0	1	1	1	1	1	1
TOTAL	**$15,000**	**8**	**15**	**21**	**21**	**21**	**21**

5E.8.2 Crockett County Summary

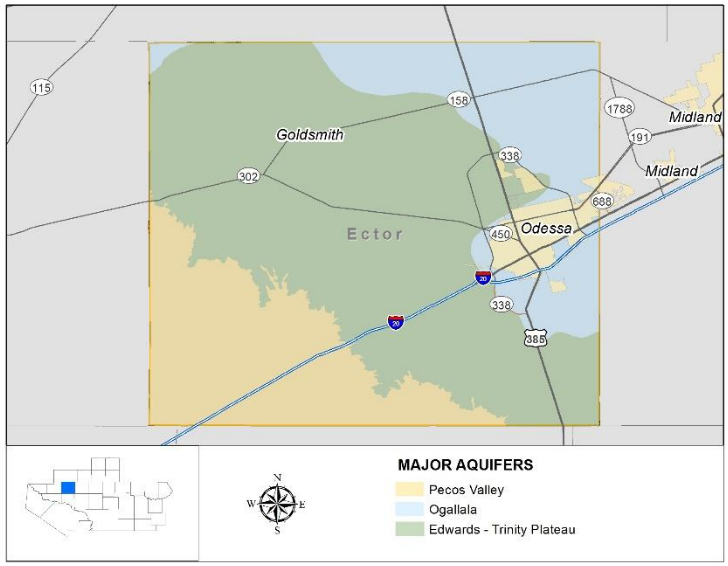
Crockett County shows adequate supplies to meet all users' needs throughout the planning period. Conservation remains recommended for Crockett County WCID #1, Irrigation, and Mining to preserve supplies for future use. Weather modification as part of the West Texas Weather Modification Association is also recommended for irrigators in Crockett County.

Table 5E- 21
Crockett County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Crockett County WCID #1	Edwards-Trinity Plateau Aquifer	None	None	Municipal Conservation
County-Other	Edwards-Trinity Plateau Aquifer	None	None	None
Irrigation	Edwards-Trinity Plateau Aquifer	None	None	Irrigation Conservation Weather Modification
Livestock	Edwards-Trinity Plateau Aquifer	None	None	None
Manufacturing	Sales Crockett County WCID #1	None	None	None
Mining	Edwards-Trinity Plateau Aquifer, Well Field Recycling	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.9 Ector County

A large portion of the supply and demand in Ector County stems from the City of Odessa. Odessa is a member city of CRMWD and receives all of its supply from their system. Recommended strategies for Odessa include conservation, a new advanced water treatment plant, and subordination of CRMWD's supplies. The City of Odessa is considered a major water provider and is discussed in detail in Chapter 5D. The rest of Ector County is primarily reliant on groundwater from several aquifers, including the Edwards-Trinity Plateau, Pecos Valley, Ogallala, Dockum, and Other aquifers. Shortages in Ector County mostly stem from growth in local municipalities, such as Ector County Utility District (ECUD) and Greater Gardendale Water Supply Corporation (WSC), and from steam electric power generating demands. The remaining water users all show no shortages after subordination.



5E.9.1 Ector County Utility District

Ector County Utility District Recommended Strategies

- Municipal Conservation

The Ector County Utility District (ECUD) receives all of its supplies from the City of Odessa. ECUD has plans to expand their service area and has already received major funding to upgrade and expand their system. Future expansion of ECUD's service is accounted for in regional planning as future sales to the County-Other population they would incorporate. These additional sales are based on a more detailed master plan that ECUD completed in June 2018. The future needs of ECUD were planned for under the Odessa as a major provider in Chapter 5D. As a member city of CRMWD, Odessa's needs, including their customers' needs, will be met through additional supplies from CRMWD and their strategies.

5E.9.2 Greater Gardendale WSC

Greater Gardendale WSC is currently reliant on groundwater from the Edwards-Trinity Plateau aquifer and Pecos Valley aquifer. However, this source is not expected to be sustainable at the current withdrawal rate, which will induce shortages after 2020. Consequently, purchasing additional water from the City of Odessa was identified as a recommended strategy for Greater Gardendale WSC to offset the decrease in groundwater supply reliability and to meet growing, future demands. Municipal conservation was also recommended as a strategy for Greater Gardendale WSC. Conservation is discussed further in Chapter 5B.

Potentially Feasible Water Management Strategies Considered for Greater Gardendale WSC:

- Municipal Conservation
- Purchase Water from City of Odessa
- Purchase Water from Midland FWSD #1

Purchase Water from City of Odessa

Greater Gardendale WSC plans to purchase water from the City of Odessa in order to compensate for growing water demands and declining groundwater levels. This strategy requires additional infrastructure to connect to Odessa's water distribution system. Details regarding the project for this additional infrastructure are discussed in Appendix C.

Greater Gardendale WSC Recommended Strategies

- Municipal Conservation
- Purchase Water from City of Odessa

Table 5E- 22
Recommended Water Management Strategies for Greater Gardendale WSC

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		319	348	379	416	457	499
Existing Supply (Groundwater)		319	222	222	222	222	222
Shortage		0	126	157	194	235	277
Recommended Strategies							
Municipal Conservation	**$0**	12	13	15	17	19	20
Purchase Water from Odessa	$6,078,000	0	375	445	445	445	445
TOTAL	**$6,078,000**	**12**	**388**	**460**	**462**	**464**	**465**

Alternative Water Management Strategies for Greater Gardendale WSC:

- Purchase Water from Midland FWSD #1

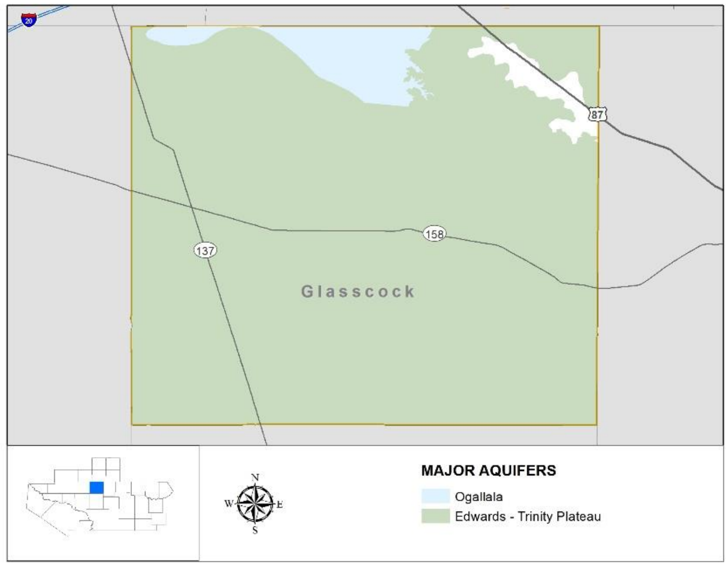
5E.9.3 Ector County Summary

Ector County has projected shortages of over 15,000 acre-feet by 2070. All of these shortages are associated municipal use from Odessa, ECUD, and Greater Gardendale WSC. However, these can all be met through sales from Odessa, which receives subordinated supplies from CRMWD and other CRMWD system supplies.

Table 5E- 23
Ector County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Ector County UD	Sales from Odessa	Included in Odessa	Included in Odessa	Municipal Conservation See Odessa
Greater Gardendale WSC	Edwards-Trinity Plateau Aquifer	0	277	Municipal Conservation Purchase Water from Odessa
Odessa	See Major Water Providers Section			
County-Other	Edwards-Trinity Plateau Aquifer, Ogallala Aquifer, sales from Odessa, sales from Great Plains	0	0	None
Irrigation	Edwards-Trinity Plateau Aquifer, Ogallala Aquifer, sales from CRMWD, reuse sales from Odessa	None	None	Irrigation Conservation
Livestock	Livestock Local Supplies, Ogallala Aquifer, Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	None
Manufacturing	Reuse and Treated Water sales from Odessa, sales from Great Plains Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer, Dockum Aquifer	None	None	None
Mining	Reuse sales from Odessa, sales from Great Plains, Well Field Recycling, Edwards-Trinity Plateau Aquifer, Dockum Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	Sales from Great Plains (Gaines and Andrews Co.), Sales from Odessa	0	0	None

5E.10 Glasscock County



Glasscock County has limited surface water and groundwater supplies. Some local surface water is used by livestock, but the nearly all water within Glasscock County is supplied from the Edwards-Trinity Plateau and Ogallala aquifers. Most of the supply from these sources is nearly fully developed for current use. The largest water demand in Glasscock County is for irrigation, with demands at approximately 51,254 acre-feet from 2020 through 2070. Mining use is the second largest water user group, with demands of approximately 5,900 acre-feet in 2020 and 1,500 acre-feet in 2070.

In Glasscock County, groundwater supplies are sufficient to meet demands from all users, so there were no identified water shortages. Irrigation conservation and mining conservation (recycling) were identified as viable means of preserving existing supplies and are recommended strategies. These strategies could potentially reduce demands within Glasscock County and are discussed in more detail in Chapter 5B. Municipal conservation was not recommended for Glasscock County-Other since there was no shortage.

5E.10.1 Glasscock County Summary

No water shortages were identified for any water user groups in Glasscock County. Irrigation and mining conservation are recommended, even though there are no needs.

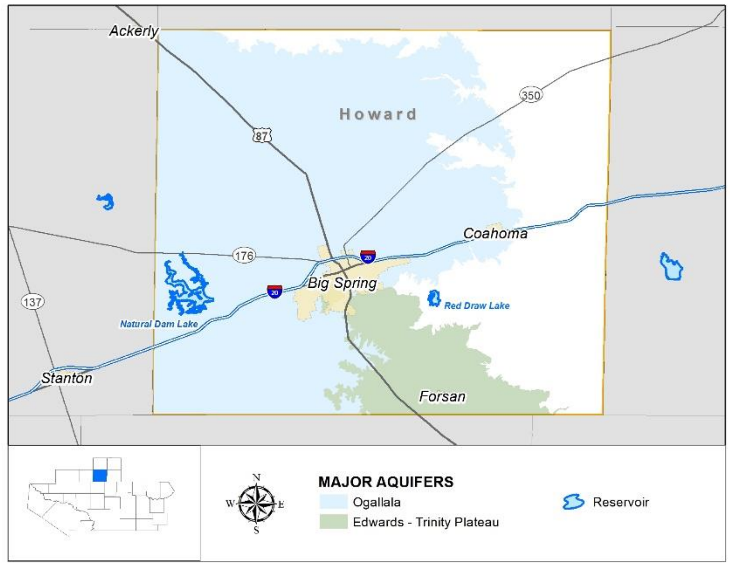
Table 5E- 24
Glasscock County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
County-Other	Edwards-Trinity Plateau Aquifer	None	None	None
Irrigation	Edwards-Trinity Plateau Aquifer, Ogallala Aquifer	None	None	Irrigation Conservation
Livestock	Stock Ponds, Edwards-Trinity Plateau, Ogallala Aquifer	None	None	None
Manufacturing	Edwards-Trinity Plateau Aquifer	None	None	None
Mining	Edwards-Trinity Plateau Aquifer, Well Field Recycling	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.11 Howard County

A major source of supply for Howard County is CRMWD's system which supplies Big Spring and its customers: Coahoma, steam electric power, and manufacturing. The shortages for these users can be met through conservation and subordination of CRMWD's supplies. All other water users in Howard County are primarily reliant on groundwater from the Ogallala and Edwards-Trinity High-Plains Aquifer and the Edwards-Trinity Plateau Aquifer. The Dockum Aquifer is also used as a supply by some County-Other, irrigation, livestock, and mining users. However, the Dockum tends to be brackish, limiting the amount and types of use without treatment. Treatment is not economically feasible for many small communities or for agricultural uses.

After considering conservation (municipal, irrigation and mining) and subordination of supplies from CRMWD, there is adequate water supply for all users in Howard County. However, a new treatment plant is necessary in Big Spring to treat these raw water supplies to meet current and potential future demands.



5E.11.1 Big Spring

The City of Big Spring is a CRMWD member city. CRMWD supplies one hundred percent of Big Spring and their customers' demand with raw water from their system. The City of Big Spring currently treats and sells water to retail customers within the city limits, Coahoma, steam electric power, and some manufacturing operations in Howard County. The projected needs for Big Spring and their customers can be fully met through conservation and subordination of CRMWD supplies. However, at these projected demand levels, the City will exceed its current water treatment plant capacity by 2020. A new water treatment plant is necessary to make the raw water supplies provided by CRMWD potable for municipal use. This plant will replace the existing facility and provide additional treatment capacity. The recommended strategies for Big Spring include municipal conservation, obtaining the contracted supplies from CRMWD and a new 20 MGD water treatment plant in 2020. The supplies shown in Table 5E-37 represent the amount of supplies Big Spring will receive from CRMWD to meet their need and their customer's needs.

Big Spring Recommended Strategies

- Municipal Conservation
- Subordination (CRMWD supplies)
- New Water Treatment Plant (20 MGD)

Potentially Feasible Strategies Considered for Big Spring:

- Municipal Conservation
- Subordination (CRMWD supplies)
- New Water Treatment Plant (20 MGD)

Table 5E- 25
Recommended Water Management Strategies for Big Spring

	Capital Cost	2020	2030	2040	2050	2060	2070
City of Big Spring		6,227	6,368	6,379	6,327	6,316	6,316
Treated Customer Demand		735	743	746	746	745	745
Raw Customer Demand		1,500	1,500	1,500	1,500	1,500	1,500
Future Raw Customer Demand		500	500	500	500	500	500
Total Demand		8,462	8,611	8,625	8,573	8,561	8,561
Existing Supply (Purchased from CRMWD)		7,632	8,611	8,625	7,695	6,890	6,141
Shortage		1,330	500	500	1,378	2,171	2,920
Recommended Strategies							
Municipal Conservation	$0	131	138	140	139	139	139
*WTP Expansion (20 MGD) **	*$104,651,000*	*1,330*	*500*	*500*	*1,378*	*2,171*	*2,920*
Subordination (CRMWD Supplies)	$0	1,330	500	500	1,378	2,171	2,920
TOTAL	**$104,651,000**	**1,461**	**638**	**640**	**1,517**	**2,310**	**3,059**

**This strategy is for infrastructure required to access the subordination supplies and is not included in the total to avoid double counting. The amount shown above is limited to the supply available from the subordination strategy.*

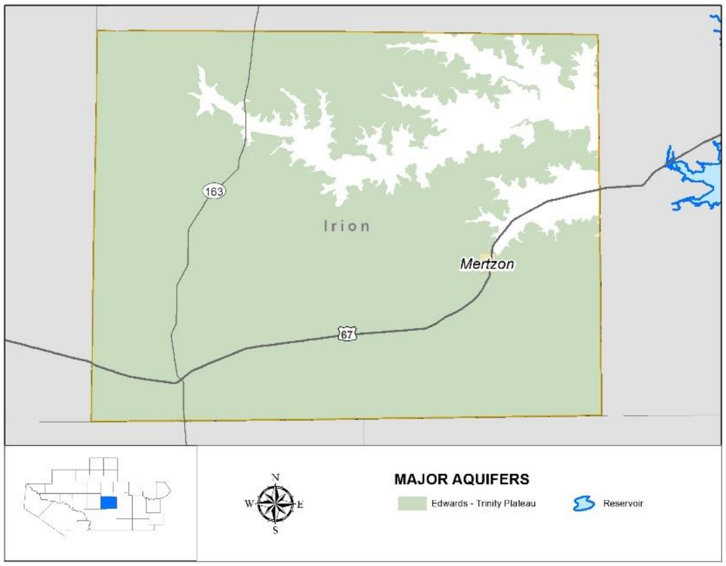
5E.11.2 Howard County Summary

All shortages in Howard County are met when considering subordination of the supplies from CRMWD. For this supply to be fully utilized, Big Spring will need a new water treatment plant in 2020 to access their subordination supplies. Conservation is also recommended as a strategy for municipal, irrigation, and mining users.

Table 5E- 26
Howard County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Big Spring	Sales from CRMWD	830	2,420	Municipal Conservation Subordination of CRMWD supplies New WTP (20 MGD)
Coahoma	Sales from Big Spring	51	152	Municipal Conservation Obtain contractual supplies from Big Spring
County-Other	Ogallala Aquifer, Dockum Aquifer, Edwards-Trinity Plateau Aquifer	None	None	None
Irrigation	Ogallala Aquifer, Dockum Aquifer, Edwards-Trinity Plateau Aquifer	None	None	Irrigation Conservation
Livestock	Livestock Local Supplies, Ogallala Aquifer, Edwards-Trinity Plateau Aquifer, Dockum Aquifer	None	None	None
Manufacturing	Sales from Big Spring, Ogallala Aquifer, Edwards-Trinity Plateau Aquifer	147	424	Supplies from Big Spring
Mining	Brackish sales from CRMWD, Ogallala Aquifer, Dockum Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	Sales from Big Spring, Ogallala Aquifer	----		----

5E.12 Irion County



The majority of the water supply for Irion County is derived from the Edwards-Trinity Plateau Aquifer. In addition to this groundwater supply, mining users obtain some water from other aquifers in the county, such as the Dockum and Lipan. Irrigators also have a small run-of-river supply and livestock has some local supplies. Current sources of supply are shown to be adequate to meet demands for all users throughout the planning horizon, except for irrigation and mining.

5E.12.1 Irion County Mining

Mining demands in Irion County have historically been met through the use of groundwater. However, the sharp increase in demands in early decades requires the development of additional groundwater supplies. In addition, the mining industry is actively pursuing recycling technologies to help meet its needs. For planning purposes, this is classified as mining conservation, and is considered as a recommended strategy. Conservation is discussed in further detail in Chapter 5B. The modeled available groundwater in Irion County is inadequate to meet the entire demand in early decades and there are few other options to meet the mining shortage. As a result, mining will have an unmet need. Mining is an exempt use and it is anticipated that mining users will continue to develop groundwater as needed, even if it exceeds the MAG.

5E.12.2 Irion County Irrigation

Irion County Irrigation has an unmet need. This need can be partially alleviated by conservation and weather modification strategies. Irion County lies within the West Texas Weather Modification Association program, where active precipitation enhancement is currently occurring. Both of these strategies are discussed in Chapter 5B.

Potentially Feasible Water Management Strategies Considered for Irion County Irrigation:

- Irrigation Conservation
- Weather Modification

Irion County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Weather Modification

The West Texas Weather Modification Association attributes an annual increase of 2.62 inches of rainfall over Irion County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 923 irrigated acres in Irion County, implementation of this strategy is expected to save 202 acre-feet of water per year at a unit cost of $0.21 per acre-feet.

Table 5E- 27
Recommended Water Strategies for Irion County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		1,053	1,053	1,053	1,053	1,053	1,053
Existing Supply (Groundwater, Run-of-River Supply)		546	546	546	546	546	546
Shortage		507	507	507	507	507	507
Recommended Strategies							
Irrigation Conservation	$120,000	53	105	158	158	158	158
Weather Modification	$0	202	202	202	202	202	202
TOTAL	**$120,000**	**255**	**307**	**360**	**360**	**360**	**360**

5E.12.3 Irion County Summary

Needs in Irion County are associated with the mining and irrigation industries. In the early decades, the mining need is nearly 1,800 acre-feet. By 2050, the demand drops significantly and there is no projected shortage. There will be unmet needs for irrigation and mining, even after conservation measures, due to a lack of viable alternatives.

Table 5E- 28
Irion County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Mertzon	Edwards-Trinity Plateau Aquifer	None	None	Municipal Conservation
County-Other	Edwards-Trinity Plateau Aquifer	None	None	None
Irrigation	Edwards-Trinity Plateau Aquifer, Run-of-River	507	507	Irrigation Conservation Weather Modification
Livestock	Stock Ponds, Edwards-Trinity Plateau Aquifer	None	None	None
Manufacturing	Edwards-Trinity Plateau Aquifer	None	None	None
Mining	Dockum Aquifer, Lipan Aquifer, Edwards-Trinity Plateau Aquifer, Well Field Recycling	1,766	0	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

Table 5E- 29
Unmet Needs in Irion County
-Values are in Acre Feet per Year-

Water User Group	2020	2030	2040	2050	2060	2070
Irrigation	252	200	147	147	147	147
Mining	1,444	1,440	225	0	0	0

5E.13 Kimble County

Kimble County has limited groundwater and surface water supplies. Surface water supplies from the South Llano River are severely limited, even under subordination. Most of the groundwater in Kimble County is derived from the Edwards-Trinity Plateau aquifer. While there is some remaining availability shown for future groundwater development from this source, wells in this area often have low production rates and can be plagued with water quality issues. The majority of Kimble County's shortages are for irrigation and manufacturing. Manufacturing shortages are mainly due to artificially inflated demands caused by the difference in diversion rates and actual consumptive use. The City of Junction also has a municipal shortage due to limited supplies from their run-of-river right.

5E.13.1 Junction

The City of Junction obtains all of its supply from a run-of-river right on the South Llano River. Under strict priority, this right has no supply. In previous plans, the subordination strategy was enough to meet all of the City's needs. However, the drought has reduced the amount of reliable yield from subordination and other water management strategies must be considered to meet the shortage for the City of Junction.

Junction Recommended Strategies

- Municipal Conservation
- Dredge River Intake to Access Subordination Supplies
- Develop Edwards-Trinity Plateau Aquifer Supplies

Potentially Feasible Water Management Strategies Considered for Junction:

- Municipal Conservation
- Dredge River Intake to Access Subordination Supplies
- Develop Edwards-Trinity Plateau Aquifer Supplies

Dredge River Intake to Access Subordination Supplies

The City is considering dredging their river intake to ensure the ongoing use of their run-of-river supply by removing sedimentation and rocks that have built up over time. This project allows the City of Junction to fully access their subordination supply by increasing the City's storage capacity and improving accessibility to their surface water. This strategy is estimated to cost $7.5 million dollars assuming the dredged material is relatively clean and a suitable location for disposal of the waste material can be found nearby.

Develop Edwards-Trinity Plateau Aquifer Supplies

Water from the Edwards-Trinity Plateau aquifer is not widely used because of low well yields in most areas. Some areas have poor water quality as well. However, there appears to be some areas within the county that have sufficient well yields for supplemental supplies to Junction. This strategy assumes that seven new wells would be drilled to provide approximately 370 acre-feet per year. Water quality from this source is assumed to have elevated salts and would be blended with surface water. However, if it is determined that the water qualities of the two sources are incompatible, the groundwater may require advanced treatment. The capital cost is estimated at $3.6 million. Costs for advanced treatment are not included.

Table 5E- 30
Recommended Water Strategies for Junction

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		626	620	609	605	604	604
Existing Supply (Run-of-River Supply)		0	0	0	0	0	0
Shortage (ac-ft/yr)		626	620	609	605	604	604
Recommended Strategies(ac-ft/yr)							
Municipal Conservation		8	8	8	8	8	8
Subordination (Colorado Run-of-River Supply)	$0	250	250	250	250	250	250
Dredge River Intake*	*$7,505,000*	*250*	*250*	*250*	*250*	*250*	*250*
Develop Edwards-Trinity Plateau Aquifer Supplies	$3,634,000	370	370	370	370	370	370
TOTAL	**$11,139,000**	**628**	**628**	**628**	**628**	**628**	**628**

**This strategy is for infrastructure required to access the subordination supplies and is not included in the total to avoid double counting.*

5E.13.2 Kimble County Manufacturing

Manufacturing demand in Kimble County is dominated by Grayden Cedarworks. The cedar process plant currently diverts around 500-600 acre-feet per year but can only consume 50 acre-feet per year, per its water right. The remainder of the diversions must be returned to the streams for downstream water-right holders. This difference in diversions and consumptive use artificially inflates the manufacturing demands in Kimble County. To address this discrepancy, the quantity of water that can reliably be diverted under subordination was assessed for the Grayden Cedarworks water right. Additional information on subordination can be found in Chapter 5C.

Kimble County Manufacturing Recommended Strategies

- Subordination
- Develop Ellenburger San Saba Aquifer Supplies

Potentially Feasible Water Management Strategies Considered for Kimble County Manufacturing:

- Subordination
- Develop Ellenburger San Saba Aquifer Supplies

Develop Ellenburger-San Saba Aquifer Supplies

Water from the Ellenburger-San Saba aquifer is not widely used because of low well yields in most areas. Some areas have poor water quality as well. However, there appears to be some areas within the county that have sufficient well yields to meet manufacturing water needs. This strategy assumes that 10 new wells would be drilled to provide approximately 500 acre-feet per year. The capital costs for this strategy are estimated to be approximately $1.6 million.

Table 5E- 31
Recommended Water Management Strategies for Kimble County Manufacturing

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		605	706	706	706	706	706
Existing Supply (Groundwater, Run-of-River Supply)		2	2	2	2	2	2
Shortage		603	704	704	704	704	704
Recommended Strategies							
Subordination	$0	228	228	228	228	228	228
Develop Ellenburger-San Saba Aquifer Supplies	$1,621,000	500	500	500	500	500	500
TOTAL	**$1,621,000**	**728**	**728**	**728**	**728**	**728**	**728**

5E.13.3 Kimble County Summary

Irrigation and manufacturing account for most of the need in Kimble County, with the City of Junction showing a projected need of 626 acre-feet per year in 2020 and 604 acre-feet per year in 2070. All of Junction's needs can be met through conservation, subordination, dredging, and new groundwater. Manufacturing needs can also be met with subordination and new groundwater, but irrigation continues to show a shortage after strategies are implemented.

Table 5E- 32
Kimble County Summary

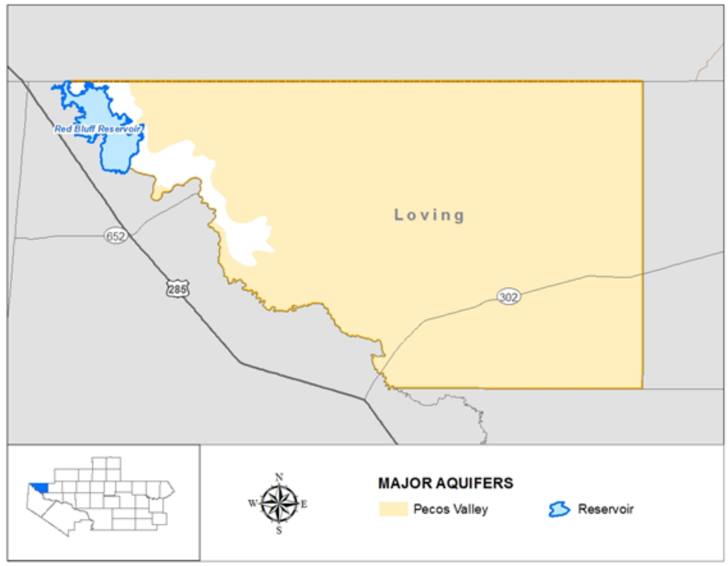
Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Junction	Run-of-River	626	604	Municipal Conservation, Subordination, Develop Edwards-Trinity Aquifer, Dredging
County-Other	Edwards-Trinity Plateau Aquifer	None	None	None
Irrigation	Edwards-Trinity Plateau Aquifer, Hickory Aquifer, Run-of-River	1,103	1,103	Irrigation Conservation
Livestock	Edwards-Trinity Plateau Aquifer, Livestock Local Supplies	None	None	None
Manufacturing	Run-of-River, Edwards-Trinity Plateau Aquifer	603	704	Develop Ellenburger-San Saba Aquifer Supplies, Subordination
Mining	Edwards-Trinity Plateau Aquifer, Run-of-River	None	None	Mining Conservation (Recycling)
Steam Electric	----	----		----

Table 5E- 33
Unmet Needs in Kimble County
-Values are in Acre Feet per Year-

Water User Group	2020	2030	2040	2050	2060	2070
Irrigation	970	837	784	784	784	784

5E.14 Loving County

Loving County is solely reliant on local groundwater sources to supply its water users, including the Pecos Valley, Dockum, and Rustler aquifers. Most demands in the county are relatively small (less than 50 ac-ft) and can be met with these supplies. However, mining water demands are projected to be as much as 7,500 acre-feet per year in 2020 due to the recent, rapid growth in oil and gas production. Due to the limited groundwater supplies available in Loving County, water shortages were identified for mining users throughout the planning horizon. The only recommended strategy in Loving County is conservation/recycling for mining. This strategy is discussed in detail in Chapter 5B. Mining users will still show an unmet need after conservation due to the limited groundwater availability in the county. Since mining is an exempt use, it is likely mining will continue to rely on and develop groundwater, even if it exceeds the MAG.



5E.14.1 Loving County Summary

Mining in Loving County is identified to have a water shortage throughout the planning horizon, particularly in early decades. Mining conservation (well field recycling) is a recommended strategy, however, due to MAG limitations, there are unmet water needs shown for mining users. All other water user groups in Loving County have sufficient water supplies to meet demands and have no shortages.

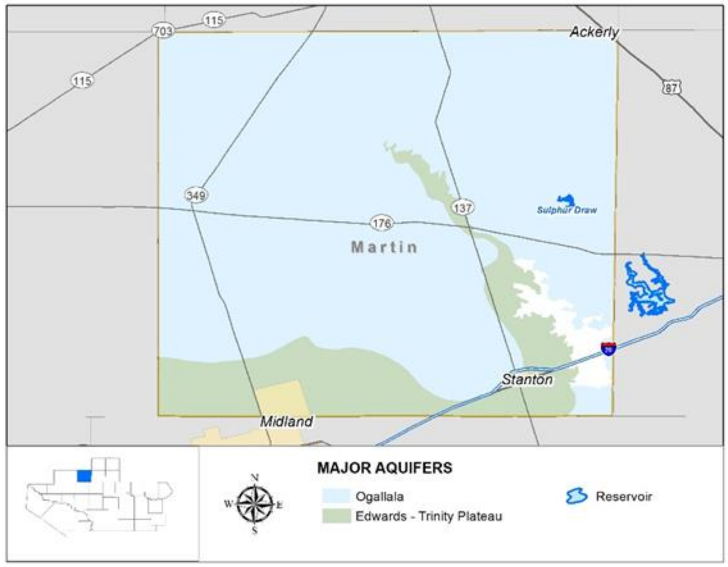
Table 5E- 34
Loving County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
County-Other	Pecos Valley Aquifer	None	None	None
Irrigation	----	----	----	----
Livestock	Livestock Local Supplies, Pecos Valley Aquifer, Dockum Aquifer	None	None	None
Manufacturing	----	----	----	----
Mining	Pecos Valley Aquifer	3,906	1,000	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

Table 5E- 35
Unmet Needs in Loving County
-Values are in Acre Feet per Year-

Water User Group	2020	2030	2040	2050	2060	2070
Mining	3,381	3,381	2,543	1,427	699	762

5E.15 Martin County



Martin County has limited surface water and groundwater supplies. Groundwater from the Ogallala aquifer is the primary source for most water users. In early decades, this source is shown to have supplies in excess of demands. However, the MAG availability decreases significantly over time, resulting in shortages for irrigators beginning in 2050. Other local groundwater sources include the Dockum and Edwards-Trinity Plateau aquifers, which have diminished water quality and are not currently used in Martin County. Outside of groundwater, Stanton purchases water from CRMWD and mining receives wastewater reuse supplies from Odessa and Midland.

Beginning in 2050, there are shortages for Martin County irrigation due to the limited amount of available groundwater under the MAG. The City of Stanton is also shown to have a shortage from 2050 to 2070, however, this shortage is met through subordination of CRMWD's supplies.

5E.15.1 Martin County Summary

Martin County has a total projected shortage of nearly 5,000 acre-feet per year by 2070. Most of these shortages are associated with the limitations of the supplies from the Ogallala aquifer based on the adopted MAGs. Irrigation shortages deepen despite conservation due to Midland's strategy to use additional supplies from the Paul Davis well field that is partially located in Martin County. The remaining shortage in Martin County is associated with Stanton, which receives subordination supplies from CRMWD and municipal conservation to meet its needs.

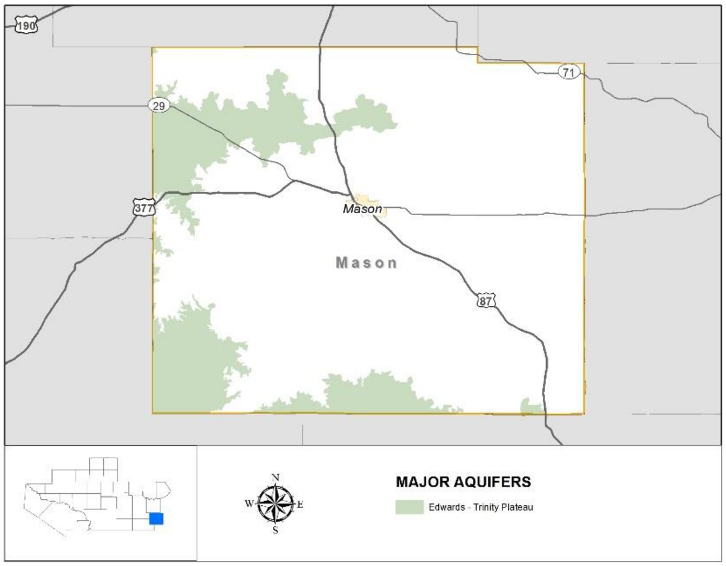
Table 5E- 36
Martin County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Strategies
Stanton	Run-of-River, Direct Reuse, Ogallala Aquifer, Pecos Aquifer	0	90	Municipal Conservation Subordination
County-Other	Ogallala Aquifer	None	None	None
Irrigation	Ogallala Aquifer	0	4,729	Irrigation Conservation
Livestock	Ogallala Aquifer, Livestock Local Supplies	None	None	None
Manufacturing	Ogallala Aquifer	None	None	None
Mining	Ogallala Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

Table 5E- 37
Unmet Needs in Martin County
-Values are in Acre-Feet per Year-

Water User Group	2020	2030	2040	2050	2060	2070
Irrigation	0	0	2,392	3,346	6,004	7,844

5E.16 Mason County



Mason County is dependent on groundwater supplies from the Hickory, Marble Falls, Ellenburger-San Saba, and undifferentiated Other aquifers. The only need identified over the planning horizon in Mason County is for the City of Mason. The City of Mason has experienced issues related to quality and will need to pursue additional treatment to be in compliance with TCEQ regulations. Conservation is recommended for the City of Mason, as well as for irrigation and mining users to preserve water for future and other uses. Conservation is discussed in detail in Chapter 5B. Conservation is not recommended for County-Other since there is no water shortage. Table 5E- 62 shows a summary of supplies, shortages and recommended strategies for Mason County.

5E.16.1 Mason

The City of Mason is supplied by groundwater from the Hickory aquifer. While there is enough volume of groundwater available, the water quality suffers due to naturally occurring radioactive materials and the supply exceeds the Maximum Contaminant Level (MCL) for gross alpha particles. Consequently, additional treatment will be necessary for Mason to continue to use this source.

Mason Recommended Strategies

- Municipal Conservation
- Additional Water Treatment

Potentially Feasible Water Management Strategies Considered for Mason:

- Municipal Conservation
- Additional Water Treatment

Additional Water Treatment

Mason is actively pursuing the development of a hydrous manganese oxide (HMO) treatment system to remove radium-226 and -228 from their water supply and become compliant with the MCL. The City has already received funding from the TWDB and working on implementation.

Table 5E- 38
Recommended Water Management Strategies for Mason

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		700	690	682	677	676	676
Supply (Groundwater)		0	0	0	0	0	0
Shortage (ac-ft/yr)		700	690	682	677	676	676
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	7	7	7	7	7	7
Additional Water Treatment	$2,605,000	700	690	682	677	676	676
TOTAL	**$2,605,000**	**707**	**697**	**689**	**684**	**683**	**683**

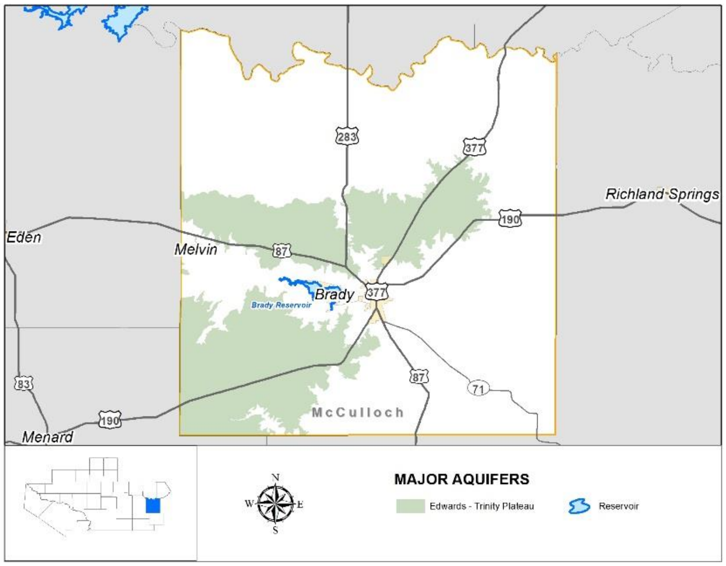
5E.16.2 Mason County Summary

The City of Mason is the only water user group identified with a shortage in Mason County, due to water quality issues with the City's groundwater supply. In order to treat this supply and become compliant with maximum contaminant level (MCL) standards for water quality, additional water treatment is a recommended strategy for the City of Mason. Municipal conservation is also recommended for the City. Otherwise, conservation is recommended for irrigation and mining users in Mason County.

Table 5E- 39
Mason County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Mason	Hickory Aquifer	700	676	Municipal Conservation Additional Water Treatment
County-Other	Ellenburger-San Saba Aquifer, Hickory Aquifer, Other Aquifer	None	None	None
Irrigation	Hickory Aquifer	None	None	Irrigation Conservation
Livestock	Livestock Local Supplies, Ellenburger-San Saba Aquifer, Hickory Aquifer	None	None	None
Manufacturing	----	----	----	----
Mining	Hickory Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.17 McCulloch County



McCulloch County has limited surface water and groundwater supplies. Some surface water is used from Lake Brady and CRMWD sources for the City of Brady and Millersview Doole WSC, respectively. Water quality from Lake Brady and the Hickory aquifer is impaired and either requires advanced treatment or blending with a high quality source for municipal use. Groundwater from the Hickory and Ellenburger-San Saba aquifers are the primary sources for other water users. The only shortage identified in McCulloch County is for the City of Brady. When subordination of the Brady Creek Reservoir is considered, Brady can blend their surface water supplies with their groundwater supplies to achieve acceptable water quality levels and a total supply to meet their demands. Conservation strategies are also identified for municipal (Brady, Millersview-Doole WSC, Richland SUD), irrigation and mining users. These strategies are discussed in Chapter 5B.

5E.17.1 Brady

The City of Brady obtains water from groundwater wells in the Hickory aquifer and surface water from Brady Creek Reservoir. The City has capacity to produce about 1,200 acre-feet of groundwater per year. The groundwater is used conjunctively with their surface water, so in some years the City may rely heavily on groundwater and exceed this amount; in other years they may use little to no groundwater. To address surface water quality concerns, the City constructed one of the first membrane filtration treatment plants in Texas for water from Brady Creek Reservoir in 2000. Water from the reservoir was then blended with Hickory groundwater to reduce radium levels. Brady Creek Reservoir has no supplies under WAM Run 3 but subordination does show supplies. While these subordinated supplies may be available in some years, drought has severely impacted Brady Creek Reservoir and the supply is not always reliable. Without surface water supplies to blend with the Hickory supplies, the City is above the TCEQ requirements for radionuclides and gross alpha particles. In order to conjunctively use the supplies made available through subordination with groundwater from the Hickory, new advanced treatment will be required. The recommended strategies for Brady are municipal conservation, subordination and advanced treatment. Conservation and subordination are discussed in Chapters 5B and 5C respectively.

