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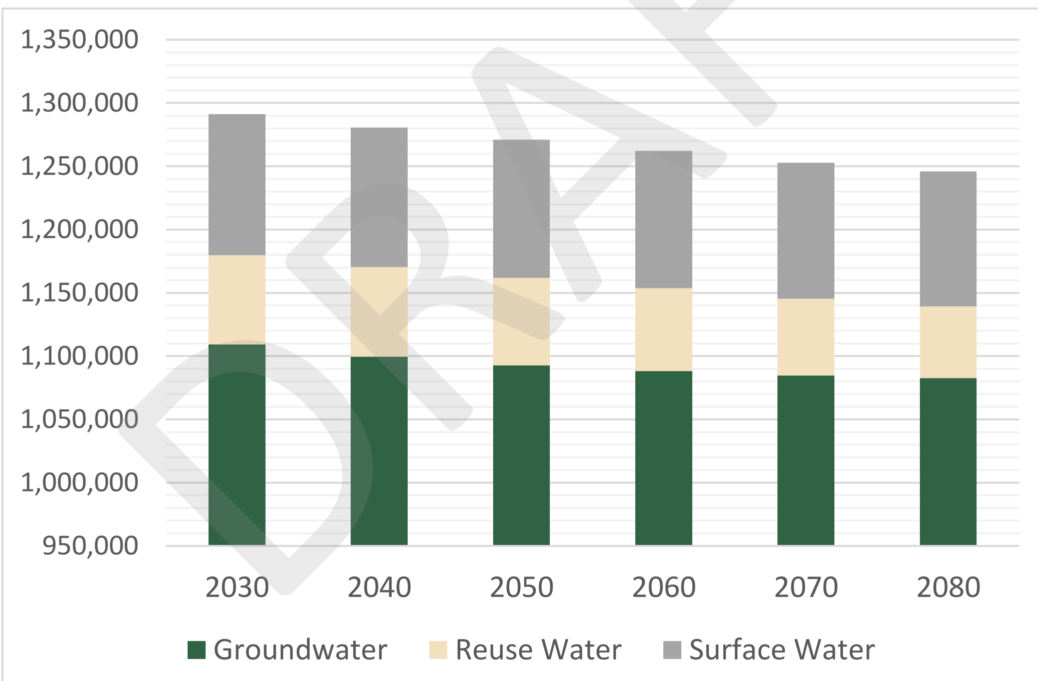
3 WATER SUPPLY ANALYSIS

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 86 percent of the total water available. Surface water supplies in Figure 3-1 total approximately 111,000 acre-feet in 2030. 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 smaller 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 TWDB designated aquifers 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 Aquifers

- Edwards-Trinity (Plateau)
- Edwards-Trinity (High Plains)
- Ogallala
- Pecos Valley
- Trinity
- Dockum
- Hickory
- Lipan
- Ellenburger San Saba
- Marble Falls

Region F historical groundwater pumping by aquifer for years 2017 through 2021 is shown in Figure 3-2. These data were calculated using the TWDB historical groundwater pumping estimates. The Edwards-Trinity (Plateau) supplied 30 percent of the region's groundwater, the Pecos Valley supplied 19 percent, and the Ogallala provided 14 percent. The minor aquifers provided the remaining 37 percent.

The same historical data set is presented in

Figure 3-3 by use category. Irrigation accounted for 70 percent of groundwater pumped in the region. Municipal pumping consumed eleven percent of the groundwater and the remaining use categories collectively accounted for about nineteen 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 (2017-2021) by Aquifer

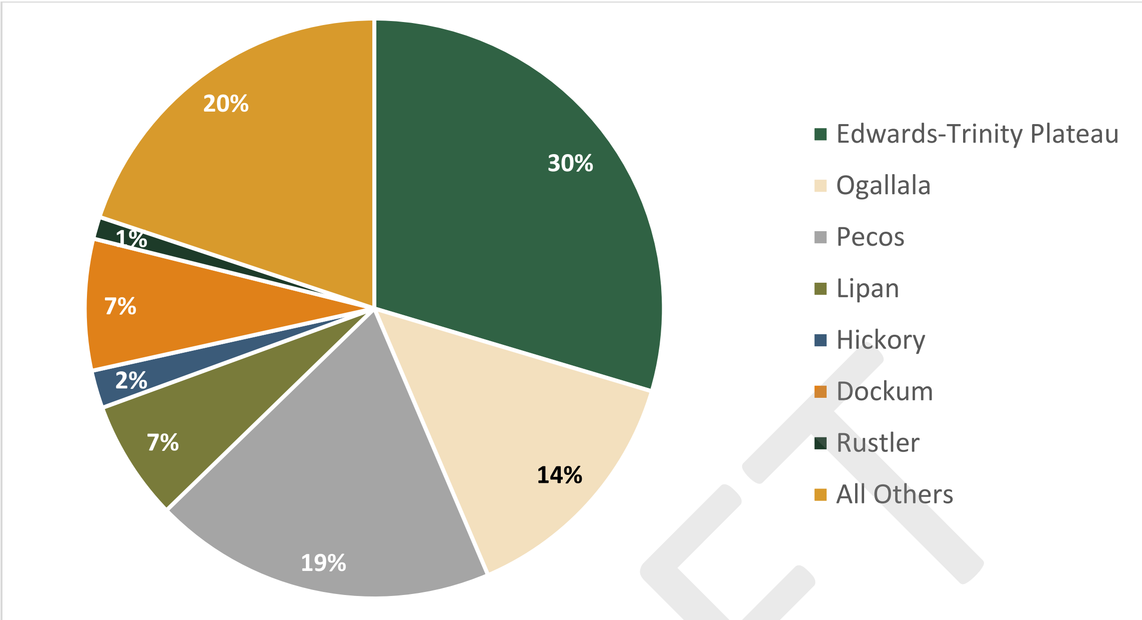
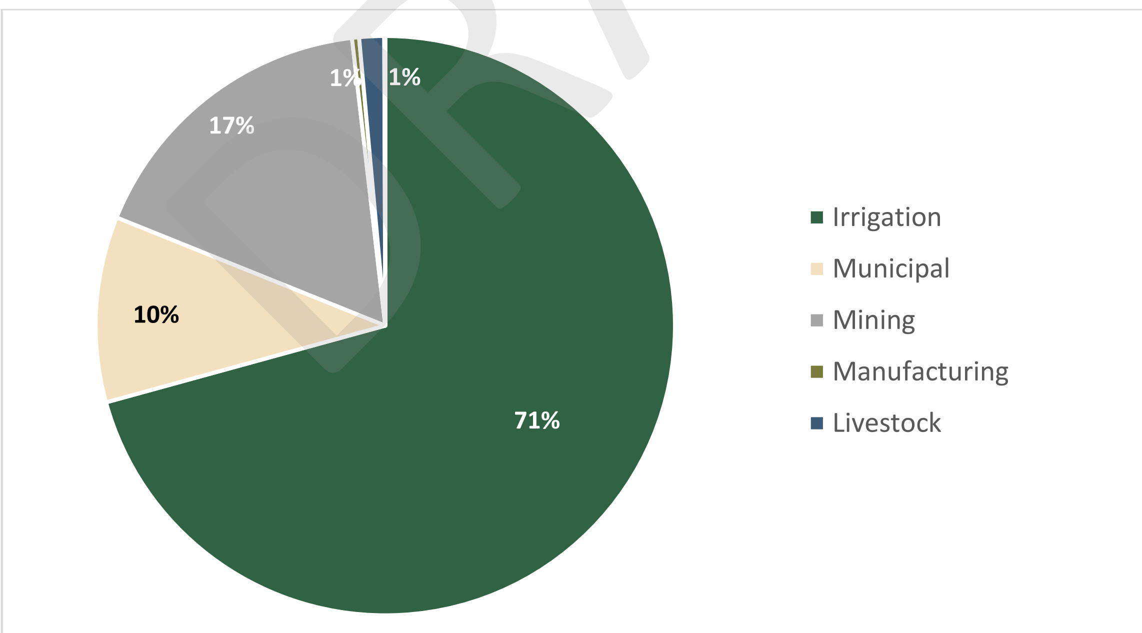
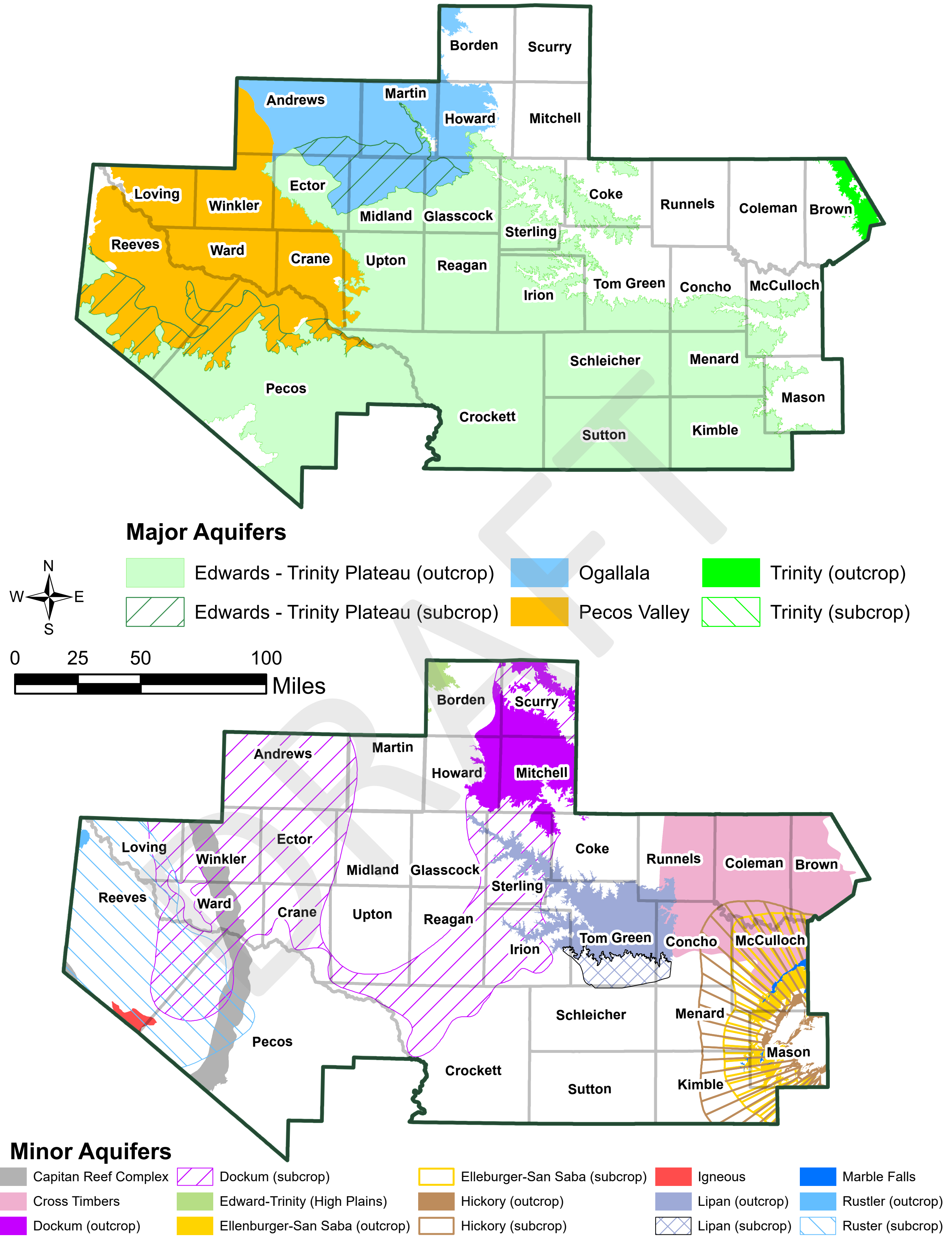


