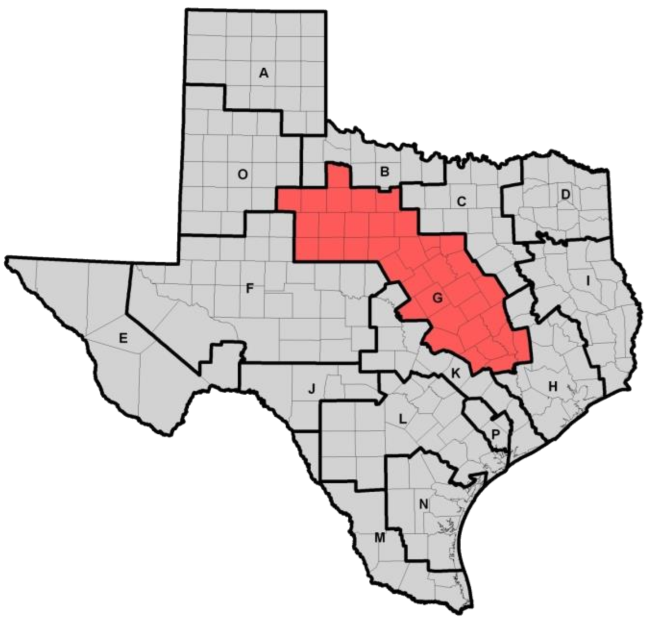


# 1

## Description of the Planning Area

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# 1 Description of the Planning Area

## 1.1 Background

Senate Bill 1 (SB1), which was passed into law in June 1997 and enacted by the 75th Texas Legislature, stemmed from increased awareness of Texas' vulnerability to drought and of the limitations of existing water supplies to meet the needs of the state's growing population. Senate Bill 2 (SB2), enacted in September 2001, expanded on the regional water planning process as created by SB1, and provided for further analysis and planning for water resources in the state. With rapidly growing populations, the need to adequately plan for existing and future water needs is vital to the economic health of the region and State. Some areas of the State are already facing near-term water shortages, and the projected population is expected to double by 2060. The purpose of SB1 and SB2 is to ensure that the water needs of all Texans are met in the 21st century.

The SB1/SB2 legislation calls for a "bottom up" water planning process wherein Regional Water Planning Groups (RWPGs) are formed with members representing a minimum of 11 different interests, including the environment, industry, municipalities, water authorities, and the public. The Texas Water Development Board (TWDB) has established 16 regional water planning areas; each with its own RWPG. Each RWPG is tasked with preparing a regional water plan for its area that assesses the available water supplies, the projected demands on these supplies and identifies a means to meet future water needs while maintaining long-term protection of the State's resources.

In accordance with SB2 (as amended), all of the regional water plans must be completed, adopted and submitted to the TWDB by November 5, 2020. The TWDB will approve and compile the 16 regional plans into the 2021 State Water Plan. The regional and state water plans will continue to be updated every 5 years.

### 1.1.1 Brazos G Regional Water Planning Area

The Brazos G Regional Water Planning Area (BGRWPA), shown in Figure 1-1, comprises all or portions of 37 central Texas counties. The Brazos G Area is about 31,600 square miles in area, or 12 percent of the State's total area. About 90 percent of the region lies in the Brazos River Basin. Figure 1-2 shows the major features of the BGRWPA, such as major cities, reservoirs, and highways. This figure also shows that parts of several counties extend into the Red, Trinity, Colorado, and San Jacinto River Basins. Cities in the region with current populations greater than 50,000 are Abilene, Bryan, Cedar Park, College Station, Killeen, Round Rock, Temple, and Waco[1].

The region's geography varies from the rugged, uneven terrain and sandy soils of Kent and Knox Counties in the northwest to the hilly, forested areas and rich soils in Grimes and Washington Counties in the southeast. In the central part of the region are the Blackland Prairies in Hill and McLennan Counties.[2]

[1] U.S. Census Bureau, *2010 Census*, http://www.census.gov/2010census/

[2] The Dallas Morning News, *1997-1998 Texas Almanac*, 1998.

Members of the Brazos G RWPG who contributed to the development of the 2021 Brazos G Regional Water Plan are listed in Table 1-1. These members represent 12 interests: the public, counties, municipalities, industries, agriculture, the environment, small businesses, electric-generating utilities, river authorities, water districts, groundwater districts and water utilities. The Brazos G RWPG has retained the services of engineering firms and other specialists to assist the RWPG with the preparation of the regional plan, and it has designated the Brazos River Authority (BRA) as its administrative contracting agency.

### Figure 1-1. Location Map

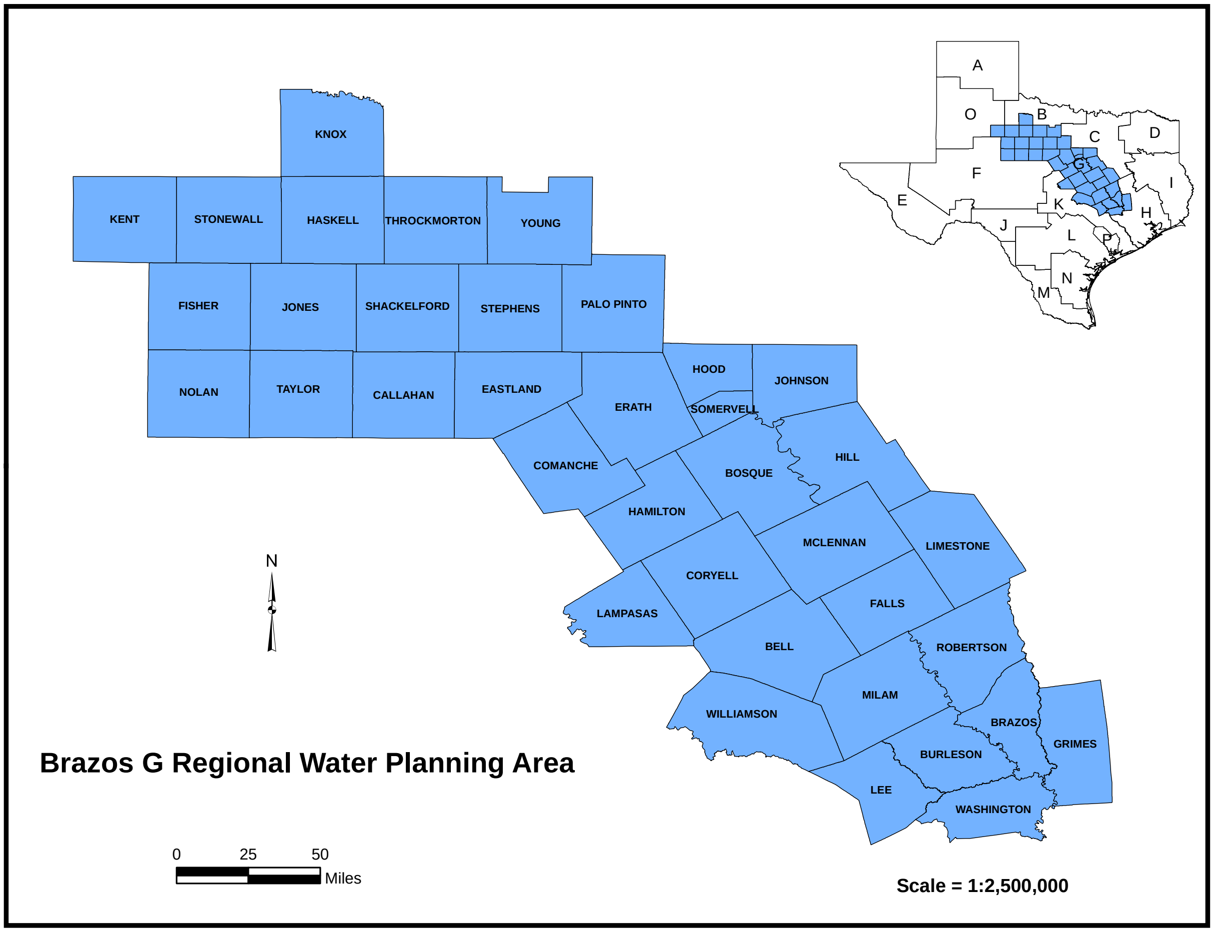
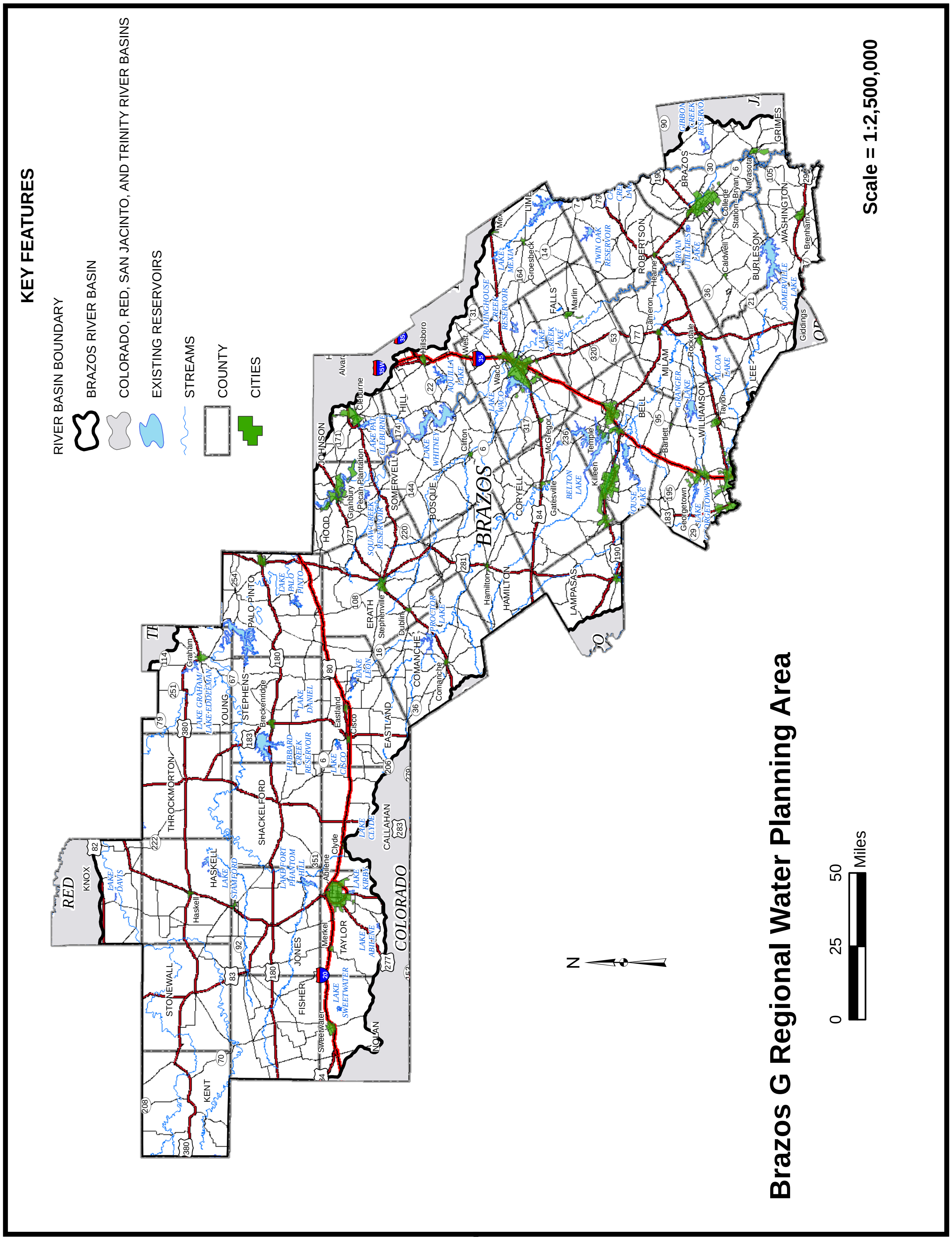