Brady Recommended Strategies

- Municipal Conservation
- Subordination (Brady Creek Reservoir)
- Advanced Groundwater Treatment

Potentially Feasible Water Management Strategies Considered for the City of Brady:

- Municipal Conservation
- Subordination (Brady Creek Reservoir)
- Advanced Groundwater Treatment

Advanced Groundwater Treatment

To address water quality issues when surface water from Brady Creek Reservoir is not available, the City plans to pursue the development of an advanced groundwater treatment facility to come into compliance with TCEQ water quality requirements. This facility is sized to treat the full capacity of Brady's groundwater well field (1,200 acre-feet per year).

Table 5E- 40
Recommended Water Strategies for Brady

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		1,396	1,425	1,407	1,415	1,417	1,419
Supply (Surface Water, Groundwater)		0	0	0	0	0	0
Shortage (ac-ft/yr)		1,396	1,425	1,407	1,415	1,417	1,419
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	18	18	19	19	19	19
Subordination (Brady Creek Reservoir)	$0	841	841	841	841	841	841
Advanced Groundwater Treatment	$29,719,000	1,200	1,200	1,200	1,200	1,200	1,200
TOTAL	**$29,719,000**	**2,059**	**2,059**	**2,060**	**2,060**	**2,060**	**2,060**

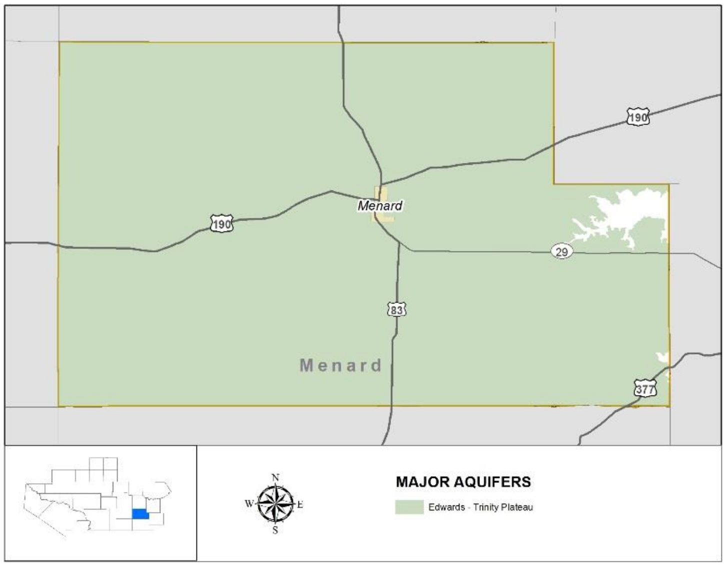
5E.17.2 McCulloch County Summary

The total need for McCulloch County is projected to be around 1,400 acre-feet per year throughout the planning horizon. This shortage is primarily due to the City of Brady's groundwater quality and lack of firm supplies in the Brady Creek Reservoir. However, when considering subordination of the Brady Creek Reservoir, Brady can blend their groundwater with surface water to achieve an acceptable water quality and have enough supplies to meet their needs. However, since the surface water supplies can be unreliable during drought conditions, additional advanced treatment is recommended so that the City has adequate supplies that meet drinking water standards when they must rely solely on groundwater. Conservation strategies are also recommended for municipal, mining, and irrigation users, which will decrease the reliance on current water supplies. These strategies are discussed further in Chapter 5B.

Table 5E- 41
McCulloch County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Strategies
Brady	Brady Reservoir, Hickory Aquifer	1,396	1,419	Municipal Conservation, Subordination, Treatment
Millersview-Doole WSC	CRMWD Supplies, Hickory Aquifer	None	None	Municipal Conservation, Subordination (CRMWD supplies)
Richland SUD	Ellenburger-San Saba Aquifer, Marble Falls Aquifer	None	None	Municipal Conservation
Irrigation	Run-of-River, Hickory Aquifer, Marble Falls Aquifer	None	None	Irrigation Conservation
County-Other	Hickory Aquifer, Other Aquifer, Sales from Brady	None	None	None
Livestock	Edwards-Trinity Plateau Aquifer, Ellenburger-San Saba, Hickory Aquifer, Marble Falls Aquifer, Other Aquifer, Local Supplies	None	None	None
Manufacturing	Hickory Aquifer, Edwards-Trinity Plateau Aquifer	None	None	None
Mining	Ellenburger-San Saba Aquifer, Hickory Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	--	--	--	----

5E.18 Menard County



Water users in Menard County obtain their water supplies from the San Saba River and local groundwater, including the Ellenburger-San Saba and Edwards-Trinity Plateau aquifers. The Hickory aquifer also underlies Menard County, but it is not currently used due to the depth of the formation and presence of radionuclides. The ongoing drought has reduced the reliability of the county's surface water supplies, resulting in shortages for the City of Menard.

5E.18.1 Menard

The City of Menard has several wells near the banks of the San Saba River that produce water from the San Saba River Alluvium. Reduced flows in the San Saba River during a severe drought have the potential to reduce the City's available supply. For the purposes of this plan, supplies for the City of Menard are considered to be surface water. However, recent actions by state agencies have re-classified the City's supply as groundwater. Based on the Colorado WAM through 2013, Menard is shown to have a shortage of about 200 acre-feet per year under drought of record conditions.

During the recent drought the City relied on water conservation and drought management to prevent shortages. Although this strategy proved successful, the City desires to increase the reliability of its supplies by developing a groundwater source. The City is currently considering developing a well in the Hickory aquifer. In addition, the City is interested in developing a direct reuse project for agricultural irrigation of the City Farm.

Previously Evaluated and Dismissed Water Management Strategies:

- San Saba Off-Channel Reservoir

Potentially Feasible Water Management Strategies Considered for Menard:

- Direct Non-Potable Reuse
- Develop Hickory Aquifer Supplies

Menard Recommended Strategies

- Municipal Conservation
- Direct Non-Potable Reuse
- Develop Hickory Aquifer Supplies

Direct Non-Potable Reuse

The City is interested in developing a direct reuse project for agricultural irrigation of the City Farm. This strategy assumes that the current WWTP will need to construct the necessary improvements in order to bring a portion of the plant's effluent to Type 1 standards. This strategy will cost approximately $700,000 and will yield 67 additional acre-feet per year.

Develop Hickory Aquifer Supplies

The City is planning to drill one well near its existing storage tank to provide approximately 200 acre-feet per year. This strategy assumes that the source can be blended with the City's other sources to meet safe drinking water standards. This strategy will cost approximately $3.3 million and will yield 200 additional acre-feet per year.

Table 5E- 42
Recommended Water Strategies for Menard

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		350	342	336	335	335	335
Supply (Run-of-River Supply)		139	139	139	139	139	139
Shortage (ac-ft/yr)		211	203	197	196	196	196
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	5	5	5	5	5	5
Reuse	$696,500	67	67	67	67	67	67
Develop Hickory Aquifer Supplies	$3,287,000	200	200	200	200	200	200
TOTAL	**$3,983,500**	**272**	**272**	**272**	**272**	**272**	**272**

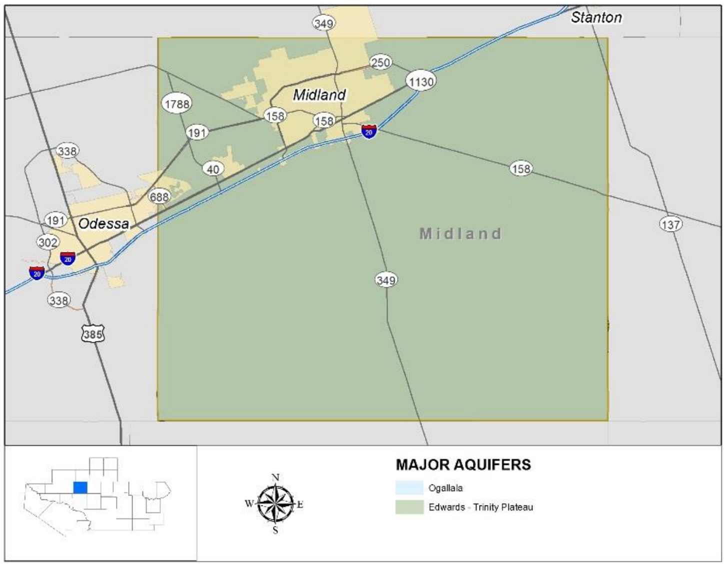
5E.18.2 Menard County Summary

Menard County is projected to have a shortage of 211 acre-feet per year in 2020 and 196 acre-feet per year in 2070. This shortage is associated with the City of Menard. The City can meet its projected needs with the recommended water management strategies. Conservation is also recommended for Mining despite there being no shortage. County-Other, Livestock and Manufacturing show no shortages and have no recommended strategies.

Table 5E- 43
Menard County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Menard	River wells	211	196	Municipal Conservation, Develop Hickory Aquifer Supplies, Direct Non-Potable Reuse
County-Other	Edwards-Trinity Plateau Aquifer, Ellenburger-San Saba Aquifer, Other Aquifer	None	None	None
Irrigation	Run-of-River	None	None	Irrigation Conservation
Livestock	Livestock Local Supplies, Edwards-Trinity Plateau Aquifer, Ellenburger-San Saba Aquifer, Other Aquifers	None	None	None
Manufacturing	Sales from Menard	None	None	None
Mining	Edwards-Trinity Plateau Aquifer, Ellenburger-San Saba Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.19 Midland County



Midland County has experienced high population growth in recent years due to the increased interest in oil and gas exploration in the region. Most of the water supply for Midland County comes from sales from the CRMWD system or groundwater. The only shortages in Midland County are associated with the City of Midland. The City of Midland is classified as a major water provider and is discussed in Chapter 5D. While there are no identified needs for County-Other, several local providers are planning new projects to serve the growing rural communities. Conservation is recommended for irrigation and mining users, despite there being no shortage for either user. Details on all conservation strategies may be found in Chapter 5B. Livestock and manufacturing show no shortages and have no recommended strategies.

5E.19.1 Midland County-Other

Midland County-Other currently obtains water from local groundwater aquifers, including the Ogallala and Edwards-Trinity Plateau aquifers. The plan assumes that these users will continue to obtain water from these sources to meet the projected demands and Midland County-Other shows no shortage. However, Midland County Utility District (which is included in Midland County-Other) is considering developing additional groundwater in conjunction with the Midland County Fresh Water District (FWD) from the Roark Ranch property. This strategy would expand groundwater supplies from the Pecos Valley aquifer in Winkler County and would be transported by the Midland County FWD pipeline to the greater Midland area. This strategy is a recommended strategy for Midland County Utility District (County-Other).

Midland County-Other Recommended Strategies

- Develop Pecos Valley Aquifer Supplies from Roark Ranch in Winkler County

Potentially Feasible Water Management Strategies Considered for Midland County-Other:

- Develop Pecos Valley Aquifer Supplies from Roark Ranch in Winkler County

Develop Pecos Valley Aquifer Supplies from Roark Ranch in Winkler County

For planning purposes, the strategy was assumed to provide up to 2,800 acre-feet of additional water to County-Other in Midland County. It is assumed that 15 new wells would be drilled in Winkler County and connected to the existing T-Bar infrastructure, if agreements can be reached with the Midland County FWD and the City of Midland to provide this capacity in the transmission line from the T-Bar Well Field. For this strategy, no treatment is included. This supply is considered reliable, but the use of the T-Bar infrastructure may limit the supplies when Midland is using the full capacity of the system. The capital cost of this strategy is $24.6 million, not including the purchase of the groundwater rights which is considered complete for the purposes of this plan.

Table 5E- 44
Recommended Strategies for Midland County-Other

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		3,253	3,506	3,689	4,050	4,441	4,819
Supply (Groundwater)		3,253	3,506	3,689	4,050	4,441	4,819
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Develop Pecos Valley Aquifer Supplies from Roark Ranch in Winkler Co.	$24,557,000	2,800	2,800	2,800	2,800	2,800	2,800
TOTAL	**$24,557,000**	**2,800**	**2,800**	**2,800**	**2,800**	**2,800**	**2,800**

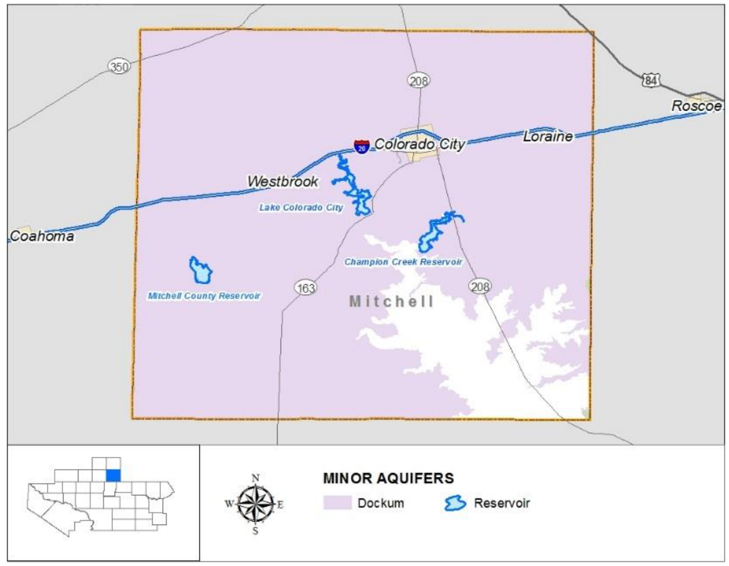
5E.19.2 Midland County Summary

The total need for Midland County is projected to be around 18,700 acre-feet per year by 2070, which is all associated with the City of Midland. Some of this need will be met with conservation and subordination, but the City of Midland is pursuing other sources of water for development to close the remaining gap. One of these strategies is the West Texas Water Partnership, which is estimated to provide 15,000 acre-feet per year to the City. The details of this strategy were not available for the publication of the Initially Prepared Region F Plan but are anticipated to be included in the final version of the Region F plan. Another strategy includes advanced treatment and additional use of water from Midland's Paul Davis well field. Additional information on the City of Midland and their strategies can be found in Chapter 5D.

Table 5E- 45
Midland County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Airline Mobile Home Park LTD	Edwards-Trinity Plateau, Aquifer, Ogallala Aquifer	None	None	Municipal Conservation
Greenwood Water	Ogallala Aquifer	None	None	Municipal Conservation
Greater Gardendale WSC	See Section 5E.9 for Ector County			
Midland	See Chapter 5D for Major Water Providers			
Odessa	See Chapter 5D for Major Water Providers			
County-Other	Edwards-Trinity Plateau Aquifer, Ogallala Aquifer	None	None	Develop Pecos Valley Aquifer Supplies from Roark Ranch in Winkler Co.
Irrigation	Edwards-Trinity Plateau Aquifer, Ogallala Aquifer	None	None	Irrigation Conservation
Livestock	Livestock Local Supplies, Edwards-Trinity Plateau Aquifer, Ogallala Aquifer	None	None	None
Manufacturing	Sales from Midland, Edwards-Trinity Plateau Aquifer, Ogallala Aquifer	None	None	None
Mining	Edwards-Trinity Plateau Aquifer, Ogallala Aquifer, Reuse, Well Field Recycling	None	None	Mining Conservation (Recycling)
Steam Electric	----	----		----

5E.20 Mitchell County



Most of the water users in Mitchell County obtain their water supplies from the Dockum aquifer. The only current surface water supply sources are a small amount of run-of river supplies used for irrigation and the Champion Creek/ Lake Colorado City system, which is used for cooling for a power plant. Mitchell County Reservoir is a brackish lake that is part of the CRMWD diverted water system. Colorado City, irrigation, and steam electric power were all identified with a shortage.

5E.20.1 Colorado City

Colorado City supplies their own municipal retail customers, manufacturing, and Westbrook (Mitchell County-Other). Colorado City obtains its water from the Dockum aquifer. The City had 11 active wells with a production capacity of about 2,100 gpm. As water levels decline over time, the capacities also declined. During the last drought, the well field had difficulty in meeting the City's demands. As a result, the City added two wells to increase their system capacities and maintain sufficient supplies during drought. However, one of the new wells produces water high in sulfides and requires blending before use. There are also concerns related to possible oil field contamination. Therefore, Colorado City is planning to pursue additional wells. However, the supply from Dockum in Mitchell County is limited by the MAG. Therefore, the well field expansion strategy is recommended as an alternate strategy until such time that the MAGs increase.

Colorado City Recommended Strategies

- Municipal Conservation
- Dockum Well Field Expansion is considered Alternative due to MAG limitations

FGE Power (part of the steam electric power demand in Mitchell County) has potential plans to develop two new combined cycle gas turbine facilities in Mitchell County. The plans have been delayed numerous times and at the writing of this plan, it is unclear if or when these facilities may come online. In the event FGE moves forward with the construction of their plant, Colorado City plans to sell their wastewater supplies to FGE. This is included in the Region F plan as a strategy for steam electric power.

Potentially Feasible Water Management Strategies Considered for Colorado City:

- Municipal Conservation
- Dockum Well Field Expansion

Dockum Well Field Expansion

This total capital cost to develop this strategy amount to $3.7 million and could potentially yield 170 acre-feet of additional water per year. Total costs include the construction of 2 new wells and the necessary piping infrastructure. However, the supply volume exceeds the current MAG in the Dockum aquifer. Consequently, this strategy is listed as alternative, rather than recommended, but should be considered for future supplies should the DFC and MAG change in future planning cycles.

Table 5E- 46
Recommended Water Strategies for Colorado City

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		1,342	1,475	1,486	1,497	1,510	1,525
Supply (Groundwater)		1,342	1,342	1,342	1,342	1,342	1,342
Shortage (ac-ft/yr)		0	133	144	155	168	183
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	16	18	18	18	18	19
Alternative Strategies (ac-ft/yr)							
Dockum Well Field Expansion	$3,744,000	170	170	170	170	170	170

5E.20.2 Mitchell County Steam Electric Power

Luminant's Morgan Creek Power Plant is located in Mitchell County and obtains water from the Lake Colorado City – Champion Creek Reservoir system, which only has available supply under subordination. There are also two proposed facilities, FGE I and II, that are included in the steam electric power demand in Mitchell County. The proposed facilities would be combined cycle gas turbine plants, which tend to use less water than conventional power generation. However, these facilities are speculative and do not yet exist. The development of these facilities will depend on market conditions and other economic factors. If FGE does develop a new power plant in Mitchell County, they plan to purchase reuse supplies from the City of Colorado City's wastewater plant. This is included as a recommended strategy for steam electric power in Mitchell County. However, there still is a significant projected shortage, even after subordination and reuse. The options to meet this need are limited since there is little available groundwater in the county that is not already being used by another entity. Therefore, the remainder of the need remains unmet. However, some of this need may never come to fruition if FGE does not move forward with the two new facilities.

Potentially Feasible Water Management Strategies Considered for Mitchell County steam electric power:

- Subordination (Lake Colorado City/Champion Lake)
- Sale of Wastewater Effluent from Colorado City

Mitchell County Steam Electric Power Recommended Strategies

- Subordination (Lake Colorado City/Champion Lake)
- Sale of Wastewater Effluent from Colorado City

Sale of Wastewater Effluent from Colorado City

Colorado City plans to sell their wastewater effluent to FGE Texas Power I to use as cooling water for a new power plant. It assumed no upgrades to the City's wastewater plant are needed to implement this strategy. A 10-inch, 10-mile pipeline and associated pump stations and storage are assumed.

Table 5E- 47
Recommended Water Strategies for Mitchell County Steam Electric Power

	Capital Cost (millions)	2020	2030	2040	2050	2060	2070
Demand		10,326	10,326	10,326	10,326	10,326	10,326
Supply (Champion Lake)		0	0	0	0	0	0
Shortage (ac-ft/yr)		10,326	10,326	10,326	10,326	10,326	10,326
Recommended Strategies (ac-ft/yr)							
Subordination (Champion Lake)	$0	1,170	1,156	1,142	1,128	1,114	1,100
Reuse Sales from Colorado City	$8,642,000	500	500	500	500	500	500
TOTAL	**$8,642,000**	**1,670**	**1,656**	**1,642**	**1,628**	**1,614**	**1,600**

5E.20.3 Mitchell County Summary

Mitchell County is projected to have shortages associated with Colorado City, steam electric power, and irrigation. Colorado City can meet its municipal needs after developing additional groundwater supplies, though this cannot be fully represented in the regional plan due to MAG limitations. Steam electric power has a large unmet need associated with a speculative demand for two new CCGT plants that may or may not be developed. Irrigation also has an unmet need despite conservation. Conservation is also recommended for mining, even though there is no shortage. County-Other, livestock, manufacturing, and mining show no shortages and have no recommended strategies.

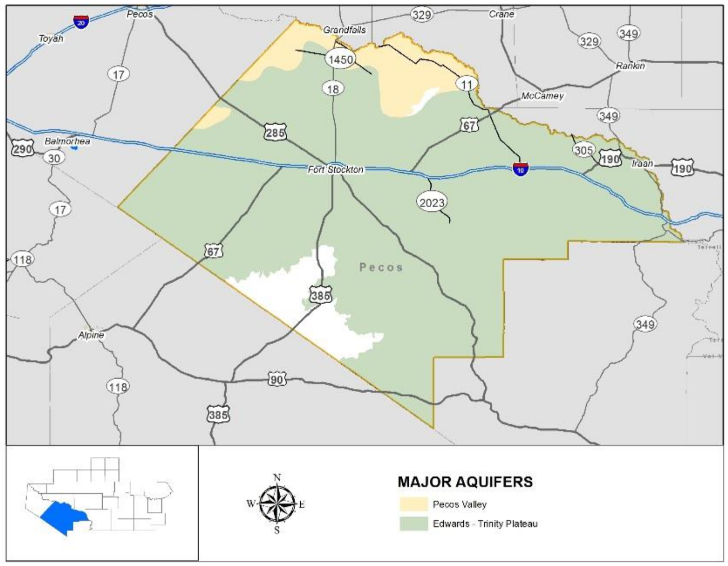
Table 5E- 48
Mitchell County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Colorado City	Dockum Aquifer	0	183	Municipal Conservation
Loraine	Dockum Aquifer	None	None	Municipal Conservation
Mitchell County Utility	Dockum Aquifer	None	None	Municipal Conservation
County-Other	Dockum Aquifer, Sales from Colorado City	None	None	None
Irrigation	Run-of-River, Dockum Aquifer	1,584	1,482	Irrigation Conservation
Livestock	Livestock Local Supplies, Dockum Aquifer, Other Aquifer	None	None	None
Manufacturing	Purchase from Colorado City	None	None	None
Mining	Dockum Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	Champion Lake	10,326	10,326	Subordination, Reuse Sales from Colorado City

Table 5E- 49
Unmet Needs in Mitchell County
-Values are in Acre-Feet per Year-

Water User Group	2020	2030	2040	2050	2060	2070
Colorado City	0	115	126	137	150	164
Irrigation	1,328	1,602	1,507	1,389	1,310	1,226
Steam Electric Power	8,656	8,670	8,684	8,698	8,712	8,726
TOTAL	**9,984**	**10,388**	**10,317**	**10,224**	**10,172**	**10,117**

5E.21 Pecos County



Pecos County relies predominantly on groundwater to meet its water needs. Pecos County is split between two Groundwater Management Areas (GMAs 3 and 7) and therefore, has two modeled available groundwater (MAG) values. Combined, the Edwards-Trinity Plateau and Pecos Valley aquifer system has over 240,000 acre-feet of modeled available groundwater. While the MAG value does not direct correspond to permit limits, the Middle Pecos Groundwater District, which is responsible for managing the aquifer to meet the Desired Future Conditions, has already issued permits in excess of 265,000 acre-feet. Historically, the permit holders have used significantly less than the permitted volume but theoretically could use the entire volume in any given year. There are other districts in Texas who have also permitted larger volumes than the MAG for some aquifers. And similar to Pecos County GCD, the historical pumping in those districts is also less than the MAG. Permits in the Rustler aquifer very slightly exceed the MAG and historical use has been near the permitted amount. The Capitan Reef and Dockum aquifers have both permitted and MAG availability, as shown in the table below.

Table 5E- 50
Modeled Available Groundwater, Permit Authorizations, and Historical Groundwater Use in Pecos Co.

Aquifer	GMA	MAG (acre-feet per year)	Permit Authorizations (ac-ft/yr)	Highest Historical Production (2014-2018) (ac-ft/yr)
Edwards-Trinity Plateau and Pecos Valley Aquifers	3	122,899	146,978	46,567
Edwards-Trinity Plateau and Pecos Valley Aquifers	7	117,309	120,205	71,554
Edwards-Trinity Pecos Valley Subtotal		***240,208***	***267,183***	***118,121***
Capitan Reef	3	4	1,796	564
Capitan Reef	7	26,164	3,347	1,536
Capitan Reef Subtotal		***26,168***	***5,143***	***2,100***
Dockum	3	6,142	0	0
Dockum	7	2,022	0	0
Dockum Subtotal		***8,164***	***0***	***0***
Rustler	3	2,378	2,378	2,378
Rustler	7	7,040	7,291	6,963
Rustler Subtotal		***9,418***	***9,669***	***9,341***

Several water user groups and major water providers in Region F have identified water supplies from Pecos County as an Alternative Water Management Strategy. It may be infeasible to develop all of these strategies, but some subset of them may be considered for implementation if an entity's recommended water management strategies were to become infeasible. However, it is beyond the scope of regional water planning to assess all of the legal, regulatory, and political facets of each Alternative Water Management Strategy.

There are limited surface water supplies within the county, which are used for irrigation purposes. Shortages within the county were identified for manufacturing and mining,. In addition, Pecos County WCID #1 expressed interest in developing specific water management strategies to increase the reliability of its supplies by diversifying their sources. Conservation is a recommended strategy for municipal, irrigation and mining use to help preserve the groundwater supplies for future use. Municipal conservation was not specifically recommended for Pecos County-Other because there are no needs.

5E.21.1 Pecos County WCID #1

Pecos County WCID #1 obtains water from the Edwards Trinity Plateau aquifer. Although no shortages were identified, developing additional groundwater supplies is a recommended strategy to increase the reliability of the WCID's current system. For this planning purpose, it is assumed that Pecos County WCID #1 will drill additional wells in the Edwards-Trinity Plateau aquifer to back up current supplies.

Potentially Feasible Water Management Strategies Considered for Pecos County WCID #1:

- Develop Edwards-Trinity Plateau Aquifer Supplies
- Transmission Pipeline Replacement

Pecos County WCID #1 Recommended Strategies

- Municipal Conservation
- Develop Edwards-Trinity Plateau Aquifer Supplies
- Transmission Pipeline Replacement

Develop Edwards-Trinity Plateau Aquifer Supplies

This strategy assumes that two new wells will be drilled and could supply up to 250 acre-feet per year. The capital costs for the wells are estimated at $3.6 million. Associated transmission costs are included as a separate strategy (see "Transmission Pipeline Replacement" below).

Transmission Pipeline Replacement

A replacement 18-inch, 20-mile transmission pipeline is included to bring the existing supplies and supplies from water management strategies to Pecos County WCID #1's distribution system. This pipeline, which would be used to transport all of the WCID's supplies, is estimated to cost $26.1 million.

Table 5E- 51
Recommended Water Strategies for Pecos County WCID #1

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		384	398	415	433	453	472
Supply (Groundwater)		384	398	415	433	453	472
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	9	10	11	11	12	12
Develop Edwards-Trinity Plateau Aquifer Supplies	$3,630,000	250	250	250	250	250	250
*Transmission Pipeline Replacement**	*$26,102,000*	*634*	*648*	*665*	*683*	*703*	*722*
TOTAL	**$29,732,000**	**509**	**509**	**509**	**509**	**509**	**509**

**This strategy is for infrastructure required to convey existing and water management strategy supplies and is not included in the total to avoid double counting. The amount shown above is the total supply available when considering current supplies and recommended water management strategies.*

5E.21.2 Pecos County Irrigation

Although Pecos County Irrigation has no projected shortages, both irrigation conservation and weather modification are recommended as water management strategies. Weather modification is recommended as a strategy because Pecos County lies within the Trans Pecos Weather Modification Association (TPWMA) precipitation enhancement area.

Potentially Feasible Water Management Strategies Considered for Pecos County Irrigation:

- Irrigation Conservation
- Weather Modification

Pecos County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Weather Modification

The TPWMA attributes an annual increase of 0.33 inches over Pecos County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 12,887 irrigated acres in Pecos County, implementation of this strategy is expected to save 106 acre-feet of water per year at a unit cost of $5.45 per acre-foot.

Table 5E- 52
Recommended Water Strategies for Pecos County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		143,345	143,345	143,345	143,345	143,345	143,345
Supply (Groundwater)		143,345	143,345	143,345	143,345	143,345	143,345
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Irrigation Conservation	$16,341,000	7,167	14,335	21,502	21,502	21,502	21,502
Weather Modification	$0	106	106	106	106	106	106
TOTAL	**$16,341,000**	**7,273**	**14,441**	**21,608**	**21,608**	**21,608**	**21,608**

5E.21.3 Pecos County Mining

Mining demands in Pecos County are projected to be as much 7,700 acre-feet per year. Currently, developed supplies are limited, and mining conservation (recycling) and additional groundwater development is recommended to meet any water shortages.

Pecos County Mining Recommended Strategies

- Mining Conservation (Recycling)
- Develop Additional Pecos Valley Aquifer Supplies

Potentially Feasible Water Management Strategies Considered for Reeves County Mining:

- Mining Conservation (Recycling)
- Develop Additional Pecos Valley Aquifer Supplies

Develop Additional Pecos Valley Aquifer Supplies

This strategy assumes that 22 new wells will need to be constructed at a 500-ft depth in order to access the additional aquifer supplies needed in the Pecos Valley aquifer. Each well is assumed to be operating at a capacity of 100 gpm. This strategy will cost approximately $492,000 and yield an additional 3,000 acre-feet of supply.

Table 5E- 53
Recommended Water Strategy for Pecos County Mining

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		7,700	7,700	7,700	6,200	4,800	3,700
Supply (Groundwater)		4,200	4,200	4,200	4,200	4,200	4,200
Shortage (ac-ft/yr)		3,500	3,500	3,500	2,000	600	500
Recommended Strategies (ac-ft/yr)							
Mining Conservation	$10,780,000	539	539	539	434	67	52
Develop Pecos Valley Aquifer Supplies	$492,000	3,000	3,000	3,000	3,000	3,000	3,000
TOTAL	**$11,272,000**	**3,539**	**3,539**	**3,539**	**3,434**	**3,067**	**3,052**

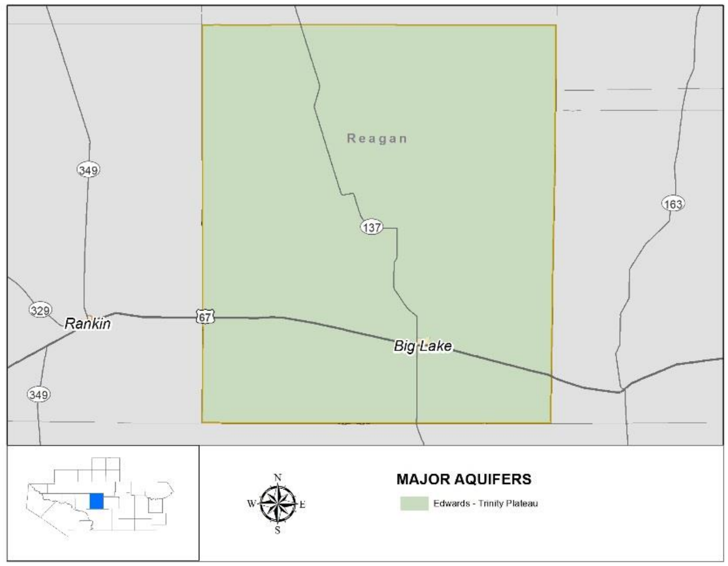
5E.21.4 Pecos County Summary

Pecos County is a groundwater rich county, but a considerable amount of the groundwater has diminished water quality. This can limit its viability for some purposes. Mining users within Pecos County have a projected shortage of around 3,500 acre-feet per year in early decades (2020 to 2040). The recommended strategy for mining users to meet this shortage is to develop additional groundwater in the Edwards-Trinity Plateau Aquifer. Furthermore, Pecos County WCID #1 is interested in diversifying their water supply sources and has a recommended strategy to develop additional groundwater. Conservation is also considered for municipal (Fort Stockton, Iraan, Pecos County WCID #1), irrigation, and mining users. Conservation is discussed further in Chapter 5B.

Table 5E- 54
Pecos County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Strategies
Fort Stockton	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Municipal Conservation
Iraan	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Municipal Conservation
Pecos County WCID #1	Pecos Valley Aquifer, Edwards Trinity Plateau Aquifer	None	None	Develop Edwards Trinity Plateau Aquifer Supplies, Transmission Pipeline Replacement
Pecos County Fresh Water	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Municipal Conservation
County-Other	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	None
Irrigation	Red Bluff Reservoir, Run-of-River, Pecos Valley Aquifer, Edwards Trinity Plateau Aquifer, Capitan Reef Aquifer, Rustler Aquifer	None	None	Irrigation Conservation Weather Modification
Livestock	Pecos Valley Aquifer, Edwards-Trinity Plateau Aquifer, Capitan Reef Aquifer, Rustler Aquifer, Other Aquifer, Local Livestock Supplies	None	None	None
Manufacturing	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	None
Mining	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer, Sales from Fort Stockton	3,500	0	Mining Conservation (Recycling)
Steam Electric	--	--	----	----

5E.22 Reagan County



Nearly all of the water used in Reagan County is obtained from the Edwards-Trinity Plateau aquifer. Groundwater availability from this aquifer is over 68,000 acre-feet per year. The projected demands in Reagan County are less than 34,000 acre-feet per year in 2020 and are projected to decline to less than 24,000 acre-feet per year by 2070. The supply and demand analysis found that Reagan County has no identified water shortages. However, conservation for the City of Big Lake, irrigation, and mining are still recommended as a way to preserve water for future use. The total amount of expected water savings from conservation is estimated at approximately 1,557 acre-feet per year in 2020 and 3,327 acre-feet per year in 2070.

5E.22.1 Reagan County Irrigation

Although Reagan County Irrigation has no projected unmet needs, both irrigation conservation and weather modification are recommended as water management strategies. Weather modification is a recommended strategy because Reagan County lies within the active precipitation enhancement area of the West Texas Weather Modification Association.

Reagan County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Potentially Feasible Water Management Strategies Considered for Reagan County Irrigation:

- Irrigation Conservation
- Weather Modification

Weather Modification

The West Texas Weather Modification Association attributes an annual increase of 2.77 inches over Reagan County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 8,098 irrigated acres in Reagan County, implementation of this strategy is expected to save 1,869 acre-feet of water per year at a unit cost of $0.19 per acre-foot.

Table 5E- 55
Recommended Water Strategies for Reagan County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		22,031	22,031	22,031	22,031	22,031	22,031
Supply (Groundwater)		22,031	22,031	22,031	22,031	22,031	22,031
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Irrigation Conservation	$2,511,534	1,102	2,203	3,305	3,305	3,305	3,305
Weather Modification	$0	1,869	1,869	1,869	1,869	1,869	1,869
TOTAL	**$2,511,534**	**2,971**	**2,203**	**3,305**	**3,305**	**3,305**	**3,305**

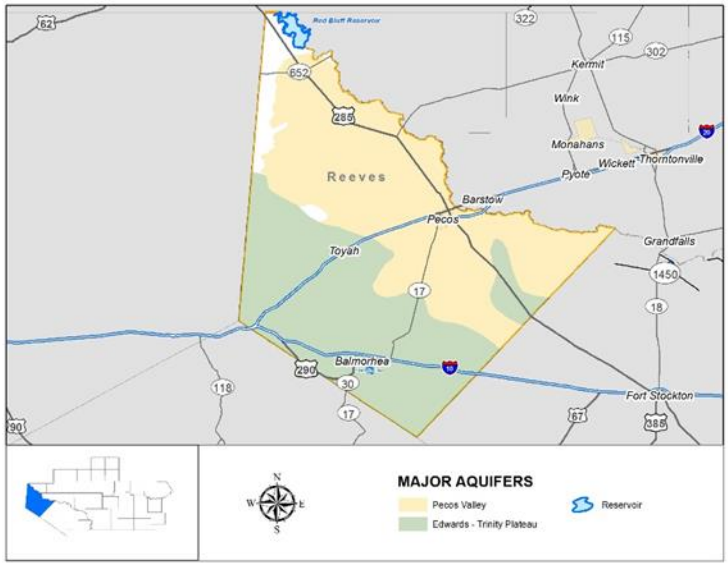
5E.22.2 Reagan County Summary

Reagan County is projected to have no water shortages throughout the planning horizon. However, conservation for municipal (Big Lake), irrigation, and mining users is still recommended as a way to preserve water for future use. In addition, Reagan County lies within the active precipitation enhancement area of the West Texas Weather Modification Association, so weather modification is recommended as a strategy for irrigation users.

Table 5E- 56
Reagan County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Big Lake	Edwards Trinity-Plateau, Pecos Valley, and Trinity Aquifer	None	None	Municipal Conservation
County-Other	Edwards Trinity-Plateau, Pecos Valley, and Trinity Aquifer	None	None	None
Irrigation	Edwards Trinity-Plateau, Pecos Valley, and Trinity Aquifer	None	None	Irrigation Conservation Weather Modification
Livestock	Edwards Trinity-Plateau, Pecos Valley, and Trinity Aquifer, Local Supply	None	None	None
Manufacturing	----	----	----	----
Mining	Edwards Trinity-Plateau, Pecos Valley, and Trinity Aquifer, Well Field Recycling, Direct Reuse sales from Midland and Odessa	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.23 Reeves County



Reeves County relies heavily on groundwater for its water needs. It also uses surface water from Lake Balmorhea and Red Bluff Reservoir for irrigation purposes. Reeves County is another groundwater-rich county in western Region F. There is nearly 200,000 acre-feet per year of groundwater available within the county. However, drought in the Rio Grande Basin, similar to what was experienced in the Colorado Basin, has severely impacted surface water supplies. The hydrology in the Rio Grande WAM has not been extended, and thus current surface water supply estimates for Red Bluff Reservoir may be overestimated.

Reeves County is in the heart of oil and gas development in West Texas. The county includes portions of the Wolfcamp, Bone Spring, and Wolfbone portions of the Delaware Basin, which are highly prolific, and this area has been the focus of significant oil and gas exploration. Since this formation can be economically produced even when oil prices are lower, exploration is anticipated to remain steady into the future, unlike previous “boom and bust” cycles. As a result, the communities in the county have also seen a recent surge in population that was not captured at the time population and demand projections were done for this plan. Therefore, additional strategies were identified to help meet these new and growing needs for water supply for Pecos City. Shortages were also identified for the City of Balmorhea and mining throughout the planning horizon. Recommended strategies to meet these needs include developing additional groundwater supplies. Conservation is also recommended for the municipal, irrigation and mining water users. Livestock and manufacturing users have no recommended strategies. The total amount of expected water savings from conservation is estimated at 3,865 acre-feet per year in 2020 and 9,318 acre-feet per year in 2070.