Figure 3-3
Historical Groundwater Pumping (2017-2021) by Use





Region F

Major and Minor Aquifers

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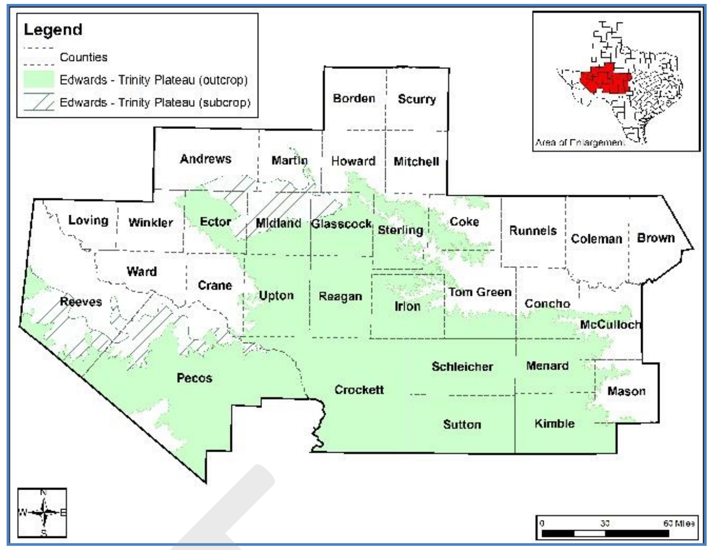
FIGURE

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 30 percent) than any other aquifer in the region, about 85 percent of which was used for irrigation in 2021. Many communities in the region use the aquifer for their public drinking-water supply. Municipal use accounted for nine percent of use in 2021.

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, evapotranspiration, and rivers in the region. Groundwater flow in the aquifer generally flows in a south-southeasterly direction but may vary locally. The horizontal hydraulic gradient in the aquifer averages about 10 feet/mile.

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 southwest of Fort Stockton in 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

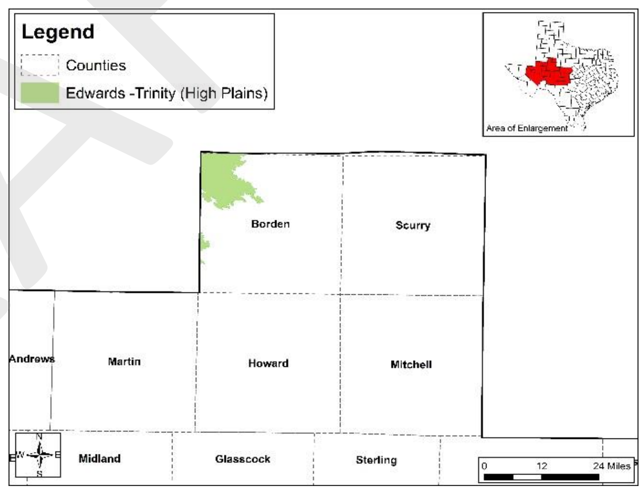
Water-bearing units of the Trinity Group are used primarily in the northern third and on the southeastern edge of the aquifer. In most of the region, the Trinity is seldom used due to the presence of the Edwards above it, which produces better quality water at generally higher rates. In the southeast 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 portion 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.

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.



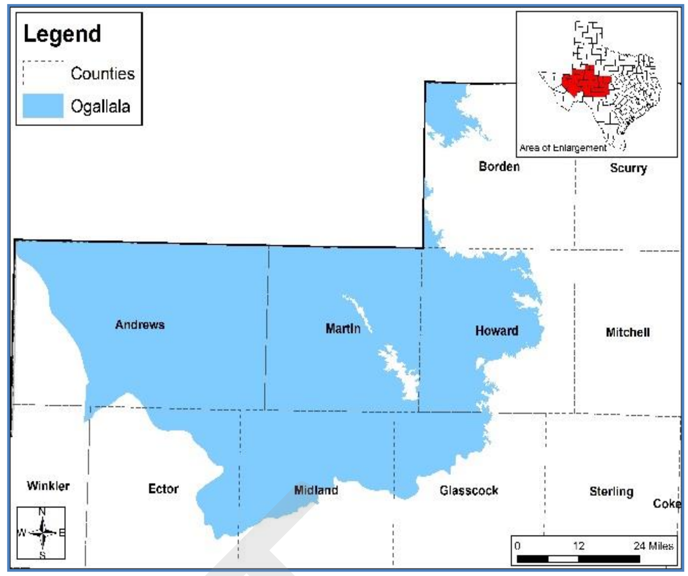
The aquifer extends into the northwestern corner of Borden County where it is a minor source of water used for irrigation purposes.

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 14 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.

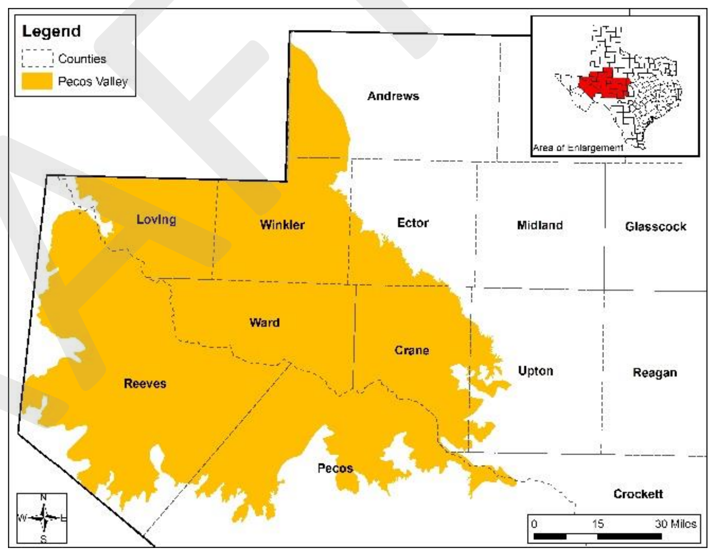
In Region F, agricultural irrigation accounted for approximately 65 percent of the total use of Ogallala groundwater in 2021. Municipal use accounted for approximately 9 percent. Most of the withdrawals from the aquifer occur in Midland, Martin, and Andrews Counties.

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 northern 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.

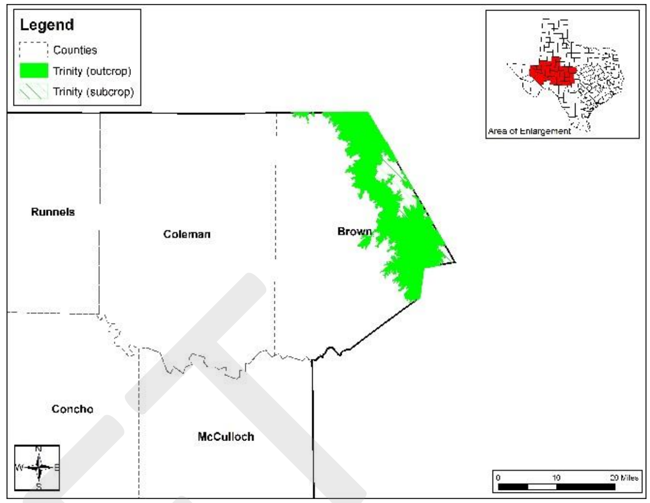


The western basin (Pecos Trough) generally contains poorer quality brackish groundwater and is used most extensively for irrigation of salt-tolerant crops. The eastern basin (Monument Draw Trough) contains relatively good quality water that is used for a variety of purposes, including industrial use, power generation, and public water supply. Most pumping occurs in Pecos and Reeves Counties for irrigation but there are several important wellfields in the Monument Draw Trough that supply water to Midland and the Colorado River Municipal Water District to supply several municipalities in Region F.

The Pecos Valley is the third most used aquifer in the region, representing approximately 19 percent of total groundwater use. Agricultural irrigation accounted for approximately 71 percent of the total in 2021, while municipal consumption and power generation accounted for about 17 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 except in areas with significant withdrawals for irrigation or municipal use.