Figure 1-2. Major Features of the Brazos G Area



### Table 1-1. Current and Recent Brazos G RWPG Members

| Interest Group | Name |
|---|---|
| **Voting Members** | |
| Agricultural | Judge Dale Spurgin<br>Wayne Wilson (Chairman) |
| Counties | Judge David Blackburn<br>Judge Scott M. Felton<br>Commissioner Gary Myers<br>Commissioner Tim Brown (Jan 2019)<br>Commissioner Mike Sutherland (Jan 2019) |
| Electric Generating Utilities | Gary L. Spicer |
| Environmental | Luci Dunn<br>Kevin Wagner (July 2017) |
| Industry | Terrill Tomecek |
| Municipalities | Jim Briggs<br>Tommy O'Brien<br>Wiley Stem<br>Jerry K. "Kenny" Weldon |
| Public | Gary Newman |
| River Authorities | David Collinsworth<br>Phil Ford (Apr 2018) |
| Small Business | Gail L. Peek |
| Water Districts | Joe Cooper<br>Kelly Kinard |
| Groundwater Management Areas | Dirk Aaron<br>Dale Adams<br>Zach Holland<br>Mike McGuire<br>Gary Westbrook<br>Judy Parker (May 2018) |
| Water Utilities | Charles Beseda |
| **Non-Voting Members** | |
| Texas Water Development Board | Jean Devlin<br>Thomas Barnett (former) |
| Texas Parks and Wildlife Department | Jennifer Bronson-Wilson |
| Texas Department of Agriculture | Michelle Bobo<br>David Kercheval (former) |
| Texas State Soil and Water Conservation Board | Rusty Ray |

* Date represents date of resignation.

# 1.2 Population

## 1.2.1 Regional Trends

Figure 1-3 illustrates population growth in the entire BGRWPA for 1900 to 2010 and projected growth for 2020 to 2070. Table A-1 in Appendix A gives historical population data for each county in the BGRWPA, as well as regional and State population totals, for 1990 to 2010.

From 1900 to 1970, population in the Brazos G Area grew slowly at an average rate of 0.4 percent per year from 680,093 people to 895,682. During the same period, the total population of Texas grew at an average rate of 1.9 percent annually, from 3,048,710 to 11,196,730. Beginning in the 1970s, however, both the State's and the region's population began to increase at faster rates. Growth in the region was about 2 percent annually, which approximates the State's total growth rate of 2 percent. Population in the BGRWPA is expected to increase by an average of 1.3 percent annually, reaching 4.35 million by 2070. This is roughly double the census population in 2010.

Population trends may be further understood by dividing the BGRWPA into three subregions: the northwestern Rolling Plains, the central IH-35 Corridor, and the southeastern Lower Basin. Table A-2 in Appendix A provides historical population data for all counties in each subregion from 1900 to 2010.