Water quality, specifically salinity, is a concern throughout the Pecos River Basin. High salinity limits the full use of the Pecos River water resources, including Red Bluff Reservoir. In May 2014, a collaborative effort between the Pecos River Commission, Pecos River Water Quality Coalition, US Army Corps of Engineers (USACE), Texas Water Development Board (TWDB), Texas Commission on Environmental Quality (TCEQ), and the U.S. Geological Survey (USGS) began a comprehensive review of existing studies, to identify data gaps, and recommended projects to reduce salinity in the region. This study is called the Pecos River Watershed Assessment and is ongoing at the writing of this plan. Since these projects are not yet defined, they cannot be fully evaluated as part of the Region F Plan. However, the projects identified as a result of this study may result in increased usable water supplies for agricultural, urban, and environmental purposes and are considered to be consistent with this plan.

5E.23.1 Balmorhea

The City of Balmorhea supplies its own municipal users, as well as the City of Toyah (classified under County-Other) and is supplied entirely by groundwater from the Edwards-Trinity Plateau and Pecos Valley Aquifers in Jeff Davis County (Region E). The currently developed supply from this groundwater source is limited, and therefore, the City is projected to have a shortage of 107 acre-feet per year in 2020 and 147 acre-feet per year in 2070. Municipal conservation and development of additional groundwater supply are recommended strategies that can be implemented to meet the needs in Balmorhea.

Potentially Feasible Water Management Strategies Considered for Balmorhea:

- Municipal Conservation
- Develop Additional Edwards-Trinity Plateau Aquifer Supplies

Balmorhea Recommended Strategies

- Municipal Conservation
- Develop Edwards-Trinity Plateau Aquifer Supplies

Develop Edwards-Trinity Plateau Aquifer Supplies

This strategy assumes that one new well will need to be constructed at a 600-ft depth in order to develop the additional groundwater supplies needed in the Edwards-Trinity Plateau aquifer. This well is assumed to be operating at a capacity of 125 gpm. A transmission pipe 6-inches in diameter and 5 miles long is also needed. This strategy will cost approximately $1.9 million to implement and is estimated to yield an additional 150 acre-feet of water per year.

Table 5E- 57

Recommended Water Strategies for Balmorhea

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		243	254	265	273	278	283
Supply (Groundwater)		136	136	136	136	136	136
Shortage (ac-ft/yr)		107	118	129	137	142	147
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	2	2	2	2	2	2
Develop Edwards-Trinity Plateau Aquifer Supplies	$1,948,000	150	150	150	150	150	150
TOTAL	**$1,948,000**	**152**	**152**	**152**	**152**	**152**	**152**

5E.23.2 Pecos City

Pecos City is the largest city in Reeves County. In addition to providing water to its own retail customer base, Pecos City also supplies Barstow. Pecos City has three existing well fields: South Worsham, North Worsham, and Ward County Well Field. Water from the North Worsham has elevated levels of TDS and chlorides and must be blended at no more than 5 percent of the total supply.

Due to increased interest in oil and gas exploration in the surrounding area, Pecos City has recently experienced rapid population growth. This population surge was not captured in the original TWDB projections, but it is anticipated to continue as a permanent workforce moves to the area. As a result, the City is pursuing several additional water management strategies that are examined as part of the Region F plan.

Potentially Feasible Water Management Strategies Considered for Pecos City:

- Municipal Conservation
- Advanced Water Treatment
- Partner with Madera Valley WSC & Expand Well Field
- Direct Non-potable Reuse
- Direct Potable Reuse
- Indirect Potable Reuse with ASR

Pecos City Recommended Strategies

- Municipal Conservation
- Advanced Water Treatment
- Partner with Madera Valley WSC & Expand Well Field
- Direct Non-Potable Reuse
- Direct Potable Reuse

Advanced Groundwater Water Treatment

Poor water quality in the City's existing North Worsham well field severely limits its use. Currently it can only be blended at up to 5 percent of the total supply. This strategy is to develop an 8 MGD advanced treatment plant which will treat the blended supplies from all three city well fields. This strategy provides additional water supplies by increasing the usable supply from the North Worsham well field. Costs are estimated at $27.6 million.

Partner with Madera Valley WSC & Expand Well Field

The Madera Valley WSC has an existing well field and 10-inch transmission line for their own use. Pecos City is considering partnering with Madera Valley to expand the well field yield an additional 6-8 MGD of average annual supply for both users. The project also includes a 24-inch transmission line for Pecos City to connect to the expanded well field. This strategy is subject to on-going negotiations between Madera Valley WSC and Pecos City and is contingent upon the two entities reaching mutually agreeable terms for the division of water and cost. The total cost for this strategy is estimated at $43.1 million.

Direct Non-Potable Reuse

Pecos City has plans to develop a purple pipe system to supply reuse supplies to irrigation. This would provide peak supplies of 1 MGD or about 560 ac-ft/yr. Costs for this strategy are estimated to be $8.7 million.

Direct Potable Reuse

Pecos City is considering a direct potable reuse project that would be triggered if the population and demand continues to grow rapidly. The size and timing of this strategy may change. For planning purposes, a 2.2 MGD Advanced Treatment Facility was assumed. Concentrate was assumed to be disposed of in a local stream. If a suitable discharge location cannot be found, injection wells may be needed, which will increase the cost estimated for this project. Cost is estimated at $29.5 million.

Table 5E- 58
Recommended Water Strategies for Pecos City

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand (Sales to Barstow)		3,035	3,190	3,343	3,454	3,540	3,605
Supply (Groundwater)		3,035	3,190	3,343	3,454	3,540	3,605
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	29	31	33	34	35	35
Advanced Groundwater Treatment	$27,680,000	3,360	3,360	3,360	3,360	3,360	3,360
Direct Non-Potable Reuse	$8,707,000	560	560	560	560	560	560
Partner w/ Madera Valley WSC & Expand Well Field	$43,107,000		8,960	8,960	8,960	8,960	8,960
Direct Potable Reuse	$29,541,000		925	925	925	925	925
TOTAL	**$109,035,000**	**3,949**	**13,836**	**13,838**	**13,838**	**13,840**	**13,840**

Alternative Water Management Strategies for Pecos City:

- Indirect Potable Reuse with ASR

5E.23.3 Reeves County Mining

Mining demands in Reeves County are projected to be as much as 12,600 acre-feet per year in 2020 and are projected to decline to 6,200 acre-feet per year by 2070. Current, developed groundwater supplies are limited to 1,500 acre-feet from the Pecos Valley Aquifer and 700 acre-feet purchased from the City of Fort Stockton. Consequently, mining users are shown to have a significant shortage throughout the planning horizon, particularly over the next two decades. Recommended strategies to meet these needs include mining conservation (recycling) and developing additional groundwater supply.

Potentially Feasible Water Management Strategies Considered for Reeves County Mining:

- Mining Conservation (Recycling)
- Develop Additional Pecos Valley Aquifer Supplies

Reeves County Mining Recommended Strategies

- Mining Conservation (Recycling)
- Develop Additional Pecos Valley Aquifer Supplies

Develop Additional Pecos Valley Aquifer Supplies

This strategy assumes that 75 new wells will need to be constructed at a 500-ft depth in order to access the additional aquifer supplies needed in the Pecos Valley Alluvium. Each well is assumed to be operating at a capacity of 100 gpm. This strategy will cost approximately $17.5 million to implement and is estimated to yield an additional 10,400 acre-feet of water per year.

Table 5E- 59
Recommended Water Strategies for Reeves County Mining

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		12,600	12,600	12,100	9,900	7,800	6,200
Supply (Groundwater, Purchased)		2,200	2,200	2,200	2,200	2,200	2,200
Shortage (ac-ft/yr)		10,400	10,400	9,900	7,700	5,600	4,000
Recommended Strategies (ac-ft/yr)							
Mining Conservation/Recycling	$17,640,000	882	882	847	693	546	434
Develop Additional Pecos Valley Aquifer Supplies	$17,465,000	10,400	10,400	10,400	10,400	10,400	10,400
TOTAL	**$35,105,000**	**11,282**	**11,282**	**11,247**	**11,093**	**10,946**	**10,834**

5E.23.4 Reeves County Irrigation

Although Reeves County Irrigation has no projected unmet needs, both irrigation conservation and weather modification are recommended as water management strategies. Weather modification is a recommended strategy because Reeves County lies within the active precipitation enhancement area of the Trans Pecos Weather Modification Association (TPWMA).

Reeves County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Potentially Feasible Water Management Strategies Considered for Reeves County Irrigation:

- Irrigation Conservation
- Weather Modification

Weather Modification

The TPWMA attributes an annual increase of 0.48 inches over Reeves County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 8,138 irrigated acres in Reeves County, implementation of this strategy is expected to save 326 acre-feet of water per year at a unit cost of $1.13 per acre-foot.

Table 5E- 60
Recommended Water Strategies for Reeves County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		58,937	58,937	58,937	58,937	58,937	58,937
Supply (Surface Water, Groundwater)		58,937	58,937	58,937	58,937	58,937	58,937
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Irrigation Conservation	$6,719,000	2,947	5,894	8,841	8,841	8,841	8,841
Weather Modification	$0	326	326	326	326	326	326
TOTAL	**$6,719,000**	**3,273**	**6,220**	**9,167**	**9,167**	**9,167**	**9,167**

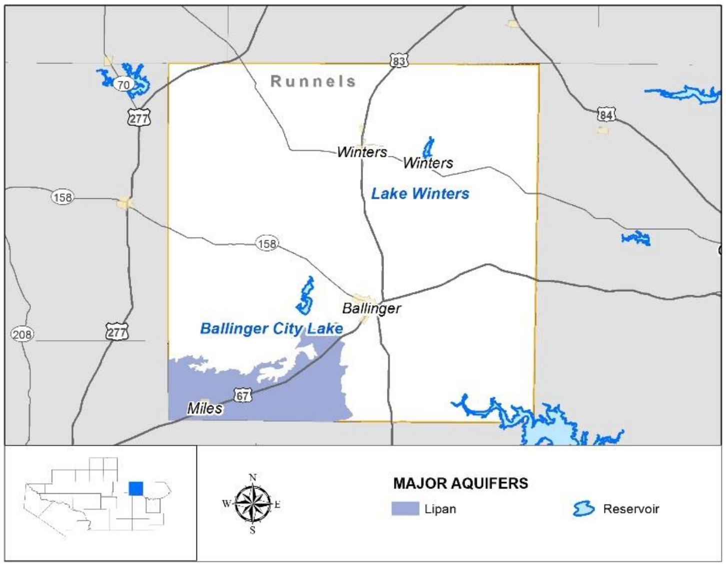
5E.23.5 Reeves County Summary

Water shortages in Reeves County are identified for the City of Balmorhea and mining due to limited supply of developed groundwater. As a result, recommended strategies to meet these needs involve developing additional groundwater supplies. Pecos City has several new strategies including groundwater development, advanced treatment, and reuse (potable and non-potable) to address rapid population growth in their area. Additionally, conservation is recommended for municipal (City of Balmorhea, Madera Valley WSC, Pecos City), irrigation, and mining users. Municipal conservation was not considered for County-Other because there was no need. Conservation is discussed in further detail in Chapter 5B.

Table 5E- 61
Reeves County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Balmorhea	Edwards Trinity Plateau Aquifer, Pecos Valley Aquifer (Jeff Davis County, Region E)	107	147	Municipal Conservation, Develop Edwards-Trinity Plateau Aquifer Supplies
Madera Valley WSC	Edwards-Trinity Plateau Aquifer, Pecos Velley Aquifers	None	None	Municipal Conservation
Pecos City	Dockum Aquifer, Edwards-Trinity Plateau Aquifer and Pecos Valley Aquifers (Ward County)	None	None	Municipal Conservation Advanced Water Treatment Partner with Madera Valley WSC and Expand Well Field Direct Non-Potable Reuse Direct Potable Reuse
County-Other	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifers, Sales from Balmorhea	None	None	None
Irrigation	Lake Balmorhea, Red Bluff, Run-of-River, Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer, Rustler Aquifer, Igneous Aquifer	None	None	Irrigation Conservation Weather Modification
Livestock	Local Supplies, Rustler Aquifer, Dockum Aquifer, Igneous Aquifer, Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	None
Manufacturing	Sales from Pecos	None	None	None
Mining	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer (Self Supplied and Sales from Fort Stockton)	10,400	4,000	Mining Conservation (Recycling), Develop Additional Pecos Valley Aquifer Supplies
Steam Electric	----	----		----

5E.24 Runnels County



Water demands in Runnels County are met through in-county groundwater sources, surface water from local lakes and sales from CRMWD and UCRA. Ballinger and Runnels County-Other show no shortages after subordination of Lake Ballinger, Moonen Lake, and Lake Ivie (accessed through contract with Millersview Doole WSC, Abilene, and CRMWD). In previous rounds, Ballinger has considered additional supplies to expand their water portfolio including connecting to Lake Fort Phantom Hill. At this time, the City is not planning to move forward with this strategy, but it may be considered in the future. After subordination and conservation, there is a projected shortage of about 190 acre-feet per year in 2020. The largest shortage in Runnels County is associated with the City of Winters. The City of Miles and North Runnels WSC also are identified with shortages during the planning horizon. The options to meet the projected shortages in Runnels County are limited. Nearly all of the available groundwater within the county is allocated to current users. Local surface water lakes are small and susceptible to drought.

5E.24.1 Miles

The City of Miles has a contract with UCRA for water from O.C. Fisher. The water is treated by San Angelo and delivered through UCRA's northeast water supply line. The contract with UCRA expires in 2031, but it is expected to be renewed. UCRA is planning to fully meet Miles' water demands; thus, when considering supplies from San Angelo's strategies that supply water to UCRA, there are no identified shortages for Miles. The recommended strategies for Miles are conservation, subordination of UCRA's water supplies, and additional supplies from UCRA/San Angelo strategies.

Miles Recommended Strategies

- Municipal Conservation
- Subordination (UCRA)
- Supplies from UCRA (San Angelo Strategies)

Table 5E- 62
Recommended Water Strategies for Miles

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		113	126	122	121	120	120
Supply (Groundwater, Purchased from UCRA)		94	92	87	81	78	73
Shortage (ac-ft/yr)		19	34	35	40	42	47
Recommended Strategies (ac-ft/yr)							
Municipal Conservation		3	3	3	3	3	3
Subordination (UCRA)	$0	10	8	7	8	6	5
Supplies from UCRA (San Angelo Strategies)	$0	9	26	28	32	36	42
TOTAL	**$0**	**22**	**37**	**38**	**43**	**45**	**50**

5E.24.2 North Runnels WSC

North Runnels WSC Recommended Strategies

- Municipal Conservation
- Subordination (Winters, Ballinger)
- Supplies from Winters Strategies

North Runnels Water Supply Corporation (WSC) purchases water from the City of Winters and has an emergency connection with the City of Ballinger. Before subordination, North Runnels WSC is projected to have a shortage of just below 200 acre-feet per year throughout the planning horizon. When considering conservation and subordination, this shortage decreases to around 100 acre-feet per year. The recommended strategies for North Runnels WSC include municipal conservation, subordination of Winters and Ballinger's supplies, and receiving water from the City of Winters strategies. There is no new infrastructure needed for North Runnels WSC to continue receiving supplies from Winters.

Table 5E- 63
Recommended Water Strategies for North Runnels WSC

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		203	201	196	195	195	196
Supply (Purchased from Winters, Ballinger)		9	10	10	10	10	9
Shortage (ac-ft/yr)		194	191	186	185	185	187
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	5	5	5	5	5	5
Subordination (Purchased from City of Winters, Ballinger)	$0	86	86	87	87	87	89
Winters Strategies Supply	$0	103	105	99	98	98	98
TOTAL	**$0**	**194**	**196**	**191**	**190**	**190**	**192**

5E.24.3 Winters

The City of Winters' source of water is Lake Winters. This lake was significantly impacted from the recent drought and the reliable supply is estimated at less than 200 acre-feet per year with subordination. Winters provides water to its residents and rural customers in Runnels County, as well as a small amount of water to manufacturing. Considering the City's current customers, Winters is shown to have a projected shortage of 220 acre-feet per year in 2020. To meet this need, Winters could purchase water from another provider, such as Ballinger, Abilene, or CRMWD. The pipeline from Lake Ivie to Abilene runs near Lake Winters, which could provide water from Lake Ivie. Another option would be to construct a new 15-mile pipeline from Ballinger to Winters. This option would be expensive for such a small quantity of water. For purposes of this plan, the recommended strategy for Winters is to purchase water from Abilene.

Potentially Feasible Water Management Strategies Considered for Winters:

- Municipal Conservation
- Purchase from Provider

Winters Recommended Strategies

- Municipal Conservation
- Purchase from Provider

Purchase Water from a Provider

There are multiple water providers that utilize the Abilene pipeline from Lake Ivie. It is assumed that the City would purchase up to 220 acre-feet per year. It would require a valve and short pipeline, where the water would then be discharged to a tributary of Lake Winters. The capital cost of the strategy is $974,000.

Table 5E- 64
Recommended Water Strategies for Winters

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand (includes sales to N. Runnels WSC)		395	385	369	367	366	367
Supply (Winters Lake)		0	0	0	0	0	0
Shortage (ac-ft/yr)		395	385	369	367	366	367
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	17	12	9	9	9	9
Subordination (Winters Lake)	$0	175	175	175	175	175	175
Purchase from Provider	$974,000	212	212	212	212	212	212
TOTAL	**$974,000**	**404**	**399**	**396**	**396**	**396**	**396**

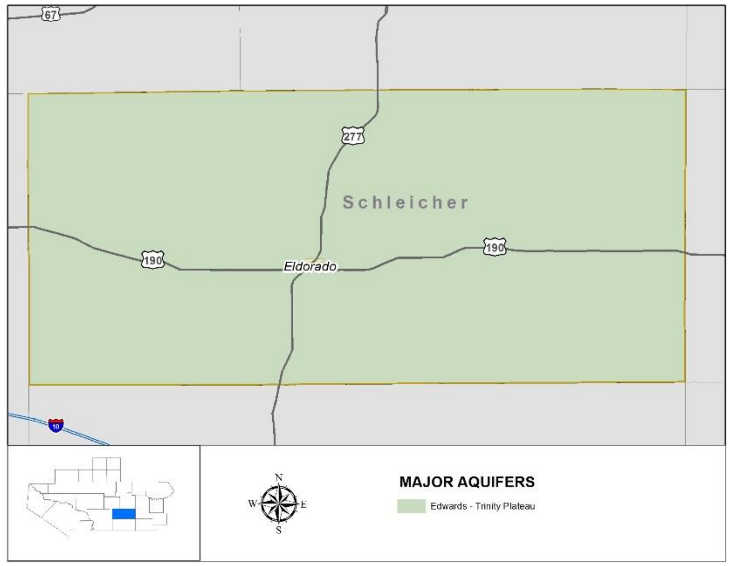
5E.24.4 Runnels County Summary

Runnels County is able to meet its projected water demands through a suite of strategies that include conservation, subordination for surface water lakes, and purchasing water from other providers.

Table 5E- 65
Runnels County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Ballinger	Sales from Millersview-Doole (CRMWD Supplies), Sales from Abilene (CRMWD Supplies) Ballinger/Moonen Lake	417	395	Municipal Conservation, Subordination
Coleman County SUD	See Coleman County			
Miles	Sales from UCRA, Lipan Aquifer	19	47	Municipal Conservation, Subordination, Supplies from UCRA (San Angelo) strategies
Millersview-Doole WSC	See McCulloch County			
North Runnels WSC	Sales from Winters, Sales from Ballinger	Included in Winters shortage	Included in Winters shortage	Municipal conservation, Subordination, Winters Strategies Supply
Winters	Winters Lake	395	367	Municipal Conservation, Subordination, Purchase from Provider
County-Other	Sales from Ballinger, Other Aquifer	Included in Ballinger shortage	Included in Ballinger shortage	Municipal Conservation, Subordination
Irrigation	Reuse sales from Winters, Other Aquifer, Run-of-River	None	None	Irrigation Conservation
Livestock	Livestock Local Supplies, Other Aquifer, Lipan Aquifer	None	None	None
Manufacturing	Sales from Ballinger, Lipan Aquifer	None	None	None
Mining	Other Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.25 Schleicher County



Schleicher County obtains all of its water from the Edwards-Trinity Plateau aquifer. Total demands for the county are less than 4,000 acre-feet per year. There are sufficient groundwater supplies in Schleicher County and the county is shown to have no shortages over the planning period. Conservation is still recommended for the City of Eldorado, Irrigation, and Mining.

5E.25.1 Schleicher County Irrigation

Although Schleicher County Irrigation has no projected unmet needs, both irrigation conservation and weather modification are recommended as water management strategies. Weather modification is a recommended strategy because Schleicher County is located within the active precipitation enhancement area of the West Texas Weather Modification Association.

Schleicher County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Potentially Feasible Water Management Strategies Considered for Schleicher County Irrigation:

- Irrigation Conservation
- Weather Modification

Weather Modification

The West Texas Weather Modification Association attributes an annual increase of 2.34 inches over Schleicher County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 1,412 irrigated acres in Schleicher County, implementation of this strategy is expected to save 275 acre-feet of water per year at a unit cost of $0.23 per acre-foot.

Table 5E- 66
Recommended Water Strategies for Schleicher County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Demands		1,811	1,811	1,811	1,811	1,811	1,811
Supply (Groundwater)		1,811	1,811	1,811	1,811	1,811	1,811
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Irrigation Conservation	$68,818	91	109	109	109	109	109
Weather Modification	$0	275	275	275	275	275	275
TOTAL	**$68,818**	**366**	**384**	**384**	**384**	**384**	**384**

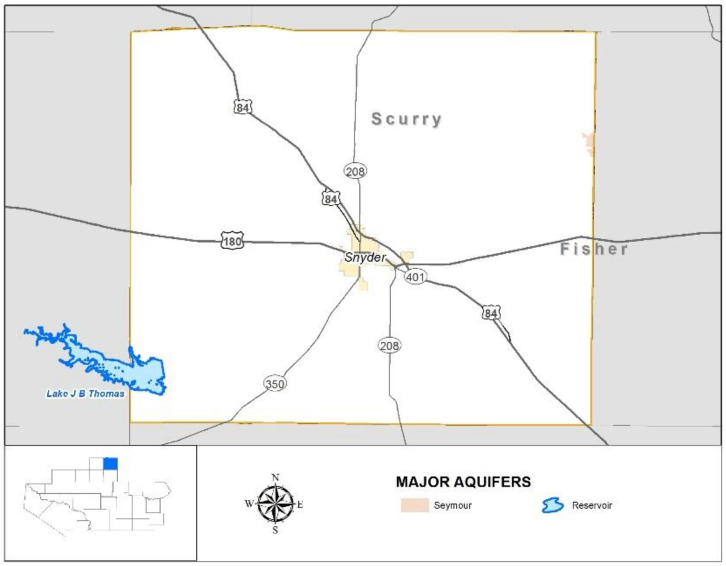
5E.25.2 Schleicher County Summary

There are no shortages over the planning horizon in Schleicher County. Municipal, irrigation, and mining conservation are all recommended to preserve water supplies for future user. Weather modification is also recommended for irrigators as part of the active West Texas Weather Modification Association program.

Table 5E- 67
Schleicher County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Eldorado	Edwards-Trinity Plateau Aquifer	None	None	Municipal Conservation
County-Other	Edwards-Trinity Plateau Aquifer	None	None	None
Irrigation	Edwards-Trinity Plateau Aquifer	None	None	Irrigation Conservation Weather Modification
Livestock	Livestock Local Supplies, Edwards-Trinity Plateau Aquifer	None	None	None
Manufacturing	----	----	----	----
Mining	Edwards-Trinity Plateau Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.26 Scurry County



Scurry County has limited surface water and groundwater supplies. Water from CRMWD sources is provided to the City of Snyder and its customers. Groundwater is obtained from the Dockum aquifer and is the primary source of supply for the other water users within the county. There is a small amount of alluvium groundwater (Other aquifer). The current demands on the Dockum aquifer exceed the availability (MAG values). As a result, there are identified shortages that may not be able to be met by supplies within Scurry County.

5E.26.1 Snyder

The City of Snyder is a member city of CRMWD and obtains all of its water from this wholesale provider. With conservation and subordination, CRMWD can fully meet Snyder's need. In the past, CRMWD and Snyder considered implementing a direct reuse project, similar to the project developed for Big Spring. At this time, there are no plans to move forward with this strategy and therefore it was not evaluated. Recommended strategies for Snyder are municipal conservation and subordination.

Potentially Feasible Water Management Strategies Considered for Snyder:

- Municipal Conservation
- Subordination

Snyder Recommended Strategies

- Municipal Conservation
- Subordination

Table 5E- 68
Recommended Water Strategies for Snyder

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		2,458	2,671	2,785	2,963	3,149	3,345
Future Demands (Scurry County-Other)		373	414	447	491	547	607
Supply (Purchase from CRMWD, Groundwater)		2,217	2,671	2,785	2,659	2,534	2,400
Shortage (ac-ft/yr)		614	414	447	795	1,162	1,552
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	41	47	51	55	59	93
Subordination (CRMWD Supplies)	$0	614	414	447	795	1,162	1,552
TOTAL	**$0**	**655**	**461**	**498**	**850**	**1,221**	**1,645**

5E.26.2 Scurry County-Other

Scurry County-Other includes rural water users living outside of a named water user group. Most of these users obtain their water from groundwater and will continue to use groundwater. However, due to the MAG limits, there is no available water from the Dockum aquifer. Other County-Other users obtain water from the City of Snyder, who purchases water from CRMWD. For purposes of this plan, this water user group is expected to meet most of their needs with water supplied by the City of Snyder, which will come from strategies developed by CRMWD. The costs for this strategy are assumed to be only the purchase cost of the water. The capital costs are zero since it is assumed no additional infrastructure would be needed to facilitate this supply. Subordination of the water supplies received by Snyder, as well as municipal conservation are also recommended strategies for Scurry County-Other.

Scurry County-Other Recommended Strategies

- Municipal Conservation
- Subordination (Snyder)
- Purchase water from Snyder (CRMWD supplies)

Potentially Feasible Water Management Strategies Considered for Scurry County-Other:

- Purchase water from Snyder
- Municipal Conservation
- Subordination

Table 5E- 69
Recommended Water Strategies for Scurry County-Other

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		808	846	886	943	1,012	1,085
Supply (Groundwater, Purchase from Snyder)		406	432	439	421	406	393
Shortage (ac-ft/yr)		402	414	447	522	606	692
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	20	22	24	26	28	30
Subordination (CRMWD Supplies through Snyder)	$0	29	0	0	31	59	85
Purchase from Snyder	$0	373	414	447	491	547	607
TOTAL	**$0**	**422**	**436**	**471**	**548**	**634**	**722**

5E.26.3 Scurry County Manufacturing

Manufacturing in Scurry County is projected to have shortages of roughly 130 acre-feet in 2020 and 156 acre-feet in 2070. Drilling supplemental groundwater wells in the local alluvium will provide additional water to their existing supply. Water from this source has been identified as being suitable for industrial use and is a recommended strategy.

Scurry County Manufacturing Recommended Strategies

- Develop Other Aquifer Supplies

Potentially Feasible Water Management Strategies Considered for Scurry County Manufacturing:

- Develop Other Aquifer Supplies

Develop Other Aquifer Supplies

This strategy assumes five new wells would be constructed to produce 160 acre-feet per year from the Other aquifer alluvium associated with the Dockum aquifer. The capital cost for this strategy is $677,000.

Table 5E- 70
Recommended Water Strategies for Scurry County Manufacturing

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		156	186	186	186	186	186
Supply (Groundwater)		26	30	30	30	30	30
Shortage (ac-ft/yr)		130	156	156	156	156	156
Recommended Strategies (ac-ft/yr)							
Develop Other Aquifer Supplies	$677,000	160	160	160	160	160	160

5E.26.4 Scurry County Mining

Scurry County is projected to have an increase in mining demands from 2020 to 2040, then a decrease until 2070. Currently, water from the Dockum aquifer is used for mining purposes, but due to limitations of the MAGs, this supply is not available under regional planning rules and mining is shown to have an unmet need. However, it is anticipated that the mining industry, as an exempt user, will continue to use groundwater from the Dockum aquifer as needed to meet their demands. Mining conservation/recycling is also recommended.

5E.26.5 Scurry County Summary

Before applying potential savings from conservation and subordination, the total need for Scurry County is projected to be nearly 7,500 acre-feet in 2020. The majority of Scurry County's shortages are for irrigation. The City of Snyder also has a shortage; however, their needs are fully met by CRMWD and municipal conservation. The shortages for County-Other are shown to be met through sales from Snyder. However, much of the County-Other demand will likely continue to be met through local groundwater supplies that cannot be shown due to MAG limitations. Some manufacturing shortages can be met through additional groundwater development. Some of the mining demands can likely be met through conservation/recycling of water, but there is still an unmet need. It is anticipated that the mining industry will continue to develop groundwater as needed beyond the MAG. The only strategy identified for irrigation is conservation of water. Due to the limitations of the groundwater supplies in Scurry County, the county is shown to have unmet needs for irrigation and mining.

Table 5E- 71
Scurry County Summary

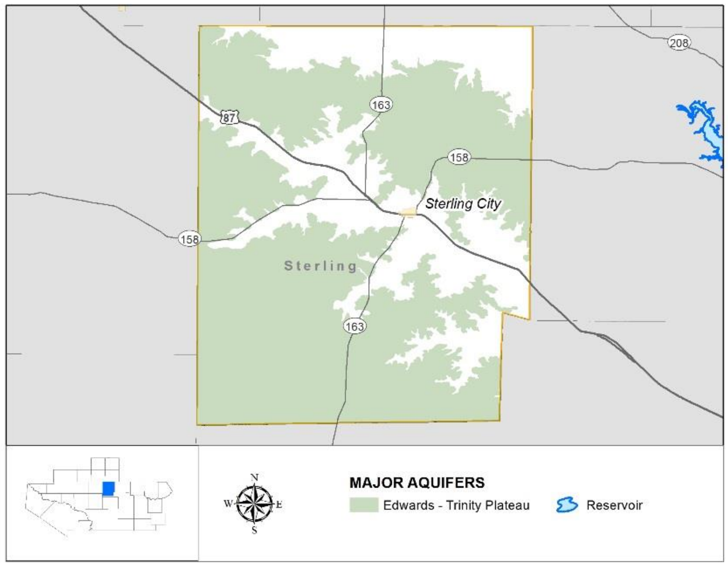
Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Strategies
Snyder	CRMWD Sources	241	945	Municipal Conservation, Subordination
County-Other	CRMWD Sources, Dockum, Local Alluvium Aquifers	373	607	Municipal Conservation, Sales from Snyder
Irrigation	Run-of-River, Dockum Aquifer	6,531	6,563	Irrigation Conservation
Livestock	Dockum Aquifer, Other Aquifer, Local Supply	None	None	None
Manufacturing	Dockum Aquifer	130	156	Additional Groundwater Development (Other Aquifer)
Mining	Dockum Aquifer	242	144	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

Table 5E- 72
Unmet Needs in Scurry County
-Values in Acre-Feet per Year-

Water User Group	2020	2030	2040	2050	2060	2070
Irrigation	6,153	5,799	5,582	5,579	5,577	5,580
Mining	222	363	385	290	196	132
TOTAL	**6,375**	**6,162**	**5,967**	**5,869**	**5,773**	**5,712**

5E.27 Sterling County

Most of the water supplies for Sterling County are obtained from the Edwards-Trinity Plateau aquifer. There is about 850 acre-feet per year of supply from the Lipan aquifer, which is used by Sterling City and agricultural users. Total demands in Sterling County are about 2,200 acre-feet per year in 2020 and decrease to about 1,600 acre-feet per year in 2070. There are sufficient supplies to meet these demands, so Sterling County has no shortages. Therefore, the only recommended strategies for water user groups in Sterling County are conservation (municipal, irrigation, and mining) and weather modification.



5E.27.1 Sterling County Irrigation

Although Sterling County Irrigation has no projected unmet needs, both irrigation conservation and weather modification are recommended as water management strategies. Weather modification is a recommended strategy because Sterling County is located within the active precipitation enhancement area of the West Texas Weather Modification Association.

Sterling County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Potentially Feasible Water Management Strategies Considered for Sterling County Irrigation:

- Irrigation Conservation
- Weather Modification

Weather Modification

The West Texas Weather Modification Association attributes an annual increase of 1.39 inches over Sterling County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 411 irrigated acres in Sterling County, implementation of this strategy is expected to save 48 acre-feet of water per year at a unit cost of $0.39 per acre-foot.

Table 5E- 73
Recommended Water Strategies for Sterling County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Irrigation Conservation	$102,000	45	109	109	109	109	109
Weather Modification	$0	48	48	48	48	48	48
TOTAL	**$102,000**	**93**	**157**	**157**	**157**	**157**	**157**

5E.27.2 Sterling County Summary

There are sufficient water supplies to meet all projected water demands in Sterling County. Although there are no water shortages, conservation is recommended for municipal (Sterling City), irrigation, and mining water user groups. In addition, the West Texas Weather Modification Association operates in Sterling County, therefore, weather modification is also shown as a recommended strategy for irrigators.

Table 5E- 74
Sterling County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Sterling City	Lipan Aquifer	None	None	Municipal Conservation
County-Other	Edwards-Trinity Plateau Aquifer	None	None	None
Irrigation	Edwards-Trinity Plateau Aquifer, Run-of-River	None	None	Irrigation Conservation Weather Modification
Livestock	Edwards-Trinity Plateau Aquifer, Livestock Local Supplies	None	None	None
Manufacturing	----	----	----	----
Mining	Edwards-Trinity Plateau Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.28 Sutton County

The Edwards-Trinity Plateau aquifer is the primary source of water for Sutton County. Small amounts of local surface water supplies for livestock and irrigation are also used. The water demands in the county total about 3,200 acre-feet per year in 2020 and are expected to slightly decrease to about 3,140 acre-feet per year by 2070. Sutton County has sufficient water resources to meet these demands and has no identified shortages. The City of Sonora is considering developing additional groundwater.

5E.28.1 Sonora

The City of Sonora has no water shortages over the planning horizon. Municipal conservation is still recommended as a way to preserve water for future or other uses. The City is also planning to develop additional groundwater wells for additional supply and water security.

Potentially Feasible Water Management Strategies Considered for Sonora:

- Municipal Conservation
- Develop Additional Groundwater

Sonora Recommended Strategies

- Municipal Conservation
- Develop Additional Edwards-Trinity Plateau Aquifer Supplies

Develop Additional Edwards-Trinity Plateau Aquifer Supplies

The City has an existing well field in the Edwards-Trinity Plateau aquifer near Interstate 10. This strategy is to develop two additional 30 gpm, 420-ft depth wells in the same well field and associated collection piping. Additional transmission infrastructure was not included since it is an expansion of an existing facility.

Table 5E- 75
Recommended Water Strategies for Sonora

	Capital Cost	2020	2030	2040	2050	2060	2070
Demands		1,048	1,108	1,126	1,142	1,153	1,159
Supply (Groundwater)		1,048	1,108	1,126	1,142	1,153	1,159
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	18	20	20	20	21	21
Develop Additional Edwards-Trinity Plateau Aquifer Supplies	$437,000	35	35	35	35	35	35
TOTAL	**$437,000**	**53**	**55**	**55**	**55**	**56**	**56**

5E.28.2 Sutton County Irrigation

Although Sutton County Irrigation has no projected unmet needs, both irrigation conservation and weather modification are recommended as water management strategies. Weather modification is a recommended strategy because Sutton County is located within the active precipitation enhancement area of the West Texas Weather Modification Association.

Sutton County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Potentially Feasible Water Management Strategies Considered for Sutton County Irrigation:

- Irrigation Conservation
- Weather Modification

Weather Modification

The West Texas Weather Modification Association attributes an annual increase of 1.21 inches over Sutton County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 341 irrigated acres in Sutton County, implementation of this strategy is expected to save 34 acre-feet of water per year at a unit cost of $0.45 per acre-foot.

Table 5E- 76
Recommended Water Strategies for Sutton County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Demands		1,120	1,120	1,120	1,120	1,120	1,120
Supply (Groundwater)		1,120	1,120	1,120	1,120	1,120	1,120
Shortage (ac-ft/yr)		0	0	0	0	0	0
Recommended Strategies (ac-ft/yr)							
Irrigation Conservation	$128,000	56	112	168	168	168	168
Weather Modification	$0	34	34	34	34	34	34
TOTAL	**$128,000**	**90**	**146**	**202**	**202**	**202**	**202**

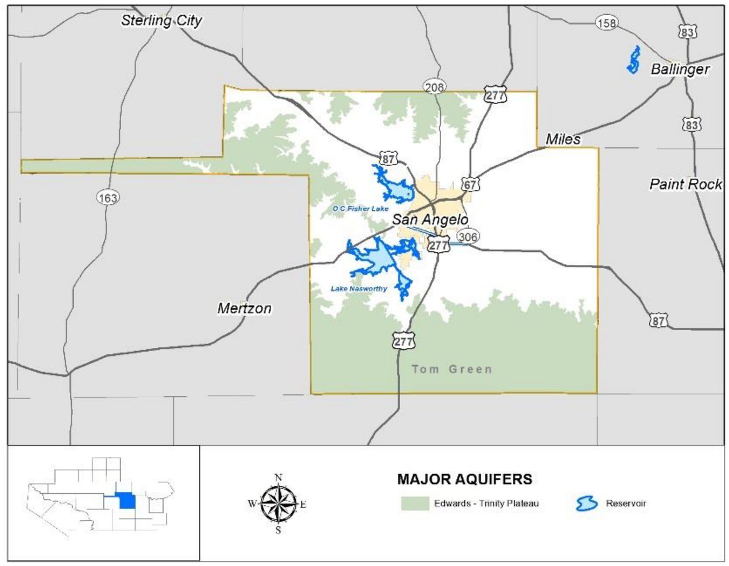
5E.28.3 Sutton County Summary

Sutton County has no identified shortages. It is recommended that water users in Sutton County implement conservation measures to preserve the water resources in the county, including municipal, irrigation and mining water users. In addition, the City of Sonora is planning to develop additional groundwater supplies for use by the City.

Table 5E- 77
Sutton County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Sonora	Edwards-Trinity Plateau Aquifer	None	None	Municipal Conservation Develop Edwards-Trinity Plateau Aquifer Supplies
County-Other	Edwards-Trinity Plateau Aquifer	None	None	None
Irrigation	Edwards-Trinity Plateau Aquifer, Run-of-River	None	None	Irrigation Conservation Weather Modification
Livestock	Edwards-Trinity Plateau Aquifer, Livestock Local Supplies	None	None	None
Manufacturing	Sales from Sonora	----	----	----
Mining	Edwards-Trinity Plateau Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.29 Tom Green County



Tom Green County is home to the City of San Angelo and a large irrigation district, the Tom Green Water Control and Improvement District 1. Over 60 percent of the water demand in the county is for irrigation water use. Most of the remaining demand is associated with San Angelo, which is classified as a major water provider in Region F. Water supplies in Tom Green County include the Concho River, surface water reservoirs, and local aquifers. The Lipan aquifer, a minor aquifer, provides the greatest amount of groundwater within the county. Due to the drought, the reliable supplies from surface water has been significantly impacted. The remainder of the shortage in the county is associated with San Angelo and its customers. No other water user groups in Tom Green County have identified water shortages. The water management strategies for San Angelo and its customers, including Goodfellow Air Force Base, manufacturing, and UCRA, are discussed in Chapter 5D (Major Water Provider Water Management Strategies).