3.1.5 Trinity Aquifer



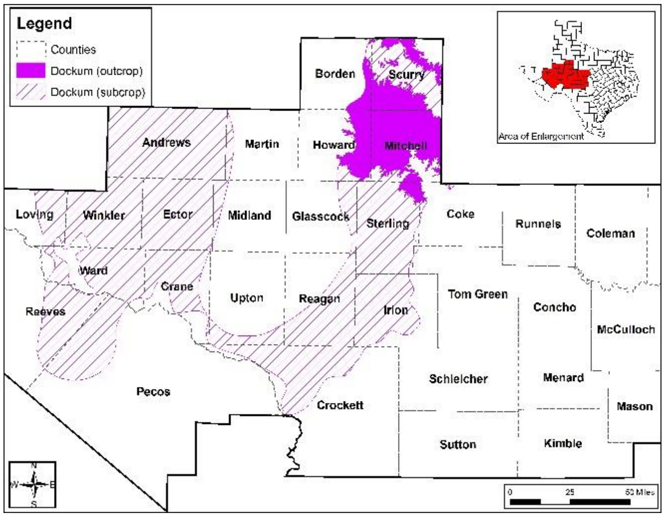
The Trinity aquifer is a groundwater source for eastern Brown County. Small isolated outcrops of Trinity Age rocks also occur in south central Brown County and northwest Coleman County. However, these two areas are not classified as the contiguous Trinity aquifer by the TWDB and the TWDB did not estimate a groundwater availability for the Trinity aquifer in Coleman County. Agricultural related consumption (irrigation and livestock) accounted for approximately 69 percent of the total withdrawal from the aquifer in 2021.

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. The 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.



About seven percent of groundwater withdrawn in the region from the Dockum Aquifer. Agricultural irrigation and livestock use accounted for 45 percent of Dockum pumpage in 2021, a decrease from previous years. 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 accounted for about 28 percent of total Dockum use. Mining uses (which include drilling and hydraulic fracing) accounted for 25 percent in 2021, a large jump from the historical use of the Dockum in Region F during 2012-2016, which was less than one percent of total Dockum use.

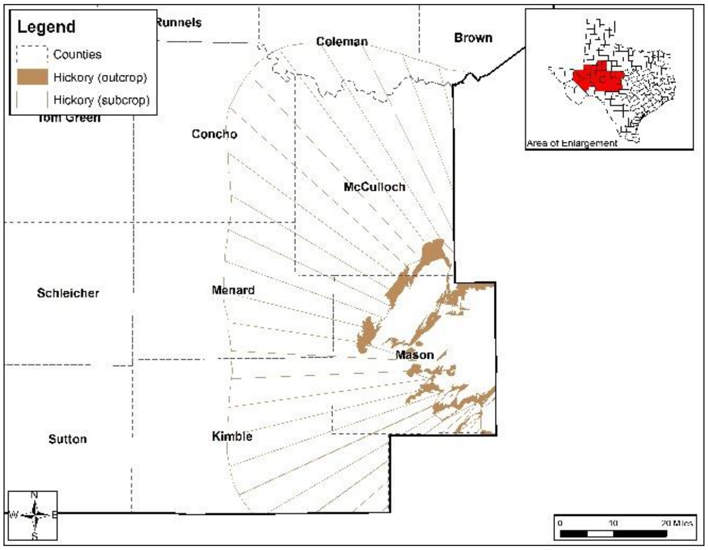
The primary water-bearing zone in the Dockum Group, commonly called the "Santa Rosa", consists of up to 700 feet of sand and conglomerate interbedded with layers of silt and shale. The Santa Rosa abuts the overlying Trinity aquifer along a corridor that traverses Sterling, Irion, Reagan and Crockett 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 largely from storage and will generally 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

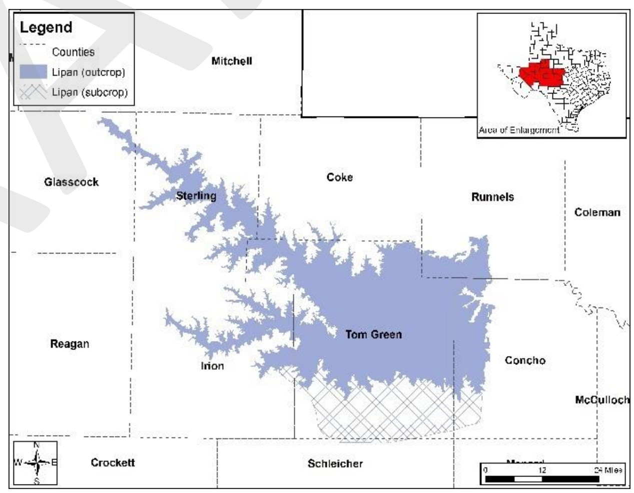
The Hickory aquifer is located in the eastern portion of Region F and outcrops in Mason and McCulloch Counties. The downdip portion of the Hickory aquifer also supplies groundwater to Concho, Kimble and Menard Counties. The Hickory Sandstone Member of the Cambrian Riley Formation is composed of some of the oldest sedimentary rocks in Texas. Irrigation and livestock accounted for approximately 57 percent of the 2021 total pumpage, while municipal water use accounts for approximately 41 percent. McCulloch County used the greatest amount of water from the Hickory aquifer, most of which was used for irrigation, while Mason County was close behind, also using most of their Hickory aquifer supply for irrigation.. 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



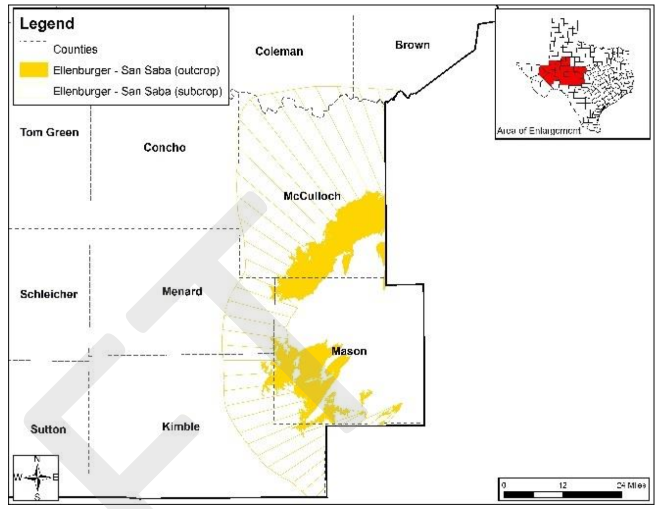
The Lipan aquifer is located primarily in Tom Green County and extends into neighboring counties. The aquifer accounts for about seven percent of regional groundwater use and is principally used for irrigation (95 percent) with limited rural domestic and livestock use. Most pumpage occurs in Tom Green 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



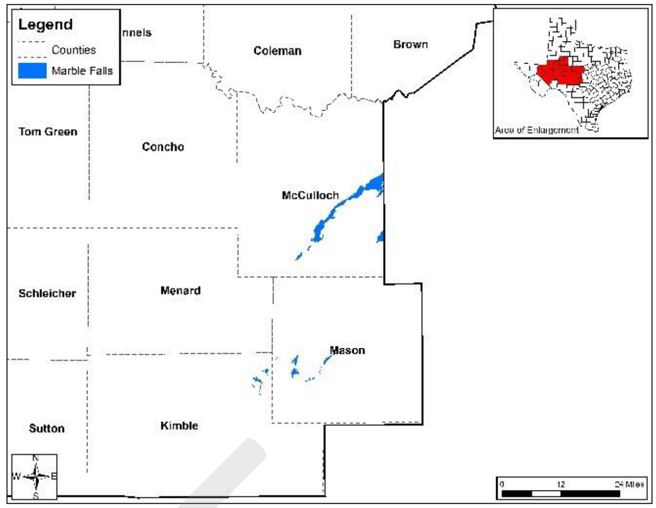
Including the downdip boundary as designated by the TWDB, the Ellenburger-San Saba aquifer occurs in Brown, Coleman, Kimble, Mason, McCulloch and Menard Counties within Region F. Currently, the aquifer supplies less than 0.1 percent of total regional use and most pumpage occurs in McCulloch County. About 77 percent of all use was for livestock in 2021 and about 13 percent was 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 Kimble and Menard Counties.   Maximum yields of large-capacity wells generally range between 200 and 600 gpm, most other wells typically yield less than 100 gpm.

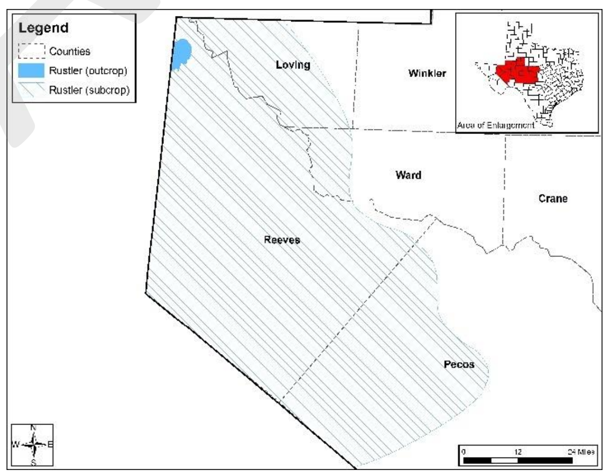
3.1.10 Marble Falls Aquifer



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 0.01 percent of total regional use, and in recent years (2017-2021) has only reported use in McCulloch County. Irrigation accounted for 60 percent of use and livestock about 25 percent in 2021. Municipal use in 2021 accounted for 15 percent of the total use of the aquifer. 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

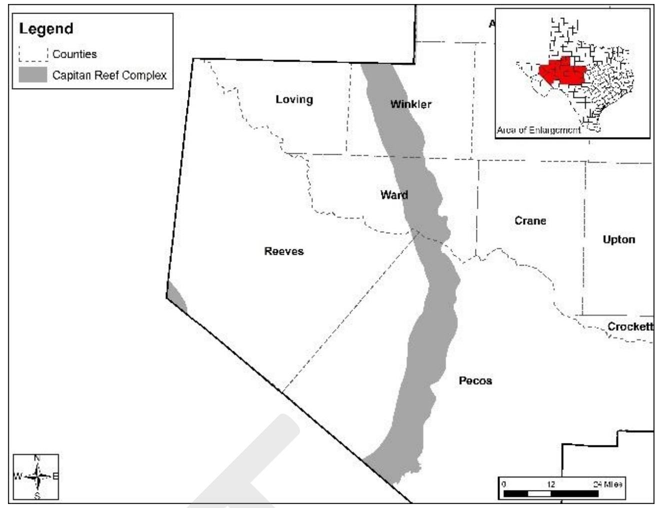


The Rustler Formation outcrops outside of Region F in Culberson County, but the majority of its downdip extent occurs in Region F in Loving, Pecos, Reeves and Ward Counties. The Rustler Formation consists of 200 to 500 feet of anhydrite and dolomite with a basal zone of sandstone and shale deposited 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 (77 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 in excess of 3,000 mg/l (TDS). 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.