## Figure 1-3. Historical and Projected BGWRPA Population

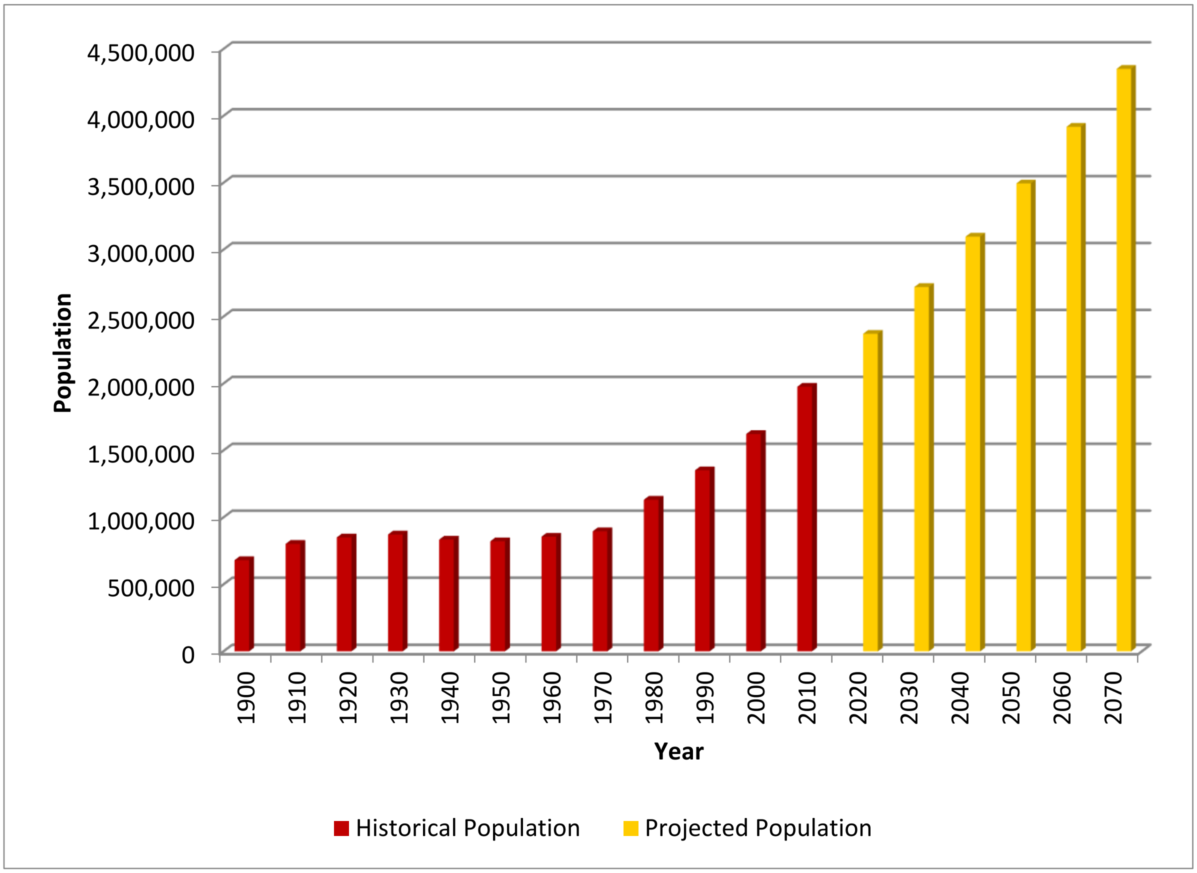
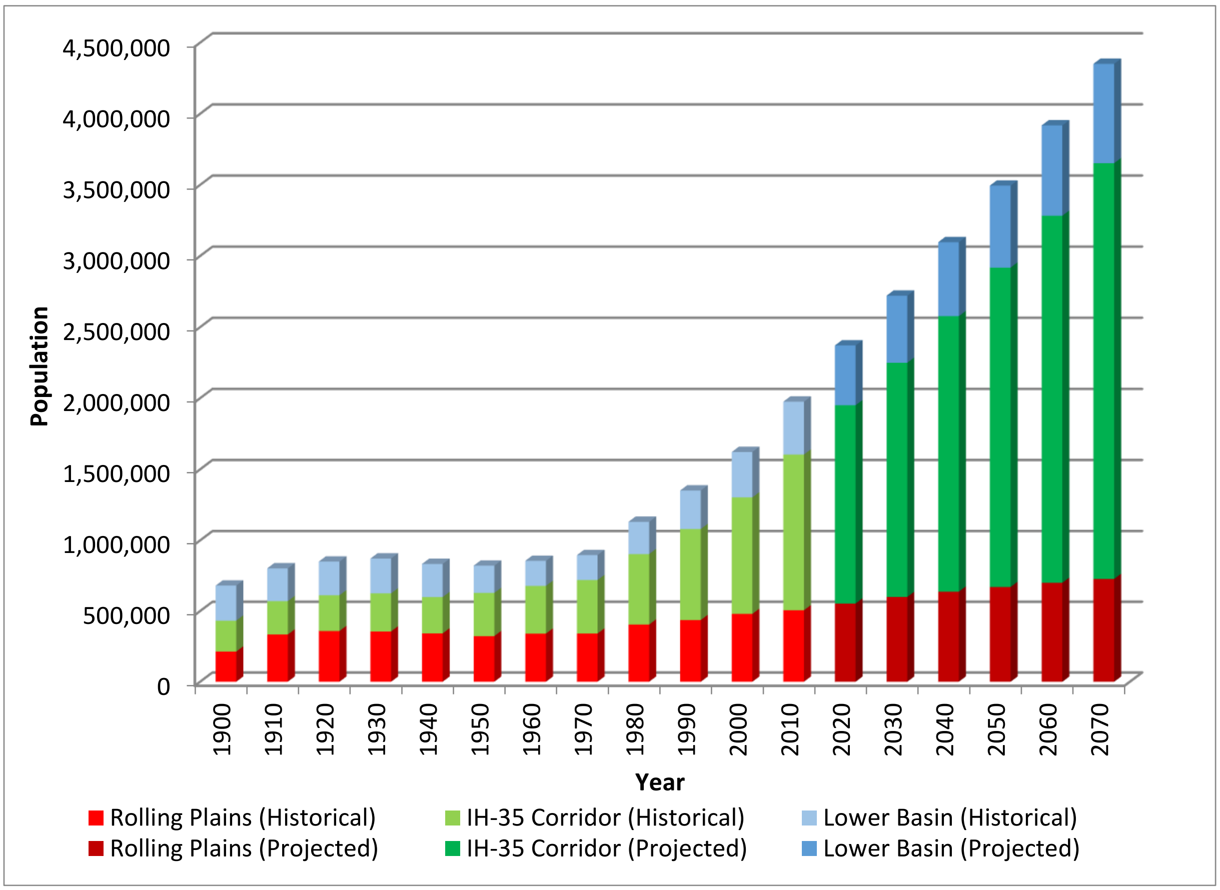


Figure 1-4 illustrates historical population growth in the three subregions from 1900 to 2010 and projected growth from 2020 to 2070. Figure 1-5 and Figure 1-6 illustrate population distribution by county for years 2020 and 2070, respectively. The greatest growth is projected to occur along the IH-35 corridor, which connects some of the larger cities in the region and the state. Table 1-2 presents 2010 populations and projected populations for 2020 and 2070 for the major cities in each subregion. Major cities are defined as those having at least 10,000 people in 2010. This table also presents the percent change in populations from 2020 to 2070 in each city. The overall division of the population between large cities and rural areas is expected to increase from 56.6 percent in 2010 to 61.2 percent by 2070.

**Figure 1-4. Historical and Projected Population by Subregion**



## 1.2.2 Rolling Plains

The counties in the Rolling Plains subregion are Knox, Kent, Stonewall, Haskell, Throckmorton, Young, Fisher, Jones, Shackelford, Stephens, Palo Pinto, Nolan, Taylor, Callahan, Eastland, Erath, Hood, Somervell, Comanche, Hamilton, Bosque, Coryell, and Lampasas. These counties, with about 25 percent of the BGRWPA's population in 2010, have grown moderately since 1970 at an average rate of 0.8 percent per year. Major cities in this subregion include Abilene, Copperas Cove, Gatesville, Mineral Wells, Stephenville, and Sweetwater.

## 1.2.3 IH-35 Corridor

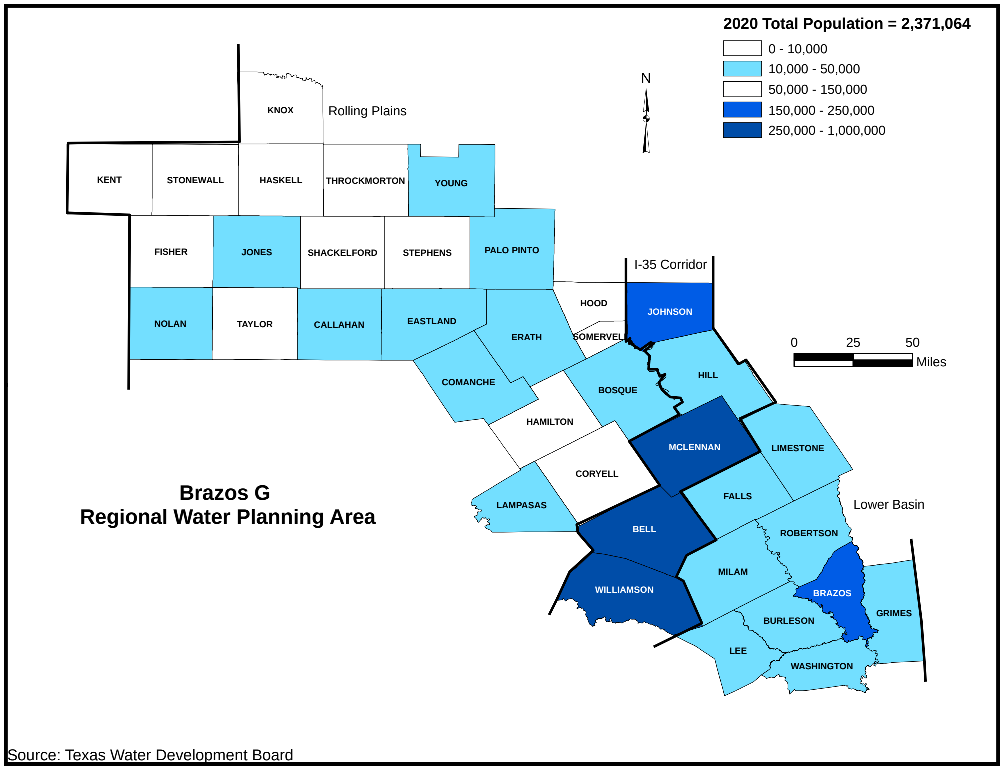
The counties in the IH-35 Corridor are Johnson, Hill, McLennan, Bell, and Williamson. Population growth in these counties has been rapid since 1970, averaging 2.4 percent annually. In this subregion, cities with a current population greater than 10,000 include Belton, Burleson, Cedar Park, Cleburne, Fort Hood, Georgetown, Harker Heights, Hewitt, Hutto, Killeen, Leander, Robinson, Round Rock, Taylor, Temple, and Waco[3]. Total population in the IH-35 Corridor was about 56 percent of the region's total in year 2010, and it is expected to keep growing rapidly.