5E.29.1 Upper Colorado River Authority (UCRA)

The Upper Colorado River Authority (UCRA) is a wholesale water provider in Tom Green County. UCRA owns the water rights in O.C. Fisher Reservoir and Mountain Creek Reservoir. The Authority has an agreement with the City of San Angelo for San Angelo to treat up to 1,000 acre-feet per year of water from any of San Angelo's sources in return for water from O.C. Fisher. The City of Miles and local rural water supply corporations in Tom Green and Concho Counties contract with UCRA to provide treated water which is transmitted through either San Angelo's or the retail customer's systems.

Table 5E- 78
Supply and Demand Summary for UCRA

Supplies	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
San Angelo System Supplies	367	330	313	293	276	257
Total Availability	**367**	**330**	**313**	**293**	**276**	**257**
Current Demands	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Miles	113	126	122	121	120	120
Concho Rural WC	100	100	100	100	100	100
Tom Green County-Other (Red Creek MUD)	100	100	100	100	100	100
Tom Green County-Other (Petrafirma)	145	145	145	145	145	145
Tom Green County-Other (Twin Buttes Water System)	20	20	20	20	20	20
Mining, Tom Green County (Globe Energy)	10	10	10	10	10	10
Total Current Demands	**488**	**501**	**497**	**496**	**495**	**495**
Potential Future Demands	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Concho Rural WC (Potential Future)	50	50	50	50	50	50
Total Future Demands	**50**	**50**	**50**	**50**	**50**	**50**
Shortage	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Current Customers	121	171	184	203	219	238
Future Customers	50	50	50	50	50	50

Due to shortages in the supply from the San Angelo, UCRA shows a shortage for current users; however, the water management strategies developed by San Angelo will ultimately enable them to meet the full contractual amount. Brush control is also a recommended strategy for UCRA, who is willing to partner with entities looking to implement a program should funding become available. Additional information on the Brush Control strategy can be found in Chapter 5C.

Potentially Feasible Water Management Strategies Considered for UCRA:

- Brush Control
- Supply from San Angelo Strategies

UCRA Recommended Strategies

- Brush Control
- Supply from San Angelo Strategies

Table 5E- 79
Recommended Water Strategies for UCRA

	2020	2030	2040	2050	2060	2070
Supply	367	330	313	293	276	257
Current Demand	488	501	497	496	495	495
Future Demands	50	50	50	50	50	50
Surplus (Shortage)	(171)	(221)	(234)	(253)	(269)	(288)
Recommended Strategies (acre-feet per year)						
San Angelo Water Management Strategies	633	670	687	707	724	743
Brush Control	Included with San Angelo Strategies. See Chapters 5C and 5D.					
Total	**633**	**670**	**687**	**707**	**724**	**743**

5E.29.2 Tom Green County Irrigation

Irrigation in Tom Green County has no projected unmet needs, however, both irrigation conservation and weather modification are recommended as water management strategies. Irrigation conservation of water can reduce demands and more efficiently use existing supplies. Tom Green County is also located within the active precipitation enhancement area of the West Texas Weather Modification Association. The recommended strategies for irrigation in Tom Green County are conservation and weather modification.

Potentially Feasible Water Management Strategies Considered for Tom Green County Irrigation:

- Irrigation Conservation
- Weather Modification

Tom Green County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Weather Modification

The West Texas Weather Modification Association attributes an annual increase of 2.73 inches over Tom Green County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 19,604 irrigated acres in Tom Green County, implementation of this strategy is expected to save 2,007 acre-feet of water per year at a unit cost of $0.44 per acre-foot.

Table 5E- 80
Recommended Strategies for Tom Green County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		42,493	42,493	42,493	42,493	42,493	42,493
Supply (Groundwater, ROR)		43,051	43,002	42,945	42,930	42,879	42,825
Surplus (ac-ft/yr)		558	509	452	437	386	332
Recommended Strategies (ac-ft/yr)							
Irrigation Conservation	$3,875,000	2,125	4,249	5,099	5,099	5,099	5,099
Weather Modification	$0	2,007	2,007	2,007	2,007	2,007	2,007
TOTAL	**$3,875,000**	**4,132**	**6,256**	**7,106**	**7,106**	**7,106**	**7,106**

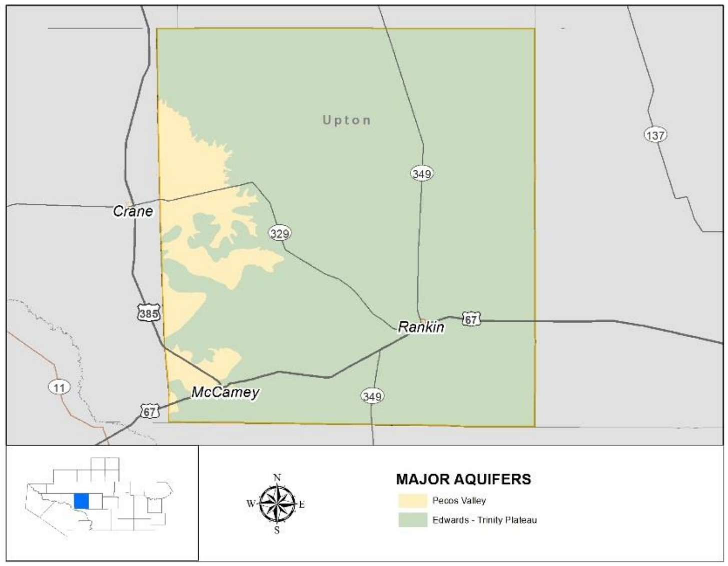
5E.29.3 Tom Green County Summary

Tom Green County is the second largest demand county in Region F. As previously discussed, supplies are limited, and the county shows a total shortage of over 7,000 acre-feet per year in 2020 and 12,000 acre-feet per year by 2070. Most of this shortage is associated with the City of San Angelo, which is discussed in Chapter 5D. Some of this shortage can be reduced through both conservation and subordination. The rest of these shortages can be met through the implementation of infrastructure strategies and transfers between water user groups.

Table 5E- 81
Tom Green County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Concho Rural WC	Lipan Aquifer, Edwards-Trinity Aquifers, Sales from UCRA	None	None	Municipal Conservation UCRA Supplies (San Angelo Strategies)
DADS Supported Living	Lipan Aquifer	None	None	Municipal Conservation
Goodfellow Air Force Base	Sales from San Angelo			Municipal Conservation, Supply from San Angelo Strategies
Millersview-Doole WSC	See McCulloch County			
San Angelo	See Chapter 5D for Major Water Providers			
Tom Green County FSD 3	Lipan Aquifer	None	None	Municipal Conservation
County-Other	Lipan Aquifer, Edwards-Trinity Aquifer, Other Aquifers, Sales from UCRA	None	None	Supply from UCRA (San Angelo Strategies)
Irrigation	Lipan Aquifer, Edwards-Trinity Aquifer, Other Aquifers, Reuse, Twin Buttes/Nasworthy, Run-of-River	None	None	Irrigation Conservation Weather Modification
Livestock	Lipan Aquifer, Edwards-Trinity Aquifer, Other Aquifers, Livestock Local Supplies	None	None	None
Manufacturing	Lipan Aquifer, Sales from San Angelo	51	193	Supply from San Angelo Strategies
Mining	Lipan Aquifer, Sales from UCRA	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.30 Upton County



Water demands in Upton County are primarily met with groundwater from the Edwards-Trinity Plateau aquifer. Some non-municipal water use groups obtain water from the Dockum aquifer; however, this water is sparsely used due to water quality concerns. In addition to groundwater, mining users in Upton County purchase wastewater from Midland and Odessa to meet their demands. The total water demands for the county are about 19,000 acre-feet per year in 2020 and 13,700 acre-feet per year in 2070. Upton County has sufficient supplies to meet these needs and no water shortages were identified. It is recommended that conservation for McCamey, Rankin, irrigation and mining be implemented as a way to preserve water for future use. County-Other, livestock, and manufacturing have no recommended strategies.

5E.30.1 Upton County Summary

Water user groups in Upton County have ample supply to meet all projected water demands. Conservation is still a recommended strategy for municipal water users, including McCamey and Rankin, as well as irrigators and mining water users.

Table 5E- 82
Upton County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
McCamey	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Municipal Conservation
Rankin	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Municipal Conservation
County-Other	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	None
Irrigation	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer, Dockum Aquifer	None	None	Irrigation Conservation
Livestock	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	None
Manufacturing	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer, Dockum Aquifer	None	None	None
Mining	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer, Sales from Midland (Reuse Water), Sales from Odessa (Reuse Water)	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.31 Ward County

Ward County is located in the western part of Region F. The county's primary source of water is the Pecos Valley aquifer. There are also smaller quantities of water associated with the Capitan Reef and Dockum aquifers. Based on developed supplies, all water users in Ward County can meet the projected demands, with the exception of steam electric power, which is shown to have artificially high demands. It is expected that any current demands can be met with groundwater supplies in Ward County, if needed.

5E.31.1 Grandfalls

Grandfalls Recommended Strategies

- Develop Pecos Valley Aquifer Supplies

Grandfalls existing water supplies are from CRMWD's Ward County Well Field. Grandfalls' contract with CRMWD for water supplies will expires in 2049. Starting in 2050, it is assumed they will need to develop their own well field in the Pecos Valley Aquifer in Ward County. Alternatively, Grandfalls could negotiate a new contract or contract extension with CRMWD if mutually agreeable terms can be reached at that time.

Potentially Feasible Water Management Strategies Considered for Grandfalls:

- Develop Pecos Valley Aquifer Supplies

Table 5E- 83
Recommended Water Strategies for Grandfalls

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		135	141	145	149	152	155
Supply (Groundwater)		135	141	145	0	0	0
Shortage (ac-ft/yr)		0	0	0	149	152	155
Recommended Strategies (ac-ft/yr)							
Municipal Conservation	$0	1	1	1	1	2	2
Develop Pecos Valley Aquifer Supplies	$2,410,000	0	0	0	155	155	155
TOTAL	**$2,410,000**	**1**	**1**	**1**	**156**	**157**	**157**

5E.31.2 Ward County Irrigation

Although Ward County Irrigation has no projected unmet needs, both irrigation conservation and weather modification are recommended as water management strategies. Weather modification is a recommended strategy because Ward County is located within the active precipitation area of the Trans Pecos Weather Modification Association (TPWMA).

Potentially Feasible Water Management Strategies Considered for Ward County Irrigation:

- Irrigation Conservation
- Weather Modification

Ward County Irrigation Recommended Strategies

- Irrigation Conservation
- Weather Modification

Weather Modification

The TPWMA attributes an annual increase of 0.95 inches over Ward County due to their weather modification efforts in 2016. This strategy assumes that the water savings from precipitation enhancement will be attributed to county irrigation and that irrigation usage occurs predominately during the growing season. Since there are approximately 3,275 irrigated acres in Ward County, implementation of this strategy is expected to save 259 acre-feet of water per year at a unit cost of $0.57 per acre-foot.

Table 5E- 84
Recommended Water Strategies for Ward County Irrigation

	Capital Cost	2020	2030	2040	2050	2060	2070
Demand		3,160	3,160	3,160	3,160	3,160	3,160
Supply (Groundwater)		6,058	6,053	6,054	6,061	6,070	6,076
Shortage (ac-ft/yr)		2,898	2,893	2,894	2,901	2,910	2,916
Recommended Strategies (ac-ft/yr)							
Irrigation Conservation	$360,000	158	316	474	474	474	474
Weather Modification	$0	259	259	259	259	259	259
TOTAL	**$360,000**	**417**	**575**	**733**	**733**	**733**	**733**

5E.31.3 Ward County Steam Electric Power

The current steam electric power demand in Ward County is associated with the Luminant Permian Basin Power Plant. This facility uses groundwater from the Pecos Valley aquifer. The demands shown in the Plan are based on 2010 use, when the power plant utilized steam technology. Over the past decade, both steam units have been retired and this plant has switched to combustion-based generation, reducing water needs significantly. Since then, the highest annual water usage from this plant was 123 acre-feet in 2012, and water needs are not expected to grow over the planning horizon. Thus, the shortages shown for steam electric power are artificial and no current water management strategies were developed for this user. This is shown as an unmet need in the Plan.

5E.31.4 Ward County Summary

Ward County has sufficient supplies to meet its needs. The only shortage identified for Ward County is for steam electric power; however, this shortage is artificial, and all needs can be met with current groundwater supplies. Conservation is also recommended for municipal (Barstow, Grandfalls, Monahans, Southwest Sandhills WSC, Wickett, County-Other), irrigation and mining users. There are no shortages and no strategies for livestock and manufacturing.

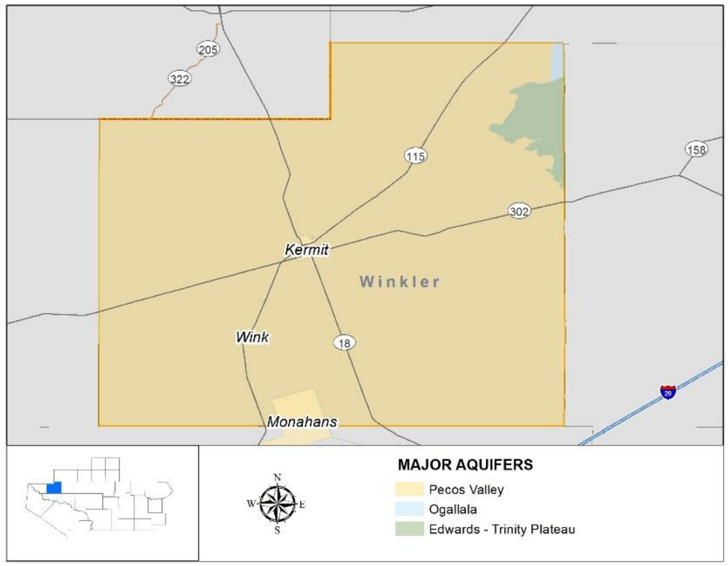
Table 5E- 85
Ward County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Barstow	Dockum Aquifer	None	None	Municipal Conservation
Grandfalls	Sales from CRMWD	None	155	Municipal Conservation Develop Pecos Valley Aquifer Supplies
Monahans	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Municipal Conservation
Southwest Sandhills WSC	Sales from Monahans	None	None	Municipal Conservation
Wickett	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Municipal Conservation
County-Other	Sales from CRMWD, Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer, Dockum Aquifer	None	None	None
Irrigation	Reuse sales from Monahans, Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer, Dockum Aquifer, Red Bluff Reservoir, Rio Grande Run-of-River	None	None	Irrigation Conservation Weather Modification
Livestock	Livestock Local Supplies, Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer, Dockum Aquifer	None	None	None
Manufacturing	Pecos Valley Aquifer	None	None	None
Mining	Pecos Valley Aquifer, Well Field Recycling	None	None	Mining Conservation (Recycling)
Steam Electric	Pecos Valley Aquifer	2,352	2,352	None

Table 5E- 86
Unmet Needs in Ward County
-Values are in Acre-Feet per Year-

Water User Group	2020	2030	2040	2050	2060	2070
Steam Electric Power	2,352	2,352	2,352	2,352	2,352	2,352

5E.32 Winkler County



Winkler County is almost entirely supplied by groundwater. Most of the supply originates from the Dockum, Pecos Valley, and Edwards Trinity Plateau aquifers. There are no water user identified shortages in Winkler County. There is over 30,000 acre-feet per year of groundwater in Winkler County that is not currently developed and could be used for strategies. Some of this water is planned for development by CRMWD for use outside of the county.

Winkler County has ample supply to meet the projected demands. Total demands for the county are less than 9,000 acre-feet per year. However, there are additional demands on the county's groundwater resources from development of Midland's T-Bar Ranch Well Field and the future development of CRMWD's Well Field. Even with these outside demands, there are sufficient supplies to meet them. Kermit, Wink, irrigation, and mining have no identified shortages, but it is still recommended that they employ conservation strategies as appropriate. Livestock, Manufacturing, and County-Other have no needs or recommended strategies.

5E.32.1 Winkler County Summary

Winkler County has sufficient groundwater supplies to meet all projected demands for water user groups. Although there are no shortages, municipal conservation is recommended for municipal entities (Kermit and Wink), and irrigation and mining conservation (recycling) are also recommended strategies.

Table 5E- 87
Winkler County Summary

Water User Group	Current Supplies	2020 Shortage (ac-ft/yr)	2070 Shortage (ac-ft/yr)	Recommended Water Management Strategies
Kermit	Dockum Aquifer	None	None	Municipal Conservation
Wink	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Municipal Conservation
County-Other	Dockum Aquifer, Edwards-Trinity Plateau, Pecos Valley Aquifer	None	None	None
Irrigation	Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Irrigation Conservation
Livestock	Dockum Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifers, Livestock Local Supplies	None	None	None
Manufacturing	Dockum Aquifer	None	None	None
Mining	Dockum Aquifer, Edwards-Trinity Plateau Aquifer, Pecos Valley Aquifer	None	None	Mining Conservation (Recycling)
Steam Electric	----	----	----	----

5E.33 Region F Water Management Strategies Summary

5E.33.1 Unmet Needs Summary

There are some instances in Region F where the recommended water management strategies do not represent enough additional supply to meet the demand associated with the water user group. Table 5E- 88 summarizes all of the remaining unmet needs in Region F. Although there are unmet needs being shown as remaining within Region F, each need is accounted for within the overall plan and is in compliance with state requirements. Chapter 6 discusses the unmet needs in detail and explains how the unmet needs do not affect public health and welfare and are consistent with the long-term protection of the state’s resources as embodied in the guidance principles.

Table 5E- 88
Unmet Needs Summary

Water User Group	County	2020	2030	2040	2050	2060	2070
Andrews	Andrews	147	361	619	1,186	1,850	2,650
County-Other	Andrews	16	43	74	134	192	254
Livestock	Andrews	9	17	25	39	50	60
Manufacturing	Andrews	31	59	87	134	174	209
Irrigation	Andrews	681	3,651	5,260	6,352	7,275	8,097
Mining	Andrews	909	868	66	0	0	0
Irrigation	Brown	1,302	1,062	1,061	1,063	1,060	1,061
Irrigation	Irion	252	200	147	147	147	147
Mining	Irion	1,444	1,440	225	0	0	0
Irrigation	Kimble	970	837	784	784	784	784
Mining	Loving	3,381	3,381	2,543	1,427	699	762
Irrigation	Martin	0	0	2,392	3,346	6,004	7,844
Colorado City	Mitchell	0	115	126	137	150	164
Irrigation	Mitchell	1,328	1,602	1,507	1,389	1,310	1,226
Steam Electric Power	Mitchell	8,656	8,670	8,684	8,698	8,712	8,726
Irrigation	Scurry	6,153	5,799	5,582	5,579	5,577	5,580
Mining	Scurry	222	363	385	290	196	132
Steam Electric Power	Ward	2,352	2,352	2,352	2,352	2,352	2,352
TOTAL		**27,853**	**30,820**	**31,919**	**33,057**	**36,532**	**40,048**

6 IMPACTS OF THE REGIONAL WATER PLAN

The development of viable strategies to meet the demand for water is the primary focus of regional water planning. A part of this goal is the long-term protection of resources that contribute to water availability, and to the quality of life in the State. The purpose of this chapter is to describe how the 2021 update to the Region F Water Plan is consistent with the long-term protection of the State's water resources, agricultural resources, and natural resources. The requirement to evaluate the consistency of the regional water plan with protection of resources is found in 31 TAC Chapter 357.41, which states:

> "RWPGs shall describe how RWPs are consistent with the long-term protection of the state's water resources, agricultural resources, and natural resources as embodied in the guidance principles in §358.3(4) and (8) of this title (relating to Guidance Principles)."

Chapter 6 addresses this issue by providing general descriptions of how the plan is consistent with protection of water resources, agricultural resources, and natural resources. Additionally, the chapter will specifically address consistency of the 2021 Region F Water Plan with the State's water planning requirements. To demonstrate compliance with the State's requirements, a matrix has been developed and is included in Appendix A.

The regulations that describe the content and process for the development of regional water plans state that the plan include "a description of the major impacts of recommended water management strategies on key parameters of water quality identified by the regional water planning group pursuant to [31 TAC 357.34(d)(8)]."

This chapter presents an assessment of the water quality parameters that could be affected by the implementation of water management strategies (WMS) for Region F. Based on this assessment, the key water quality parameters for each type of WMS are identified. From this determination, the specific water management strategies selected for Region F were evaluated with respect to potential impacts to the key water quality parameters. In addition, this chapter discusses the potential impacts of moving water from rural areas to urban uses.

6.1 Potential Impacts of Water Management Strategies on Key Water Quality Parameters

The key water quality parameters to be evaluated are dependent on the recommended water management strategy. Table 6-1 summarizes the most pertinent water quality parameters for the types of strategies proposed in this plan.

The implementation of specific strategies can potentially impact both the physical and chemical characteristics of water resources in the region. The following is an assessment of the characteristics of each recommended WMS type that may affect water quality and an identification of the specific water quality parameters that could be affected based on those characteristics. Water management strategy types that were not recommended for Region F, and therefore are not evaluated in this section, include drought management and system operations.

Table 6-1
Key Water Quality Parameters by Water Management Strategy Type

Water Quality Parameter	Water Conservation	Reuse	Subordination	Voluntary Transfer	Conjunctive Use	New/ Expanded Supply Development	Desalination (Advanced Treatment)	Brush Control	Precipitation Enhancement
Total dissolved solids (TDS)	+	+ / -		+ / -	+		-	+ / -	
Alkalinity	+				+				
Hardness	+				+				
Dissolved Oxygen (DO)	+	+ / -		+ / -	+			+ / -	
Nitrogen	+	+ / -		+ / -	+		-	+ / -	
Phosphorus	+	+ / -		+ / -	+			+ / -	
Radionuclides [a]						- [a]	- [a]		
Metals [a]		+		- [a]		- [a]	- [a]		

a. Only for specific constituents where there are significant discharges of the constituent.
\+ Positive Impact - Negative Impact

6.1.1 Water Conservation

The water conservation measure with the greatest potential for water savings to be implemented in Region F is improvements in the efficiency of water used for irrigated agriculture. These recommended strategies are not expected to affect water quality adversely. The results should be beneficial because the demand on surface and groundwater resources will be decreased. Mining conservation also represents the potential for significant reduction in water usage through recycling of flowback water from oil and gas operations in the region. Reducing mining's dependence on other water sources is expected to have a beneficial impact on the water quality of those sources. It also reduces the amount of waste injected underground or to a stream. Municipal conservation is expected to have similar beneficial impacts but on a smaller scale.

6.1.2 Reuse of Treated Wastewaters

In general, there are three possible water quality effects associated with the reuse of treated wastewaters:

- There can be a reduction in instream flow if treated wastewaters are not returned to the stream, which could affect TDS, nutrients, and DO concentrations of the receiving stream.
- Conversely, in some cases, reducing the volume of treated wastewater discharged to a stream could have a positive effect and improve levels of TDS, nutrients, DO, and possibly metals in the receiving stream.
- Reusing water multiple times and then discharging it can significantly increase the TDS concentration in the effluent and in the immediate vicinity of the discharge in the receiving stream. Total loading to the stream (i.e. the amount of dissolved material in the waste stream) should not change significantly.

These impacts will vary depending on the quality and quantity of treated wastewater that has historically been discharged to the stream and the existing quality and quantity of the receiving stream. For some entities in Region F, wastewater effluent is not discharged to a stream, but is land applied.

In Region F, there are four recommended direct non-potable reuse strategies including:

- Bangs (Direct Non-Potable)
- Menard (Direct Non-Potable)
- Mitchell County Steam-Electric Power (Direct Non-Potable)
- Pecos (Direct Non-Potable)

All of these non-potable strategies involve small volumes of water and are expected to have minimal to no impacts on key water quality parameters.

In addition to these projects, there is one direct potable reuse project recommended for Pecos City. Water from this project could potentially be used multiple times, increasing the TDS concentration in the effluent. The water that is discharged and not reused could impact the receiving stream in the immediate vicinity of the discharge. This would be evaluated as part of a discharge permit. Total loading to the stream however should not change significantly.

There is also one indirect potable reuse project recommended for San Angelo, the Concho River Project. The wastewater discharged into the Concho River will be highly treated to state permit requirements and is expected to have minimal impacts on key water quality parameters. Diversion of this water is not expected to significantly change stream flows (and thus water quality) since the water was previously diverted for agricultural use.

6.1.3 Subordination

The plan recommends the subordination of downstream senior water rights holders to major reservoirs in Region F. This reflects the current operation of the basin, so there are no expected changes in water quality associated with this strategy.

6.1.4 Voluntary Transfers

Voluntary redistribution in Region F involves the sales of water from a source to a water user group or wholesale water provider. None of the recommended strategies in Region F involve placing water from one source into another source. The amount of water proposed to be transferred should not significantly impact source reservoir or stream quantities beyond current commitments. Impacts to key water quality parameters are expected to be minimal.

In Region F, most of the surface water is fully utilized and there would not be significant changes to the quantities of surface water diversions and distribution to users within the region. Voluntary transfers are likely to have a neutral impact for surface water users. Drought will have a much greater impact on key water quality parameters.

Voluntary redistribution of groundwater sources will have minimal impacts on water quality parameters assuming there is no relative change in the amount of groundwater pumped. Impacts on key water quality parameters for large increases in groundwater pumpage to meet contractual sales are discussed in Section 6.2.6. Depending on the quality of the groundwater, municipal wastewater discharges could have a positive or negative impact to the water quality of the receiving stream.

Depending on the location and use of the water under voluntary redistribution, changes in locations of return flows (if applicable) could impact flows in receiving streams. Such impacts would be site specific and could be positive or negative, depending on the changes.

Generally, these impacts are relative to the quantities of water that are diverted or redistributed. Small quantities are likely to have minimal to no impacts, while large quantities may have measured impacts. In Region F, no large surface water volume transfers are expected.

6.1.5 Conjunctive Use

Conjunctive use allows for surface water sources to be operated in conjunction with groundwater sources such that impacts to key water quality parameters can be minimized while still providing users with sufficient supplies from groundwater. Recommended strategies for CRMWD, San Angelo, and others in Region F involve conjunctive use of surface water and groundwater supplies. These users systems already employ conjunctive use and continued and expanded use of this strategy is expected to have minimal to no impacts.

6.1.6 New and/or Expanded Supply Development

Increased use of groundwater can decrease instream flows if the base flow is supported by spring flow. This is not expected to be a concern for the recommended water management strategies in Region F. Most new groundwater development is in areas that have no flowing surface water, such as Winkler County, or from relatively deep portions of aquifers that most likely do not have significant impact on surface flows, such as McCulloch County.

Increased use of groundwater has the potential to increase TDS concentrations in area streams if the groundwater sources have higher concentrations of TDS or hardness than local surface water and are discharged as treated effluent. This is not the case in most areas in Region F. Naturally occurring salt seeps and high TDS waters are common in Region F. The development of new supplies from brackish groundwater is discussed under desalination.

New development of groundwater from the Hickory aquifer could potentially introduce radionuclides to surface water if wastewaters are discharged to local streams. San Angelo has already developed treatment systems to remove radionuclides from the Hickory aquifer supplies so large-scale introduction to surface water is not expected. The net concentrations in the receiving streams are expected to be low and should not impact water use from the stream.

6.1.7 Desalination /Advanced Treatment

Advanced treatment of groundwater and/or surface water is a recommended strategy for the cities of Midland, Odessa, Brady and Mason. Some of the source water is impaired for TDS, while others are impaired for radionuclides or other constituents. In terms of impacts on water quality, these systems produce a waste stream that may adversely impact waters if discharged to surface waters. Key water quality parameters that may be affected include TDS, nutrients, radionuclides, and metals.

6.1.8 Brush Control

Brush control is a recommended strategy in Region F. Impacts to the water quality of area streams will depend upon the methods employed to control the brush. It is assumed that chemical spraying will not be used near water sources. Mechanical removal, prescribed burns and use of the salt cedar beetle are the preferred methods near water sources. With these assumptions, chemical contamination of water sources is very low. Increases in stream flow due to reduced evapotranspiration associated with the removed brush should improve water quality in watersheds where brush control is employed.

6.1.9 Precipitation Enhancement

Precipitation enhancement is a recommended strategy for irrigators in counties with an active weather modification program, such as the West Texas Weather Modification Association (WTWMA) or the Trans Pecos Weather Modification Program (TPWMA). These operations are already in progress, so there are no expected changes in water quality associated with this strategy.

6.2 Impacts of Moving Water from Rural and Agricultural Areas

The recommended water management strategies that involve taking water from primarily rural areas or water currently used for agricultural purposes for use in primarily urban areas include:

- CRMWD Ward County Well Field Expansion, Winkler County Well Field Development
- City of San Angelo McCulloch County Well Field Phase 2
- San Angelo Indirect Reuse
- Paul Davis Wellfield with Advanced Treatment

Of these three strategies, all entities already hold the rights to that water. Although all of the proposed well fields are located in rural areas, these strategies are not expected to have significant impact on those areas. The CRMWD well field is located in areas where very little groundwater is used for other purposes. The San Angelo well field may impact wells in rural communities that also depend on the Hickory aquifer. However, pumping and well spacing limits set by the Hickory Underground Water Conservation District should minimize the potential impacts.

San Angelo's treated wastewater effluent is currently used to supply the local irrigation district as a substitute for Twin Buttes water. Implementation of this reuse strategy will make this water unavailable to the irrigation district at certain times and may impact these users. When the City does not need the supply, it will still be available for irrigators, reducing the potential impacts somewhat. During drought times, irrigators may need to plant less water intensive crops, convert to dry land farming, find alternative sources of supply, or reduce the number of irrigated acres.

Smaller municipalities are also planning to develop additional groundwater. These entities are considered rural and therefore do not constitute any movement of water from rural and agricultural areas.

6.3 Socio-Economic Impacts of Not Meeting Water Needs

Region F will face substantial shortages in water supply over the planning period. The TWDB provided technical assistance to regional planning groups in the development of specific information on the socio-economic impacts of failing to meet projected water needs.

The TWDB's analysis calculated the impacts of a severe drought occurring in a single year at each decadal period in Region F. It was assumed that all of the projected shortage was attributed to drought. Under these assumptions, the TWDB's findings can be summarized as follows:

- With the projected shortages, the region's projected 2020 population would be reduced by 18,030, which is approximately 2.6%.
- Without any additional supplies, the projected water needs would reduce the region's projected 2020 employment by approximately 98,000 jobs (23 percent reduction). This declines to around 39,000 lost jobs by 2070. The mining sector

accounts for 96 percent of these jobs losses in 2020 and 56 percent in 2070. Municipal and manufacturing sectors are the next biggest contributors, particularly in later decades.

- Without any additional supplies, the projected water needs would reduce the region's projected annual income by $19.6 billion, approximately 95 percent of which is within the mining industry. This represents nearly 40 percent of the region's current income. The loss in income reduces to approximately $6.4 billion in 2070, after the mining boom is projected to decline.

The full analysis performed by the TWDB is included in Appendix G.

6.4 Other Potential Impacts

The U.S. Army Corps of Engineers has published a list of the navigable portions of the rivers in Texas.[1] 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. Therefore, the Region F Plan does not have an impact on navigation.

The Region F Plan protects existing water contracts and option agreements by reserving the contracted amount included in those agreements where the amounts were known. In some cases, there were insufficient supplies to meet existing contracts. In those cases, water was reduced proportionately for each contract holder.

A special water resource is a major water supply source that is committed to provide water outside the region. TWDB has designated two special water resources in Region F: 1) Oak Creek Reservoir, which supplies water to Sweetwater in Brazos G, and 2) Ivie Reservoir, which supplies water to Abilene in Brazos G.

6.5 Consistency with the Protection of Water Resources

The water resources in Region F include three river basins providing surface water, and 14 aquifers providing groundwater. Most of Region F is located in the upper portion of the Colorado River Basin and in the Pecos portion of the Rio Grande River Basin. A small portion of the region is located in the Brazos River Basin. Figure 6-1 shows the major streams in Region F, including the Colorado River, Concho River, Pecan Bayou, San Saba River, Llano River, and Pecos River.

Figure 6-1
Major Surface Water Features in Region F

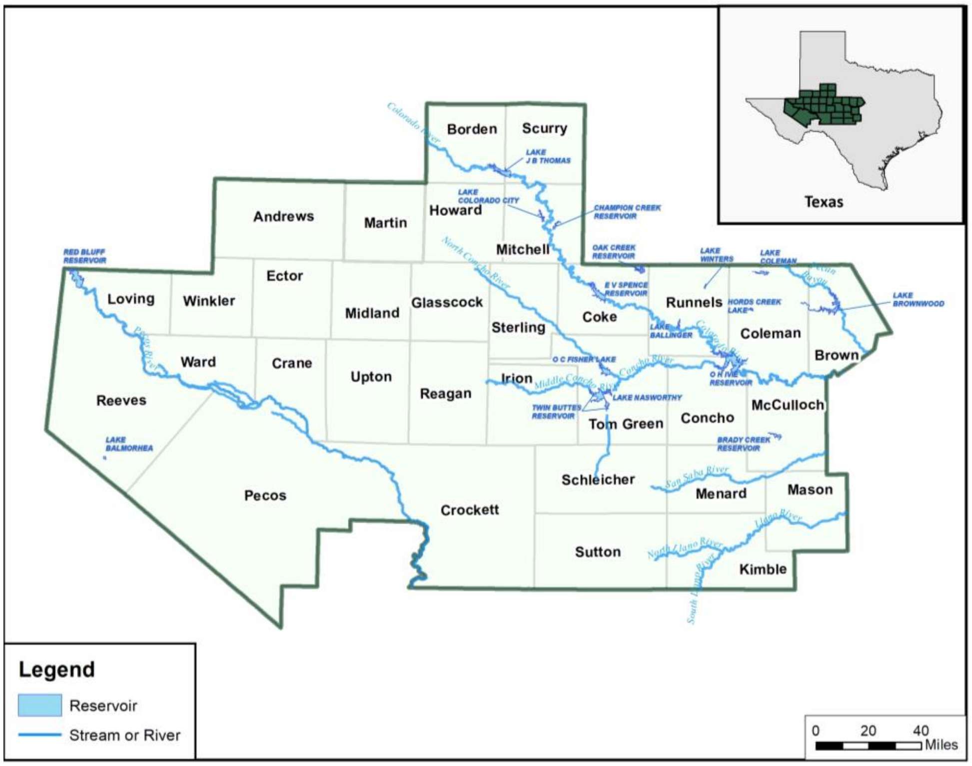


Figure 6-2
Springs in Region F

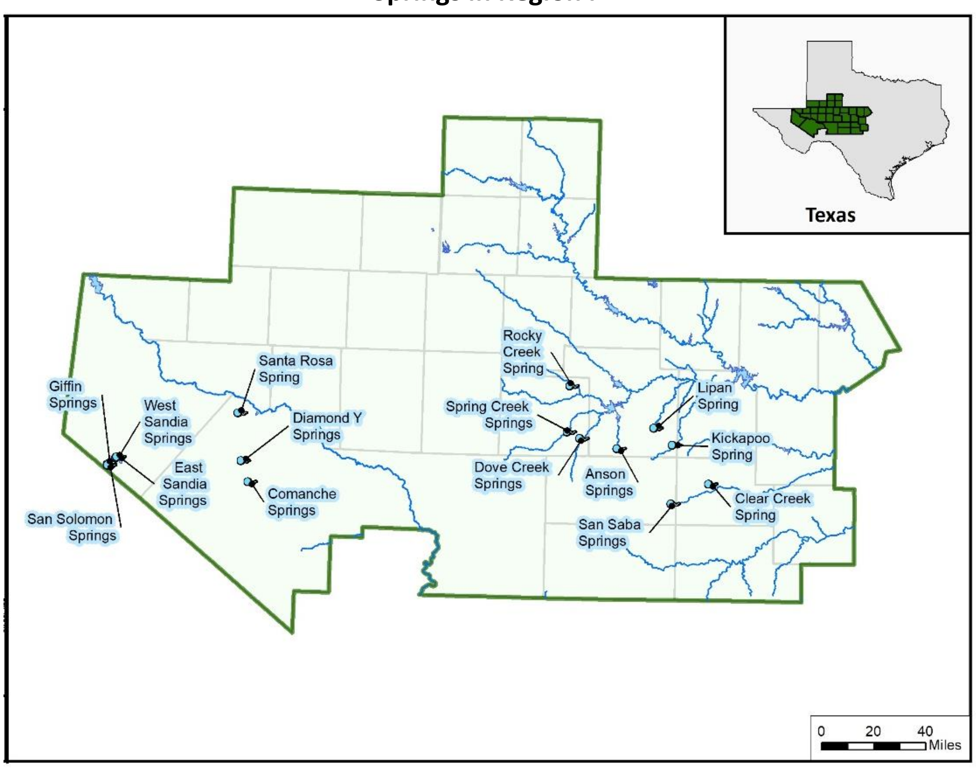


Figure 6-3
Major Aquifers in Region F

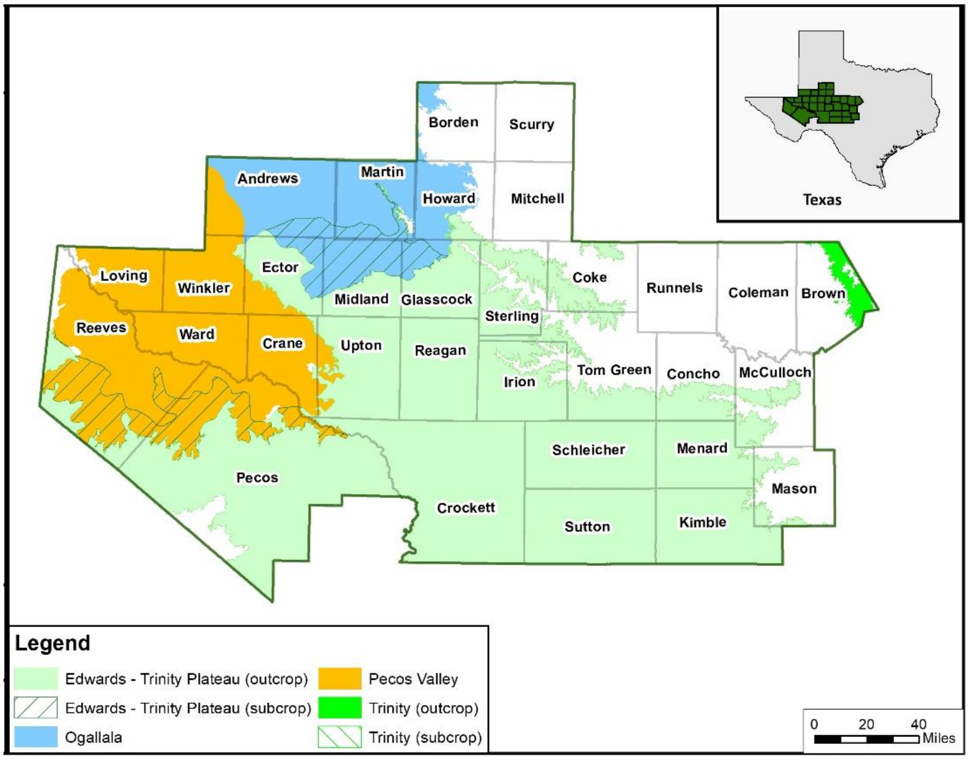
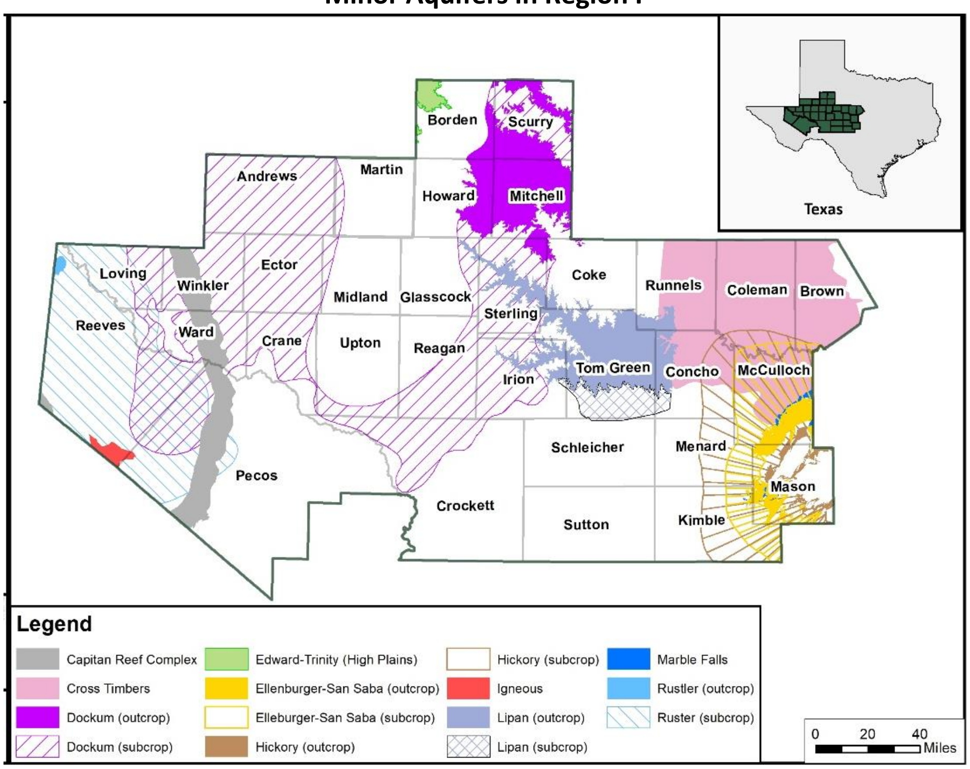


Figure 6-4
Minor Aquifers in Region F



The source of most of the region's surface water supply is the upper Colorado River Basin and the Pecos portion of the Rio Grande Basin, which supply municipal, industrial, mining and irrigation needs in the region. Major reservoirs in Region F include Red Bluff Reservoir, Lake J.B. Thomas, E.V. Spence Reservoir, O.C. Fisher Lake, Twin Buttes Reservoir, O.H. Ivie Reservoir, and Lake Brownwood.