In Region F, 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 2017 through 2021 attribute all use of the aquifer to irrigation in Pecos County only. The Capitan supplies less than 0.5 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

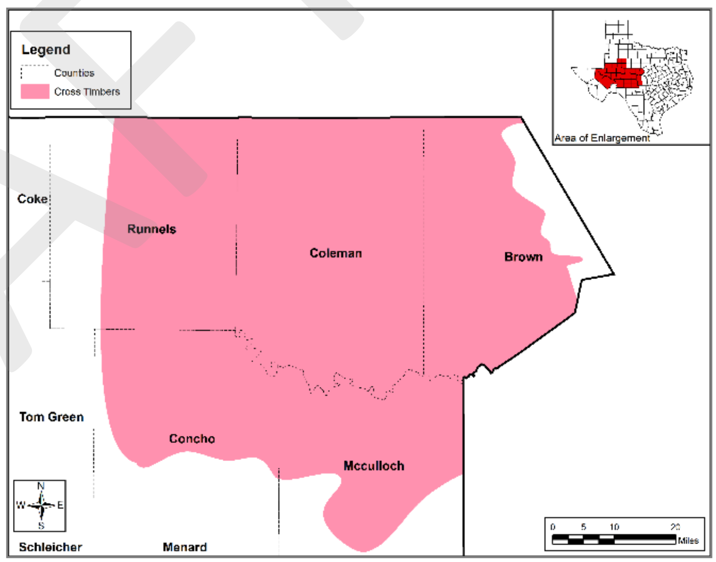
The Blaine aquifer extends from Wheeler County in the Panhandle to Coke County in West-Central Texas. In Region F, there are only isolated portions of the aquifer in Coke County. Most of the groundwater currently produced from the Blaine is used for livestock and irrigation purposes because the water 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 relatively 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 TWDB recently designated a new minor aquifer known as the Cross Timbers Aquifer. The aquifer has been a source of groundwater mainly in areas northeast of Region F, but it does extend into the northeast portion of Region F as well. 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.

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 3-5 shows the regulatory boundaries of the GCDs and GMAs within Region F.

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.

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 estimated volume of groundwater that can be produced to meet the DFC. It is also the maximum amount of groundwater that can be used for existing uses and new recommended strategies in Regional Water Plans.

Groundwater Conservation Districts and Groundwater Management Areas

Region F

FIGURE 3-8

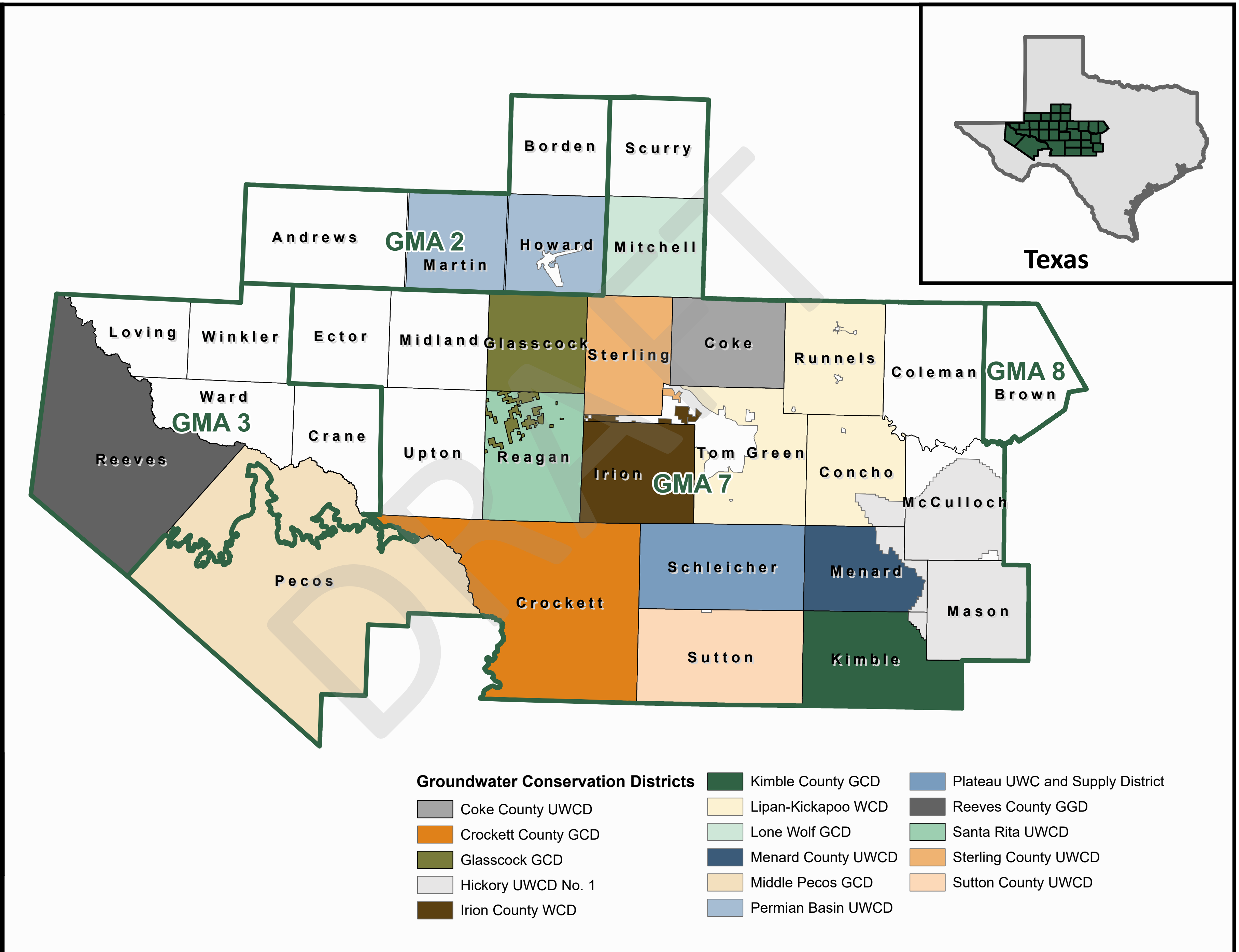


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Table 3-1
Desired Future Conditions for Region F Aquifers

Aquifer	Groundwater Management Area[1]	Desired Future Condition (DFC)	Region F Non-Relevant
Edwards-Trinity (Plateau)	2, 3 and 7	Net water level decline by 2070 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	Average drawdown by 2080 is 28 feet for all counties in GMA 2.	None
Ogallala	2, 3 and 7	Net water level declines vary from 6 ft. in Glasscock County by 2070 to 28 ft. for all of GMA 2 by 2080.	Midland, Ector (GMA 7), Winkler (GMA 3)
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 from 148 ft. in Glen Rose and Hensell to 193 ft. in Antlers, to 207 ft. in Travis Peak, and 262 ft. in Hosston.	None
Dockum	2, 3 and 7	Net drawdown by 2080 is 31 ft. for all counties in GMA 2. For GMA 3, net drawdown ranges from 0 ft. (Crane County) to 52 ft. (Pecos County) by 2070. In GMA 7, net drawdown is 14 ft. (Reagan) and 52 ft. (Pecos) by 2070.	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 53 ft. (Concho County) by 2070 for GMA 7. In GMA 8, average drawdown is 3 ft. (Brown County) through 2080.	Outside of Hickory UWCD, Hill County UWCD, Kimble County GCD, Menard GCD, and Llano County (GMA 7)
Lipan	7	Aquifer determined non-relevant for joint planning purposes and no DFC was established.	All counties
Ellenburger-San Saba	7	Total drawdown ranges from 5 ft. (Region K) to 46 ft. (Menard) by 2070.	Outside of Hickory UWCD, Hill County UWCD, Kimble County GCD, and Menard GCD
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) by 2070.	None
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 by 2070.	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 available for use in the Region F Plan. Table 3-2 presents the MAG numbers by county, aquifer, and river basin for planning years 2030 through 2080. MAG volumes are an estimate of the largest amount of water that can be withdrawn by all users from a given source without violating DFCs. Table 3-2 only includes county aquifer combinations in each basin where a DFC has been defined by a 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	2030	2040	2050	2060	2070	2080
Andrews	Dockum	Colorado	1,503	1,503	1,503	1,503	1,503	1,503
		Rio Grande	0	0	0	0	0	0
	Ogallala	Colorado	19,391	17,897	16,937	16,260	15,764	15,378
		Rio Grande	0	0	0	0	0	0
Borden	Dockum	Brazos	323	323	323	323	323	323
		Colorado	703	703	703	703	703	703
	Ogallala and Edwards-Trinity (High Plains)	Brazos	673	615	581	559	543	532
		Colorado	3,759	3,278	3,010	2,834	2,684	2,540
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	1,376	1,376	1,376	1,376	1,376	1,376
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	7,673	7,372	7,058	6,803	6,570	6,570
Howard	Ogallala	Colorado	15,631	14,818	14,365	14,090	13,915	13,800
	Dockum	Colorado	6,770	6,770	6,770	6,770	6,770	6,770
Irion	Edwards-Trinity (Plateau)	Colorado	3,289	3,289	3,289	3,289	3,289	3,289
Kimble	Edwards-Trinity (Plateau)	Colorado	1,386	1,386	1,386	1,386	1,386	1,386