## 1.2.4 Lower Basin

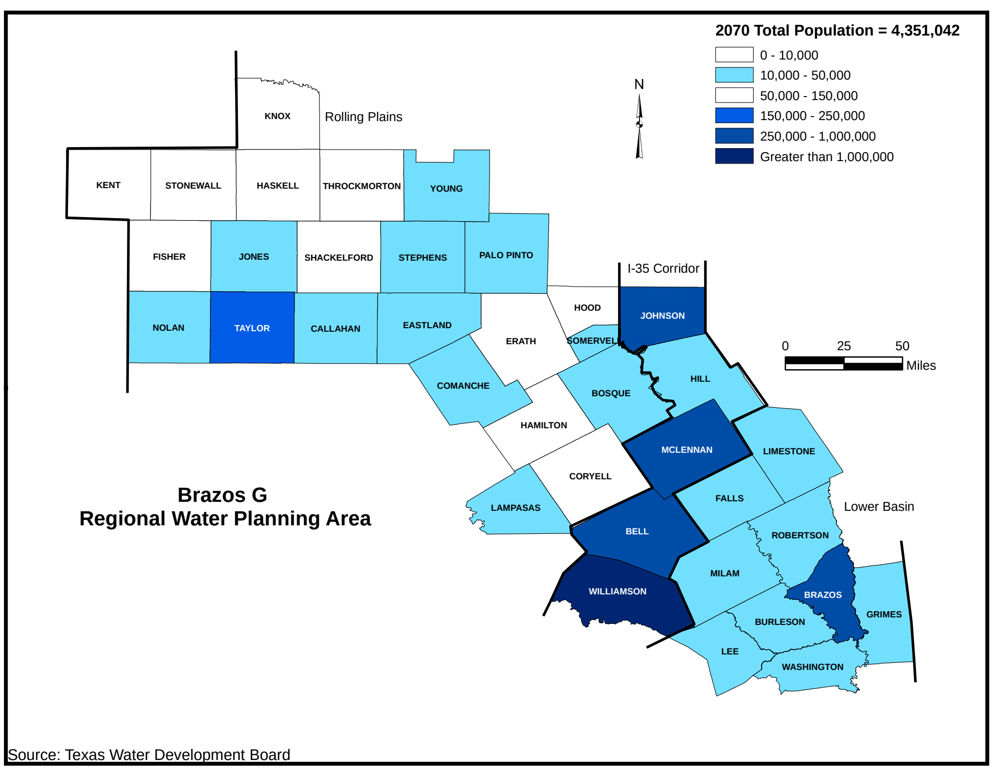
Counties in the Lower Basin are Limestone, Falls, Milam, Robertson, Lee, Burleson, Brazos, Washington, and Grimes. This subregion also has seen a relatively high growth rate averaging 1.5 percent annually since 1970. Major cities include Brenham, Bryan, and College Station. The Lower Basin had 19 percent of the population of the BGRWPA in 2010.

[3] U.S. Census Bureau, *2010 Census*, http://www.census.gov/2010census/

## Figure 1-5. 2020 Population Distribution by County




## Figure 1-6. 2070 Population Distribution by County



### Table 1-2. Population of Major Cities in the BGRWPA (Greater than 10,000 People in 2010)

| City | County | Population Data[1] | | | % Change |
|---|---|---|---|---|---|
| | | ***2010*** | ***2020*** | ***2070*** | ***(2020 to 2070)*** |
| ***Rolling Plains*** | | | | | |
| Abilene | Jones, Taylor | 117,063 | 122,542 | 141,659 | 15.6 |
| Copperas Cove | Coryell | 32,032 | 35,213 | 59,807 | 69.8 |
| Gatesville | Coryell | 15,751 | 17,489 | 29,702 | 69.8 |
| Mineral Wells[2] | Palo Pinto | 14,644 | 15,820 | 19,470 | 23.1 |
| Stephenville | Erath | 17,123 | 19,044 | 27,953 | 46.8 |
| Sweetwater | Nolan | 10,906 | 12,196 | 14,609 | 19.8 |
| ***IH-35 Corridor*** | | | | | |
| Belton | Bell | 18,216 | 21,753 | 41,063 | 88.8 |
| Burleson[2] | Johnson | 29,111 | 34,351 | 66,588 | 93.8 |
| Cedar Park | Williamson | 48,448 | 81,716 | 90,641 | 10.9 |
| Cleburne | Johnson | 29,337 | 38,220 | 78,919 | 106.5 |
| Fort Hood | Bell, Coryell | 29,589 | 30,950 | 31,296 | 1.1 |
| Georgetown | Williamson | 47,400 | 118,763 | 358,109 | 201.5 |
| Harker Heights | Bell | 26,700 | 31,372 | 59,222 | 88.8 |
| Hewitt | McLennan | 13,549 | 17,373 | 29,034 | 67.1 |
| Hutto | Williamson | 14,698 | 17,326 | 101,202 | 484.1 |
| Killeen | Bell | 127,921 | 144,243 | 272,291 | 88.8 |
| Leander | Williamson | 25,444 | 48,575 | 185,879 | 282.7 |
| Robinson | McLennan | 10,509 | 12,851 | 24,296 | 89.1 |
| Round Rock[2] | Williamson | 98,525 | 123,598 | 239,565 | 93.8 |
| Taylor | Williamson | 15,191 | 17,233 | 27,220 | 58.0 |
| Temple | Bell | 66,102 | 81,736 | 154,295 | 88.8 |
| Waco | McLennan | 124,805 | 132,512 | 178,976 | 35.1 |
| ***Lower Basin*** | | | | | |
| Brenham | Washington | 15,716 | 18,423 | 23,810 | 29.2 |
| Bryan | Brazos | 76,201 | 84,196 | 211,266 | 150.9 |
| College Station | Brazos | 93,857 | 100,854 | 195,852 | 94.2 |
| **Total, Major Cities** | **—** | **1,118,838** | **1,378,349** | **2,662,724** | **93.2** |
| **% of Region Total** | **—** | **56.6** | **58.1** | **61.2** | |
| **Total, Rural Areas** | **—** | **856,996** | **992,715** | **1,688,318** | **70.1** |
| **% of Region Total** | **—** | **43.4** | **41.9** | **38.8** | |
| **Region Total** | **—** | **1,975,834** | **2,371,064** | **4,351,042** | **83.5** |

[1] 2010 population data obtained from U.S. Census. 2020 and 2070 projections are based on TWDB.
[2] Represents only the portion of the city located in Region G

## 1.3 Economic Activities

The BGRWPA includes all or part of the following metropolitan statistical areas as defined by the Texas State Data Center: Abilene, Waco, Dallas-Fort Worth-Arlington Killeen-Temple-Fort Hood, Austin-Round Rock, and College Station - Bryan. The economy of the region can be divided into the following general sectors: agriculture, agribusiness, mineral production, wholesale and retail trade, and varied manufacturing. Table 1-3 lists 2016 payrolls and employment in the BGRWPA by subregion and economic sector.[4] As of this writing, 2016 was the most recent year for which such data were available. Payroll and employment in the Brazos G Area were concentrated along the IH-35 Corridor, which in 2016 had a total payroll of about $16.4 billion and employment of approximately 440,000 people. Primary economic activities were manufacturing, retail trade, and services, accounting for about 64 percent of the region's total payroll in 2016.