Springs are an important water resource in Region F. They supplement surface water sources and provide water for aquatic and riparian habitat. Region F identified 16 major springs, which are shown on Figure 6-2. Lake Balmorhea, Twin Buttes Reservoir, Concho River and San Saba River are just some of the important water supply sources in Region F that rely on spring-fed streamflow.

Figure 6-3 shows the major aquifers in Region F, and Figure 6-4 shows the minor aquifers. There are a total of 14 aquifers that supply water to the 32 counties in Region F. Major aquifers include the Edwards-Trinity Plateau, Ogallala, Pecos Valley, and a small portion of the Trinity. Minor aquifers include the Dockum, Hickory, Lipan, Ellenburger-San Saba, Marble Falls, Rustler, Cross Timbers, Igneous and the Capitan Reef Complex. The Edwards-Trinity High Plains is used only on a limited basis. More detailed information on water resources in Region F is presented in Chapters 1 and 3.

The Edwards-Trinity Plateau, Pecos Valley, and Ogallala aquifers are the largest sources of groundwater in Region F, providing 36, 20, and 13 percent of the total groundwater pumped in 2016, respectively. The Lipan and Dockum aquifers each provided 5 percent of the 2016 totals. All remaining aquifers within the region contributed 21 percent combined.

The protections of water resources were considered through the supply allocation process and the development of water management strategies. For surface water, the distribution of supplies does not exceed the safe yield of the reservoir under subordination. This provides some water in the lakes through the drought of record and provides some protections from future droughts. For groundwater, the desired future conditions, as adopted by the GMAs, were honored for both currently developed supplies and potential future strategies. By not exceeding the modeled available groundwater, long-term effects on groundwater and surface water interrelationships were minimized since these complex relationships are considered by the respective GMA when selecting the DFCs.

To be consistent with the long-term protection of water resources, the plan must recommend strategies that minimize threats to the region's sources of water over the planning period. The water management strategies identified in Chapter 5 were evaluated for threats to water resources. The recommended strategies represent a comprehensive plan for meeting the needs of the region while effectively minimizing threats to water resources. Descriptions of the major strategy types and the ways in which they minimize threats to water resources are outlined in the following sections.

6.5.1 Water Conservation

Strategies for water conservation have been recommended that will reduce the demand for water, thereby reducing the impact on the region's groundwater and surface water sources. Water conservation practices are expected to save over 31,000 acre-feet of water annually by 2020, reducing demands on both groundwater and surface water resources. By 2070, the recommended conservation strategies savings (excluding wastewater reuse) total nearly 66,000 acre-feet per year. These savings are in addition to the water savings assumed in the demands.

6.5.2 Wastewater Reuse

Strategies involving wastewater reuse will provide high quality treated wastewater effluent for municipal and mining water needs in the region. These strategies will decrease the future demands on surface and groundwater sources and will not have a major impact on water resources. However, at times, San Angelo's reuse project may impact agricultural users that currently rely on the treated effluent for irrigation. In this case, these users may actually increase their demand on other local surface and groundwater sources.

6.5.3 Subordination of Downstream Water Rights

The Colorado WAM makes many assumptions that are contrary to the way the Colorado Basin has historically operated, showing that most surface water sources in the region have no supply. In conjunction with the Lower Colorado Region (Region K), a subordination strategy was developed that protects the supply of Region F water rights and the water resources in Region F. This strategy is described in Subchapter 5C.

6.5.4 Voluntary Transfers

Under this strategy, surface and ground water rights holders with surplus water supplies will provide water to areas with current or projected needs. This strategy is for proposed customers of wholesale water providers and expanded sales to entities with a projected future need. As proposed, this strategy will only use water that is available on a sustainable basis and will not significantly impact water resources.

6.5.5 Conjunctive Use

Conjunctive use supports the management of surface water and groundwater sources to provide water necessary for beneficial use while protecting the individual water resource during periods of drought.

6.5.6 New or Expanded Use of Groundwater

This strategy is recommended for entities with limited alternative sources and sufficient groundwater supplies to meet needs. Recommended strategies for groundwater supplies do not exceed the MAG values that were determined to meet the desired future conditions of the groundwater source. Large transfers of groundwater may have potential impacts to local surface water and springs. Such impacts were considered during the evaluation of the strategies. Where possible, strategies were selected that minimized impacts to surface water.

While the Region F water plan does not recommend strategies that exceed the MAG, several water providers are planning to develop strategies that would ultimately exceed the MAGs. These strategies are currently permitted or located in counties without GCDs. Based on technical review of the potential impacts of these strategies, water resources would not be significantly impacted. The need for water and the protections for public health and safety is paramount in this plan.

6.5.7 Desalination/ Advanced Treatment

Desalination and advanced treatment increase the usability of marginal quality water for municipal use. These strategies reduce the need to develop other fresh water supplies.

6.5.8 Brush Control

This strategy will support the surface water supplies in the region by reducing losses associated with evapotranspiration of invasive brush species.

6.5.9 Precipitation Enhancement

This strategy will support the water supplies in the region by increasing streamflows and reducing irrigation demands due to increased rainfall.

6.6 Consistency with Protection of Agricultural Resources

Agriculture is an important economic and cultural cornerstone in Region F. Given the relatively low rainfall rates, irrigation is a critical component for agriculture in the region. The RWPG is recommending improved irrigation efficiency as a strategy to maximize the efficient use of available water supplies and protect current and future agricultural resources in the region. These efficiency increases will reduce the projected deficit in heavily irrigated counties and preserve water supplies for future use in counties with no identified shortage. In some cases, development of additional supplies for irrigated agriculture is not economically feasible. In these cases, the irrigation need is shown as unmet in this plan. However, it is likely that the demands will decrease in response to this economic reality during dry years. Irrigated agriculture is likely to rebound during wet years when supplies are more abundant and economical. A summary of all unmet irrigation needs is shown in the table below.

Table 6-2
Unmet Irrigation Needs in Region F

Water User Group	2020	2030	2040	2050	2060	2070
Andrews	Andrews	(681)	(3,651)	(5,260)	(6,352)	(7,275)
Brown	Brown	(1,302)	(1,062)	(1,061)	(1,063)	(1,060)
Irion	Irion	(252)	(200)	(147)	(147)	(147)
Kimble	Kimble	(970)	(837)	(784)	(784)	(784)
Martin	Martin	0	0	(2,392)	(3,346)	(6,004)
Mitchell	Mitchell	(1,328)	(1,602)	(1,507)	(1,389)	(1,310)
Scurry	Scurry	(6,153)	(5,799)	(5,582)	(5,579)	(5,577)
Total	**Total**	**(10,686)**	**(13,151)**	**(16,733)**	**(18,660)**	**(22,157)**

In addition to irrigated agriculture, dry land agriculture and the ranching industry are important economically and culturally to the region. All livestock demands in the region are met through local surface water (stock ponds) or groundwater supplies, except for livestock in Andrews County, which is shown to have an unmet need of 10 to 60 acre-feet per year due to MAG limitations. However, local ranchers will develop additional local surface or groundwater supplies as needed to meet any water demands, and it is anticipated that this will not impact the livestock industry in this area.

All agricultural enterprises depend on the survival of small rural communities and their assurance of a reliable, affordable water supply. These communities increase the local area's tax base and provide government services, health services, fire protection, education facilities, and businesses where agriculture obtains fuels, crop processing and storage, banking, and general products and supplies. If small rural communities do not have an affordable water supply to sustain themselves and provide for economic stability, agriculture will suffer an increase in the cost of doing business and the loss of services that contribute to its overall well-being and safety. The Governor's Office, the Texas Department of Agriculture, and U.S. Department of Agriculture are working to enhance the validity and sustainability of Texas agriculture and small rural communities.

6.7 Consistency with Protection of Natural Resources

Region F contains many natural resources that must be considered in water planning. Natural resources include threatened or endangered species; local, state, and federal parks and public land; and energy/mineral reserves. The Region F Water Plan is consistent with the long-term protection of these resources. Following is a brief discussion of consistency of the plan with protection of natural resources.

6.7.1 Threatened/Endangered Species

A list of threatened or endangered species potentially present within Region F is contained in Table 1-12, in Chapter 1. Included are sixteen species of birds, two crustaceans, twelve fishes, one mammal, nine reptiles, eleven mollusks, and four flowering plants that are considered threatened or endangered on a state or federal level in Texas. None of the recommended water management strategies in this plan inherently impact the listed species. However, some strategies may require site-specific studies to verify that threatened or endangered species will not be impacted.

6.7.2 Parks and Public Lands

Seven state parks (Lake Brownwood, Big Spring, Lake Colorado City, Monahans Sandhills, San Angelo, Balmorhea and South Llano River) and one state wildlife management area (Mason Mountain) are located in Region F. The state parks and wildlife management area are not expected to be impacted by the recommended strategies. The subordination strategy simply continues the current operations in the basin and will not change lake or stream operations. There are no new recommended surface water strategies to impact streamflows.

In addition to the state parks, there are several city parks, recreational facilities, and public lands located throughout the region. None of the recommended water management strategies evaluated for the Region F Water Plan are expected to adversely impact these facilities or public land. The development of adequate water supplies would be beneficial for these facilities.

6.7.3 Energy Reserves

Thousands of producing oil and gas wells are located within Region F, representing an important economic base for the region. The RWPG is recommending recycling of flowback water from oil and gas operations (otherwise referred to in the plan as "mining conservation") as a strategy for all mining entities in the region, as it has the potential to significantly reduce water usage. Mining conservation, as well as all other recommended water management strategies for mining are expected to positively impact oil or gas production in the region. Some counties in Region F still show an unmet mining need, especially in counties with limited availability under the MAG, since water used for the protection of public health and safety is considered paramount in this plan. Advances in technology to reuse fracking water may help to close this gap. Furthermore, water used for the oil and gas industry is exempt from GCD regulation, and operators may exceed the MAG availability. The mining industry is not expected to be adversely impacted by this plan. Table 6-3 summarizes the unmet mining needs.

Table 6-3
Unmet Mining Needs in Region F

Water User Group	2020	2030	2040	2050	2060	2070
Andrews	(909)	(868)	(66)	0	0	0
Irion	(1,444)	(1,440)	(225)	0	0	0
Loving	(3,381)	(3,381)	(2,543)	(1,427)	(699)	(762)
Scurry	(222)	(363)	(385)	(290)	(196)	(132)
Total	**(5,956)**	**(6,052)**	**(3,219)**	**(1,717)**	**(895)**	**(894)**

6.7.4 Power Generation

Four counties in Region F are projected to have a steam electric power water demand over the next fifty years, including Ector, Howard, Mitchell, and Ward Counties. Steam electric power users in Mitchell and Ward Counties are identified to have an unmet need. Table 6-4 summarizes the unmet steam electric power needs in the 2021 Region F Plan.

Unmet steam electric power needs in Mitchell County are associated with two proposed FGE Texas Power facilities. These facilities do not currently exist, and development is dependent upon market conditions and other economic factors. If these power plants are developed in Mitchell County, steam electric power is projected have a large shortage, even after considering recommended strategies, such as reuse sales from Colorado City and subordination. Options to meet this shortage are restricted due to limited groundwater availability in Mitchell County. However, some of the water needs associated with these facilities may not come to fruition if FGE does not move forward with construction.

Ward County steam electric power demands are associated with the Luminant Permian Basin Power Plant, which uses groundwater from the Pecos Valley Aquifer. The demands shown in this plan (~2,500 acre-feet per year) are based on water usage from 2010, when the power plant utilized steam technology. However, over the past decade, the steam units at this plant have been retired and switched to combustion-based generation, which significantly reduced water needs. Since this replacement, the highest annual water usage from this plant was 123 acre-feet in 2012, and water demands are not expected to increase. Therefore, the unmet needs shown for steam electric power in Ward County are artificial and can be met with current groundwater supplies.

Table 6-4
Unmet Steam Electric Power Needs in Region F

Water User Group	2020	2030	2040	2050	2060	2070
Mitchell	(8,656)	(8,670)	(8,684)	(8,698)	(8,712)	(8,726)
Ward	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)	(2,352)
Total	**(11,008)**	**(11,022)**	**(11,036)**	**(11,050)**	**(11,064)**	**(11,078)**

6.8 Consistency with Protection of Public Health and Safety

Consistent with the guiding principles for regional water planning, the Region F Water Plan protects the public health and safety of current and future residents in the region.

The City of Andrews, Andrews-County Other, and Colorado City have limited supplies to serve future municipal water needs without exceeding the MAG. This plan is unable to show the full supply amount expected from future groundwater development strategies for these entities because of this limitation. As a result, the City of Andrews, Andrews County-Other, and Colorado City show an unmet municipal need in this plan. However, these users are planning to pursue the development of additional groundwater above the MAG to in order protect the public health and safety of their residents. Andrews and Andrews County-Other are able to do this because there is no GCD limit on groundwater production within Andrews County. However, Colorado City will have to coordinate with the GCD in Mitchell County (Lone Wolf GCD) to determine potential groundwater development above the MAG.

Conservation was considered and recommended as a strategy to help reduce the unmet needs and protect the human health and safety of the residents of Andrews, Andrews County-Other, and Colorado City. Drought management was also considered for both entities but was not considered feasible for meeting long-term growth in demands. Instead it is intended and encouraged to be used as means to reduce water usage during drought emergencies through the implementation of the entity's Drought Contingency Plan. Table 6-4 below summarizes all municipal unmet needs in Region F.

Table 6-5
Municipal Unmet Needs

Water User Group	2020	2030	2040	2050	2060	2070
Andrews	(147)	(361)	(619)	(1,186)	(1,850)	(2,650)
County-Other, Andrews	(16)	(43)	(74)	(134)	(192)	(254)
Colorado City	0	(115)	(126)	(137)	(150)	(164)
Total	**(163)**	**(586)**	**(895)**	**(1,573)**	**(2,343)**	**(3,250)**

6.9 Consistency with Economic Development

Consistent with the guiding principles for regional water planning, the Region F Water Plan provides for the further economic development of the region through water supply development for manufacturing and industrial use as well as increasing municipal demands associated with economic growth. The only unmet manufacturing need in Region F is in Andrews County. Similar to other entities in Andrews County, limited groundwater supplies under the MAG inhibit showing groundwater development as a recommended strategy, thus causing this unmet need. However, manufacturing users in Andrews County can pursue groundwater development of additional supplies above the MAG to meet all future water needs since production is not limited by a GCD. Table 6-5 shows the manufacturing unmet need in Region F.

Table 6-6
Manufacturing Unmet Needs

Water User Group	2020	2030	2040	2050	2060	2070
Andrews	(31)	(59)	(87)	(134)	(174)	(209)
Total	**(31)**	**(59)**	**(87)**	**(134)**	**(174)**	**(209)**

6.10 Consistency with State Water Planning Guidelines

To be considered consistent with long-term protection of the State's water, agricultural, and natural resources, the Region F Water Plan must be determined to be in compliance with the following regulations:

- 31 TAC Chapter 357.35
- 31 TAC Chapter 357.40
- 31 TAC Chapter 357.41
- 31 TAC Chapter 358.3

The information, data, evaluation, and recommendations included in the 2021 Region F Water Plan collectively comply with these regulations. To assist with demonstrating compliance, Region F has developed a matrix addressing the specific recommendations contained in the above referenced regulations.

The matrix is a checklist highlighting each pertinent paragraph of the regulations. The content of the Region F Water Plan has been evaluated against this matrix. Appendix A contains a completed matrix.

6.11 Summary of the Protections of the State's Resources

The RWPG balanced meeting water shortages with good stewardship of water, agricultural, and natural resources within the region. During the strategy selection process, long-term protection of the State's resources was considered through assessment of environmental impacts, impacts to agricultural and rural areas and impacts to natural resources. These evaluations are documented in Appendices C and E.

In this plan, existing in-basin or region surface water and groundwater supplies were utilized as feasible before recommendations for new water supply projects. Wastewater reuse is also an active water source to meet long-term needs in Region F. The plan assumes that this resource will be fully utilized to meet the growing demands in the region. The proposed conservation measures for municipalities, irrigators, and mining operators will continue to protect and conserve the State's resources for future water use.

LIST OF REFERENCES

[1] U.S. Army Corps of Engineers. *Fort Worth District: Navigable Waters of the United States in the Fort Worth, Albuquerque, and Tulsa Districts within the State of Texas*, December 20, 2011.

7 DROUGHT RESPONSE INFORMATION, ACTIVITIES, AND RECOMMENDATIONS

During the past century, recurring drought has been a natural part of Texas' varying climate, especially in the arid and semi-arid regions of the state. An old saying about droughts in west Texas is that "droughts are continual with short intermittent periods of rainfall." Droughts, due to their complex nature, are difficult to define and understand, especially in a context that is useful for communities that must plan and prepare for drought. Drought directly impacts the availability of ground and surface water supplies for agricultural, industrial, municipal, recreational, and designated aquatic life uses. The location, duration, and severity of drought determine the extent to which the natural environment, human activities, and economic factors are impacted.

Geography, geology, and climate vary significantly from east to west in Region F. Ecoregions within Region F vary from the Edwards Plateau to the east, Central Great and Western High Plains in the central and northern portions of the region, and Chihuahuan Deserts to the west. Annual rainfall in Region F ranges from an average of more than 30 inches in the east to slightly more than 11 inches in the west. Likewise, the annual gross reservoir evaporation rate ranges from 60 inches in the east to approximately 75 inches in the western portion of the region.

Numerous definitions of drought have been developed to describe drought conditions based on various factors and potential consequences. In the simplest of terms, drought can be defined as "a prolonged period of below-normal rainfall." However, the State Drought Preparedness Plan provides more specific and detailed definitions shown in the box at right.

These definitions are not mutually exclusive, and provide valuable insight into the complexity of droughts and their impacts. They also help to identify factors to be considered in the development of appropriate and effective drought preparation and contingency measures.

Types of Drought

- **Meteorological Drought.** A period of substantially diminished precipitation duration and/or intensity that persists long enough to produce a significant hydrologic imbalance.
- **Agricultural Drought.** Inadequate precipitation and/or soil moisture to sustain crop or forage production systems. The water deficit results in serious damage and economic loss to plant and animal agriculture. Agricultural drought usually begins after meteorological drought but before hydrological drought and can also affect livestock and other agricultural operations.
- **Hydrological Drought.** Refers to deficiencies in surface and subsurface water supplies. It is measured as streamflow, and as lake, reservoir, and groundwater levels. There is usually a lack of rain or snow and less measurable water in streams, lakes, and reservoirs, making hydrological measurements not the earliest indicators of drought.
- **Socioeconomic Drought.** Occurs when physical water shortages start to affect the health, well-being, and quality of life of the people, or when the drought starts to affect the supply and demand of an economic product.

Droughts have often been described as "insidious by nature." This is mainly due to several factors:

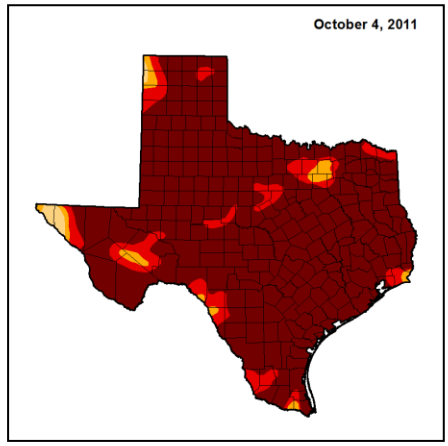
- Droughts cannot be accurately characterized by well-defined beginning or end points.
- Severity of drought-related impacts is dependent on antecedent conditions, as well as ambient conditions such as temperature, wind, and cloud cover.

- Droughts, depending on their severity, may have significant impacts on human activities; and human activities during periods of drought may exacerbate the drought conditions through increased water usage and demand.

Furthermore, the impact of a drought may extend well past the time when normal or above-normal precipitation returns.

7.1 Drought of Record in the Regional Water Planning Area (RWPA)

Various indices have been developed in an attempt to quantify drought severity for assessment and comparative purposes. One numerical measure of drought severity that is frequently used by many federal and state government agencies is the Palmer Drought Severity Index (PDSI). It is an estimate of soil moisture that is calculated based on precipitation and temperature. Another measure is the Drought Monitor that incorporates measurement of climate, hydrologic and soils conditions as well as site specific observations and reports. The Drought Monitor is distributed weekly and is often the tool used to convey drought conditions to the public and water users. In 2011, all counties of Region F experienced at least some periods of severe or extreme drought. Conditions have improved since 2011 but the Region is still experiencing ongoing drought conditions



Drought Monitor, October 2011

7.1.1 Drought of Record in Region F

The drought of record is commonly defined as the worst drought to occur in a region during the entire period of meteorological record keeping. For most of Texas, the drought of record occurred from 1950 to 1957. During the 1950's drought, many wells, springs, streams, and rivers went dry and some cities had to rely on water trucked in from other areas to meet drinking water demands. By the end of 1956, 244 of the 254 Texas counties were classified as disaster areas due to the drought, including all of the counties in Region F.

During the past decade, most regions of Texas have experienced droughts resulting in diminished water supplies for agricultural and municipal use, decreased flows in streams and reservoirs, and significant economic loss. Droughts of severe to extreme conditions occurred in the 1950s, 1990s, 2000s, and 2010s in Region F. The worst year during the recent drought was 2011, when most Region F counties experienced extreme drought. Despite some improvements from the worst part of 2011, drought conditions continue to persist throughout the region today.

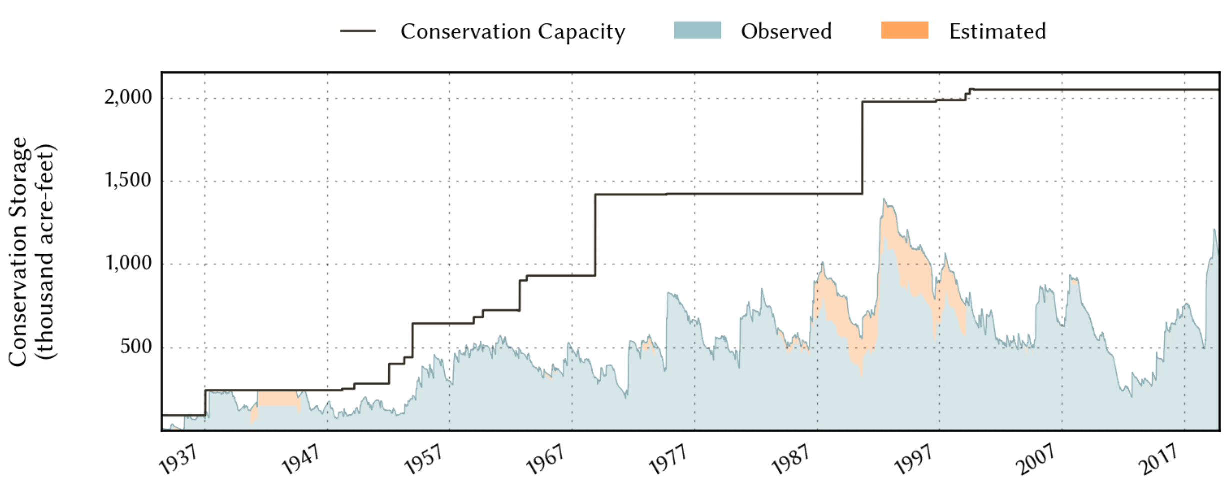
For reservoirs, the drought of record is defined as the period of record that includes the minimum content of the reservoir. The period is recorded from the last time the reservoir spills before reaching its minimum content to the next time the reservoir spills. If a reservoir has reached its minimum content but has not yet filled enough to spill, then it is considered to be still in drought of record conditions. Based on the water availability modeling, most of the reservoirs in Region F are currently experiencing a new drought of record. The minimum content of many reservoirs in the Colorado River Basin occurs at or near the end of the modeling simulation for TCEQ WAM Run 3 in December 2013. If the drought continues, the minimum content of the reservoir could continue to decrease, reducing the firm yield of the reservoirs. The modeled drought of records for the reservoirs in Region F are shown below in Table 7-1. Figure 7-1 is another perspective of reservoir storage in the region during the most recent drought which is generated by TWDB[1].

Table 7-1
Modeled Droughts of Record in Region F

Reservoir	Date last full in WAM	Date of minimum content in WAM	Drought of Record based on the WAM
Ballinger/Moonen	March 2008	August 2012	2008 – Current
Balmorhea	February 1997	September 2000	1997 – 2000
Brady Creek	March 1998	June 2013	1998 – Current
Brownwood	July 2007	September 2013	2007 – Current
Champion Creek	May 1987	August 2012	1987 – Current
Coleman	August 2007	December 2013[b]	2007 – Current
Colorado City	May 1994	May 2003	1994 – Current
Hords Creek	July 2007	December 2013[b]	2007 – Current
Lake Clyde	August 2007	December 2013[b]	2007 – Current
Mountain Creek	May 2008	August 2012	2008 – Current
Nasworthy	April 2008	October 2013	2008 – Current
Oak Creek	June 1997	August 2012	1997 – Current
O.C. Fisher	June 1987	September 2013	1987 – Current
O.H. Ivie	June 1997	December 2013[b]	1997 – Current
Red Bluff	March 1943	September 2000[b,c]	1943 – 2000
Spence	June 1992[a]	August 2012	1992 – Current
Thomas	September 1962	December 2013[b]	1962 – Current
Twin Buttes	March 1993	December 2013[b]	1993 – Current
Winters	June 1997	August 2012	1997 – Current

(1) This reservoir has never filled. The Date Last Full is based on the firm yield analyses. (Note: Firm yield analyses assume the reservoir is full at the beginning of the simulation.)
(2) Date of the end of the simulation.
(3) Hydrology for WAM simulations for the Rio Grande River Basin end in 2000. It was not extended.

Figure 7-1
TWDB Region-F Planning Region Reservoirs

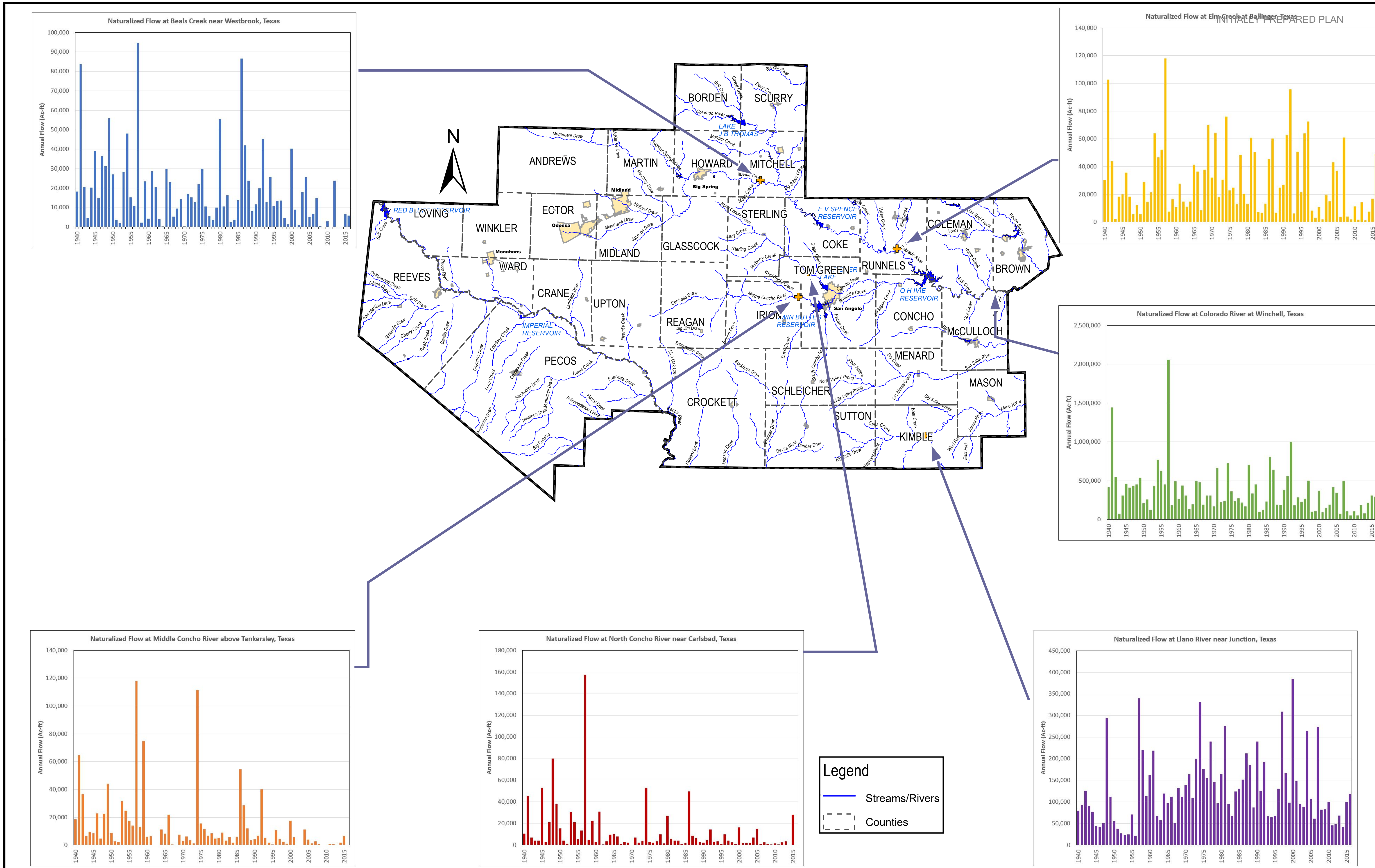


Drought of record conditions for run of the river supplies are typically evaluated based on minimum annual stream flows. Figure 7-2 shows the variations in naturalized flows from the WAM for seven U.S. Geological Survey (USGS) streamflow gages in Region F.[2] The five gages on tributaries have watersheds with limited development and show the natural variation in streamflows in this region. The Colorado gage near Winchell is the most downstream gage on the main stem of the Colorado River in Region F. Flows at the Pecos River gage near Girvin are largely controlled by releases from Red Bluff Reservoir. Based on the naturalized flows at these locations, the 2011 drought is the drought of record for the run-of-river supplies in the Colorado Basin with the exception of the Llano River where the drought of record is still in the 1950s. The drought of 2011 is also the drought of record for the Rio Grande River Basin in Region F.

For groundwater, meteorological and agricultural conditions were considered for defining the drought of record in Region F. The National Atmospheric and Oceanic Administration (NOAA) maintains data on the historical meteorological conditions and drought indices across the country. Figure 7-3 shows the historical precipitation for Midland, Texas. As is typical in Texas, the average annual precipitation in Region F increases from west to east. Midland is further west, and averages about 14.6 inches a year over the period shown. The years with the lowest historical precipitation occurred in 1951, 1998, and 2011. In 1951, 4.60 inches were recorded and 5.16 inches were recorded in 1998. In 2011, 5.47 inches were recorded. For both the 1950's drought and the recent drought, annual rainfall is significantly below average for an extended number of years. The current drought rivals the 1950's drought. Seven of the last fifteen years show rainfall less than the historic average. This is similar to the drought of the 1950s.

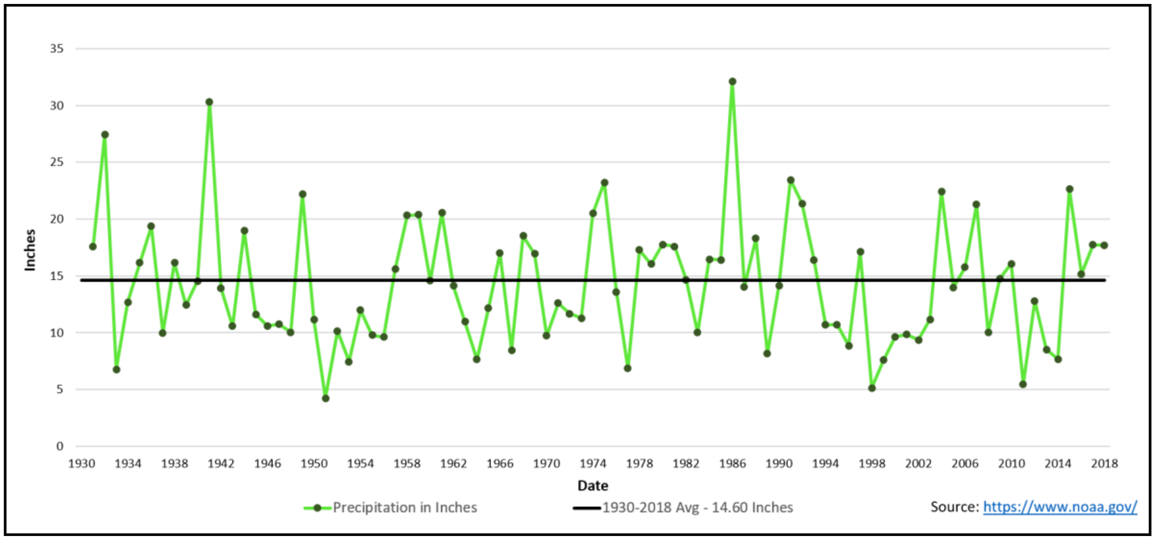
Drought of Record in Region F:

- The drought of record is worst drought in recorded history.
- For reservoirs, the drought of record is measured from the last time the reservoir was full before reaching its minimum content until the next time the reservoir fills and spill.
- For most of the region, the most recent drought in the 1990s, 2000s, and 2010s is the drought of record.
- This is different than most of the state where the drought of the 1950s is still the drought of record.
- In some cases, reservoirs in Region F still have not fully filled, indicating the drought of record is still on-going even though conditions have significantly improved over the past few years.
- 2011 was the worst single year of drought in Region F.



* Natural Dam Lake, which is above the Beals Creek gage, spilled intermittantly during 1986 and 1987. Natural Dam has subsequently been improved so that spills from the lake will not reoccur.

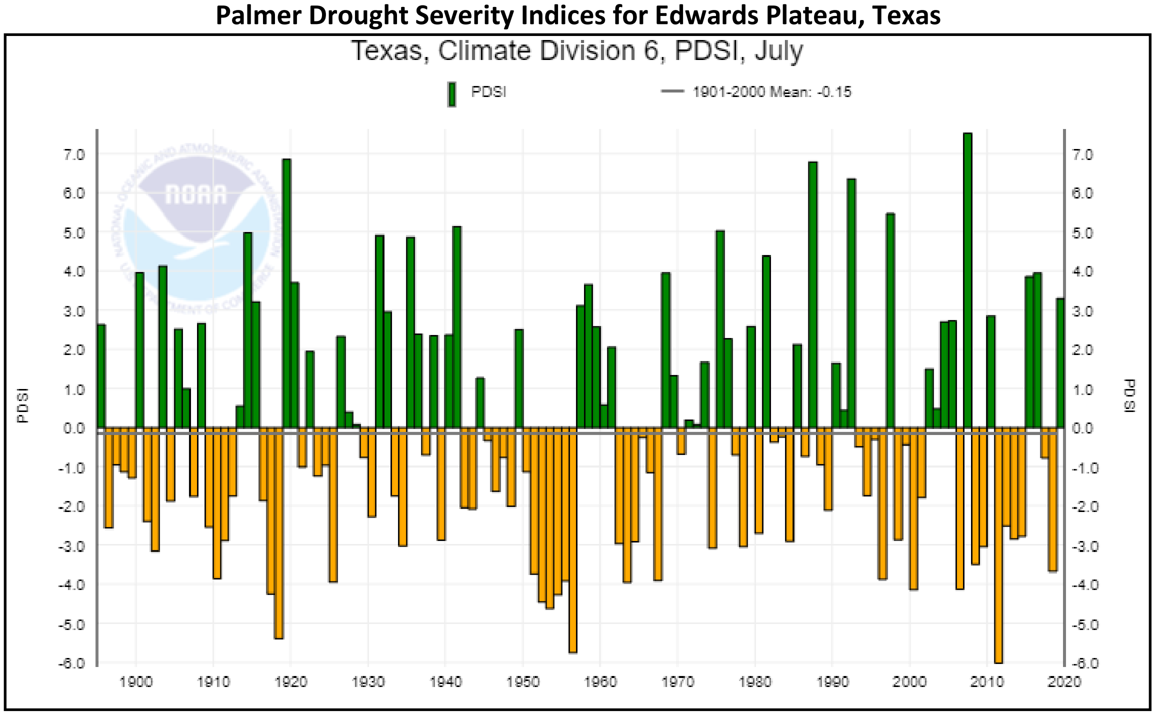
Figure 7-3
Historical Annual Precipitation in Midland, Texas



Looking at the Palmer Drought Severity Indices over the same time period for Climate Region 6 (where most of Region F is located), Figure 7-4 clearly shows the drought impacts during the 1950s and again since 2011. The Palmer Drought Severity Indices (PDSI) provide a measurement of long-term drought based on the intensity of drought during the current month plus the cumulative patterns of previous months. It considers antecedent soil moisture and precipitation. For Region F, these considerations are important in assessing the potential impacts to groundwater sources during drought from increases in water demands and agricultural water needs.