County	Aquifer	Basin	2030	2040	2050	2060	2070	2080
	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
Martin	Ogallala	Colorado	48,293	43,032	39,019	36,358	34,521	33,171
	Dockum	Colorado	11,449	11,449	11,449	11,449	11,449	11,449
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
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
Menard	Edwards-Trinity (Plateau)	Colorado	2,597	2,597	2,597	2,597	2,597	2,597
	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	962	962	962	962	962	962
	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	Edwards-Trinity (Plateau) and Pecos Valley	Colorado	21,243	21,243	21,243	21,243	21,243	21,243
		Rio Grande	1,126	1,126	1,126	1,126	1,126	1,126
Ward	Capitan Reef	Rio Grande	103	103	103	103	103	103

County	Aquifer	Basin	2030	2040	2050	2060	2070	2080
	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

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 and a related officially determined MAG developed by the TWDB, the RWPG may use an alternate methodology to estimate availability from the aquifer. In some cases, the TWDB published “DFC-compatible availability values.” These estimates typically originate from the DFC/MAG modeling but are not a part of the MAG documentation because a DFC was not established for an area. However, a “DFC-Compatible” pumping is typically assumed for each county and aquifer in the GAM and is a part of the modeling assumptions that define and constrain the DFCs and MAGs in other parts of the model. Therefore, they are considered “compatible” with existing DFCs. For this reason, “DFC-Compatible” values in non-relevant areas are considered appropriate for regional planning purposes because they do not jeopardize or invalidate DFCs or MAGs in nearby relevant areas. 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 3-4 includes availability estimates for other aquifers. Other aquifers are localized pockets of water that are not designated by TWDB as a major or minor aquifer. They are generally small but can be locally significant. For many of the non-relevant and other aquifers, the groundwater availability estimates determined for the 2021 Region F Water Plan were retained.

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

County	Aquifer	Basin	2030	2040	2050	2060	2070	2080	Methodology
Andrews	Edwards-Trinity (Plateau) and Pecos Valley	Colorado	1,198	1,198	1,198	1,198	1,198	1,198	Groundwater Availability Model (GAM) Modified
	Pecos Valley	Rio Grande	150	150	150	150	150	150	Estimate based on TCEQ State Well Reports Filed 1968-2000.
Brown	Cross Timbers Aquifer	Colorado	993	993	993	993	993	993	Published Reports/Data
Coke	Dockum	Colorado	100	100	100	100	100	100	Estimate based on Groundwater Assessment
	Lipan	Colorado	160	160	160	160	160	160	Estimate based on Groundwater Assessment
Coleman	Cross Timbers Aquifer	Colorado	108	108	108	108	108	108	Published Reports/Data
	Hickory Aquifer	Colorado	500	500	500	500	500	500	Published Reports/Data
Concho	Edwards-Trinity (Plateau)	Colorado	459	459	459	459	459	459	Published Reports/Data
	Lipan	Colorado	4,000	4,000	4,000	4,000	4,000	4,000	Groundwater Availability Model (GAM)
Crane	Rustler	Rio Grande	1,000	1,000	1,000	1,000	1,000	1,000	Published Reports/Data
Crockett	Dockum	Colorado	4	4	4	4	4	4	Groundwater Availability Model (GAM) Modified
	Dockum	Rio Grande	2	2	2	2	2	2	Groundwater Availability Model (GAM)
Ector	Dockum	Colorado	28	28	28	28	28	28	Published Reports/Data
	Dockum	Rio Grande	721	721	721	721	721	721	Published Reports/Data
	Ogallala	Colorado	206	213	218	222	226	226	Published Reports/Data
Glasscock	Dockum	Colorado	900	900	900	900	900	900	Groundwater Availability

County	Aquifer	Basin	2030	2040	2050	2060	2070	2080	Methodology
									Model (GAM) Modified
	Lipan	Colorado	10	10	10	10	10	10	Based on Groundwater Analysis
Howard	Edwards-Trinity (Plateau)	Colorado	672	672	672	672	672	672	Groundwater Availability Model (GAM) Modified
Irion	Dockum	Colorado	150	150	150	150	150	150	Groundwater Availability Model (GAM) Modified
	Lipan	Colorado	13	13	13	13	13	13	Estimate Based on Groundwater Analysis
Kimble	Marble Falls	Colorado	100	100	100	100	100	100	Estimate Based on Groundwater Analysis
McCulloch	Cross Timbers Aquifer	Colorado	103	103	103	103	103	103	Max 4-Year Annual Historical Pumpage (2012-2015)
	Edwards-Trinity (Plateau)	Colorado	600	600	600	600	600	600	Groundwater Availability Model (GAM)
	Marble Falls	Colorado	50	50	50	50	50	50	Estimate Based on WSP Groundwater Analysis
Martin	Edwards-Trinity (Plateau)	Colorado	242	242	242	242	242	242	Groundwater Availability Model (GAM) Modified
Mason	Edwards-Trinity (Plateau)	Colorado	18	18	18	18	18	18	Groundwater Availability Model (GAM)
	Marble Falls	Colorado	100	100	100	100	100	100	Estimate Based on Groundwater Analysis
Midland	Dockum	Colorado	1,000	1,000	1,000	1,000	1,000	1,000	Published Reports/Data
	Ogallala	Colorado	15,442	14,369	13,732	13,258	12,745	12,745	Published Reports/Data

County	Aquifer	Basin	2030	2040	2050	2060	2070	2080	Methodology
Mitchell	Dockum	Colorado	14,018	14,018	14,018	14,018	14,018	14,018	Published Reports/Data
	Pecos Valley, Edwards-Trinity (Plateau)	Colorado	0	0	0	0	0	0	No Methodology Selected
Pecos	Igneous	Rio Grande	80	80	80	80	80	80	Estimate Based on Groundwater Analysis
Reeves	Capitan Reef Complex	Rio Grande	1,007	1,007	1,007	1,007	1,007	1,007	Published Reports/Data
	Igneous	Rio Grande	300	300	300	300	300	300	Estimate Based on Groundwater Assessment of TWDB 2016 Groundwater Pumpage
Runnels	Cross Timbers Aquifer	Colorado	0	0	0	0	0	0	No Methodology Selected
	Lipan	Colorado	45	45	45	45	45	45	Groundwater Availability Model (GAM)
Schleicher	Lipan	Colorado	0	0	0	0	0	0	No Methodology Selected
Scurry	Dockum	Brazos	2,151	2,151	2,151	2,151	2,151	2,151	Published Reports/Data
	Dockum	Colorado	9,546	9,546	9,335	9,248	9,175	9,175	Published Reports/Data
	Seymour	Brazos	10	10	10	10	10	10	Estimate Based on Groundwater Analysis
Sterling	Dockum	Colorado	300	300	300	300	300	300	Groundwater Availability Model (GAM) Modified
	Lipan	Colorado	850	850	850	850	850	850	Groundwater Availability Model (GAM)
Tom Green	Dockum	Colorado	200	200	200	200	200	200	Estimate Based on Groundwater Analysis
	Edwards-Trinity (Plateau)	Colorado	2,797	2,797	2,797	2,797	2,797	2,797	Groundwater Availability Model (GAM)

County	Aquifer	Basin	2030	2040	2050	2060	2070	2080	Methodology
	Lipan	Colorado	43,568	43,568	43,568	43,568	43,568	43,568	Groundwater Availability Model (GAM)
Upton	Dockum	Rio Grande	1,000	1,000	1,000	1,000	1,000	1,000	Published Reports/Data
Winkler	Ogallala	Rio Grande	40	40	40	40	40	40	Estimate Based on Groundwater Analysis

Table 3-4
Groundwater Supplies from Other Aquifers

County	Aquifer Name	Basin	2026 Availability
Borden	Other Aquifer	Colorado	2,598
Coke	Other Aquifer	Colorado	2,100
Coleman	Other Aquifer	Colorado	109
Concho	Other Aquifer	Colorado	5,964
Mason	Other Aquifer	Colorado	873
McCulloch	Other Aquifer	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

To determine potential needs and conflicts between where pumping has occurred historically and MAG availability, historical pumping estimates for years 2017 through 2021 were compared to the MAGs (Table 3-5). The highlighted county-aquifer-basin combinations represent 5-year average historical use that exceeds the year 2030 MAG.

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.