**Table 1-3. 2016 Economic Data (x$1,000)**

| Economic Sector[1] | Rolling Plains | IH-35 Corridor | Lower Basin | Region Total |
|---|---|---|---|---|
| Agricultural, Forestry, Fishing | $9,970 | $795 | $2,032 | $12,797 |
| Mining | $205,657 | $198,476 | $138,260 | $542,393 |
| Construction | $442,424 | $1,269,836 | $457,709 | $2,169,969 |
| Manufacturing | $496,570 | $1,751,183 | $510,386 | $2,758,139 |
| Transportation, Public Utilities | $377,470 | $595,876 | $159,640 | $1,132,986 |
| Wholesale Trade | $235,224 | $796,502 | $200,670 | $1,232,396 |
| Retail Trade | $590,413 | $1,625,922 | $437,986 | $2,654,321 |
| Finance, Insurance, Real Estate | $324,404 | $1,370,931 | $271,515 | $1,966,850 |
| Services | $1,687,746 | $7,674,877 | $1,390,313 | $10,752,936 |
| Unclassified | $174,430 | $522,329 | $137,545 | $834,304 |
| Not Categorized | $81,829 | $494,275 | $105,931 | $682,035 |
| Total Payroll | $4,788,661 | $16,403,984 | $3,907,547 | $25,100,192 |
| Total Employed[2] | 169,336 | 440,058 | 153,010 | 762,404 |

[1] Data from U.S. Census Bureau
[2] Data from Bureau of Labor Statistics

## 1.4 Climate

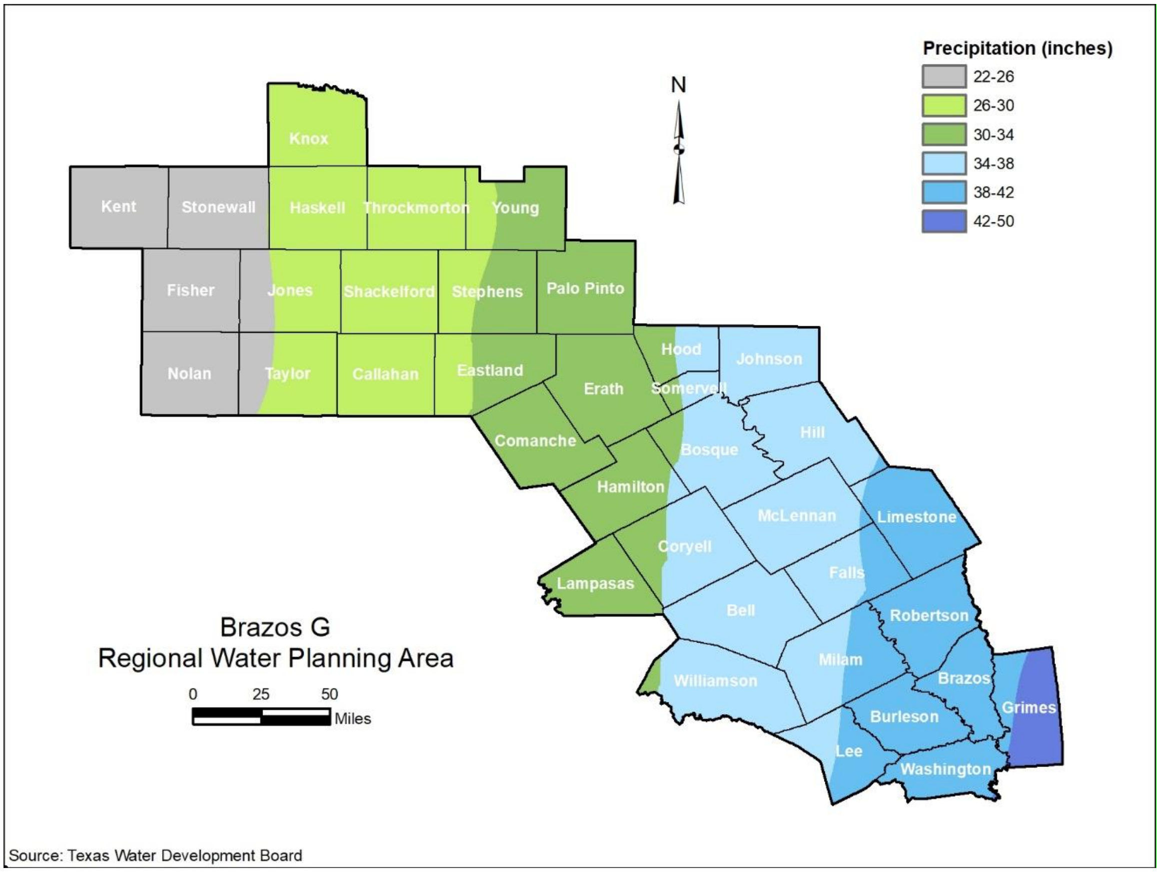
Temperatures[5] in the Brazos G area range from an average low of 28° F to 41° F to an average high of 55° F to 62° F in January. For July, temperatures across the planning area range from an average low of 69° F to 74° F to an average high of 93° F to 97° F. Average

[4] U.S. Census Bureau, "2016 Economic Data," Online: available URL: http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml.

[5] PRISM Climate Group - Northwest Alliance for Computation Science and Engineering, 2019. Historical Past and Recent Years Datasets for Precipitation and Temperature. http://www.prism.oregonstate.edu/

annual precipitation[6] ranges from 22 to 26 inches in in the northwestern most counties of the region to 38 to 50 inches in the southeastern most counties. Figure 1-7 depicts average annual precipitation for the entire region.

**Figure 1-7. Average Annual Precipitation (1981 to 2017)**

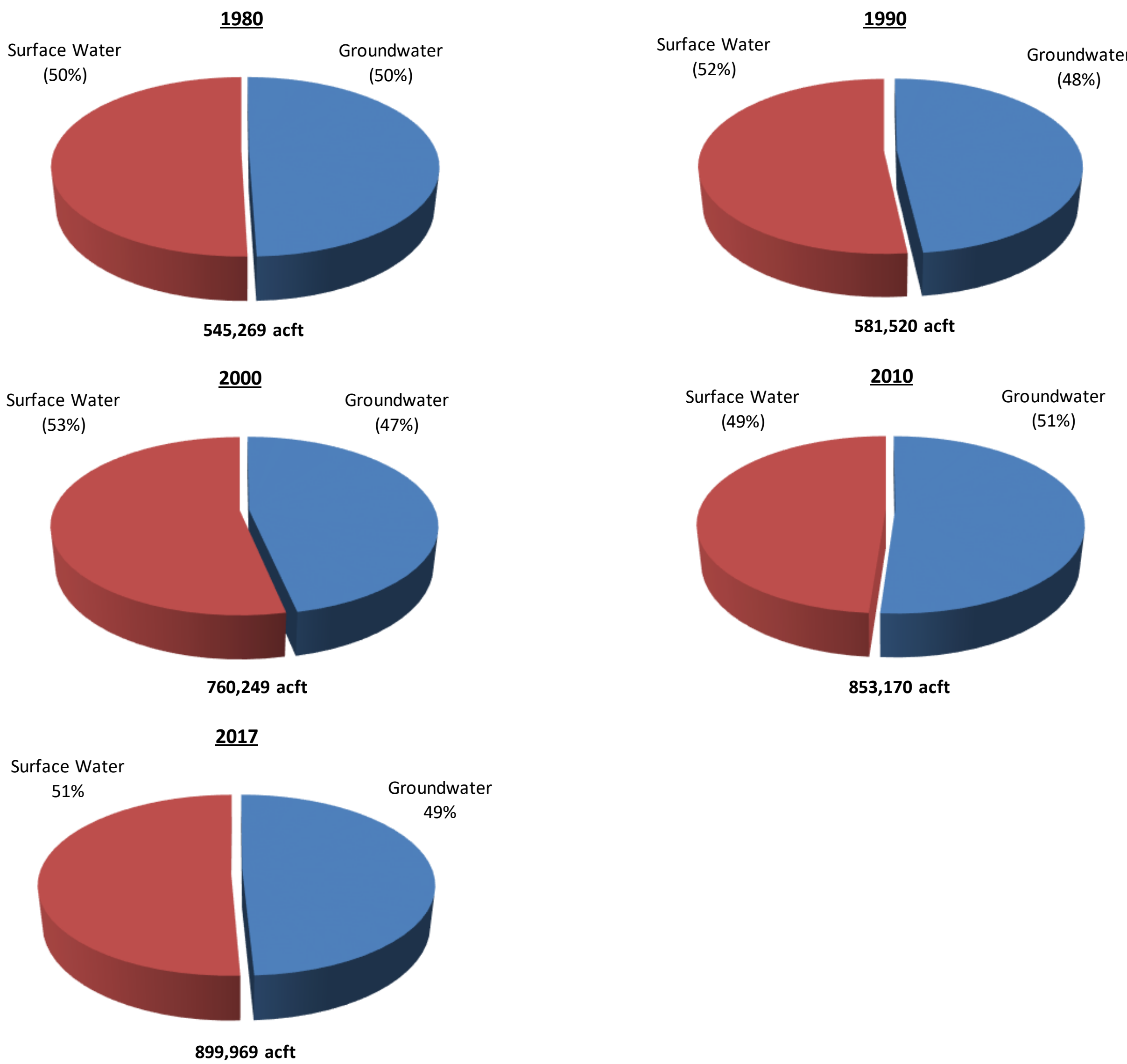



## 1.5 Sources of Water

Table A-3 in Appendix A provides historical data on use of groundwater and surface water within the BGRWPA from 1980 to 2017. These data suggest that the planning area depended slightly more on surface water than on groundwater. Figure 1-8 shows the proportion of surface water use to groundwater use in 1980, 1990, 2000, 2010 and 2017. While the proportions were equal in 1980, surface water use was greater by 2 percent in 1990, and 3 percent in 2000. In 2010, the surface water use was 2 percent less than groundwater. In 2017, surface water use was 2 percent more than groundwater.