Considering both the annual precipitation and PDSI in the region, the drought of record for groundwater and run of the river sources is still the drought of the 1950s, although the current drought that began in 2011 is nearly as severe.

Figure 7-4
Palmer Drought Severity Indices for Edwards Plateau, Texas



7.1.2 Impacts of Drought on Water Supplies

Drought is a major threat to surface water supplies in Region F. For surface water, hydrological drought is significant because it impacts the yield of water sources. Typically, multi-year droughts have the greatest impact on a reservoir yield. Impacts of the new drought on reservoir yields in Region F using WAM Run 3 (no subordination) are negligible in most cases where the yields were already at or near zero. Impacts are more readily seen with the subordination strategy, which is discussed in Chapter 5C. With subordination, the analysis showed that most of the Colorado Basin reservoirs in Region F are currently experiencing new ongoing drought-of-record conditions. As a result of this current drought, many reservoirs have shown reductions in yield and may continue to decline if the drought persists.

Drought can also be a major threat to groundwater supplies that rely heavily on recharge. While some aquifers are less impacted by reduced recharge, others may be heavily impacted by the ongoing agricultural drought which can increase the demands on these sources. Furthermore, the reduced reliability of surface water sources in the region from the drought has caused many to shift to groundwater sources to secure a more drought-tolerant source of water supply. Over time the increased demands can impact the amount of storage in the aquifers for future use.

7.2 Current Drought Preparations and Response

In 1997, the Texas Legislature directed the TCEQ to adopt rules establishing common drought plan requirements for water suppliers in response to drought conditions throughout the State. Since 1997, the TCEQ has required all wholesale public water suppliers, retail public water suppliers serving 3,300 connections or more, and irrigation districts to develop, implement, and submit Drought Contingency Plans (DCPs) every five years. The most recent updates were to be submitted to the TCEQ by May 1, 2019. Retail public water suppliers serving less than 3,300 connections must prepare and adopt a DCP but are not required to submit plans to TCEQ. All DCPs should be made available for inspection by TCEQ. DCPs typically identify different stages of drought (e.g., mild, moderate, severe) and specific triggers and responses for each stage. In addition, DCPs specify quantifiable targets for water use reductions for each stage, and a means and method for enforcement.

Most wholesale water providers and municipalities in Region F have taken steps to prepare for and respond to drought through efforts, including the preparation of individual DCPs and readiness to implement them as necessary. Region F DCPs include specific water savings goals and drought contingency measures associated with multiple drought stages. In addition to these Plans, many water providers have a Management Supply Factor (or safety factor) greater than 1.0 for demands that are essential to public health and safety.

7.2.1 Drought Preparedness

Frequent recurring drought is a fact of life in Region F. Droughts have occurred in almost every decade since the 1940s. Recent experience with critical drought conditions attests to the effectiveness of drought management in the region. These reductions are at least partially due to the implementation of drought response activities included in the municipality's drought plan. However, according to city officials, the most significant factor in reducing water consumption is public awareness of drought conditions and voluntary reductions in water use. Some cities are pursuing aggressive water conservation programs that include using xeriscaping and efficient irrigation practices for public properties such as parks and buildings, and reuse of treated effluent for municipal and manufacturing supplies.

In general, water suppliers in Region F identify the onset of drought (set drought triggers) based on either their current level of supply or their current level of demand. Often the triggers for surface water reservoirs are based on the current capacity of the reservoir as a percentage of the total reservoir capacity. In Region F, the reservoir operators use a combination of reservoir storage (elevation triggers) and/or demand levels. Triggers for groundwater supplies are commonly determined by demand as a percentage of total supply or total delivery capacity. Suppliers set these triggers as needed based on the individual parameters of their system. Customers of a wholesale water provider (WWP) are subject to the triggers and measures of the WWPs' Drought Plans.

Fourteen updated Drought Contingency Plans were either submitted to Region F or adopted by an entity during this round of planning. The majority of these DCPs use trigger conditions that are supply-based, while the rest either use triggers that are based on the demands placed on the water system or are a combination of multiple conditions.

Table 7-2 summarizes the basis of the drought triggers by provider. Appendix G, Table G-1 summarizes the triggers and actions by water provider for initiation and response to drought.

Table 7-2
Type of Trigger Condition for Entities with Drought Contingency Plans Submitted to the Region F Planning Group

Entity	Type Trigger Conditions	
	Demand	Supply
Brookesmith SUD	X	
Brownwood	X	X
Brown County WID		X
CRMWD		X
Ector County UD		X
Eden		X
Fort Stockton	X	
Grandfalls	X	
Midland	X	
Red Bluff Power Control District		X
San Angelo		X
Snyder	X	X
Sonora	X	X
UCRA		X

Challenges to the drought preparedness in Region F include the resources available to smaller cities to adequately prepare for drought and respond in a timely manner. Also, for many cities the drought of 2011 truly tested the entity's drought plan and triggers. Some water providers found that the triggers were not set at the appropriate level to initiate different stages of the drought plan. The 2011 drought came quickly and was very intense. This increased demands on local resources and for many groundwater users increased competition for the water. Some systems had difficulty meeting demands and little time to make adjustments.

Many water providers of surface water sources have proactively developed supplemental groundwater sources, providing additional protections during drought. Many of the groundwater users have expanded groundwater production or are planning to develop additional groundwater in response to the current drought. Groundwater in Region F provides a more drought-resilient water source, but it needs to be managed to assure future supplies.

7.3 Existing and Potential Emergency Interconnects

According to Texas Statute §357.42(d),(e) regional water planning groups are to collect information on existing major water infrastructure facilities that may be used in the event of an emergency shortage of water. Pertinent information includes identifying the potential user(s) of the interconnect, the potential supplier(s), the estimated potential volume of supply that could be provided, and a general description of the facility. Texas Water Code §16.053(c) requires information regarding facility locations to remain confidential. This section provides general information regarding existing and potential emergency interconnects among water user groups within Region F.

7.3.1 Existing Emergency Interconnects

Major water infrastructure facilities within Region F were identified through a survey process to better evaluate existing and potentially feasible emergency interconnects. Most interconnections provide water to a specific recipient. Pecos County WCID and the City of Fort Stockton have an interconnection that can move water to or from each entity. In addition, two of the four systems within Concho Rural Water North Concho Lake Estates system are linked. Table 7-3 presents the survey results for the existing emergency interconnects among water users and neighboring systems.

Table 7-3
Existing Emergency Interconnects to Major Water Facilities in Region F

Entity *Providing* Supply	Entity *Receiving* Supply
CRMWD	Monahans
Millersview-Doole WSC	City of Paint Rock
City of San Angelo	Millersview-Doole WSC
City of Fort Stockton	Pecos Co. Water District
Pecos Co. WCID #1	City of Fort Stockton
Concho Rural Water N. Concho Lake Estates	CRWC Grape Creek
Zephyr WSC	City of Blanket
City of Odessa	Steam Electric Power, Ector County

7.3.2 Potential Emergency Interconnects

Responses to survey questions helped identify other potential emergency interconnects for various WUGs in Region F. Table 7-4 presents a list of cities for those receiving and those supplying the potential emergency interconnects. Emergency interconnects were found to be not practical for many of the entities that were evaluated for potential emergency water supplies. The type of infrastructure required between entities to provide or receive water during an emergency shortage was deemed impractical due to long transmission distances. Furthermore, it was deemed impractical during an emergency situation, to complete the required construction in a reasonable timeframe.

Table 7-4
Potential Emergency Interconnects to Major Water Facilities in Region F

Entity *Providing* Supply	Entity *Receiving* Supply
CRMWD (O.H. Ivie Lake)	Ballinger
Midland County FWSD#1	Greater Gardendale WSC
City of Ballinger	North Runnels WSC
Texland Great Plains WSC	City of Andrews
Millersview-Doole WSC	City of Miles
CRMWD	Wickett

7.4 Emergency Responses to Local Drought Conditions or Loss of Municipal Supply

Texas Statute §357.42(g) requires regional water planning groups to evaluate potential temporary emergency water supplies for all County-Other WUGs and municipalities with 2010 populations less than 7,500 that rely on a sole source of water. The purpose of this evaluation is to identify potential alternative water sources that may be considered for temporary emergency use in the event that the existing water supply sources become temporarily unavailable due to extreme hydrologic conditions such as emergency water right curtailment, unanticipated loss of reservoir conservation storage, or other localized drought impacts.

This section provides potential solutions that should act as a guide for municipal water users that are most vulnerable in the event of a loss of supply. This review was limited and did not require technical analyses or evaluations in accordance with 31 TAC §357.34.

7.4.1 Emergency Responses to Local Drought Conditions

A survey was conducted to identify and evaluate the municipal water users that are most vulnerable in the event of an emergency water shortage. The analysis included all County-Other WUGs and rural cities with a population less than 7,500 and on a sole source of water. A sole source is defined here as a single well field or single surface water source. If an entity receives water from a single wholesale provider with only one source, they were considered as part of this analysis. If an entity receives water from a single wholesale provider who has multiple sources, they were not considered to have a sole source and were not included in this analysis.

Table 7-5 presents potential temporary responses that may or may not require permanent infrastructure. It was assumed in the analysis that the entities listed would have approximately 180 days or less of remaining water supply.

Releases from Upstream Reservoirs and Curtailment of Rights

Releases from upstream reservoirs and curtailment of water rights was considered as a temporary measure that may help increase water supplies during an emergency water shortage. This response was only considered for those entities who receive surface water and may not be viable for all water right holders. Surface water in Texas is operated on a priority system and the water right holder may have no legal authority on which to request a release from an upstream reservoir or the curtailment of other water rights if their rights are junior. Even if the water user has a senior water right, in some cases, these strategies may result in what is known as a futile call. This occurs if shutting down a junior water right will not actually result in water being delivered to the senior right. In which case, the call will not be enforced.

Brackish Groundwater

Brackish groundwater was evaluated as a temporary source during an emergency water shortage. Some brackish groundwater is found in certain places in the Ogallala, but other brackish groundwater supplies can be obtained from the Dockum, Hickory, Ellenburger-San Saba, Lipan, Capitan Reef, Pecos Valley Alluvium and other formations which underlie the shallow aquifers found in Region F.

Required infrastructure would include additional groundwater wells, potential treatment facilities and conveyance facilities. Brackish groundwater at lower TDS concentrations may require only limited treatment. Twelve of the entities listed in Table 7-5 may not be able to potentially use brackish groundwater as a feasible solution to an emergency local drought condition.

Drill Additional Local Groundwater Wells and Trucking in Water

In the event that the existing water supply sources become temporarily unavailable, possible solutions include drilling additional groundwater wells or trucking in water. Table 7-5 presents this option as viable for all entities listed.

Table 7-5
Emergency Responses to Local Drought Conditions in Region F

Entity				Implementation Requirements									
Water User Group	**County**	**2020 Population**	**2020 Demand (AF/YR)**	**Release from upstream reservoir**	**Curtailment of water rights**	**Local groundwater wells**	**Brackish groundwater limited treatment**	**Brackish groundwater desalination**	**Emergency interconnect**	**Trucked - in water**	**Type of infrastructure required**	**Entity providing supply**	**Emergency agreements already in place**
Bangs	Brown	2,506	310			▪	▪		▪	▪			
Barstow	Ward	375	119			▪				▪			
Big Lake	Reagan	3,357	730			▪	▪	▪		▪			
Colorado City	Mitchell	5,149	1,308			▪	▪			▪			
Crockett Co. WCID1	Crockett	3,885	1,153			▪	▪			▪			
DADS Supported Living Center	Tom Green	253	109			▪				▪			
Early	Brown	2,907	292			▪	▪		▪	▪	Pipeline	Brownwood	
Eldorado	Schleicher	2,104	662			▪				▪			
Grandfalls	Ward	427	135			▪				▪			
Greater Gardendale WSC	Ector	2,547	211			▪	▪	▪		▪			
	Midland	1,299	108			▪	▪	▪		▪			
Greenwood Water	Midland	993	310			▪	▪			▪			
Iraan	Pecos	1,347	458			▪	▪	▪	▪	▪	Pipeline; PS; Treatment	Pecos Co. Precinct #3	
Junction	Kimble	2,632	626			▪	▪	▪		▪			
Kermit	Winkler	5,917	1,811			▪	▪	▪	▪	▪	Pipeline; PS; Treatment	Midland Freshwater District/ WRTA	

Entity				Implementation Requirements									
Water User Group	**County**	**2020 Population**	**2020 Demand (AF/YR)**	**Release from upstream reservoir**	**Curtailment of water rights**	**Local groundwater wells**	**Brackish groundwater limited treatment**	**Brackish groundwater desalination**	**Emergency interconnect**	**Trucked - in water**	**Type of infrastructure required**	**Entity providing supply**	**Emergency agreements already in place**
Loraine	Mitchell	656	76			▪				▪			
Madera Valley WSC	Reeves	1,541	446			▪	▪	▪		▪			
Mason	Mason	2,134	700			▪				▪			
McCamey	Upton	2,215	827			▪	▪	▪		▪			
Menard	Menard	1,492	350			▪	▪			▪			
Mertzon	Irion	823	101			▪	▪			▪			
Mitchell Co. Utility	Mitchell	1,596	210			▪	▪			▪			
Pecos Co. Fresh Water	Pecos	748	201			▪				▪			
Pecos Co. WCID 1	Pecos	3,019	384			▪	▪	▪	▪	▪	Pipeline	Fort Stockton	▪
Rankin	Upton	856	276			▪				▪			
Santa Anna	Coleman	1,121	156			▪	▪			▪			
Sonora	Sutton	2,800	1,045			▪				▪			
Southwest Sandhills WSC	Ward	1,937	185			▪	▪			▪			
Sterling City	Sterling	944	276			▪	▪	▪		▪			
Tom Green Co. FWSD 3	Tom Green	1,132	131			▪				▪			
Wickett	Ward	512	208			▪				▪			
Wink	Winkler	1,059	358			▪	▪	▪		▪			
Winters	Runnels	2,763	226			▪		▪	▪	▪	Pipeline	Abilene (Ivie Pipeline)	
Zephyr WSC	Brown	4,173	343			▪	▪			▪			▪

7.5 Region Specific Drought Response Recommendations and Model Drought Contingency Plans

As required by the TWDB, the RWPG (Regional Water Planning Group) shall develop drought recommendations regarding the management of existing groundwater and surface water sources. These recommendations must include factors specific to each source as to when to initiate drought response and actions to be taken as part of the drought response. These actions should be specified for the manager of a water source and entities relying on the water source. The RWPG has defined the manager of water sources as the entity that controls the water production and distribution of the water supply from the source. For purposes of this assessment, a manager must also meet the TCEQ requirements for development of a Drought Contingency Plan. Entities that rely on the water sources include customers of the water source manager and direct users of the water sources, such as irrigators.

A list of each surface water and groundwater source in Region F and the associated managers and users of the source is included in Table G-2 in Appendix G.

In addition, the RWPG must identify unnecessary or counterproductive variations in specific drought response strategies, including outdoor watering restrictions, among user groups in the regional water planning area that may confuse the public or otherwise impede drought response efforts. The Region F RWPG recognizes the benefit of additional coordination between drought responses within more urban planning areas where people living in very close proximity to one another may have different outdoor water restrictions. However, this situation does not occur in Region F. Region F maintains that DCPs developed by the local, individual water providers are the best available tool for drought management. Region F fully supports the use and implementation of individual DCPs during times of drought and did not find the differences in local response to be unnecessary or counterproductive.

7.5.1 Drought Trigger Conditions for Surface Water Supply

Drought trigger conditions for surface water supply are customarily related to reservoir levels. Region F acknowledges that the Drought Contingency Plans for the suppliers who have surface water supplies are the best management tool for these water supplies. The RWPG recommends that the drought triggers and associated actions developed by the regional operator of the reservoirs are the Region F regional triggers for these sources. A summary of these triggers and actions for major Region F reservoirs follows as defined by each source manager. Triggers and actions for other reservoirs are included in Table G-3 in Appendix G. The region also recognizes any modification to these drought triggers that are adopted by the regional operator.

Lake Brownwood (Brown County WCID #1)

BCWID #1 adopted their current Drought Contingency Plan in March of 2019. The triggers and actions are related to the elevation of Lake Brownwood and are summarized below in Table 7-6.

Table 7-6
Lake Brownwood Triggers and Actions

Drought Stage	Trigger	Action
Mild	Elevation below 1,420 ft. (76% capacity)	Advise customer of early conditions. Initiate Stage I of DCPs. Increase public education. Request voluntary conservation measures.
Moderate	Elevation below 1,417 ft. (64% capacity)	Request decrease in water usage. Implement watering restrictions. Request monitoring of irrigation facilities. District may reduce water delivery in accordance with pro rate curtailment.
Severe	Elevation below 1,414 ft. (53% capacity)	Request to severely reduce water usage. Watering restrictions. May conduct site visits to irrigation facilities. District may reduce water delivery in accordance with pro rata curtailment. May utilize alternate water sources, with TCEQ approval.
Exceptional	Elevation below 1,411 ft. (43% capacity)	District may call an emergency meeting with customers. Completely restrict watering. District may evaluate the need to discontinue delivery of water for second crops and non-essential uses. May reduce water delivery in accordance with pro rata curtailment. May utilize alternate water sources, with TCEQ approval.
Emergency	Elevation below 1408 ft. (34% capacity)	Same as the Exceptional drought stage. Any other necessary actions.

O.H. Ivie Reservoir (CRMWD)

The Board of Directors of CRMWD adopted their current Drought Contingency Plan in May 2019. In CRMWD's DCP, drought contingency triggers and actions are separated into two categories: the non-system portion of the O.H. Ivie Reservoir (Ivie) and the remaining CRMWD System. Triggers for these two categories are associated with their respective storage capacities. The triggers and actions related to the capacities of the O.H. Ivie Reservoir are outlined below in Table 7-7.

Lake Spence during 2010s Region F Drought

Table 7-7
O.H. Ivie Reservoir Drought Triggers and Actions

Drought Stage	Trigger	Action[a]
Mild	Capacity below 138,028 ac-ft.	Initiate studies to evaluate alternative actions if conditions worsen. Request any WUG solely dependent on Ivie water to implement Stage 1 of their DCP.
Moderate	Capacity below 107,060 ac-ft.	Continue or initiate actions under Stage 1. Initiate studies to evaluate alternative actions if conditions worsen. Request any WUG solely dependent on this source to implement Stage 2 of their DCP.
Severe	Capacity below 76,092 ac-ft.	Continue or initiate actions under Stage 1 and 2. Initiate studies to evaluate alternative actions if conditions worsen. Request any WUG solely dependent on this source to implement Stage 3 of their DCP.
Critical	Pipeline break, equipment failure, or source contamination that severely limits distribution capacity.	Assess the severity of the problem and identify actions and time need to resolve it. Inform responsible officials for each wholesale water customer and suggest actions to alleviate problems. If appropriate, notify city, county, and/or state emergency response officials. Undertake necessary actions. Prepare a post-event assessment report.

a. During each stage, the following actions may be implemented by the District:
(1) Contact wholesale water customers monthly to discuss water supply and/or demand actions.
(2) Requesting wholesale water customers to reduce non-essential water use.
(3) Discussing the possibility of pro rate curtailment of water diversions and/or deliveries.
(4) Preparing a monthly water usage allocation baseline for each wholesale customer.

CRMWD System (CRMWD)

The CRMWD System includes supplies from Lake J.B. Thomas, E.V. Spence Reservoir, O.H. Ivie Reservoir, North Ward County Well Field, and the Big Spring Raw Water Production Facility. The triggers and actions related to the capacity of the CRMWD System are outlined below in Table 7-8.

Table 7-8
CRMWD System Drought Triggers and Actions

Drought Stage	Trigger	Action[a]
Mild	Capacity below 77,998 ac-ft.	Initiate studies to evaluate alternative actions if conditions worsen. Request any WUG solely dependent on Ivie water to implement Stage 1 of their DCP.
Moderate	Capacity below 58,499 ac-ft.	Continue or initiate actions under Stage 1. Initiate studies to evaluate alternative actions if conditions worsen. Request any WUG solely dependent on this source to implement Stage 2 of their DCP.
Severe	Capacity below 38,999 ac-ft.	Continue or initiate actions under Stage 1 and 2. Initiate studies to evaluate alternative actions if conditions worsen. Request any WUG solely dependent on this source to implement Stage 3 of their DCP.
Critical	Pipeline break, equipment failure, or source contamination that severely limits distribution capacity.	Assess the severity of the problem and identify actions and time need to resolve it. Inform responsible officials for each wholesale water customer and suggest actions to alleviate problems. If appropriate, notify city, county, and/or state emergency response officials. Undertake necessary actions. Prepare a post-event assessment report.

a. During each stage, the following actions may be implemented by the District:
(1) Contact wholesale water customers monthly to discuss water supply and/or demand actions.
(2) Requesting wholesale water customers to reduce non-essential water use.
(3) Discussing the possibility of pro rate curtailment of water diversions and/or deliveries.
(4) Preparing a monthly water usage allocation baseline for each wholesale customer.

O.C. Fisher, Twin Buttes, Nasworthy (San Angelo)

O.C. Fisher, Twin Buttes, and Nasworthy are all operated by the City of San Angelo. The City of San Angelo adopted their most recent Drought Contingency Plan in September of 2019. The triggers and actions in the City's DCP are based on combined storage and supply from all of the City's sources, which includes these reservoirs, as well as groundwater. These are outlined in Table 7-9 below.

Table 7-9
O.C Fisher, Twin Buttes and Nasworthy Drought Triggers and Actions

Drought Stage	Trigger	Action
Mild	Less than 24 months supply	Outdoor watering restrictions, watering schedule, water usage fees.
Moderate	Less than 18 months supply	Same as Stage 1 ("Mild" drought stage).
Critical/Emergency	Less than 12 months supply	Outdoor watering, filling of fountains or swimming pools, and/or washing of vehicles are all prohibited, water usage fees.

7.5.2 Drought Trigger Conditions for Run-of-River and Groundwater Supply

Both run-of-river and ground water supplies are more regional than reservoirs and typically there are many users of these sources. As noted in Section 7.2, some water providers will have developed Drought Contingency Plans that are specific to their water supplies. Other water users, such as agricultural or industrial users, may not have Drought Contingency Plans. To convey drought conditions to all users of these resources in Region F, the RWPG proposes to use the Drought Monitor. This information is easily accessible and updated regularly. It does not require a specific entity to monitor well water levels or stream gages. It is also geographically specific so that drought triggers can be identified on a sub-county level that is consistent with the location of use. Region F has adopted the same nomenclature as the Drought Monitor for corresponding Region F drought triggers. Table 7-10 shows the categories adopted by the U.S. Drought Monitor and the associated Palmer Drought Index.

Table 7-10
Drought Severity Classification

Category	Description	Possible Impacts	Palmer Drought Severity Index
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered	-1.0 to -1.9
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested	-2.0 to -2.9
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed	-3.0 to -3.9
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions	-4.0 to -4.9
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less

U.S. Drought Monitor: https://droughtmonitor.unl.edu/AboutUSDM/AbouttheData/DroughtClassification.aspx

For groundwater and run-of-river supplies, Region F recognizes that the initiation of drought response is the decision of the manager of the source and/or user of the source. Region F recommends the following actions based on each of the drought classifications listed above:

- *Abnormally Dry* – Entities should begin to review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage is necessary.
- *Moderate Drought* – Entities should review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage is necessary.
- *Severe Drought* – Entities should review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage or changing to a more stringent stage is necessary. At this point if the review indicates current supplies may not be sufficient to meet reduced demands the entity should begin considering alternative supplies.
- *Extreme Drought* – Entities should review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage or changing to a more stringent stage is necessary. At this point if the review indicates current supplies may not be sufficient to meet reduced demands the entity should consider alternative supplies.
- *Exceptional Drought* – Entities should review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage or changing to a more stringent stage is necessary. At this point if the review indicates current supplies are not sufficient to meet reduced demands the entity should implement alternative supplies

7.5.3 Model Drought Contingency Plans

Model Drought Contingency Plans (DCPs) were developed for Region F and can be accessed online at www.regionfwater.org. Each plan identifies four drought stages: mild, moderate, severe and emergency. The recommended responses range from notification of drought conditions and voluntary reductions in the "mild" stage to mandatory restrictions during an "emergency" stage. Entities using the model plan can select the trigger conditions for the different stages and appropriate responses for each stage.

In 2019, the Drought Preparedness Council recommended that a model DCP be in place for any water user group that exceeds ten percent of the Region's water demands. For Region F, these user groups include irrigation, municipal, and mining. Region F developed Model DCPs for municipal, irrigation, and industrial users, which can be accessed at http://regionfwater.org/index.aspx?id=Documents. The TCEQ does not require a DCP for mining users since mining is a private industry and is not subject to TCEQ enforcement. Thus, no model DCP was developed for mining.

7.6 Drought Management Water Management Strategies

Drought management is a temporary strategy to conserve available water supplies during times of drought or emergencies. This strategy is not recommended to meet long-term growth in demands, but rather acts as a means to minimize the potential for adverse impacts or water supply shortages during drought. The TCEQ requires Drought Contingency Plans (DCPs) for wholesale and retail public water suppliers and irrigation districts. A DCP may also be required for entities seeking state funding for water projects. Region F does not recommend specific drought management strategies. Region F recommends the implementation of DCPs by suppliers when appropriate to reduce demand during drought and prolong current supplies.

7.7 Other Drought-Related Considerations and Recommendations

7.7.1 Texas Drought Preparedness Council and Drought Preparedness Plan

In accordance with TWDB rules, all relevant recommendations from the Drought Preparedness Council were considered in the writing of this Chapter. The Texas Drought Preparedness Council is composed of representatives from multiple State agencies and plays an important role in monitoring drought conditions, advising the governor and other groups on significant drought conditions, and facilitating coordination among local, State, and federal agencies in drought-response planning. The Council meets regularly to discuss drought indicators and conditions across the State and releases Situation Reports summarizing their findings. Additionally, the Council has developed the State Drought Preparedness Plan, which sets forth a framework for approaching drought to minimize impacts to people and resources. Region F supports the efforts of the Texas Drought Preparedness Council and recommends that water providers regularly review the Situation Reports as part of their drought monitoring.

The Council provided two new recommendations in 2019 to all RWPGs which are addressed in this chapter:

- Follow the outline template for Chapter 7 provided to the regions by Texas Water Development Board staff in April of 2019, making an effort to fully address the assessment of current drought preparations and planned responses, as well as planned responses to local drought conditions or loss of municipal supply.
- Develop region-specific model drought contingency plans for all water use categories in the region that account for more than 10 percent of water demands in any decade over the 50-year planning horizon. To meet these recommendations, Region F has developed this Chapter to correspond with the sections of the outline template. Region F also prepared Model DCPs for municipal, irrigation, and industrial users. Region F did not prepare a Model DCP for mining despite its accounting for greater than 10 percent of the Region's water demands in some decades. The primary drivers for mining water use are economic, not drought conditions. Thus, the Region F RWPG did not feel it was appropriate to develop a Model DCP for mining. Further discussion of these Model DCPs are discussed in Section 7.5.3.

7.7.2 Other Drought Recommendations

Region F recognizes that while drought preparedness, including DCPs, are an important tool, in some instances drought cannot be prepared for, it must be responded to. Region F recognizes the Drought Preparedness Council's ability to assist with drought response when needed. Region F, however, maintains that DCPs developed by the local, individual water providers are the best available tool for drought management. Region F fully supports the use and implementation of individual DCPs during times of drought.

To better prepare for future droughts, Region F makes the following recommendations:

- That the Regional Water Plans remain a separate process for developing long-term water supply solutions for increased growth. The Regional Water Plans should not be the resource for times of emergency drought.
- The Drought Preparedness Council should increase coordination with local providers regarding drought conditions and potential implementation of drought stages, particularly during times of limited precipitation.

LIST OF REFERENCES

[1] Texas Water Development Board “Water Data for Texas” <https://www.waterdatafortexas.org/reservoirs/region/region-f>

[2] U.S. Geological Survey. "Streamflow Gage Records." <http://waterdata.usgs.gov/tx/nwis.>.

8 UNIQUE STREAM SEGMENTS, RESERVOIR SITES, AND LEGISLATIVE RECOMMENDATIONS

The Texas Water Development Board (TWDB) regional water planning rules require that a regional water plan include recommendations for regulatory, administrative, legislative or other changes that:

“the regional water planning group believes are needed and desirable to achieve the stated goals of the state and regional water planning, including to facilitate the orderly development, management, and conservation of water resources and preparation for and response to drought conditions.” [357.43(d)]

The rules also call for regional water planning groups to make recommendations on the designation of ecologically unique river and stream segments and unique sites for reservoir development and encourage the planning groups to consider recommendations that would facilitate more voluntary transfers. This section presents the regulatory, administrative, legislative, and other recommendations of the Region F Water Planning Group and the reasons for the recommendations.

8.1 Recommendations for Ecologically Unique River and Stream Segments

For each planning region, the Texas Parks and Wildlife Department (TPWD) developed a list of river and stream segments that meet one or more of the criteria for being considered ecologically significant. In Region F, TPWD identified 20 segments as listed in Table 8-1 and shown in red on Figure 8-1 as ecologically significant.

In previous planning cycles, the Region F Water Planning Group decided not to recommend any river or stream segments as ecologically unique because of unresolved concerns regarding the implications of such a designation. The Texas legislature has since clarified that the only intended effect of the designation of a unique stream segment was to prevent the development of a reservoir on the designated segment by a political subdivision of the State. However, the TWDB regulations governing regional water planning require analysis of the impact of water management strategies on unique stream segments, which implies some level of protection beyond the mere prevention of reservoir development.

Region F Recommendations

Region F recommends no unique stream segments or reservoir sites. However, Region F does make several legislative recommendations which are summarized into a bulleted list in Section 8.5 of this chapter.

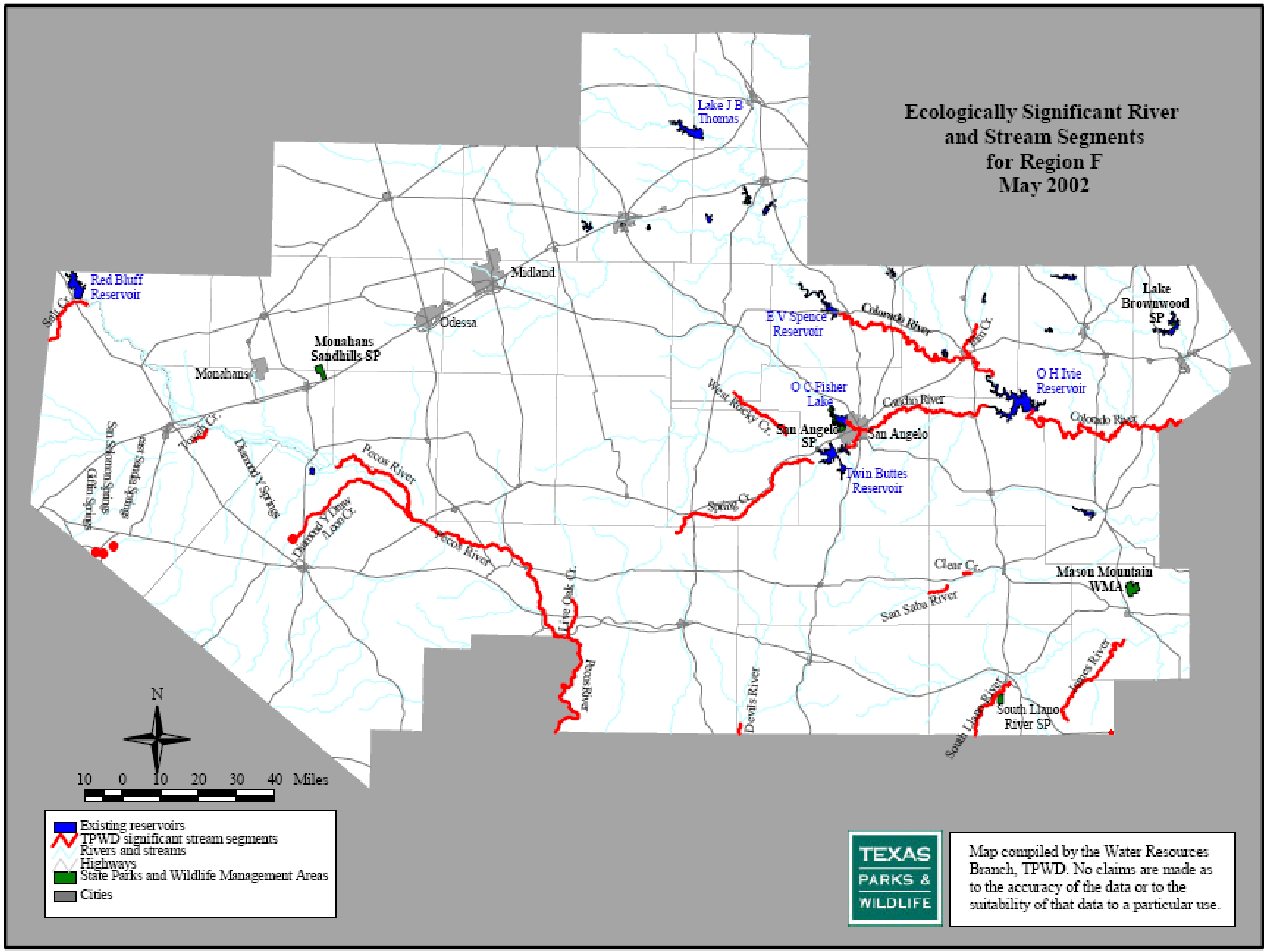
Table 8-1
Texas Parks and Wildlife Department Ecologically Significant River and Stream Segments

River or Stream Segment	Description	Basin	County	TPWD Reasons for Designation[a]				
				Biological Function	Hydrologic Function	Riparian Conservation Area	Water Quality/ Aesthetic Value	Endangered Species/ Unique Communities
Clear Creek	Impounded headwater springs	Colorado	Menard					X
Colorado River	Regional boundary upstream to E.V. Spence Reservoir dam, excluding O.H. Ivie Reservoir	Colorado	Multiple	X			X	X
Concho River	Above O.H. Ivie Reservoir to San Angelo Dam on North Concho River and Nasworthy Dam on South Concho River	Colorado	Concho, Tom Green				X	X
Devils River	Sutton/Val Verde County line upstream to Dry Devils River	Rio Grande	Sutton				X	X
Diamond Y Springs	Headwaters to confluence with Leon Creek	Rio Grande	Pecos					X
East Sandia Springs	Springs in Reeves County	Rio Grande	Reeves					X
Elm Creek	Elm Creek Park Lake to FM 2647 bridge	Colorado	Runnels				X	X
Giffen Springs	Springs in Reeves County	Rio Grande	Reeves					X
James River	Headwaters to confluence with Llano River	Colorado	Mason, Kimble				X	
Diamond Y Draw	Headwaters to confluence with Pecos River	Colorado	Pecos					X
Live Oak Creek	Headwaters to confluence with Pecos River	Colorado	Crockett				X	X
Pecos River	Val Verde/Crockett County line upstream to FM 11 bridge on Pecos/Crane County line	Rio Grande	Multiple	X			X	X
Pedernales River	Kimble/Gillespie County line upstream to FM 385	Colorado	Kimble	X			X	
Salt Creek	Confluence with Pecos River upstream to Reeves/ Culberson County line	Rio Grande	Reeves					X

River or Stream Segment	Description	Basin	County	TPWD Reasons for Designation[a]				
				Biological Function	Hydrologic Function	Riparian Conservation Area	Water Quality/ Aesthetic Value	Endangered Species/ Unique Communities
San Saba River	From FM 864 upstream to Fort McKavett	Colorado	Menard			X		X
San Solomon Springs	Spring in Reeves County	Rio Grande	Reeves			X		X
South Llano River	Confluence with North Llano River upstream to Kimble/ Edwards County line	Colorado	Kimble			X	X	X
Spring Creek	Headwaters to FM 2335 crossing in Tom Green County	Colorado	Crockett, Irion, Tom Green				X	X
Toyah Creek	Confluence with Pecos River upstream to FM 1450	Rio Grande	Reeves					X
West Rocky Creek	Headwaters to confluence with Middle Concho River	Colorado	Irion, Tom Green, Sterling				X	X

[a]. The criteria listed are from Texas Administration Code Section 357.8. The Texas Parks and Wildlife Department feels that their recommended stream reaches meet those criteria marked with an X.

Figure 8-1
Texas Parks and Wildlife Department Ecologically Significant River and Stream Segments



Considering the remaining uncertainty for designation and the regional consensus that there are no new reservoirs recommended for development, the Region F Water Planning Group is not recommending the designation of any river or stream segment as ecologically unique at this time.

The Region F Water Planning Group recognizes the ecological benefits of major springs, which are discussed in Chapter 1, and the benefits of possible protection for these important resources. Several of the potential ecologically significant streams identified by TPWD are springs or spring-fed streams. The list includes springs that provide water to water supply reservoirs and/or ecologically sensitive species. The South Llano River in Kimble County, which is spring-fed, is an important water supply source for the City of Junction and Kimble County water users and may warrant additional protections. Other important stream segments include the South Concho River and Dove Creek. Both are spring-fed streams that flow into Twin Buttes Reservoir, which is a major water source for the City of San Angelo. The Region F Water Planning Group will reconsider the possible designation of unique streams for the 2026 Water Plan.

8.2 Recommendations for Unique Sites for Reservoir Construction

Section 357.43(c) of the Texas Water Development Board regional water planning rules allows a regional water planning group to recommend unique stream sites for reservoir construction:

> Unique Sites for Reservoir Construction. A RWPG may recommend sites of unique value for construction of reservoirs by including descriptions of the sites, reasons for the unique designation and expected beneficiaries of the water supply to be developed at the site. [357.43(c)]

Evaluations of available water supply in the upper Colorado River Basin show limited availability for new surface water supplies. The Region F Water Planning Group does not recommend any unique sites for new reservoir development.

8.3 Policy and Legislative Recommendations

The Region F Water Planning Group has identified specific water policy topics relevant to the development and management of water supplies in the region. The following is a synopsis of the recommendations presented by the Region F Water Planning Group.