Table 3-5
Modeled Available Groundwater and Historical Pumping Estimates (2017-2021)

-All Values are in Acre-Feet per Year-

County	Aquifer	Basin	MAG 2030	Historical Pumping Average (2017-2021)
Andrews	Dockum	Colorado	1,503	2
		Rio Grande	0	0
	Ogallala	Colorado	19,391	17,574
		Rio Grande	0	581*
Borden	Dockum	Brazos	323	0
		Colorado	703	121
	Ogallala and Edwards-Trinity (High Plains)	Brazos	673	590
		Colorado	3,759	1,306
Brown	Ellenburger-San Saba	Colorado	131	1
	Hickory	Colorado	12	0
	Marble Falls	Colorado	25	0
	Trinity	Brazos	51	39
		Colorado	1,376	1,015
Coke	Edwards-Trinity (Plateau)	Colorado	997	170
Coleman	---	Colorado	---	0
Concho	Hickory	Colorado	27	298*
Crane	Dockum	Rio Grande	94	341*
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	4,991	1,403
Crockett	Edwards-Trinity (Plateau)	Colorado	20	1,032*
		Rio Grande	5,427	630
Ector	Edwards-Trinity (Plateau) and Pecos Valley	Colorado	4,925	2,001
		Rio Grande	617	474
Glasscock	Edwards-Trinity (Plateau)	Colorado	65,186	33,347
	Ogallala	Colorado	7,673	4,983
Howard	Ogallala	Colorado	15,631	6,490
	Dockum	Colorado	6,770	272
Irion	Edwards-Trinity (Plateau)	Colorado	3,289	607
Kimble	Edwards-Trinity (Plateau)	Colorado	1,386	679
	Ellenburger-San Saba	Colorado	521	7
	Hickory	Colorado	165	20
Loving	Dockum	Rio Grande	453	24
	Pecos Valley	Rio Grande	2,982	917
	Rustler	Rio Grande	200	1
McCulloch	Ellenburger-San Saba	Colorado	4,364	251
	Hickory	Colorado	24,377	5,544
Martin	Ogallala	Colorado	48,293	34,326
	Dockum	Colorado	114,49	0
Mason	Ellenburger-San Saba	Colorado	3,237	73
	Hickory	Colorado	13,212	5,484

County	Aquifer	Basin	MAG 2030	Historical Pumping Average (2017-2021)
Menard	Edwards-Trinity (Plateau)	Colorado	2,597	457
	Ellenburger-San Saba	Colorado	309	4
	Hickory	Colorado	2,725	398
Midland	Edwards-Trinity (Plateau)	Colorado	23,233	5,750
Pecos	Capitan Reef	Rio Grande	26,168	2,399
	Dockum	Rio Grande	8,164	0
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	122,899	72,080
	Rustler	Rio Grande	7,043	3,196
Reagan	Dockum	Colorado	962	1,514*
	Edwards-Trinity (Plateau)	Colorado	68,205	23,441
		Rio Grande	28	63*
Reeves	Dockum	Rio Grande	2,539	3,062*
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	189,744	7,042
	Rustler	Rio Grande	2,387	3,678*
Schleicher	Edwards-Trinity (Plateau)	Colorado	6,403	2,359
		Rio Grande	1,631	1,089
Sterling	Edwards-Trinity (Plateau)	Colorado	2,495	521
Sutton	Edwards-Trinity (Plateau)	Colorado	388	200
		Rio Grande	6,022	2,085
Upton	Edwards-Trinity (Plateau) and Pecos Valley	Colorado	21,243	6,099
		Rio Grande	1,126	346
Ward	Capitan Reef	Rio Grande	103	0
	Dockum	Rio Grande	2,150	36
	Pecos Valley	Rio Grande	49,976	10,674
	Rustler	Rio Grande	0	3*
Winkler	Capitan Reef	Rio Grande	274	0
	Dockum	Colorado	13	5,955*
		Rio Grande	5,987	2,419
	Edwards-Trinity (Plateau) and Pecos Valley	Rio Grande	49,949	2
* Average historical pumping exceeds MAG				

3.2 Existing Surface Water Supplies

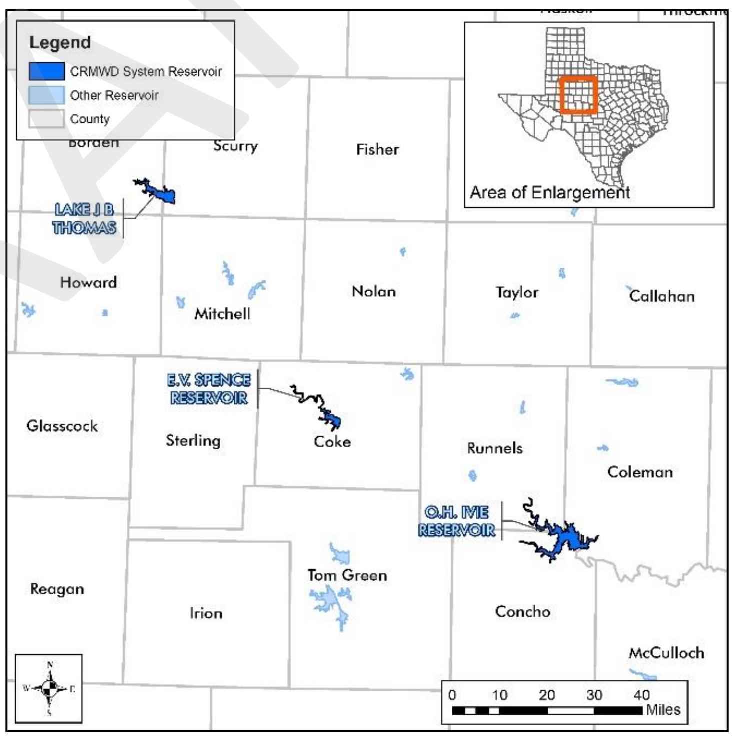
Existing surface water includes supplies from reservoirs, river diversions, and local stock tanks for livestock use. While surface water provides only a fraction of the total water supplies in the region, it is a very important source for municipal and industrial use. In the year 2021, surface water provided only 14 percent of the total water used in the region, yet surface water accounted for 51 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, Paint Rock, San Angelo 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 3-6 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 saltwater control. The CRMWD reservoirs are 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 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 drought left the two upper reservoirs (J.B. Thomas and E.V. Spence) at storage levels less than 2 percent of conservation capacity in 2013. By 2023, the CRMWD surface water reservoirs were at approximately 31 percent of the combined capacity, with the greatest amount of stored water in O.H. Ivie.



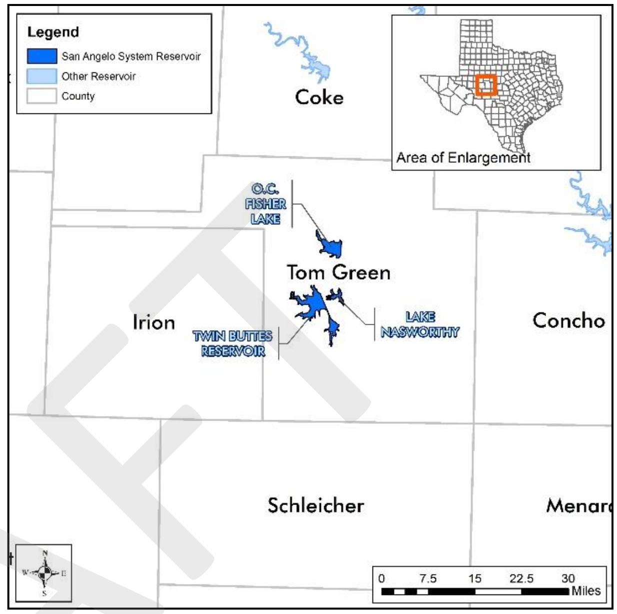
Lake Colorado City/Champion Creek Reservoir System

Lake Colorado City and Champion Creek Reservoir are 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.