[6] Texas Water Development Board (TWDB), Water Data for Texas – Lake Evaporation and Precipitation Dataset. Accessed at: https://waterdatafortexas.org/lake-evaporation-rainfall

**Figure 1-8. BGRWPA Historical Water Use by Source**




## 1.5.1 Groundwater

### Aquifers[7,8,9]

Portions of six major and eleven minor aquifers extend into the Brazos G Area (Figure 1-9 and Figure 1-10). Major aquifers are defined generally as those aquifers that supply large amounts of water to large areas of the State. Minor aquifers are defined as those that supply large amounts of water to small areas of the State or provide small supplies to wide

[7] Texas Water Commission, *Groundwater Quality in Texas - An Overview of Natural and Man-Affected Conditions*, TWC Report No. 89-01, 1989.

[8] Texas Water Development Board (TWDB), *Water for Texas*, 1997.

[9] TWDB, *Estimated Groundwater Pumpage by County and Aquifer*, 2010.

areas. Figure 1-11 shows historical water pumpage for each aquifer in the BGRWPA in 1980, 1990, 2000, 2010 and 2017. In 2017, about 74 percent of the groundwater pumped came from four aquifers: Brazos Valley Alluvium, Carrizo-Wilcox, Seymour, and Trinity. Table 1-4 presents historical pumpage in 2010 and projected availability in 2070 of groundwater in each aquifer in the BGRWPA.

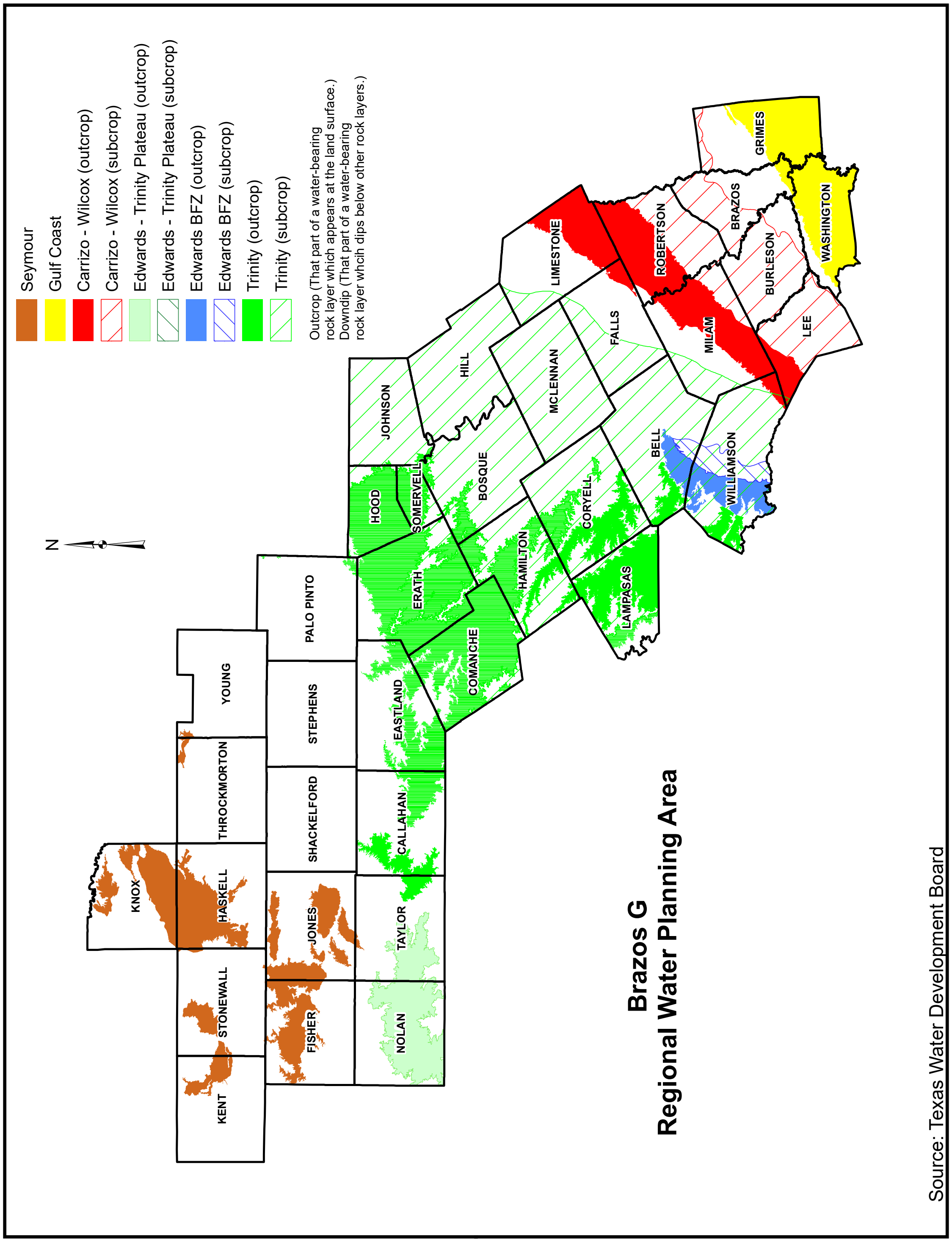
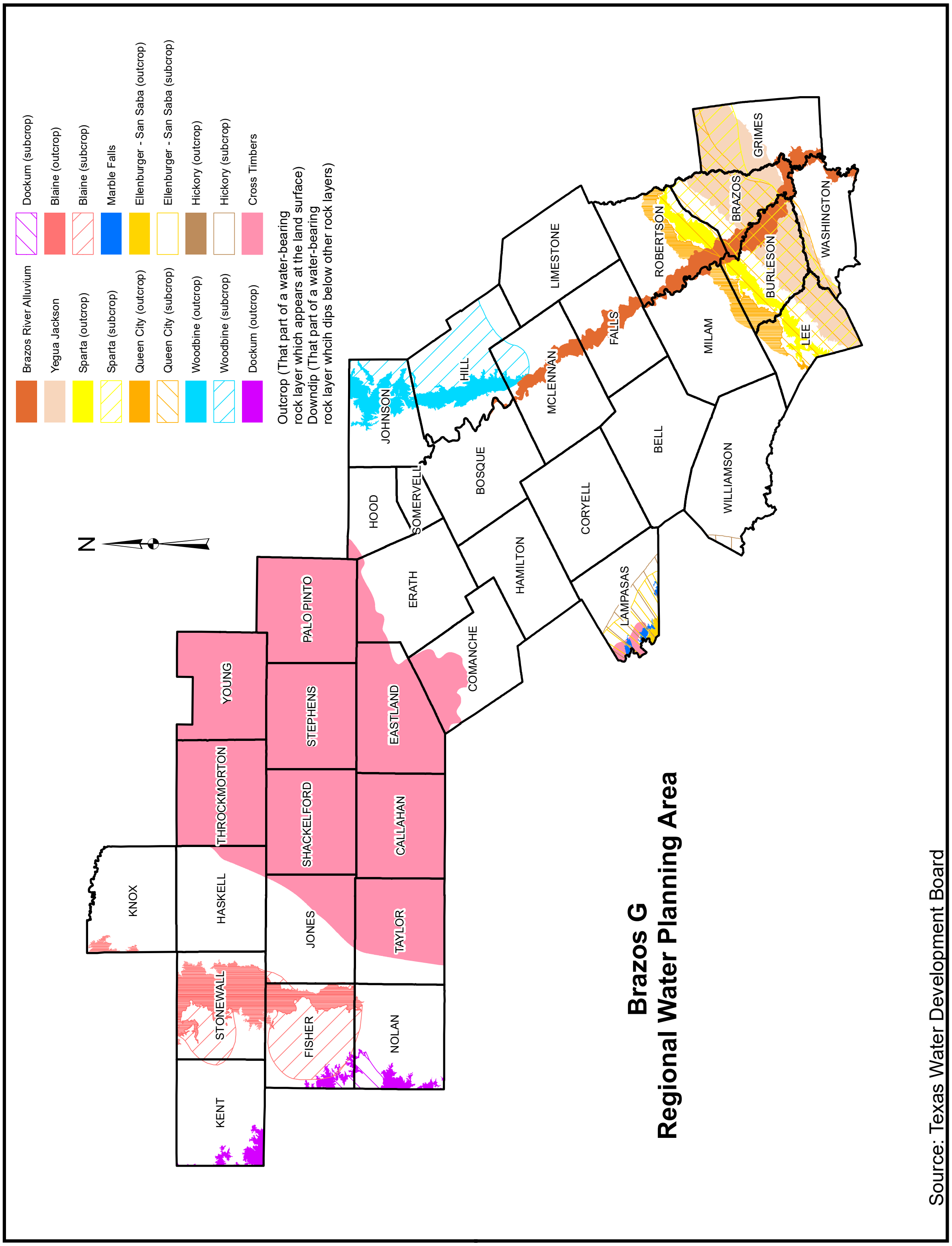
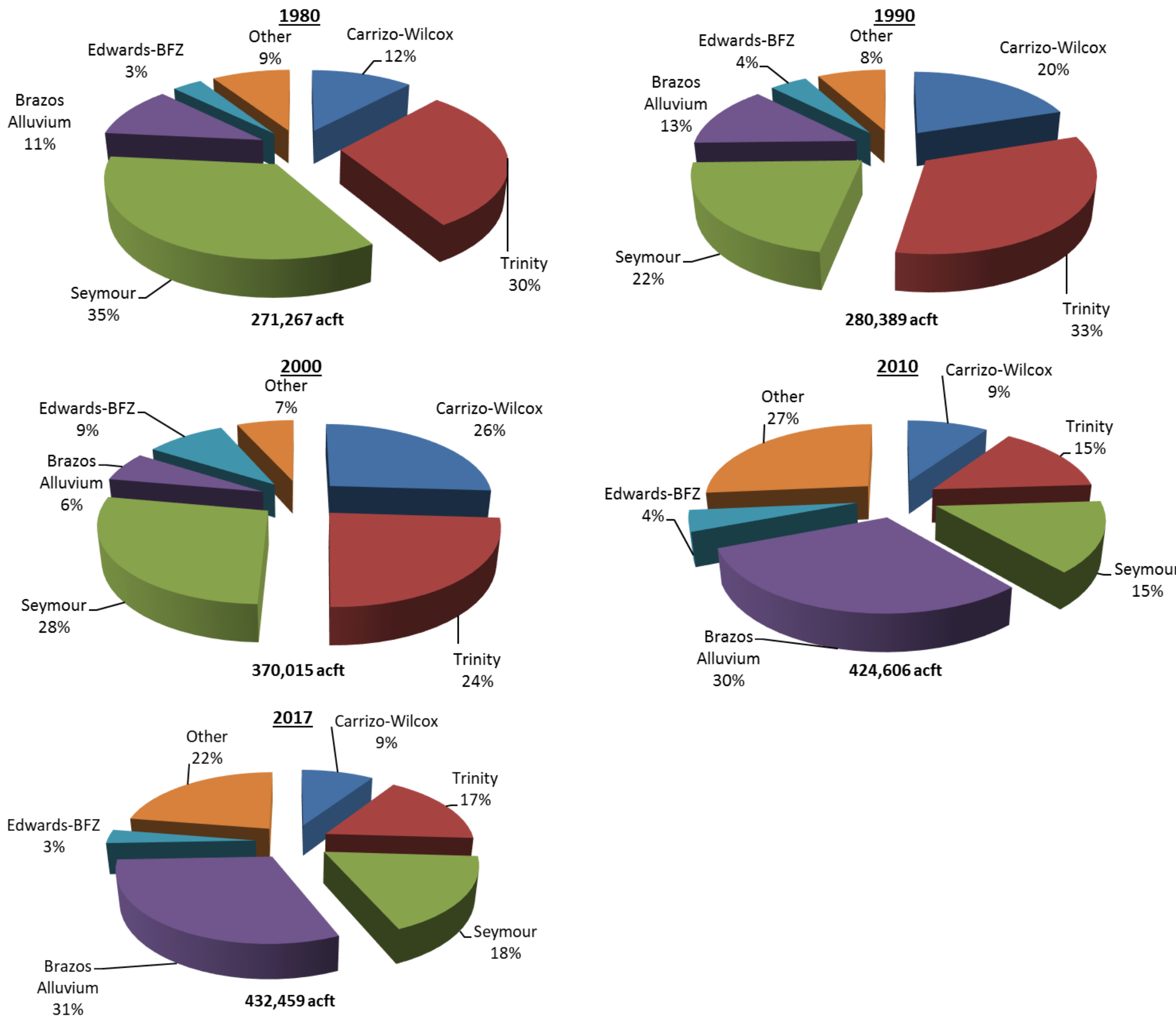