8.3.1 Surface Water Policies

In Region F over 70 percent of the population (511,000 people) in 2020 will depend on surface water from the upper Colorado River Basin for all or part of their municipal water needs. Making sure that this water remains a dependable part of Region F's existing supplies is crucial.

The Colorado River Basin is over appropriated and became that way in about 1938. This was well before there was any substantial population in Region F. Most of the "senior water rights" are in the lower Colorado Basin. The majority of these water rights are held by the Lower Colorado River Authority, City of Austin, and City of Corpus Christi. It is imperative that any changes to water rights, such as a change in use, change in point of diversion, transfers of water or transfer of water rights out of the Colorado Basin do not impair existing water rights even if they are junior in priority.

Surface water policy recommendations include the following:

- Require that any time a request is made to amend a water right, if the change involves an increase in the quantity, a change in the purpose of use or a change in the place of use, all water rights holders in the basin must be notified.
- The water availability models show that the Colorado River Basin is over appropriated. Region F opposes any legislation that would repeal or modify the "junior priority provision" for interbasin transfers from the Colorado River Basin (Water Code 11.085 (t)).
- Review the State's surface water policy of prior appropriation to see if this is a policy that will work in Texas over the next 50 years.
- Recommend that State water law be amended to incorporate river basin subordinations as set forth in regional water plans.

8.3.2 Groundwater Policies

Groundwater policy recommendations include the following:

- To support retention of the Rule of Capture while encouraging fair treatment of all stakeholders, and the State's policy that groundwater districts are the preferred method for managing Texas' groundwater resources.
- To support local control and management of groundwater through confirmed groundwater conservation districts, while providing encouragement and incentives for cooperation among the groundwater conservation districts within the region.
- That all persons or entities seeking to export a significant amount of water from a groundwater district must submit notice of their plan to the affected GCD and the Regional Water Planning Group.
- All state agencies with land within GCDs must be subject to groundwater district rules and production limits and must provide information on existing and proposed groundwater projects to the relevant Regional Water Planning Group.

8.3.3 Environmental Policies

Region F believes in good stewardship of the region's water and natural resources. Environmental policy recommendations include the following:

- That brush control and desalination are Region F priority strategies for protecting environmental values while developing new water supply for municipal and other economic purposes.
- That because of the very limited water resources in this region, there must be a carefully managed balance in the development, allocation and protection of water supplies, between supporting population growth and economic enterprise and maintaining environmental values. Consequently, while recognizing the need for, and importance of, reservations of adequate water resources for environmental purposes, the RWPG will not designate any special stream segments until the Texas Parks and Wildlife Department, working in cooperation with local entities such as groundwater districts, county soil and water conservation districts, local conservation groups and landowners, completes comprehensive studies

identifying and quantifying priority environmental values to be protected within the region and the quantification of minimum stream flows necessary to maintain those environmental values.

  - To support legislative funding and diversion of TPWD resources, for undertaking the studies described above; and
  - To support the creation of cooperative local stakeholder groups to assist the TPWD in studies described above.

- There are insufficient water supplies within Region F to meet projected municipal, agricultural and environmental needs through 2070; therefore, Region F RWPG opposes the export of surface water outside of the region except for existing contracts for such export, and will give priority consideration to needs within the region, including protection of environmental values, in evaluating any future proposed contracts for export.
- Land (range and cropland) conservation and management practices (including brush management and proper follow-up grazing and burn management) are priority strategies to provide optimum conditions for most efficient utilization of the region's limited rainfall. These practices should receive top priority for funding from the Texas legislature and State agencies charged with protecting and developing our water resources.

8.3.4 Instream Flows

Region F is located in an arid area with much of the rainfall occurring in short bursts. This results in widely varying stream flows with many streams being intermittent, having water only part of the year. During drought, stream flows can be very low, but this is a natural occurrence and the ecological environment in Region F has developed under these conditions. Region F recognizes that future flow conditions in Texas' rivers and streams must be sufficient to support a sound ecological environment that is appropriate for the area. As required under Senate Bill 3, TCEQ has established instream flow requirements for the Colorado River Basin and Brazos River Basin. No instream flow requirements have been established to date for the Pecos River Basin. Under current policy, these standards apply only to new water rights and some amendments to existing water rights. Region F supports this policy and believes it is imperative that existing water rights are protected now and in the future.

8.3.5 Interbasin Transfers

The State of Texas has 23 river basins that provide surface water to users in 16 regions. The current statutes require any new water right diverted from one river basin to another to become "junior" in priority to other rights in that basin. Also, as part of the water rights application, an economic impact analysis is required for both basins involved in the transfer. These requirements are aimed at protecting the basin of origin while allowing transfers of water to entities with needs. The Region F Water Planning Group:

- Supports retention of the junior water rights provision (Water Code 11.085(s) and (t)).
- Urges the legislature and TCEQ to study and develop mechanisms to protect current water rights holders.

8.3.6 Uncommitted Water

The Texas Water Code currently allows the TCEQ to cancel any water right, in whole or in part, for ten consecutive years of non-use. This rule inhibits long-term water supply planning. Water supplies are often developed for ultimate capacity to meet needs far into the future. Some entities enter into contracts for supply that will be needed long after the first ten years. Many times, only part of the supply is used in the first ten years of operation.

The regional water plans identify water supply projects to meet water needs over a 50-year use period. In some cases, there are water supplies that are not currently fully utilized or new management strategies that are projected to be used beyond the 50-year planning period. To support adequate supply for future needs and encourage reliable water supply planning policy recommendations include the following:

- Opposes cancellation of uncommitted water contracts/rights.
- Supports long term contracts that are required for future projects and drought periods.
- Supports shorter term "interruptible" water contracts as a way to meet short term needs before long-term water rights are fully utilized.

8.3.7 Brush Control

Brush control is recognized as an important tool in the management and maintenance of healthy rangelands that can allow for more efficient circulation of rainfall into the soil profile. This in turn can add to the effectiveness of aquifer recharge and restoration of streams and springs.

Region F supports brush control where it has the greatest effect on rivers, streams, and springflow, such as riparian zones, and areas of the region with the highest rainfall per year. Region F recognizes that the key to water restoration is managing the land to promote a healthy and vigorous soil and vegetative condition, of which brush control can play an important part.

Region F supports legislative efforts to promote funding for brush control activities for the purpose of river, stream, and spring enhancement in those areas that allow for the greatest success. The Region F Water Planning Group recommends the Texas legislature continue to support the State Water Supply and Enhancement Program through:

- Funding for on-going maintenance of brush removal in the region, and
- Continued cooperation with federal agencies to secure funds for brush control projects that will improve water quality.

8.3.8 Desalination

There are significant reserves of brackish groundwater in Region F. Region F Planning Group recommends the Texas Legislature continue to provide funds to assist local governments in the implementation of development of these water resources.

8.3.9 Weather Modification

There are currently two operational weather modification programs in the region – the West Texas Weather Modification Association (WTWMA) and the Trans Pecos Weather Modification Association (TPWMA). The WTWMA estimated a 15% increase in rainfall in their targeted area during 2014 due to their rain enhancement efforts, while the TPWMA estimated a 6.8% increase. Weather modification is one of the region's recommended strategies, together with brush control and desalination, for augmenting water supply. Recommendations include:

- Support legislative funding for operational programs, research, and evaluation of impact on rainfall.
- Support the creation of additional programs.

8.3.10 Water Quality

Region F has multiple water sources that are impaired for water quality. Local geologic formations contribute salts and total dissolved solids to streams and reservoirs. Some groundwater sources are affected by elevated minerals (including arsenic and fluoride), nitrates, and radionuclides. For many smaller communities, these impaired water sources are the only available water supply. Region F recognizes the challenges in developing new water supplies and/or treating the impaired water supply for these communities.

To provide greater certainty in supply development and use of impaired water sources, Region F recommends:

- TCEQ authorize small, rural water suppliers who currently cannot afford the necessary capital improvements to their existing water systems and who have no reasonable available alternate water source to utilize bottled water options to the fullest extent possible and apart from the threat of TCEQ enforcement. The alternative is for the water supplier to receive grants, not loans, to construct, operate, and maintain a treatment system to reduce drinking water constituents that exceed the established MCLs of the federal drinking water standard level.
- The State of Texas sponsor an oral ingestion study to determine the epidemiology of radium in potable water before enforcing minimum MCLs for radium. Region F is concerned about enforcement of State and federal regulations for radium in drinking water. A cluster cancer investigation was conducted by the Texas Cancer Registry of the Texas Department of Health and found that the cancer incidence and mortality in the area were within ranges comparable to the rest of the State. The Texas Radiation Advisory Board also expressed concern that EPA rules are "unwarranted and unsupported by public health information (specifically epidemiological data)".
- TCEQ revise its policy on requiring the use of secondary water standards, particularly TDS, when granting permits. Meeting secondary water standards should be the option of local water suppliers who must consider local conditions such as the economy, availability of water, community concerns, and the volunteer use of technologies such as point-of-use.

8.3.11 Municipal Conservation

The Region F Water Planning Group recognizes the importance of water conservation as a means to prolong existing water supplies that have shown to be vulnerable under drought conditions. The Water Conservation Task Force presented to the Texas legislature a summary of conservation recommendations, including statewide municipal conservation goals. Since that time, the legislature has created the Water Conservation Advisory Council which was given multiple duties including monitoring new technologies for inclusion by the TWDB as best management practices. Considering the drought-prone nature of Region F and the role of the Water Conservation Advisory Council, the Region F Water Planning Group:

- Supports that conservation targets should be voluntary.
- Supports the State's efforts to encourage conservation by providing technical assistance to water users and not force conservation through mandatory goals for water use.
- Recommends the State continue participation in research and demonstration projects for the development of new conservation ideas and technologies.
- Supports the funding of a statewide public information and education program to promote water conservation. Water conservation can only be successful with the willing support of the general public.
- Recommends consideration of excess use rates, water budget rates and seasonal rates that encourage water conservation, and recognition of water conservation as an appropriate goal in determining water rates.

8.3.12 Reuse

Reuse of water is a major source of "new water" especially in Region F. Reclaimed or new water developed from a demineralization or reclamation project can be stored for use in aquifers that have been depleted. Region F Water Planning Group recognizes the importance of reuse for the region and State, and recommends the following:

- Support legislation that will encourage and allow the reuse of water in a safe and economical manner.
- Work with the State's congressional delegation and federal agencies to develop procedures that will allow reject water from demineralization and reclamation projects to be disposed of in a safe and economical manner.
- Support legislation that will encourage and allow aquifer storage and recovery projects to be developed and managed in an economical manner.

  Support legislation at both the State and federal levels to provide funding for demineralization, reclamation and aquifer storage and recovery pilot projects.

8.3.13 Groundwater Conservation Districts

There are 16 established groundwater conservation districts in Region F that oversee groundwater production in more than half of the region. Region F recognizes and supports the State's preferred method of managing groundwater resources through locally controlled groundwater districts. In areas where groundwater management is needed, existing districts could be expanded or new districts could be created taking into consideration hydrological units (aquifers), sociological conditions, and political boundaries. Recommendations include:

- Legislation developed for managing the beneficial use and conservation of groundwater must be fair for all users.
- Rules and regulations must respect property rights and protect the right of the landowners to capture and market water within or outside of district boundaries.
- The region does not support the use of historical use limits in granting permits.

- The region does not support the use of groundwater fees for wells used exclusively for dewatering purposes.
- The legislature should support the collection of groundwater data that would be used to carry out regional water planning.

The region also recognizes that the State has groundwater resources associated with state lands that may or may not be governed by local groundwater districts. Region F encourages the State to review its groundwater resources on all state-owned land and how those resources should be managed to the benefit of all of Texas.

8.3.14 Oil and Gas Operations

Protection of the quality of the region's limited groundwater resources is very important within Region F. Prevention of groundwater contamination from oil and gas well operations requires constant vigilance on the part of the Railroad Commission rules. Orphan oil and gas wells that need proper plugging have become a problem and a liability for the State, the oil and gas industry as a whole, and the Texas Railroad Commission. In response to this problem, the State initiated a well plugging program that is directed by the Railroad Commission. This program enables a large number of abandoned wells to be properly plugged each year and has accomplished much by preventing water pollution.

In light of the importance of local groundwater supplies to users in Region F and the vulnerability of these supplies to contamination, the Region F Water Planning Group recommends:

- Stringent enforcement of the oil and gas operations rules and supports the levy of fines by the Commission against operators who violate the rules.
- Continuing support for the industry funded, Commission supported abandoned well and plugging program.
- The Legislative Budget Board and the Texas Legislature provide adequate personnel and funding to the Railroad Commission to carry out its mandated responsibility to protect water supplies affected by oil and gas industry activities.
- The Texas Legislature restore funds to the industry-initiated and industry-funded well plugging account, which were transferred to the general revenue following the 2003 budget crisis. The well plugging fund is not tax money, but industry funds contributed for a specific purpose.
- The clean-up and remediation of all contamination related to the processing and transportation of oil and gas. This includes operational or abandoned gas processing plants, oil refineries, and product pipelines.

8.3.15 Electric Generation Industry

Region F encourages the use of higher TDS water for electric generation when possible to conserve available fresh water sources within the region. In addition, Region F encourages the continued assessment of generation technologies that use less water.

8.4 Regional Planning Process

8.4.1 Funding

The Region F Water Planning Group recognizes that the ability to implement the water plan will depend in part on the ability to fund the recommended projects. The TWDB and Texas Legislature have responded to this concern by providing different funding vehicles for water projects, including the State Water Implementation Fund that is specifically dedicated to implementing projects identified in the State Water Plan. However, many entities are still struggling with financing water projects. For many of these entities, the regional water planning process is essential in identifying water needs and potential strategies. The Region F Water Planning Groups recommends:

- The State provides increased grant funding to smaller communities with limited financial resources for implementation of strategies in the regional water plans.
- The State should continue to fund the regional water planning process at a sufficient level to adequately address the Legislative requirements and provide a planning assessment for the many smaller communities in rural Texas.
- Consider providing adequate funds for the administration of the regional water planning process since the TWDB and the Legislature has continued to increase the responsibilities of the administrator.

8.4.2 Frequency of State Water Plan Development

The State is required by law to develop and update the State Water Plan every five years. The 2022 State Water Plan will be the fifth plan since the passage of SB1. Over the past 20 years, the regional and state water plans have captured the local water supply issues and a comprehensive path forward has been developed. In response to recommendations that the development of the State Water Plan be conducted every 10 years instead of every five years, with funding of special studies between planning cycles, the Texas Legislature provided a simplified planning option for non-census planning cycles. The simplified planning option still requires the planning groups to develop and independently verify most, if not all, of the data required under the standard methodology. The simplified planning option does not meet the intent of changing the planning cycle from every five years to ten years. It also does not provide a funding mechanism to conduct more in-depth region-specific special studies. Region F recommends that the Texas Legislature reconsider changing the planning cycle from five years to ten years with the opportunities for regions to apply for funding for special studies during non-regional planning periods.

8.4.3 Allow Waivers of Plan Amendments for Entities with Small Strategies

Region F recommends that the Texas Water Development Board (TWDB) allow waivers for consistency issues for plan amendments that involve projects resulting in small amounts of additional supply rather than requiring the regional water planning groups to grant consistency waivers. With the change in structure of the TWDB, TWDB Directors are fully capable of making such decisions.

8.4.4 Coordination between TWDB and TCEQ Regarding Use of the WAMs for Planning

The TWDB requires that the Water Availability Models (WAMs) developed under the direction of TCEQ be used in determining available surface water supplies. The models were developed for the purpose of evaluating new water rights permit applications and are not appropriate for water supply planning. The TWDB and TCEQ should coordinate their efforts to determine the appropriate data and tools available through the WAM program for use in regional water planning. The TWDB should allow the regional water planning groups some flexibility in applying the models made available for planning purposes.

8.4.5 Expand Consistency with the State Water Plan for SWIFT Funding to Include Adopted Regional Water Plans

The current legislation specifies that a water supply project must be in the adopted State Water Plan for eligibility for SWIFT funds. To allow the TWDB sufficient time to develop the State Water Plan, there is a one-year period between when a regional water plan is adopted and when the TWDB approves the corresponding State Water Plan. During this year period the State Water Plan is based on recommended projects in a superseded regional water plan. Under current law, if a project is included in the current regional water plan but not in the superseded plan, the project sponsor must amend the superseded plan to receive SWIFT funding. This could mean that the regions and project sponsors are expending funds for a process that has already been completed for the current regional water plan. It is recommended that the consistency requirement with the State Water Plan for eligibility for SWIFT funds be expanded to include the currently adopted regional water plan.

8.5 Summary of Recommendations

The following is a summary of the region's policy and legislative recommendations as agreed to by the Region F Regional Water Planning Group. The region:

- Does not recommend the designation of any ecologically unique stream segments or unique reservoir sites.
- Supports recognition of the importance of springs and spring-fed streams.
- Supports protection of existing water rights and encourages review and study of mechanisms to protect rights, including potential modification of the prior appropriation doctrine.
- Supports the protection of environmental values and developing water supply using brush control and desalination.
- Supports state funding for environmental studies with local stakeholder input.
- Supports existing TCEQ policy to protect existing water rights when considering instream flows.
- Recommends that state water law be amended to incorporate river basin subordinations as set forth in regional water plans.
- Supports state funding of land management activities to promote conservation of the region's natural resources.
- Supports a requirement for notification of all water rights holders in a basin any time a request is made to amend a water right if the change involves an increase in the quantity, a change in the purpose of use or a change in the place of use.

- Opposes any legislation that would repeal or modify the "junior priority provision" for interbasin transfers (Water Code 11.085 (t)) from the Colorado River Basin.
- Opposes cancellation of uncommitted or unused water contracts or water rights.
- Supports long-term contracts as a means for reliable water supply planning and shorter-term "interruptible" water contracts as a way to meet short-term needs before long-term water rights are fully utilized.
- Recommends the State change the Legislative requirements to update the regional water plans from every five years to ten years and provide interim funding for special studies that would benefit the regional water planning process.
- Supports continued and future funding of the Water Supply Enhancement Program, including but not limited to:
    - Funding for on-going maintenance of brush removal in the region, and
    - Continued cooperation with federal agencies to secure funds for project brush control projects that will improve water quality such as salt cedar control.
- Supports state funding for desalination projects of brackish groundwater.
- Recommends the State provide increased grant funding for smaller communities with limited financial resources and adequately fund the regional water planning process, including funding the administration of the process.
- Supports state funding for existing weather modification programs and the creation of new programs.
- Recommends that the TCEQ consider alternative programs (such as bottled water) to meet water quality standards for radionuclides and other constituents that are very costly to treat.
- Recommends the State of Texas sponsor an oral ingestion study to determine the epidemiology of radium in potable water before enforcing minimum MCLs for radium.
- Recommends that TCEQ revise its policy on requiring the use of secondary water standards, particularly TDS, when granting permits.
- Supports continued State participation in water conservation through technical assistance to water users and monetary incentives to entities that implement advanced conservation.
- Opposes mandatory targets and goals for water use.
- Supports continued State participation in research and demonstration projects for conservation.
- Supports the funding of a statewide public information and education program to promote water conservation.
- Supports the use of water conservation pricing and recognition of water conservation as an appropriate goal when setting rates.
- Supports legislation that would allow the reuse of water in a safe and economical manner.
- Supports the development of procedures for disposal of waste streams from desalination and reclamation projects in a safe and economical manner.
- Supports legislation that will encourage and allow aquifer storage and recovery projects to be developed in an economical manner.

- Supports state funding of pilot projects for desalination, reclamation and aquifer storage and recovery projects.
- Supports the use of groundwater conservation districts to manage groundwater resources, and recommends that:
    - The legislation for managing the beneficial use and conservation of groundwater must be fair for all users.
    - Rules and regulations must respect property rights and protect the right of the landowners to capture and market water within or outside of district boundaries.
    - Historical use limits should not be used in granting permits.
    - Groundwater fees should not be applied to wells used exclusively for dewatering purposes.
    - Encouragement and incentives for cooperation among groundwater conservation districts be provided.
    - All state lands within a groundwater conservation district be subject to that district's rules.
- Supports retention of the Rule of Capture while encouraging fair treatment of all stakeholders.
- Supports a requirement for notification of Regional Water Planning Groups and GCDs whenever a significant amount of water is being exported from a groundwater conservation district.
- Supports the collection of groundwater data that would be used to carry out the intent of Regional Water Planning and Joint Planning for Groundwater.
- Supports the protection of groundwater resources through the current oil and gas operation rules and the state-initiated well plugging program.
- Encourages the Legislature to adequately fund and staff the Railroad Commission to carry out its mandated responsibility to protect water supplies affected by oil and gas operations.
- Recommends the Legislature restore funds to the well plugging account, which were transferred to the general revenue fund in 2003.
- Recommends the clean-up and remediation of all contamination related to the processing and transportation of oil and gas.
- Encourages the use of higher TDS water for stream-electric generation.
- Encourages the continued assessment of generation technologies that use less water.
- Recommends the following changes to the Regional Water Planning process:
    - Provision of clear guidance on resolving consistency issues
    - Waivers of the requirement to amend the regional water plan for small entities
    - Coordination between TWDB and TCEQ regarding the use of WAMs for regional water planning, and
    - Expansion of Consistency with State Water Plan for SWIFT Funding to Include Adopted Regional Water Plans.

9 INFRASTRUCTURE FUNDING RECOMMENDATIONS

The Infrastructure Financing Survey will be conducted after the publication of the 2021 Initially Prepared Region F Water Plan. This chapter will be completed for the Final 2021 Region F Water Plan.

10 PUBLIC PARTICIPATION AND PLAN ADOPTION

This section describes the plan approval process for the Region F Water Plan and the efforts made to encourage public participation in the planning process. During the development of the regional water plan, special efforts were made to inform the general public, water suppliers, and others with special interest in the planning process and to seek their input.

10.1 Regional Water Planning Group

As part of SB1, regional water planning groups were formed to guide the planning process. These groups were comprised of local representatives of twelve specific interests:

- General public
- Counties
- Municipalities
- Industrial
- Agricultural
- Environmental
- Small businesses
- Electric generating utilities
- River authorities
- Water districts
- Water utilities
- Groundwater Management Areas

Table 10-1 lists the voting members of the Region F Water Planning Group, the interests they represent, and their counties as of February 19, 2020. The Region F Water Planning Group also has non-voting members to represent counties that are not otherwise represented by voting members.

Table 10-2 lists the non-voting members. The Region F Water Planning Group held regular meetings during the development of the plan, receiving information from the region's consultants and making decisions on planning efforts. These meetings were open to the public, and proper notice was made under SB1 and Texas Government Code Chapter 551 guidelines.

Public Participation Elements:

- Outreach to the Public
  - RWPG meetings
  - Website: www.regionfwater.org
  - Opportunity to Review and Comment on Initially Prepared Plan
- Outreach to Water Suppliers
  - Surveys
  - Meetings and Teleconferences
  - Review of Published Planning Documents (Long Range Plans, Master Plans, Drought Contingency Plans, Water Conservation Plans)
- Outreach to Adjoining Regions
  - Regional Liaisons to Other Planning Groups
  - Inter-regional Coordination
- Adoptions Process
  - Public Meeting on Scope of Work
  - Initially Prepared Plans Sent to Each County
  - Hearing on Initially Prepared Plan
  - Solicit and Respond to Comments

10.2 Outreach to the Public

The public were given opportunities to participate throughout the regional water planning process, including the following:

Regional water planning group meetings held throughout the planning process presented opportunities for dissemination of information to the public and receiving public comments. Notices for the meetings were posted in accordance with TWDB rules and open meetings act.

A website specific to Region F was developed to provide information on the planning process to the public and planning group members. This website can be accessed at www.regionfwater.org.

Scope of Work, meeting minutes and other information were available on the Region F and TWDB websites.

Table 10-1
Voting Members of the Region F Water Planning Group

Name	Interest	County
Tom Arsuffi	Public	Kimble
Vacancy	Public	
Jerry Bearden	Counties	Mason
Raul B. Rodriguez	Counties	Reeves
Allison Strube	Municipalities	Tom Green
Merle Taylor	Municipalities	Scurry
Michelle Guelker	Municipalities	Mitchell
Jimmy Carlile	Industries	Midland
Kenneth Dierschke	Agricultural	Tom Green
Douglas Wilde	Agricultural	Tom Green
Don Daniel	Agricultural	Coleman
Gilbert Van Deventer	Environmental	Midland
Caroline Runge	Environmental	Menard
Tommy Ervin	Small Business	Ector
Tim Warren	Elec. Gen. Util.	Mitchell
Chuck Brown	River Authorities	Tom Green
Ava Gerke	Water Districts	Reeves
John Grant	Water Districts	Howard
Richard Gist	Water Utilities	Brown
Raymond Straub, Jr.	GMA 2	Martin
Ty Edwards	GMA 3	Pecos
Scott Holland	GMA 7	Irion

Table 10-2
Non-Voting Members of the Region F Water Planning Group

Name	County/ Agency
Tom Hoysa	Coleman
Winton Milliff	Coke
Tisha Burnett	Glasscock
Todd Darden	Howard
Billy Hopper	Loving
Leatrice Adams	Martin
David Huie	McCulloch
Sue Young	Mitchell
Dale Adams	Nolan
Michael McCulloch	Pecos
Cindy Weatherby	Reagan
Jon Cartwright	Schleicher
Diana Thomas	Sterling
Joe David Ross	Sutton
A. Ryland Howard	Tom Green
Elizabeth McCoy	Texas Water Development Board
Nathan Rains	Texas Parks and Wildlife
Russ Robertson	Texas Department of Agriculture

10.3 Outreach to Water Suppliers, Water User Groups and Adjacent Regions

The Region F Water Planning Group made special efforts to contact municipalities, water districts, and rural water supply corporations and others in the region and obtain their input in the planning process. Outreach included both questionnaires and meetings with selected water user groups and wholesale water providers. The questionnaires sought information on water use projections, current sources of water and supplies, drought planning, water quality issues, water management strategies, and other water supply issues. Particular emphasis was placed on receiving input from water user groups with water supply needs.

Region F continued to coordinate with adjacent regions that provide and/or receive water from Region F. This included regional liaisons who attended planning group meetings and coordination with the Llano- Estacado (Region O), Brazos G, Region J, Region K, and Far West Texas (Region E), regions.

10.4 Public Meetings and Public Hearings

As required by SB1 rules, the Region F Water Planning Group held an initial public meeting to discuss the planning process and the scope of work for the region on February 2, 2017. Presentations were made on the planning process and input was solicited from participants. Public meetings were held approximately three times per year throughout the planning process.

Prior to March 16, 2020, copies of the Initially Prepared Region F Water Plan were mailed to Region F county courthouses and libraries for public review. Copies of the Initially Prepared Plan were also posted on the Region F website. Notices of the upcoming public meetings were sent to the Secretary of State, all voting and non-voting planning group members, county clerks, county judges, regional legislators, groundwater and irrigation districts, and regional newspapers along with a description of how to obtain copies of the draft plan for review.

On April 16, 2020, the Region F Water Planning Group will hold a public hearing in Big Spring to present the draft Initially Prepared Region F Water Plan and seek public input. Oral comments will be requested following the presentation and written comments were will be accepted through June 15, 2020. Public comments received during the comment period will be documented in the Final Region F Water Plan. Where appropriate, modifications to the plan will be made and incorporated into the adopted Regional Water Plan. Responses to the public comments will be included in Appendix J of the Final Plan.

10.5 Comments from State and Federal Agencies

Comments from state and federal agencies will be included in the Final Plan. Responses to agency comments will be documented and included in the Final Plan. Where appropriate, modifications to the plan will be made and incorporated into the adopted Region F Water Plan.

10.6 Comments from Water Providers

As part of the region's outreach efforts, a survey on the recommended water management strategies will be sent to water user groups after the publication of the Initially Prepared Plan. Reponses to this survey may result in changes to plans for some water providers.

10.7 Plan Implementation Issues

As part of the development of the 2021 Region F Water Plan, implementation issues were identified for some providers and specific water management strategies. These issues are documented in the descriptions and evaluations of the strategies (Chapters 5B through 5E and Appendix C). This section summarizes the issues for users in Region F. The implementation issues identified for the Region F Regional Water Plan include:

1) financial issues associated with paying for the proposed capital improvements,
2) additional studies associated with subordination of Colorado Basin water rights,
3) implementation of conservation measures that were assumed in this plan, and
4) groundwater issues.

10.7.1 Financial Issues

It is assumed that the entities for which strategies were developed will utilize existing financial resources, incur debt through bond sales and/or receive state-supported financial assistance. Most likely the funding of identified strategies will increase the cost of water to the customers. The economic feasibility to implement the strategies will depend on the economic burden to the customer base. Some strategies may not be able to be implemented without state assistance.

10.7.2 Additional Water Rights Studies in the Colorado Basin

The subordination strategy described in Chapter 5C was developed for regional water planning to better represent surface water supplies that are currently in use within Region F. The results are for planning purposes only and do not represent legal findings or recommendations. Should entities in Region F choose to enter into subordination agreements with downstream water right holders, additional studies will be required. Further study may still be needed to clarify water rights issues in the Colorado Basin.

10.7.3 Water Conservation

The water conservation plans and water loss audit reports were reviewed to help identify appropriate municipal water conservation measures and identify suggested Best Management Practices (BMPs). Water savings achieved through these BMPs can be difficult to estimate since there is little data over an extended time period. Also, entities normally implement multiple strategies at once making it difficult to estimate individual water savings. Savings associated with irrigation conservation are based on strategies that must be implemented by the irrigator. There is no confirmation that irrigation water saved will be available for future use.

Experience during the recent droughts has demonstrated that significant savings can be made through water conservation and drought management. However, without specific data, it is difficult to quantify the potential long-term savings for water conservation activities and rely on these savings to meet future needs.

10.7.4 Groundwater Issues

The Modeled Available Groundwater (MAG) was considered to be a cap for allocating groundwater supplies in the current plan. For counties without a GCD, this limit is unenforceable and will likely be exceeded in reality. Furthermore, in some cases, a GCD has already issued permits that exceed the MAG. However, these strategies cannot be included in this plan if existing use exceeds the MAG. This makes these strategies ineligible for certain state funding programs until the MAG values are changed and may make implementation more difficult.

Also, desalination of brackish groundwater is becoming an increasingly popular water supply alternative for regions heavily affected by drought. Although brackish groundwater is plentiful in Texas, additional understanding about this historically underutilized source is needed. For example, no legal definition currently exists in the State of Texas for ‘brackish groundwater’. During the 86th Texas Legislative Session[1], House Bill 722 passed which created a separate GCD permitting system for the production of brackish groundwater in “Brackish Groundwater Production Zones”.

LIST OF REFERENCES

[1] Texas Alliance of Groundwater Districts. 86th Legislative Session Wrap-Up, 2019.

11 IMPLEMENTATION AND COMPARISON TO THE PREVIOUS REGIONAL WATER PLAN

The Regional and State Water Planning process administered by the Texas Water Development Board (TWDB) operates on a five-year cycle. Inherently, this cycle enables continual refinements and changes to major components of the planning process, such as water demands, supplies, and recommended strategies. This chapter assesses the changes between cycles of Regional Water Plans (RWPs), in accordance with TWDB requirements for the development of the 2021 RWP. Specifically, this chapter contains a discussion of the implementation of previously recommended water management strategies (WMS) (Section 11.1), as well as a summary of how various components of the current 2021 RWP compare to the previously adopted 2016 RWP (Section 11.2). In addition, this chapter addresses the progress of the Region F Water Planning Group in encouraging the cooperation between entities for the purpose of achieving economies of scales and otherwise incentivizing strategies that benefit the region as a whole (Section 11.3).

11.1 Implementation of Previously Recommended Water Management Strategies

The following sections discuss those WMSs that were recommended in the 2016 Regional Water Plan and have been partially or completely implemented since that plan was published. These WMSs are included in the 2021 plan as currently available supply. Information was collected on the implementation status of projects in the 2021 plan via an implementation survey.

11.1.1 Mining Conservation – Well Field Recycling/Reuse

In at least 11 counties across Region F, the Texas Water Development Board water use survey showed that mining operators were already employing the 2016 plan mining conservation strategy to reuse, and recycling water used for fracking operations.

11.1.2 City of Eden – Direct Non-Potable Reuse

Eden had a recommended strategy in the 2016 Plan to supply a golf course with direct non-potable reuse supplies from their wastewater treatment plant (WWTP). This strategy has been implemented and is currently in use.

11.1.3 Mining WUGs – City of Midland Reuse Supply

One proposed water management strategy for some mining users in the previous Region F Water Plan involved purchasing wastewater effluent from the City of Midland. This strategy included improvements to the City's wastewater treatment plant (WWTP) and the construction of a transmission pipeline to move water to surrounding counties. The City of Midland has since negotiated a contract to sell their treated effluent to Pioneer Resources for mining use. For planning purposes, it is an existing supply in the 2021 plan to mining users in Midland, Martin, Reagan, and Upton Counties. The contract is for up to 15 MGD but current flows are limited to 10 MGD. The City is currently completing improvements to the WWTP to treat the full 15 MGD. These improvements are expected to be completed by 2020.

11.2 Differences Between Previous and Current Regional Water Plan

The following sections provide a discussion of changes from the 2016 plan to the current 2021 plan. Specifically, these sections address differences in:

- Water demand projections
- Drought of record and hydrologic modeling and assumptions
- Source water availabilities
- Existing water supplies for water users
- Identified water needs for WUGs and WWPs
- Recommended and alternative water management strategies

11.2.1 Water Demand Projections

The total projected water demand in Region F is about 9 to 13 percent lower for the 2021 plan than in the 2016 plan. This equates to a decrease of about 73,000 to 109,000 acre-feet per year in total demands over the planning horizon. This is displayed in Figure 11-1. Table 11-1 shows the differences in demand by use type. These differences and their causes are explored more fully in the following sections.

Figure 11-1
Comparison of Region F Water Demand in 2016 and 2021 Plans

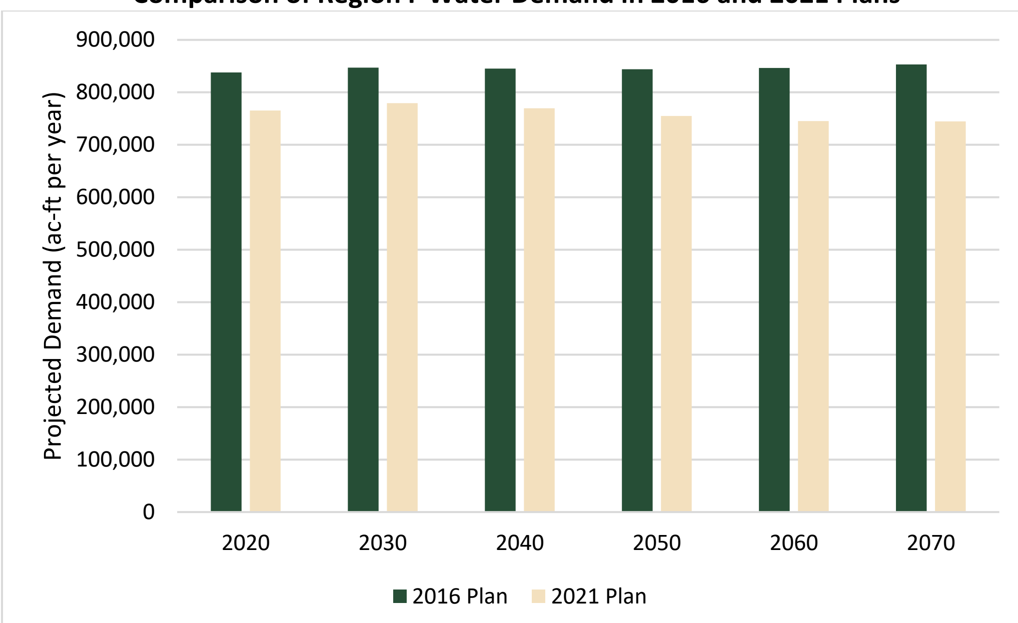


Table 11-1
Changes in Projected Demands from the 2016 Plan to the 2021 Plan by Use Type

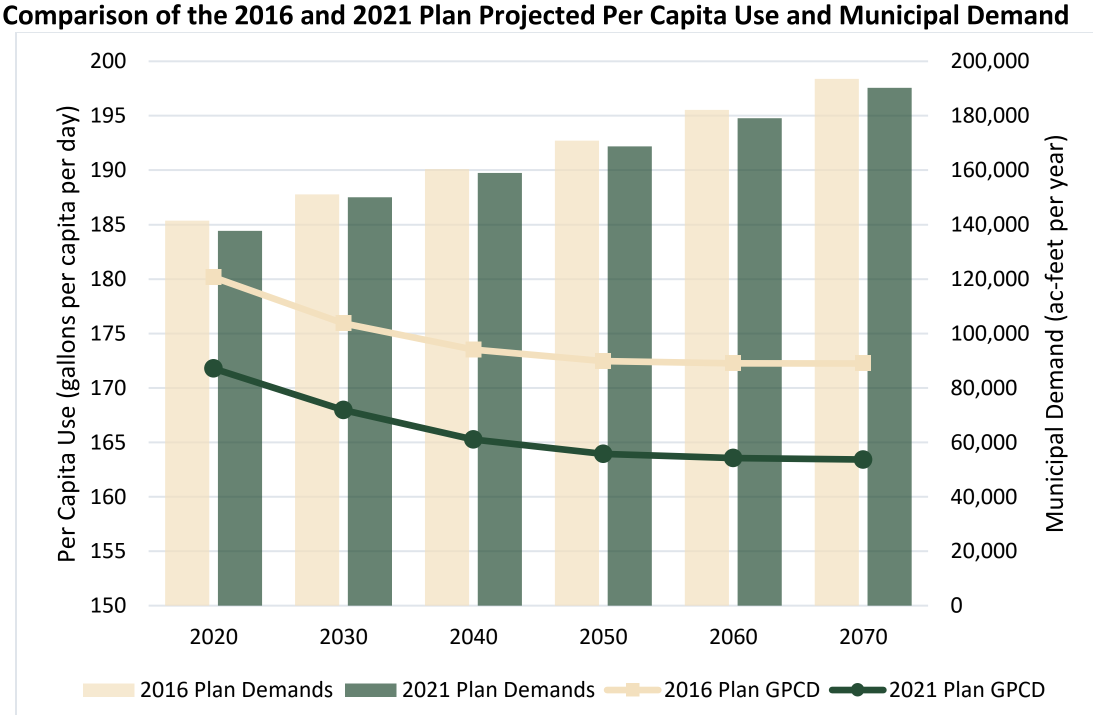
Use Type	Percent Change in Projected Water Demand					
	2020	2030	2040	2050	2060	2070
Irrigation	-19.7%	-19.1%	-18.5%	-17.9%	-17.4%	-16.8%
Livestock	-29.4%	-29.4%	-29.4%	-29.4%	-29.4%	-29.4%
Manufacturing	3.8%	6.1%	0.4%	-4.0%	-9.5%	-14.7%
Mining	95.6%	94.9%	97.0%	94.3%	89.4%	83.9%
Municipal	-2.6%	-0.7%	-0.9%	-1.3%	-1.6%	-1.7%
Steam Electric Power	-5.2%	-15.1%	-24.8%	-34.1%	-42.8%	-49.9%
Region F Total	**-8.7%**	**-8.0%**	**-9.0%**	**-10.5%**	**-12.0%**	**-12.8%**

Municipal Demands

One of the major changes for this round of planning is the use of water utility boundaries rather than city limits for municipal water user groups (WUGs). This resulted in changes of individual WUG populations as customers outside the city limits were included in the WUG population. Also, the criteria for defining a municipal WUG was changed from a population basis to a water demand basis. This resulted in the addition of seven new municipal WUGs in the 2021 Region F Plan and no removed WUGs. While this change in definition of municipal WUGs changed how the demands were delineated, it made little difference in the overall municipal demand projections.