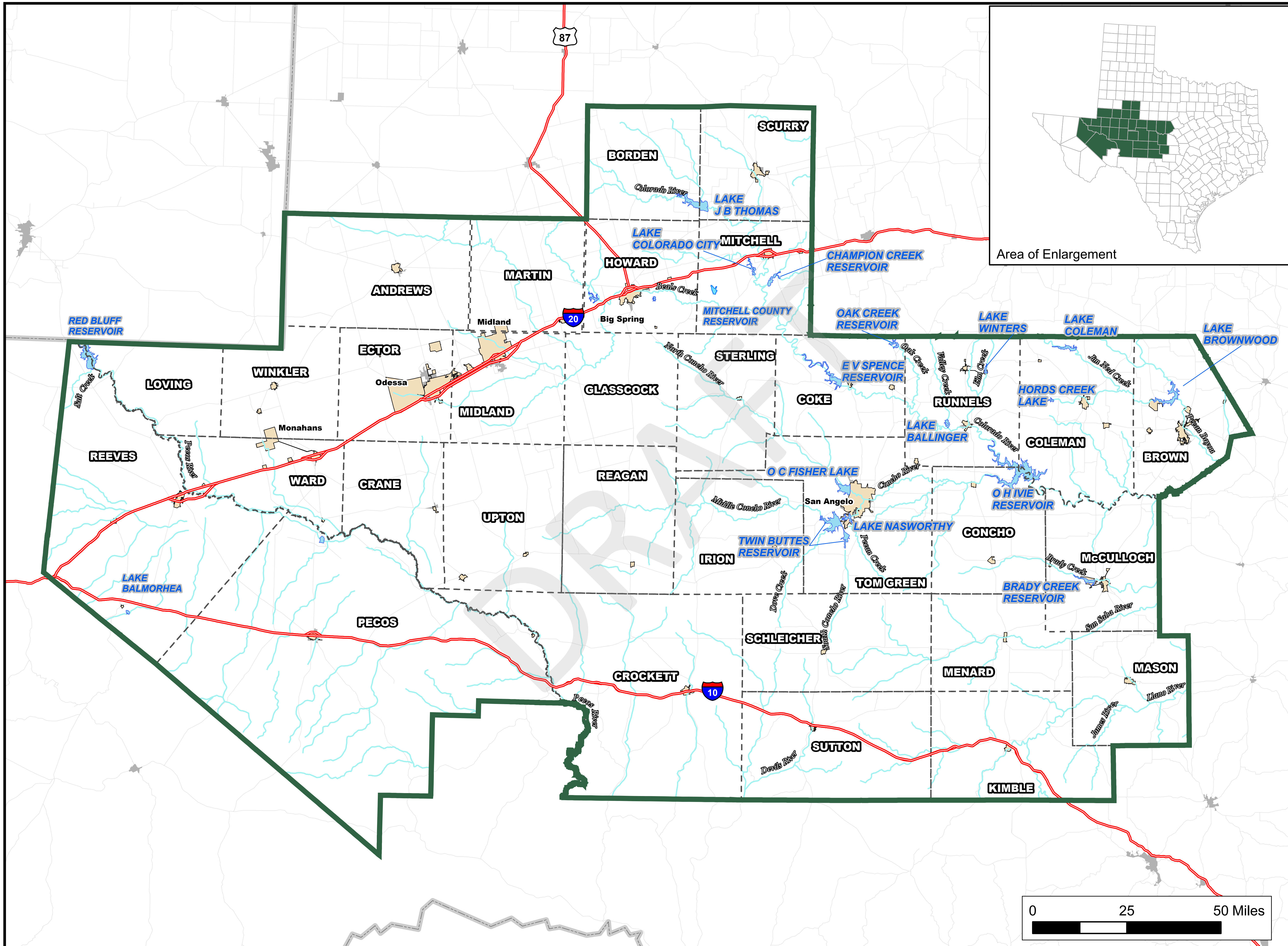
O.C. Fisher Reservoir

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 to no water available from O.C. Fisher. In August 2024 the reservoir was at 0.8 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)	2022 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	14,454	CRMWD	CRMWD
Lake Colorado City	Colorado	Morgan Creek	Mitchell	CA-1009	11/22/1948	29,934	5,500	4	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	159	City of Sweetwater	City of Sweetwater
Lake Coleman	Colorado	Jim Ned Creek	Coleman	CA-1702	8/25/1958	40,000	9,000	1,265	City of Coleman	City of Coleman
E V Spence Reservoir	Colorado	Colorado River	Coke	CA-1008	8/17/1964	488,760	43,000	13,802	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	1	City of Winters	City of Winters
Lake Brownwood	Colorado	Pecan Bayou	Brown	CA-2454	9/29/1925	114,000	29,712	12,537	Brown Co. WID	Brown Co. WID
Hords Creek Lake	Colorado	Hords Creek	Coleman	CA-1705	3/23/1946	7,959	2,240	0	COE	City of Coleman
Lake Ballinger	Colorado	Valley Creek	Runnels	CA-1072	10/4/1946	6,850	1,000	268	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	34,677	CRMWD	CRMWD
O.C. Fisher Lake	Colorado	North Concho River	Tom Green	CA-1190	5/27/1949	80,400	80,400	0	COE	Upper Colorado River Authority
Twin Buttes Reservoir	Colorado	S. Concho River	Tom Green	CA-1318	5/6/1959	170,000	29,000	11,787	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	55	City of San Angelo	City of San Angelo
Brady Creek Reservoir	Colorado	Brady Creek	McCulloch	CA-1849	9/2/1959	30,000	3,500	0	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	23,582	Red Bluff WCD	Red Bluff WCD
Lake Balmorhea	Rio Grande	Toyah Creek	Reeves	A-0060 P-0057	10/5/1914	13,583	41,400	2,260	Reeves County WID #1	Reeves County WID #1
Total						***2,158,136***	***723,757***	***114,850***		

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.



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Region F

Major Reservoirs

Figure 3-9

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 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 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.

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.

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 earth fill 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 then made other corrections to the model in 2019, including updating to reflect LCRA's 2019 WMP. The updated Colorado River WAM was released in early 2020 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 drought of record.

Reservoirs lose capacity over time due to sedimentation. For this reason, it is important to update the elevation-area-capacity relationship of the reservoir to reflect future sedimentation prior to calculating the future yield of a reservoir. In Region F, elevation-area-capacity relationships were derived for 2030 and 2080 conditions based on historical sedimentation rates using the average end-area method. More information on the sediment rates and future storage capacities is included in Appendix B.

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
-Values in Acre-Feet per Year-

Reservoir Name	Basin	2030		2080	
		WAM Firm Yield	WAM Safe Yield	WAM Firm Yield	WAM Safe Yield
Lake J. B. Thomas	Colorado	0	0	0	0
E. V. Spence Reservoir	Colorado	0	0	0	0
O. H. Ivie Reservoir	Colorado	33,600	28,540	29,300	24,540
Lake Colorado City	Colorado	0	0	0	0
Champion Creek Reservoir	Colorado	0	0	0	0
Oak Creek Reservoir	Colorado	0	0	0	0
Lake Coleman	Colorado	0	0	0	0
Lake Winters/ New Lake Winters	Colorado	0	0	0	0
Lake Brownwood	Colorado	19,000	15,550	18,300	14,900
Hords Creek Lake	Colorado	0	0	0	0
Lake Ballinger / Lake Moonen	Colorado	0	0	0	0
O. C. Fisher Lake	Colorado	0	0	0	0
Twin Buttes Reservoir	Colorado	0	0	0	0
Lake Nasworthy	Colorado	0	0	0	0
Brady Creek Reservoir	Colorado	0	0	0	0
Red Bluff Reservoir	Rio Grande	20,350	16,180	20,170	16,040
Lake Balmorhea	Rio Grande	19,600	19,600	19,600	19,600
Total		**92,550**	**79,870**	**87,370**	**75,080**

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	8
Borden	0	Reagan	0
Brown	162	Reeves	0
Coke	8	Runnels	236
Coleman	5	Schleicher	0
Concho	181	Scurry	0
Crane	0	Sterling	27
Crockett	0	Sutton	0
Ector	0	Tom Green	2,117
Howard	0	Upton	0
Irion	111	Ward	0
Kimble	902	Winkler	0
Loving	0	*Rio Grande River Basin*	
Martin	0	Pecos	19,642
Mason	0	Reeves	714
McCulloch	68	Ward	980
Menard	2,034		
Midland	0	***Total***	***27,195***

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. The local supply availability estimates are known historical quantities, which represent firm supply during drought conditions for planning purposes. 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	7	McCulloch	Colorado	136
Borden	Colorado	221	Menard	Colorado	49
Brown	Brazos	78	Midland	Colorado	2
Brown	Colorado	825	Mitchell	Colorado	266
Coke	Colorado	62	Pecos	Rio Grande	32
Coleman	Colorado	797	Reagan	Colorado	40
Concho	Colorado	287	Runnels	Colorado	383
Crane	Rio Grande	3	Schleicher	Colorado	15
Crockett	Colorado	5	Schleicher	Rio Grande	9
Crockett	Rio Grande	22	Scurry	Brazos	129
Ector	Colorado	17	Scurry	Colorado	241
Glasscock	Colorado	24	Sterling	Colorado	26
Howard	Colorado	33	Sutton	Colorado	4
Irion	Colorado	55	Sutton	Rio Grande	5
Kimble	Colorado	104	Tom Green	Colorado	209
Loving	Rio Grande	1	Ward	Rio Grande	4
Martin	Colorado	25	Winkler	Rio Grande	2
Mason	Colorado	176			

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.

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 but is considering it for municipal use in the future. The Cities of Andrews, Crane, Eden, Monahans, Fork Stockton, and Snyder employ reuse supplies to irrigate golf courses. 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, either through direct purchases of wastewater effluent or recycling produced water. The cities of Kermit, Midland and Odessa have contracts to supply treated wastewater to mining and manufacturing customers that support the mining industry. 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 developed in Region F by 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, and projected reuse supplies for the 2026 planning period. 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	2030	2040	2050	2060	2070	2080
Andrews	Colorado	709	709	709	709	709	709
Concho	Colorado	187	187	187	187	187	187
Crane	Rio Grande	123	123	123	123	123	123
Howard	Colorado	1,855	1,855	1,855	1,855	1,855	1,855
Midland	Colorado	11,210	11,210	11,210	11,210	11,210	11,210
Pecos	Rio Grande	1,511	1,511	1,511	1,511	1,511	1,511
Scurry	Colorado	1,124	1,124	1,124	1,124	1,124	1,124
Tom Green	Colorado	8,300	8,300	8,300	8,300	8,300	8,300
Ward	Rio Grande	1,017	1,017	1,017	1,017	1,017	1,017

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

County	Basin	2030	2040	2050	2060	2070	2080
Andrews	Colorado	741	741	680	556	392	247
Borden	Colorado	596	596	546	447	315	199
Crane	Rio Grande	109	109	109	108	5	5
Ector	Colorado	9,893	9,893	9,862	9,802	9,721	9,650
Glasscock	Colorado	2,445	2,445	2,241	1,833	1,293	815
Howard	Colorado	2,178	2,178	1,997	1,634	1,153	726
Irion	Colorado	1,882	1,882	1,725	1,411	996	627
Loving	Rio Grande	2,118	2,118	2,118	2,118	2,118	2,118
Martin	Colorado	2,928	2,928	2,684	2,196	1,549	976
Midland	Colorado	2,595	2,595	2,379	1,946	1,373	864
Pecos	Rio Grande	2,851	2,851	2,851	2,851	2,851	2,851
Reagan	Colorado	3,499	3,499	3,207	2,624	1,851	1,166
Reeves	Rio Grande	6,175	6,175	6,175	6,175	6,175	6,175
Scurry	Colorado	54	54	50	41	29	18
Sterling	Colorado	538	538	493	403	285	179
Tom Green	Colorado	174	174	160	130	92	58
Upton	Rio Grande	2,798	2,798	2,565	2,098	1,480	933
Ward	Rio Grande	1,159	1,159	1,159	1,159	1,159	1,159
Winkler	Colorado	578	578	578	578	578	578
Winkler	Rio Grande	1,290	1,290	1,290	1,290	1,290	1,290

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 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 is 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, 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[5]. 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.[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 operates a reverse osmosis facility to treat water for high radionuclide levels . 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 3-7. Summary tables included within Appendix I, *Database (DB27) 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, Madera Valley WSC whose supply is also located in Region E, Borden County Water System (Borden County-Other) whose supply comes from Region O and Steam Electric Power in Ector County whose supply is located in Region O. These supplies represent about 0.6 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 Rotan and Sweetwater (G), and the portions of Richland SUD (K) and Coleman County SUD (G) not located in Region F. Less than 0.1 percent of Region F's current supplies goes to supply users in other regions.