Figure 1-9. Major Aquifers

# Figure 1-10. Minor Aquifers



### Figure 1-11. Brazos G Area Historical Water Pumpage by Aquifer




Fewer than half of the aquifers in the BGRWPA have potential for further development. Seven of them extend only slightly into the planning area. The aquifers that do offer potential for further development are all in the southeastern part of the region.

In the western part of the region, the Seymour Aquifer is the most significant in terms of usage and yield. The Seymour Aquifer has an uneven distribution, is highly developed, and most of its water is used for irrigation. The Seymour Aquifer is prone to depletion if subjected to a combination of prolonged drought and heavy use, but groundwater supply in the aquifer has remained mostly constant. Along with the Seymour, the fringes of three aquifers, the Dockum, Blaine, and Edwards-Trinity (Plateau), extend into the west end of the planning area, but these offer little room for further development. In the northeastern part of the region, there is a wide area with no major or minor aquifers, including Throckmorton, Young, Shackelford, Stephens, and Palo Pinto Counties. In these areas, locally occurring groundwater is not associated with a defined major or minor aquifer system and is primarily used for domestic and livestock purposes.

**Table 1-4. Historical Pumpage and Future Availability in Brazos G Area Aquifers**

| Aquifer | 2017 Pumpage (acft) | 2070 Availability (acft/yr) | Remarks |
|---|---|---|---|
| **Western Area** | | | |
| Seymour | 76,410 | 79,424 | Fully developed |
| Dockum | 14,330 | 12,079 | Limited extent within region |
| Blaine | 340 | 22,320 | Limited extent within region |
| Edwards-Trinity (Plateau) | 2,170 | 1,182 | Limited extent within region |
| Cross Timbers | ND[1] | 2,714 | Recently named minor aquifer |
| Subtotal: | 93,250 | 117,719 | |
| **Central Area** | | | |
| Trinity | 72,120 | 121,296 | Overdeveloped in some areas |
| Edwards (BFZ) | 13,700 | 9,921 | Overdeveloped in drought |
| Woodbine | 410 | 2,566 | Limited extent within region |
| Marble Falls | 20 | 2,837 | Limited extent within region |
| Ellenburger-San Saba | 20 | 2,593 | Limited extent within region |
| Hickory | ND[1] | 113 | Limited extent within region |
| Subtotal: | 86,270 | 139,326 | |
| **Southeastern Area** | | | |
| Brazos River Alluvium | 133,070 | 257,587 | Added potential, water quality variable |
| Carrizo-Wilcox | 40,090 | 206,988 | Large added potential |
| Queen City | 2,680 | 2,532 | |
| Sparta | 4,530 | 17,248 | Added potential |
| Gulf Coast | 2,710 | 28,216 | Added potential |
| Navasota River Alluvium | ND[1] | 2,216 | |
| Yegua-Jackson | 3,080 | 20,497 | |
| Subtotal: | 186,160 | 535,284 | |
| Other and Undifferentiated | 66,820 | 847 | Many widely-scattered sources |
| **Total:** | | | |

[1] ND indicates no data available.

The Trinity Aquifer is the most significant groundwater source in the central part of the BGRWPA. It is widespread and furnishes small to moderate amounts of groundwater in 17 counties. In the confined portions of the aquifer, however, development has resulted in significant declines in water levels.

In the southeastern part of the area, groundwater supplies are dominated by the Carrizo-Wilcox System and the Gulf Coast Aquifer. The Carrizo-Wilcox has significant potential for further development, but the Gulf Coast Aquifer in this area has low to moderate potential.

Several minor aquifers also have potential for further development over wide areas in this sector. The Brazos Alluvium, which lies along the Brazos River, also extends into the central portion of the area and has some potential for additional development, but most of the BGRWPA's undeveloped groundwater lies in the southeastern sector.