The methodology for development of the municipal demands in both plans were similar. A dry year per capita demand was estimated for each entity. Then, the per capita demand was multiplied by the projected population of each entity to determine the total demand in acre-feet per year. For some users, the 2021 plan population projections were updated to reflect population growth caused by increased oil and gas activities that were not captured in the 2010 Census or the 2016 plan. The per capita water use for both plans was based on the year 2011 (with a few exceptions). One notable exception for the 2021 plan, was Midland's request to use a lower gpcd value based on more recent historic use. Due to Midland's significant population, this change contributed to a slightly lower municipal demand for the region as a whole. As shown in Figure 11-2, the per capita use and the total municipal demand for the region is less in the 2021 plan than it was in the 2016 plan.

Figure 11-2
Comparison of the 2016 and 2021 Plan Projected Per Capita Use and Municipal Demand



Non-Municipal Demands

There were significant differences in the methodologies used to develop the non-municipal demands for the 2016 and 2021 plans. As a result, non-municipal demands decreased for the region by about 10 to 15 percent.

A decrease in irrigation demands is the largest contribution to the overall decrease in demands for the region in the 2021 plan. Irrigation demands in the 2021 plan were based on a five-year average (2010 to 2014) of historical TWDB irrigation water use estimates, while irrigation demands in the 2016 plan were based on a five-year maximum (2005 to 2009) of water use. The difference in the data used as the baseline for calculations (average versus maximum) between the plans is the primary cause for the decrease in the projected irrigation demands.

Steam electric power demands decreased between the 2021 and 2016 plan due to the removal of more speculative future steam electric demands. Future water demands for steam electric power are no longer considered in the regional plans unless there is a specific facility planned in that location. Demands associated with steam electric power plants in Region F that are no longer in operation were also removed. This results in a lower, more realistic steam electric power demand in Region F. However, the methodology may underestimate the need for water for future power generation on a state-wide basis.

Similarly, when comparing the 2021 plan to the 2016 plan, livestock demands are nearly 30 percent lower throughout the planning horizon. This is also due to a differing methodology of using the 5-year average (2010-2014) historical use for the baseline instead of a five-year maximum (2005-2009) historical use.

Manufacturing demands increased in the first two decades for the 2021 plan but decreased after 2030. This is due to the methodology used in the demand development for the 2021 plan where manufacturing demands were increased between 2020 and 2030 based on growth in the county. After 2030, the manufacturing demands were held constant. This may underestimate demands, especially in high growth areas, after 2030.

In contrast, mining demands nearly doubled in the 2021 plan compared to the 2016 plan. This is largely due to the renewed interest in oil and gas development in the Permian Basin that is anticipated to be sustained for several decades.

11.2.2 Drought of Record and Hydrologic Modeling Assumptions

In general, the drought of record is defined as the worst drought to occur in a region during the period of available meteorological records. For most of Texas, the drought of record began around 1950 and continued through early 1957. In Region F, most surface water sources were in drought-of-record conditions as of the publication of the 2011 and 2016 plans. The extreme drought conditions have lessened since the 2016 plan, but many reservoirs have never filled and the availability of surface water supplies in the region may still be impacted in future plans. The impacts of the drought on surface water availability under WAM Run 3 (strict priority analysis) does not show the full impact of the drought since many of the reservoirs already had little to no yield. The impacts are more fully shown in the subordination strategy. However, the full impact of ongoing drought conditions cannot be fully evaluated until the current drought is officially over (which is defined by the refilling of the reservoir).

WAM Run 3 (Strict Priority Analysis)

In 2013, the TCEQ recognized the new drought of record in Region F and updated the full Colorado WAM to include naturalized flows from 1940 through the end of 2013. However, the finalized version was not available in time for use in the 2016 Plan. Instead a draft of the updated version of the Colorado WAM was used for the 2016 plan analysis. For the 2021 plan, the final version of the TCEQ Colorado WAM was available and used. This change resulted in several relatively small changes in surface water availability under WAM Run 3.

Subordination

The subordination strategy changes key assumptions in the WAM such that downstream water rights do not constantly make priority calls on the upstream rights in Region F. This is consistent with the historical operation of the basin.

For the 2016 plan, Region F adopted the premise of the Region K cutoff model for the subordination strategy. The cutoff model modifies priority dates for all water rights above Lakes Ivie and Brownwood. The draft Colorado WAM with hydrology through 2013 was used for the subordination strategy in the 2016 plan. For the 2021 plan, Region F used the same cutoff model concept from Region K but with updated hydrology through 2016. The model used for the 2021 plan was developed by Region K and adopted by Region F with some minor modifications. The Region F Plan cutoff model differs slightly from the Region K model by including Junction’s run-of-river right, Brady Creek Reservoir, and including priority operation only under certain conditions for the Pecan Bayou watershed. The Region F adjustments to the Region K cutoff model were the same for the 2016 and 2021 plans. More information on the subordination strategy is included in Chapter 5C.

11.2.3 Source Water Availability

The total source water availability (not considering infrastructure or permit constraints) in Region F is greater in the 2021 plan than in the previous 2016 plan. Major differences in groundwater availability stem from changes to the Groundwater Availability Models, and in some cases, small changes in Desired Future Conditions for aquifers. Slight differences in surface water availability were caused by using an updated, final version of the WAM Run 3 for the 2021 Plan. The increase in reuse supplies in the 2021 plan are largely attributed to an increase in reuse water supplied to mining entities in the region. Overall, there was about a 4 to 7 percent increase in water availability throughout the region between the 2016 and 2021 plans.

Groundwater

In accordance with TWDB rules, the groundwater availability in the 2021 and 2016 plans are determined by the Modeled Available Groundwater (MAG) estimate. These plans were both required to use groundwater estimates developed through the state-sponsored groundwater joint planning process, which is discussed in further detail in Chapter 3, Section 3.1.1. Most of the increased groundwater availability came from volumes estimated from new Groundwater Availability Models (GAMs). Specifically, the updated Ogallala aquifer model, known as the High Plains Aquifer System GAM and the Llano Uplift Aquifers GAM. The new HPAS GAM significantly increased the available volume from the southern portion of the Ogallala and in Region F Counties. In the 2016 Plan, the Llano Uplift Aquifer GAM was not available to estimate MAGs. The availability from the Llano Uplift Aquifers generally increased with the use of the Llano Uplift Aquifers GAM in conjunction with some changes in DFCs for the aquifers in Region F counties.

Figure 11-3
Comparison of Groundwater Availability in the 2016 and 2021 Plans

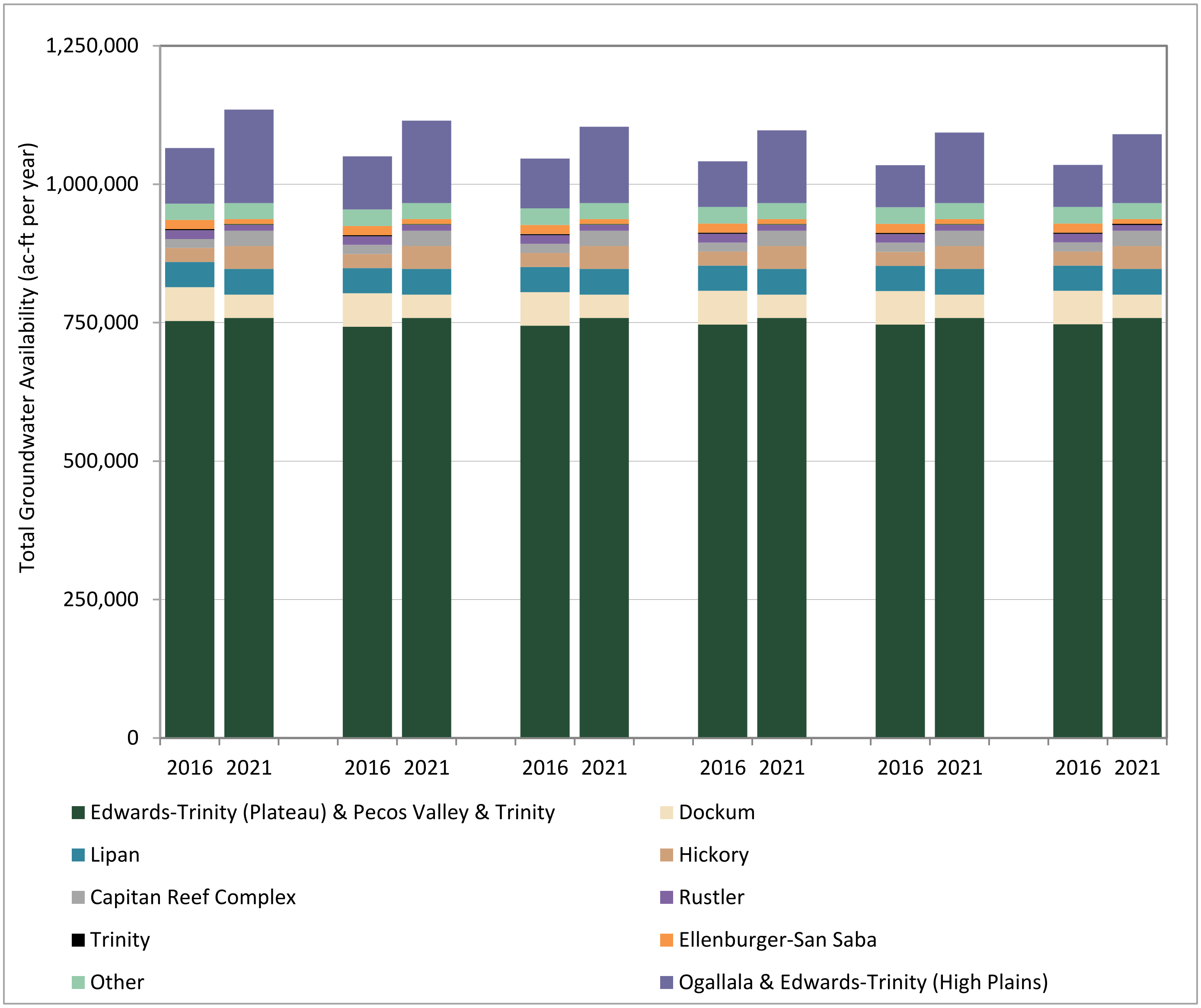
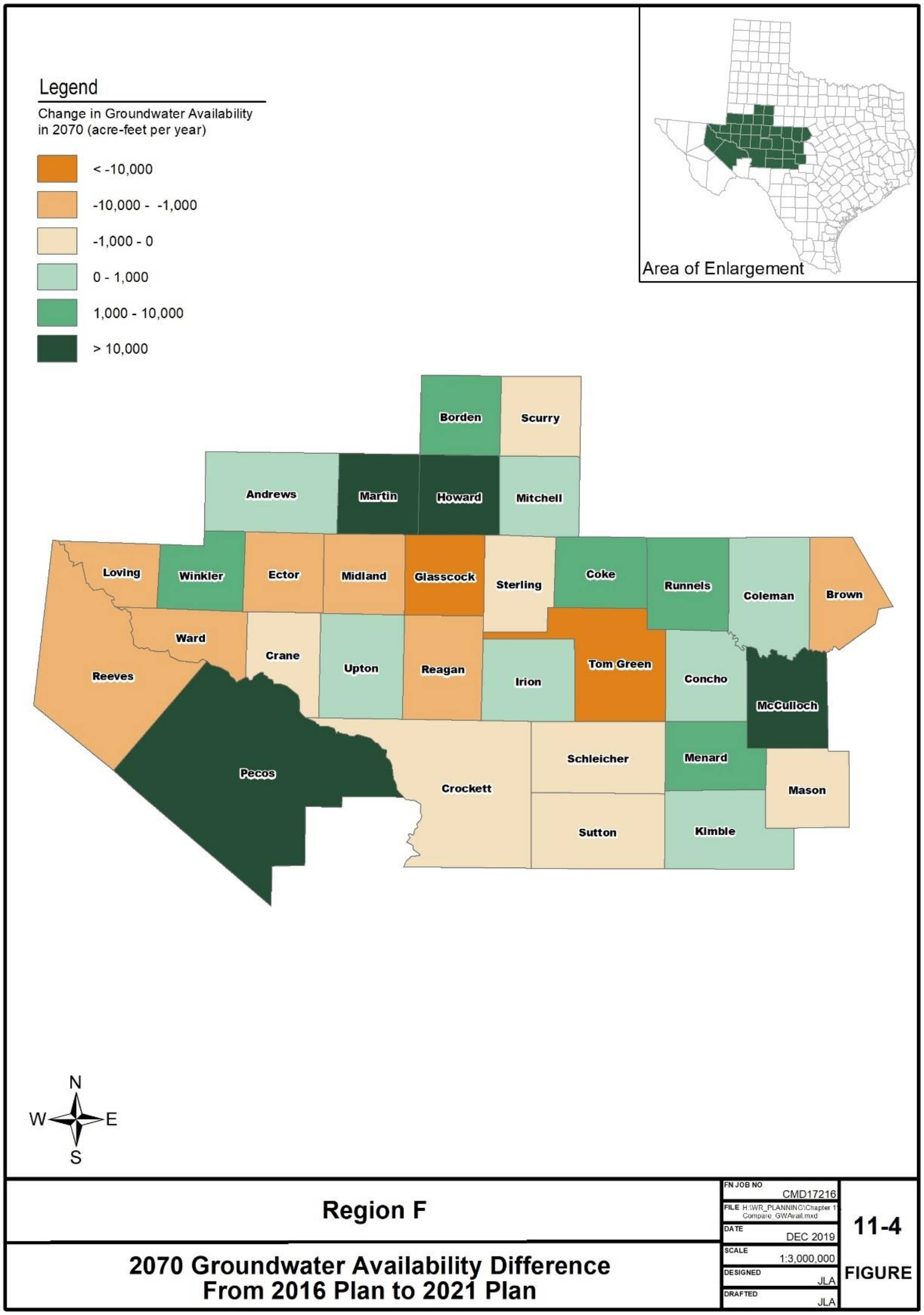


Figure 11-4
Groundwater Availability Difference



Surface Water

In the 2016 plan, a draft version of the WAM Run 3 (strict priority analysis) was used to model surface water availability. For the 2021 plan, the final version of this WAM run was used. Consequently, the volume of surface water supply shown from major reservoirs in the 2021 plan is around five percent lower than amount of reservoir supplies shown in the 2016 plan (see Figure 11-5). The decline in major reservoir supplies between the 2016 plan and 2021 are further illustrated through the subordination strategy, where the reservoir supplies also declined around 10 percent. This is shown in Figure 11-6.

Figure 11-5
Comparison of Existing Surface Water Availability (WAM Run 3) in the 2016 and 2021 Plans

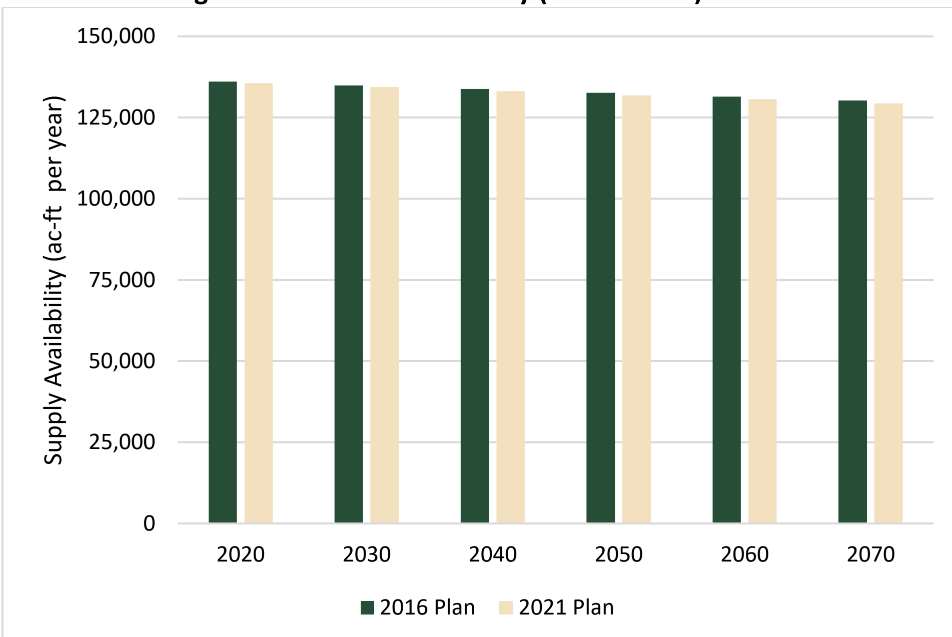
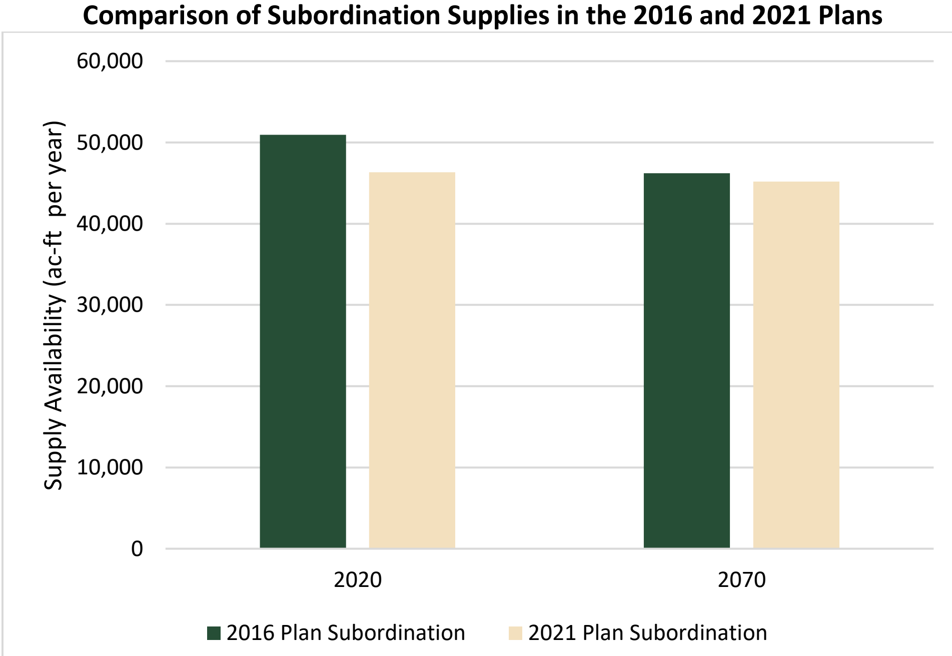


Figure 11-6
Comparison of Subordination Supplies in the 2016 and 2021 Plans

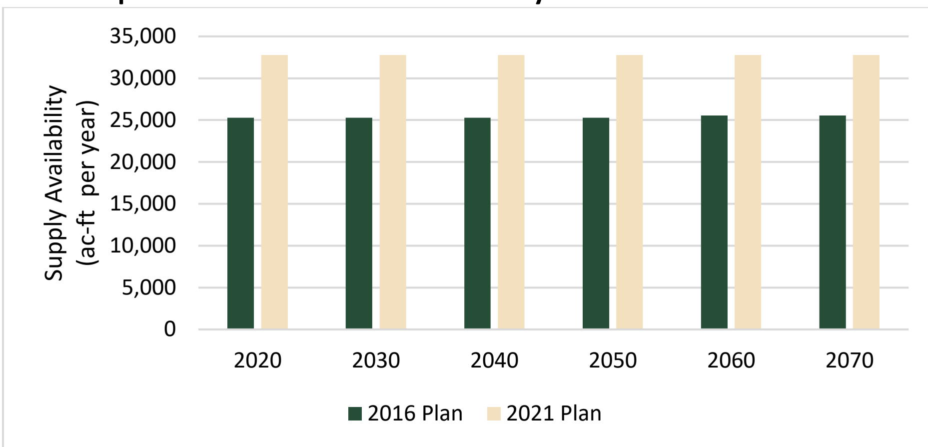


Reuse

Existing reuse source availability went up from the 2016 plan to the 2021 plan, as shown in Figure 11-7. This is largely attributed to the increase in oil and gas well field recycling and reuse that was observed in several counties.

Figure 11-7

Comparison of Reuse Water Availability in the 2016 and 2021 Plans



11.2.4 Existing Water Supplies of Water Users

New Sources of Existing Supply for Water Users

Drought conditions in Region F not only reduced the yield from each source, but also greatly impact the quality of the supplies from those sources. In many cases, water quality has become too poor to use the remaining dwindling supply. In addition, further development of oil and gas operations within the region has caused increased demands for these supplies. As a result, communities are seeking more drought tolerant sources of water including reuse and groundwater.

Table 11-2 shows users in Region F that have new sources of supply in the 2021 plan that were not included in the 2016 plan. Some of these new supplies were recommended strategies in the 2016 plan that have since been implemented and are discussed in Section 11.3. This changes the status of these supplies from "new supplies" to "existing supplies". Other supplies not considered in the 2016 plan were developed in response to drought and are now new sources of existing supply.

Table 11-2

Entities with New Sources of Existing Supply in the 2021 Plan

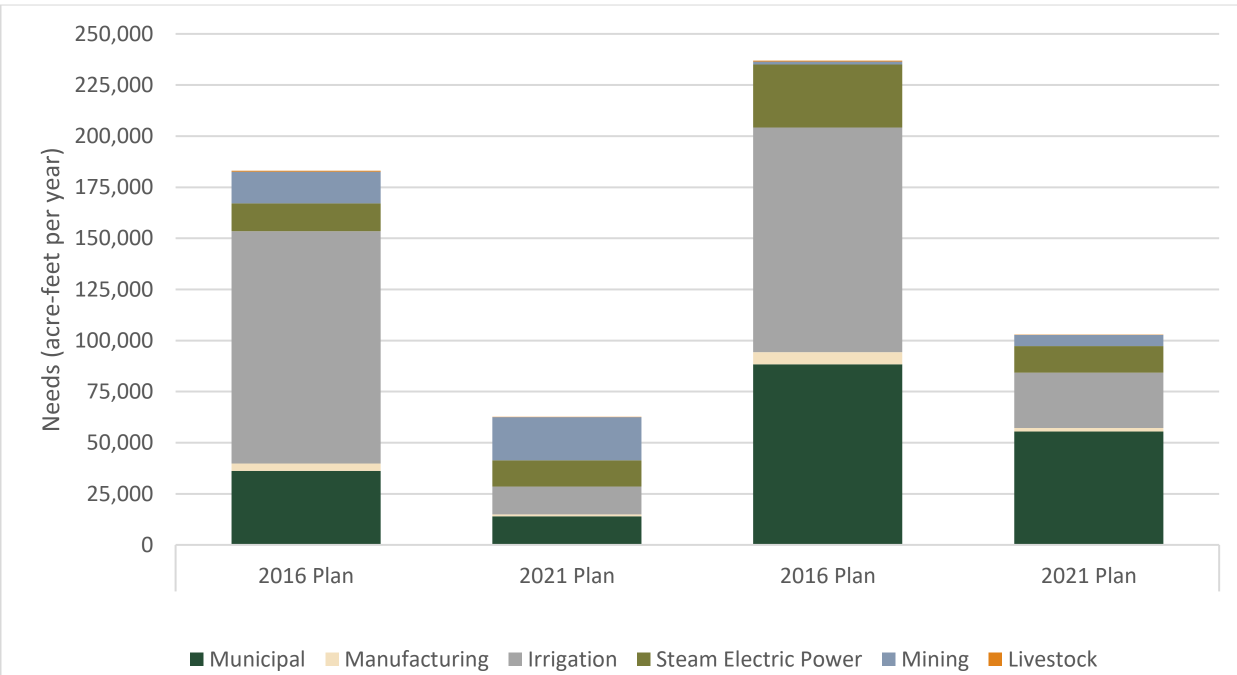
Entity	New Existing Supply
Concho Rural Water; Mining, Tom Green	Purchase from UCRA
Eden	Direct Reuse
County-Other, Mitchell; Manufacturing, Mitchell	Purchase from Colorado City
Grandfalls	Purchase from CRMWD
Mining (Andrews, Martin, Reagan, Upton)	Purchase from Odessa
Mining (Martin, Midland, Reeves, Upton)	Purchase from Midland
Mining (Reeves, Pecos)	Purchase from Fort Stockton
Mining (Ector, Glasscock, Howard, Irion, Martin, Midland, Reagan, Upton, Ward)	Well Field Recycling
Steam Electric Power, Howard	Purchase from Big Spring

Most of the new existing supplies included in the 2021 plan are purchased water from wholesale water providers or nearby cities. In particular, mining users in Region F are purchasing wastewater effluent or recycling water from their well fields to meet the water needs of their expanded oil and gas operations. Various water user groups also show groundwater supplies from sources named differently in the 2021 plan. However, these name changes are not substantive changes to the user's water supply source. Rather the differences are attributed to differences in naming convention and groupings of aquifers for the MAG runs for the 2021 plan. Where appropriate, specific aquifers are identified in the written plan, while the grouped aquifer naming convention is shown in the TWDB database reports (Appendix I). These non-substantive changes are not considered new "existing supplies".

11.2.5 Identified Water Needs

Due to decreased demands and increases in modeled groundwater availability, needs across Region F decreased approximately 55 to 65 percent from the 2016 plan to the 2021 plan. The composition of these needs also changed significantly. Figure 11-8 highlights the differences in need by use type between the two plans in the years 2020 and 2070.

Figure 11-8
Need by Use Type in the 2016 2021 Plan



Needs for irrigated agriculture reduced significantly in the 2021 plan. Existing supplies changed minimally between the two plans, so this change this is mainly due to a significant decrease in irrigation demands throughout the planning horizon.

In contrast, mining needs increased from the 2016 plan to the 2021 plan, especially during the early decades. The changes in mining needs were primarily fueled by increased demands associated with interests in oil and gas exploration in the region.

In the 2016 plan, livestock showed a small shortage (less than 500 acre-feet total). This was mainly due to counties in which all users were shorted due to limited groundwater availability under the MAG. The 2021 plan shows an even smaller shortage (less than 50 acre-feet total). This is also due to limited groundwater availability under the MAG, but only in Andrews County.

Manufacturing needs decreased by around 70 percent from the 2016 plan to the 2021 plan. This difference is attributed to two factors: 1) lower manufacturing demands, especially in the later decades of the 2021 plan and 2) an increase in manufacturing supplies, particularly in Howard and Midland Counties where there were severe MAG limitations in the 2016 plan that do not exist in the 2021 plan.

Steam electric power needs in the 2021 plan are lower than in the 2016 plan, particularly in the later decades. In the 2016 plan, the TWDB included the speculative future demands and demands associated with shuttered facilities in their demand projections. In many cases, these demands were not realistic and resulted in higher needs for steam electric power in the 2016 plan. In the 2021 plan, the demands only included known potential future facilities and demands associated with the shuttered steam electric power facilities were removed. This resulted in a more realistic demand and lower needs throughout the planning horizon.

Municipal needs decreased by about 60 percent in 2020 and about 35 percent in 2070 from the 2021 plan to the 2016 plan. The decrease in municipal needs between these plans is largely due to increased groundwater availability from the MAG.

11.2.6 Recommended and Alternative Water Management Strategies

New Water Management Strategies

New strategies were developed to meet new shortages or better represent entities' current plans that have changed since the previous round of planning. There are 17 new infrastructure strategies in the 2021 plan that were not included in the 2016 plan. This does not include the new conservation strategies for municipal, irrigation, or mining use for new municipal WUGs or non-municipal WUGs with needs. The new recommended strategies are outlined in Table 11-3. New alternative strategies are included in Table 11-4.

Table 11-3
New Recommended Water Management Strategies in the 2021 Plan

Water User Group or Wholesale Provider	New Recommended Water Management Strategy
Balmorhea	Develop Edwards-Trinity Plateau Aquifer Supplies
Bronte	Develop Other Aquifer Supplies in Southwest Coke County
Colorado River MWD	Ward County Well Field Replacement
Concho Rural WSC	Purchase from Provider (UCRA)
Grandfalls	Develop Pecos Valley Aquifer Supplies
Greater Gardendale WSC	Purchase from City of Odessa - Treated Water
Manufacturing, Scurry	Develop Other Aquifer Supplies
Midland	Advanced RO Treatment, Expanded Use of Paul Davis Well Field
Mining, Brown	Develop Cross Timbers Aquifer Supplies
Mining, Reeves	Develop Pecos Valley Aquifer Supplies
Pecos	Partner with Madera Valley WSC and Expand Pecos Valley Aquifer Supplies
Pecos	Advanced Water Treatment Plant
Pecos	Direct Potable Reuse
Pecos	Direct Non-Potable Reuse
Pecos County WCID #1	Replace Transmission Pipeline
Sonora	Develop Additional Edwards-Trinity Aquifer Supplies
Steam Electric Power, Mitchell	Direct Non-Potable Reuse Sales from Colorado City

Table 11-4
New Alternative Water Management Strategies

Water User Group or Wholesale Provider	New Alternative Water Management Strategy
Bronte	Develop Other Aquifer Supplies in Runnels County
Brown County WCID	Develop New Groundwater (previously recommended)
Grandfalls	Purchase from Provider (CRMWD)
Great Plains	Develop Ogallala Aquifer Supplies
Greater Gardendale WSC	Purchase from Midland County FWSD No. 1 - Winkler County Water
Manufacturing, Andrews	Develop Additional Groundwater[a]
Pecos	Indirect Potable Reuse with ASR

a. Listed as an alternative strategy due to constraints of MAG availability in the county.

Altered Water Management Strategies

Several strategies in the current plan were also in the previous plan but have been altered in some way. This section focuses on strategies that were significantly changed from the last plan either due to major conceptual changes, better available data, or considerable changes in assumptions used to calculate the water available from the strategy. The changes to these strategies are outlined below. This section is meant to highlight the differences, not give a full description of the strategy. More information on these strategies can be found in Chapter 5 and Appendix C. Strategies with only minor adjustments that did not change the spirit of the strategy are considered to be the same and are not discussed in this section.

Municipal Conservation

The municipal conservation strategy was fundamentally similar in both the 2021 and 2016 plans, e.g., municipal conservation was considered as a strategy for all named municipal WUGs, regardless of if they had a need, and all conservation best management practices (BMPs) considered were the same. However, there were some slight changes in the strategy assumptions in the 2021 plan that changed the entities that receive municipal conservation and the conservation volumes shown. For instance, in the 2016 plan, municipal conservation was considered for County-Other entities if their per-capita usage was over the state goal of 140 gallons per capita per day (GPCD), while in the 2021 plan, municipal conservation was only considered for County-Other entities that had a need. Furthermore, the WUG adoption rate assumed for certain BMPs, such as education and outreach and water waste ordinance, was decreased from the 2016 plan to the 2021 plan to reflect that some entities have already adopted these BMPs. More information of the municipal conservation strategy can be found in Subchapter 5B.

Weather Modification

In the previous plan, data from the WTWMA's 2013 growing season estimated a 9.6 average percent increase in rainfall across counties in Region F. This was the basis for the water savings calculations in the 2016 plan. More updated information from the 2016 growing season for the WTWMA and TPWMA estimated average increases in rainfall of 9.3 and 4.7 percent, respectively, with percent increases varying by county. This more recent data was used for the water savings calculations associated with this strategy in the 2021 plan.

Big Spring Water Treatment Plant

In the previous plan, there was a strategy for the City of Big Spring to implement a 5.5 MGD expansion to their current water treatment facility. However, after further consideration, the City has decided to construct an entirely new water treatment facility with a capacity of 18 to 20 MGD. The details and estimated costs for this project were updated to reflect this change in the 2021 plan.

San Angelo Indirect Reuse (Concho River Water Project)
The City of San Angelo recently initiated an engineering feasibility study to investigate various water supply alternatives, including strategies to re-purpose their treated effluent. The results from this study were not available during the publication of the 2016 plan, therefore, a general reuse strategy was included in that plan. Since then, this study has been completed and the City has identified an indirect potable reuse project (commonly referred to as the "Concho River Water Project") as the recommended water supply strategy for the City. The 2021 plan includes the specific logistics for this strategy, including project details, volumes, estimated costs, and timelines. For more information, refer to Appendix C.

Removed Water Management Strategies

In addition to new and altered strategies, some strategies included in the 2016 plan are no longer being considered for the entity for various reasons. These are outlined in Table 11-5.

Table 11-5
Strategies No Longer Considered in the 2021 Plan

Water User Group or Wholesale Provider	Strategies from the 2016 Plan No Longer in the 2021 Plan
Ballinger	Purchase Water Rights from Clyde (Fort Phantom Hill Reservoir)
Bronte	New Groundwater at Oak Creek Reservoir
Bronte	New Groundwater Southeast of Bronte
Bronte; Robert Lee	Purchase Water From UCRA
Colorado River MWD	ASR of Existing Surface Water Supplies in Ward County Well Field
Colorado River MWD	ASR of Brackish Groundwater
Colorado River MWD	Desalination of Brackish Groundwater
Colorado River MWD	Desalination of Brackish Surface Water (CRMWD Diverted Water System)
Concho Rural Water Corporation	Develop Additional Lipan Aquifer Supplies
Concho Rural Water Corporation	Desalination of Other Aquifer Supplies in Tom Green County
County-Other, Coke	Voluntary Transfer (Purchase)
County-Other, Howard	Voluntary Transfer (Purchase)
County-Other, Martin	Develop Additional Dockum Aquifer Supplies
County-Other, McCulloch	Voluntary Transfer (Purchase)
County-Other, Midland	Develop Pecos Valley Aquifer Supplies
County-Other, Winkler	Develop Pecos Valley Aquifer Supplies
Livestock, Andrews	Develop Pecos Valley Aquifer Supplies
Livestock, Howard	Develop Additional Dockum Aquifer Supplies
Livestock, Martin	Develop Additional Dockum Aquifer Supplies
Livestock, McCulloch	Develop Additional Edwards-Trinity Plateau Aquifer Supplies
Livestock, Scurry	New Groundwater from Local Alluvium Aquifer
Manufacturing, Martin	Voluntary Transfer (Purchase)

Water User Group or Wholesale Provider	Strategies from the 2016 Plan No Longer in the 2021 Plan
Manufacturing, McCulloch	Voluntary Transfer (Purchase)
Midland	Development of Groundwater in Midland County (Previously Used For Mining)
Midland	Additional T-Bar Groundwater with Treatment
Mining, Coke	Develop Additional Edwards-Trinity Plateau Aquifer Supplies
Mining, Coleman	Develop Additional Hickory Aquifer Supplies
Mining, Concho	Develop Additional Hickory Aquifer Supplies
Mining, Howard	Develop Additional Dockum Aquifer Supplies
Mining, Howard	Develop Additional Ogallala Aquifer Supplies
Mining, Irion	Develop Additional Dockum Aquifer Supplies
Mining, Irion	Develop Additional Edwards-Trinity Plateau Aquifer Supplies
Mining, Martin	Develop Additional Dockum Aquifer Supplies
Mining, Martin	Develop Additional Edwards-Trinity Plateau Aquifer Supplies
Mining, Runnels	Develop Other Aquifer Supplies
Mining, Scurry	Develop Local Alluvium Aquifer Supplies
San Angelo	Desalination of Other Aquifer Supplies in Tom Green County
San Angelo	Development of Capitan Reef Complex Aquifer Supplies in Pecos County
San Angelo	Red Arroyo OCR
San Angelo	West Texas Water Partnership
Sonora	Direct Non-Potable Reuse for Irrigation of Industrial and Municipal Parks (Type I)
Steam Electric Power, Coke	Steam Electric Power Conservation
Steam Electric Power, Ector	Steam Electric Power Conservation
Steam Electric Power, Mitchell	Steam Electric Power Conservation
Steam Electric Power, Ward	Develop Pecos Valley Aquifer Supplies
Steam Electric Power, Ward	Conservation - Alternative Cooling Technology
Upper Colorado River Authority	Voluntary Transfer (Purchase)

11.3 Assessment of Regionalization Across Region F

As a part of the regional planning process, regional water planning groups (RWPGs) are required to prepare long-term plans that consider ongoing local and regional planning efforts and are consistent with other regional plans across the state. In addition, regional water plans are required to meet the projected needs of water user groups (WUGs) with strategies that, among other requirements, are cost-effective. Regional water management strategies, or strategies that meet needs of multiple WUGs, can be more cost-effective than localized strategies due to economies of scale and potential reductions in the unit cost of planning, design, and construction of one, regionalized infrastructure project in densely populated areas. However, in more sparsely populated areas, the cost of long transmission lines can outweigh the potential benefits and cost savings from the economies of scale of a regional project.

In Region F, regional strategies that meet the needs of multiple WUGs and achieve economies of scale are implemented in areas where it is cost-effective and technically feasible. For example, the Colorado River Municipal Water District (CRMWD) sells and distributes water to multiple water users in Region F, including other major water providers (Midland, Odessa, and San Angelo) that distribute water to their own customers. Strategies implemented by CRMWD are inherently regional as they provide for the needs of their customers and any potential future customers. In addition, the cities of Midland, San Angelo, and Abilene (Region G) are collaborating and considering the development of a regional water supply strategy (referred to as the "West Texas Water Partnership") that could provide for the growing needs of their customers. Growing communities outside Midland (Midland County Utility District and Midland County FWD) and San Angelo (UCRA) are considering regional solutions to meet their needs. Another potential regional strategy in Region F includes the development of a regional system between the cities of Bronte, Ballinger, Winters, and Robert Lee that would transport water from either Lake Brownwood or Lake Fort Phantom Hill. However, regional strategies for Bronte, Ballinger, Winters, and Robert Lee have not been found to be cost effective due to the long distances of transmission pipeline that is needed for relatively small amounts of water.

Regional strategies can achieve economies of scales and be cost-effective, particularly for centralized areas that have a large water need. However, in comparison to other regions across Texas, Region F has demographic and geographic characteristics that limit the advantages of regional strategies. With the exception of a few metropolitan areas, the majority of Region F is rural, and demands are primarily met with local water supplies, such as groundwater or local reservoirs. Furthermore, Region F is geographically expansive, as it encompasses 32 counties and spans across nearly half the state of Texas. Consequently, the need for large-scale projects are limited since many communities already have local supplies available. Also, unless water user groups are relatively nearby, regional projects can be cost-prohibitive due to long transmission distances.

11.4 Conclusion

Overall, the 2021 Region F Water Plan has changed in various ways from the 2016 Region F Water Plan. Surface water supplies are slightly lower due to changes to the finalized Water Availability Model for existing supplies and extended hydrology for the subordination strategy. Groundwater supplies increased significantly due to the Joint Planning Efforts with the GMAs, resulting in higher MAG values and less artificial shortages. These increases in groundwater availability coupled with lower overall demands in the region resulted in the reduction or removal of needs for water users across the region. The region removed 48 strategies and added 17 strategies, resulting in a net decrease of 31 strategies in the 2021 plan.