Figure 3-7
Supplies Currently Available to Water User Groups by Type of Use

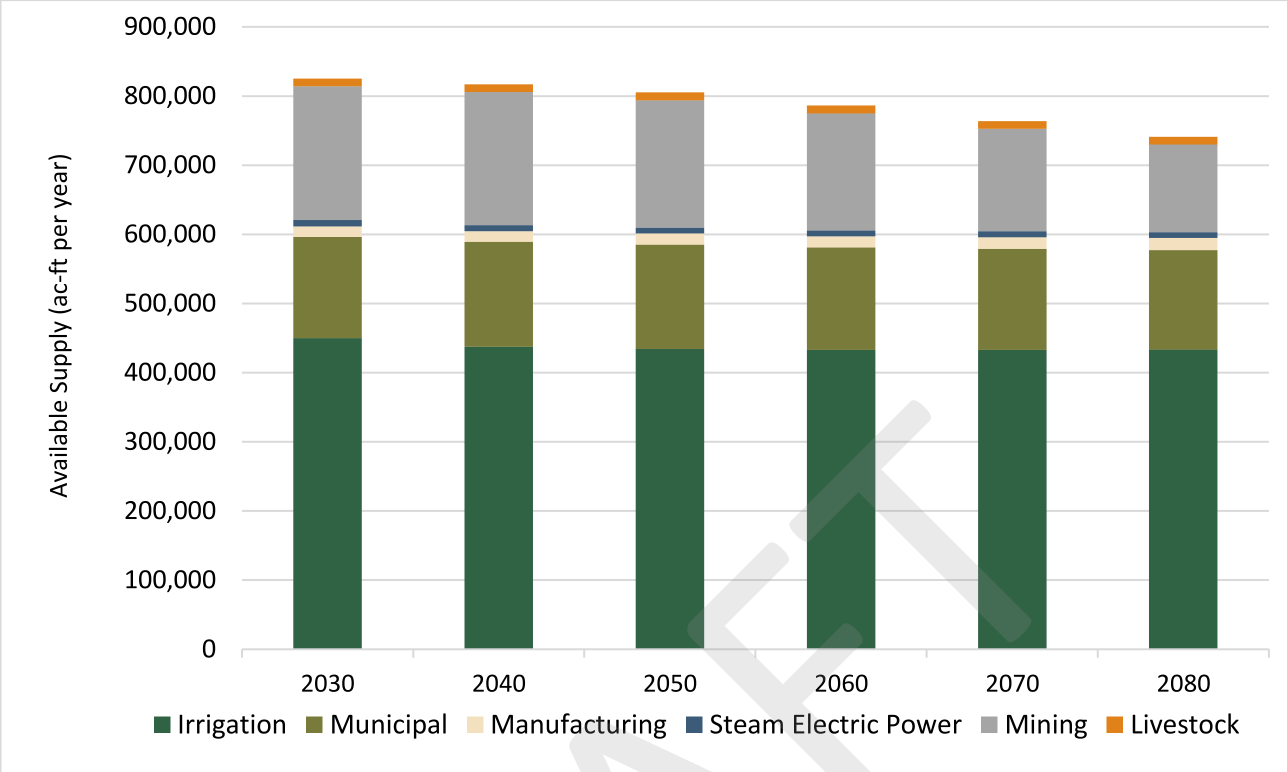

Table 3-13
Summary of Currently Available Supply to Water Users by County [a]
-Values in Acre-Feet per Year-

County	2030	2040	2050	2060	2070	2080
Andrews	19,825	18,635	17,924	17,518	17,324	17,186
Borden	5,874	5,882	5,848	5,586	4,821	4,137
Brown	16,052	16,125	16,156	16,197	16,241	16,288
Coke	1,216	1,226	1,236	1,252	1,270	1,290
Coleman	1,517	1,476	1,440	1,414	1,392	1,369
Concho	6,214	6,206	6,185	6,158	6,131	6,105
Crane	4,966	5,253	5,438	5,437	5,334	5,334
Crockett	5,459	5,459	5,459	5,459	4,608	3,361
Ector	41,961	43,253	42,408	40,628	39,659	38,733
Glasscock	57,548	57,541	56,385	54,069	51,002	48,281
Howard	28,236	26,899	25,271	23,667	22,298	19,415
Irion	5,500	5,500	5,343	5,029	4,614	4,245
Kimble	1,881	1,856	1,839	1,837	1,833	1,827
Loving	5,325	5,325	5,325	5,325	5,326	5,326
Martin	49,836	45,046	41,128	38,200	35,869	34,056
Mason	6,423	6,394	6,375	6,373	6,371	6,369
McCulloch	4,929	4,900	4,876	4,850	4,829	4,808
Menard	3,675	3,669	3,664	3,663	3,662	3,661
Midland	85,077	85,430	83,938	79,912	75,250	70,649
Mitchell	14,312	14,312	14,312	14,312	14,312	14,312
Pecos	159,999	160,104	160,212	160,421	160,655	160,910
Reagan	42,446	42,467	40,825	37,523	33,147	29,268
Reeves	99,468	99,553	99,635	99,667	99,675	99,683
Runnels	4,846	4,821	4,761	4,706	4,663	4,626
Schleicher	6,521	6,446	6,082	5,436	4,594	3,837
Scurry	10,363	10,301	10,125	9,940	9,794	9,681
Sterling	2,986	3,128	3,307	3,425	3,425	3,038
Sutton	2,737	2,633	2,529	2,451	2,368	2,282
Tom Green	70,437	65,765	65,675	65,503	65,333	65,162
Upton	25,571	25,611	24,325	21,728	18,278	15,232
Ward	15,157	15,660	16,185	16,639	17,127	17,647
Winkler	18,949	19,944	20,960	21,813	22,615	23,073
Total	825,306	816,820	805,171	786,138	763,820	741,191

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 16.5 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	2030	2040	2050	2060	2070	2080
BCWID	Lake Brownwood [a]	15,550	15,420	15,290	15,160	15,030	14,900
	Subtotal	*15,550*	*15,420*	*15,290*	*15,160*	*15,030*	*14,900*
CRMWD	Lake Ivie [b]	28,540	27,740	26,940	26,140	25,340	24,540
	Lake Ivie Non-System	*15,263*	*14,785*	*14,266*	*13,772*	*13,310*	*12,855*
	System Portion	*13,277*	*12,955*	*12,674*	*12,368*	*12,030*	*11,685*
	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]	40,055	37,921	36,154	32,655	30,891	29,123
	Martin County Well Field	1,035	922	836	779	740	711
	Subtotal	*71,485*	*68,438*	*65,785*	*61,429*	*58,826*	*56,229*
City of Midland	T- Bar Ranch (Winkler/Loving Counties) Well Field	16,815	16,815	16,815	16,815	16,815	16,815
	CRMWD	15,921	14,962	13,550	12,405	11,615	10,872
	Paul Davis Well Field (Andrews County)[c]	1,087	948	870	819	777	741
	Paul Davis Well Field (Martin County)[c]	3,485	3,105	2,816	2,624	2,491	2,394
	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	*49,078*	*47,600*	*45,261*	*43,873*	*42,908*	*42,032*
City of Odessa	CRMWD System [a]	30,026	31,935	32,377	30,735	30,062	29,280
	Direct Reuse (non-potable)	9,530	9,530	9,530	9,530	9,530	9,530
	Subtotal	*39,556*	*41,465*	*41,907*	*40,265*	*39,592*	*38,810*
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]	4,721	4,588	4,456	4,324	4,191	4,059
	Concho River	497	497	497	497	497	497
	Reuse	8,300	8,300	8,300	8,300	8,300	8,300
	McCulloch County Well Field (Hickory aquifer)	10,000	12,200	12,200	12,200	12,200	12,200
	Subtotal	*23,518*	*25,585*	*25,453*	*25,321*	*25,188*	*25,056*
	Total	***199,187***	***198,508***	***193,696***	***186,048***	***181,544***	***177,027***

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	2030	2040	2050	2060	2070	2080
BCWID #1	Irrigation	6,000	6,000	6,000	6,000	6,000	6,000
	Livestock	0	0	0	0	0	0
	Manufacturing	454	471	488	506	525	544
	Mining	560	560	560	560	560	560
	Municipal	7,277	7,291	7,268	7,264	7,266	7,271
	Steam Electric Power	0	0	0	0	0	0
	Surplus	1,259	1,098	974	830	679	525
	Total	**15,550**	**15,420**	**15,290**	**15,160**	**15,030**	**14,900**
CRMWD	Irrigation	1,620	1,500	1,317	1,169	1,073	985
	Livestock	0	0	0	0	0	0
	Manufacturing	1,850	1,713	1,503	1,336	1,226	1,125
	Mining	0	0	0	0	0	0
	Municipal	62,199	62,608	60,734	57,003	54,814	52,610
	Steam Electric Power	3,100	2,872	2,518	2,236	2,054	1,885
	Surplus	2,491	0	0	0	0	0
	Total	**71,260**	**68,693**	**66,072**	**61,744**	**59,167**	**56,605**
Midland	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	72	72	72	72	72	72
	Mining	11,210	11,210	11,210	11,210	11,210	11,210
	Municipal	37,236	35,758	33,979	32,591	31,626	30,750
	Steam Electric Power	0	0	0	0	0	0
	Total	**48,518**	**47,040**	**45,261**	**43,873**	**42,908**	**42,032**
Odessa	Irrigation	1,220	1,130	992	880	808	742
	Livestock	0	0	0	0	0	0
	Manufacturing	7,077	7,051	7,011	6,980	6,958	6,939
	Mining	2,803	2,803	2,803	2,803	2,803	2,803
	Municipal	26,214	28,404	29,279	27,985	27,537	26,963
	Steam Electric Power	2,242	2,077	1,822	1,617	1,486	1,363
	Total	**39,556**	**41,465**	**41,907**	**40,265**	**39,592**	**38,810**
San Angelo	Irrigation	8,300	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	318	350	339	331	321	312
	Mining	0	0	0	0	0	0
	Municipal	14,900	16,935	16,814	16,690	16,567	16,443
	Steam Electric Power	0	0	0	0	0	0
	Total	**23,518**	**17,285**	**17,153**	**17,021**	**16,888**	**16,755**

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