The Trinity Aquifer and all other aquifers to the southeast have outcrop areas under water-table conditions and downdip areas with overlying confining layers where artesian conditions may occur. Most of these aquifers contain fresh water to considerable depths, and all contain slightly saline water just downdip (commonly to the southeast) of the fresh water. Maps in Appendix B show the locations of fresh water, defined as containing less than 1,000 milligrams per liter (mg/L) total dissolved solids (TDS), and slightly saline water, defined as having 1,000 to 3,000 mg/L TDS, within various aquifers. Maps are included for all aquifers within the BGRWPA that have availability estimated to exceed 5,000 acre-feet per year (acft/yr). The use of aquifers with groundwater containing more than 1,000 mg/L TDS is an option only where consumers can use the saline water or where special treatment (desalination or blending) is available. More detailed descriptions and availability of water from each aquifer in the BGRWPA are in Appendix B.

### Major Springs

The BGRWPA contains few major springs, defined as springs with discharges commonly greater than 1 cubic foot per second (cfs). The majority of these issue from the Edwards-Balcones Fault Zone (BFZ) Aquifer in Bell and Williamson Counties and from the Marble Falls Aquifer in Lampasas County. Of the Edwards Aquifer springs, all but one are intermittent. The three largest Edwards springs are:

1. Salado Springs at Salado in Bell County along the Lampasas River with discharges ranging from 5 to 60 cfs.
2. Berry Springs, which is located 5 miles north of Georgetown in Williamson County, with discharges ranging from 0 to 50 cfs.
3. San Gabriel Springs at Georgetown in Williamson County with discharges ranging from 0 to 25 cfs.

Springs from the Marble Falls Aquifer include Hancock Park Springs along the Sulfur River, which is a tributary to the Lampasas River, with discharges reportedly ranging from 6 to 12 cfs, and Swimming Pool Springs at Hancock Park with a reported discharge of 1.3 to 1.6 cfs. Both springs are in the City of Lampasas in Lampasas County.

Some springs in the region significantly affect the quality of the water in the Brazos River. These are primarily the salt springs and seeps, such as those along Salt Croton and Croton Creeks, in the upper Brazos River Basin in Dickens, Kent, and Stonewall Counties. These natural saltwater sources cause the water in the main stem of the Brazos River above Possum Kingdom Lake to be too saline for most uses during low flow periods. For example, from 1963 to 1986, TDS and chloride concentrations in Croton Creek near Jayton averaged 7,933 mg/L and 3,169 mg/L, respectively. The mean values for TDS and chlorides in the Salt Croton Creek near Aspermont from 1969 to 1977 were 71,237 mg/L and 41,516 mg/L, respectively. Water in Possum Kingdom Lake usually contains more than 400 mg/L chloride and 1,200 mg/L TDS. The natural chloride pollution in the upper Brazos River affects water quality in the lower basin. In the Brazos River at Richmond, it has been estimated that 85 percent (or about 95 mg/L for the years 1946 to 1986)[10] of the chloride is from the upper basin.

There are many smaller springs in the Brazos G Area, but cataloging is inconsistent and incomplete. Only a few small springs have been cataloged in just nine of the 37 counties in the BGRWPA.[11] These springs flow substantially less than 1 cfs, and most flow only a few gallons per minute (1 cfs = 448.8 gpm).

### 1.5.2 Surface Water

The BGWRPA lies within the Brazos River Basin, the boundaries of which are the Red River Basin to the north, the Colorado River Basin to the west, the Trinity and San Jacinto River Basins to the east, and the counties of Fayette, Austin, Waller, and Montgomery to the south. The total drainage area for the Brazos River Basin is about 45,400 square miles, and of this about 28,400 square miles are in the BGRWPA.

The Brazos River is the third-largest river in Texas and the largest river between the Rio Grande River and the Red River in terms of total watershed area.[12] The Brazos River rises in three upper forks: the Double Mountain Fork, Salt Fork, and Clear Fork. Twenty-nine major reservoirs provide surface water to the BGRWPA. Major reservoirs, listed in Table 1-5, are defined as having an authorized conservation capacity greater than 10,000 acft. This table shows amounts of storage and annual use that the Texas Commission on Environmental Quality (TCEQ) authorizes for each reservoir. Figure 1-2 shows locations of some of the reservoirs in the BGRWPA, and Table A-5 in Appendix A provides more detailed information about all reservoirs in the BGRWPA with a permitted capacity greater than 2,500 acft. Diversions permitted for municipal, industrial, irrigation, and mining uses for each BGRWPA subregion are listed in Table 1-6. Total diversions permitted by use in each BGWRPA county are given in Table A-6 in Appendix A.

[10] Ganze, C. Keith and Ralph A. Wurbs, "Compilation and Analysis of Monthly Salt Loads and Concentrations in the Brazos River Basin," U.S. Army Corps of Engineers, Contract No. DACW63-88-M-0793, January 1989.

[11] Brune, Gunnar, *Major and Historical Springs of Texas: TWDB Report 189*, 1970.

[12] The Dallas Morning News, *2004-2005 Texas Almanac*, 2004.

### Table 1-5. Major Reservoirs in BGRWPA (Authorized Capacity Greater than 10,000 acft)

| Reservoir | Stream | County | Authorized Storage (acft) | Authorized Use (acft/yr) | Owner |
|---|---|---|---|---|---|
| Abilene | Elm Creek | Taylor | 11,868 | 1,675 | City of Abilene |
| Alcoa Lake | Sandy Creek | Milam | 15,650 | 14,000 | Aluminum Co. of America |
| Aquilla | Aquilla Creek | Hill | 52,400 | 13,896 | U.S. Army Corps of Engineers[1] |
| Belton | Leon River | Bell | 469,600 | 130,257 | U.S. Army Corps of Engineers[2] |
| Cisco | Sandy Creek | Eastland | 45,000 | 2,027 | City of Cisco |
| Cleburne | Nolan Creek | Johnson | 25,600 | 6,000 | City of Cleburne |
| Daniel | Gonzales Creek | Stephens | 11,400 | 2,100 | City of Breckenridge |
| Dansby Power Plant | Unnamed Trib. Brazos River | Brazos | 15,227 | 850 | City of Bryan |
| Fort Phantom Hill | Elm Creek | Jones | 73,960 | 33,190 | City of Abilene |
| Georgetown | North Fork San Gabriel River | Williamson | 37,100 | 13,610 | U.S. Army Corps of Engineers[1] |
| Gibbons Creek | Gibbons Creek | Grimes | 32,084 | 9,740 | Texas Municipal Power Agency |
| Graham/Eddleman | Flint Creek | Young | 52,386 | 20,000 | City of Graham |
| Granbury | Brazos River | Hood | 155,000 | 64,712 | Brazos River Authority |
| Granger | San Gabriel River | Williamson | 65,500 | 19,840 | U.S. Army Corps of Engineers[1] |
| Hubbard Creek | Hubbard Creek | Stephens | 317,750 | 56,000 | West Central Texas MWD |
| Leon | Leon River | Eastland | 28,000 | 6,300 | Eastland Co. WSD |
| Limestone | Navasota River | Robertson | 225,400 | 65,074 | Brazos River Authority |
| Millers Creek Lake[3] | Millers Creek | Baylor | 30,696 | 5,000 | North Central Texas MWA |
| Palo Pinto | Palo Pinto Creek | Palo Pinto | 44,124 | 18,500 | Palo Pinto MWD |
| Possum Kingdom | Brazos River | Palo Pinto | 724,739 | 230,750 | Brazos River Authority |
| Proctor | Leon River | Comanche | 59,400 | 19,658 | U.S. Army Corps of Engineers[1] |
| Somerville | Yegua Creek | Washington | 160,110 | 48,000 | U.S. Army Corps of Engineers[1] |
| Squaw Creek | Squaw Creek | Somervell | 151,500 | 23,180 | Texas Utilities Electric Co. |
| Stamford | Paint Creek | Haskell | 60,000 | 10,000 | City of Stamford |

### Table 1-5. Major Reservoirs in BGRWPA (Authorized Capacity Greater than 10,000 acft)

| Reservoir | Stream | County | Authorized Storage (acft) | Authorized Use (acft/yr) | Owner |
|---|---|---|---|---|---|
| Stillhouse Hollow | Lampasas River | Bell | 235,700 | 67,768 | U.S. Army Corps of Engineers[1] |
| Tradinghouse | Tradinghouse Creek | McLennan | 37,800 | 15,000 | Texas Utilities Electric Co. |
| Truscott Brine | Bluff Creek | Knox | 107,000 | N/A | Red River Authority of Texas |
| Twin Oak | Duck Creek | Robertson | 30,319 | 13,200 | Texas Utilities Electric Co. |
| Waco | Bosque River | McLennan | 192,062 | 192,062 | U.S. Army Corps of Engineers[5] |
| Whitney | Brazos River | Hill | 50,000 | 18,336 | U.S. Army Corps of Engineers[1] |
| **Totals** | **—** | **—** | **3,517,375** | **1,025,334** | — |

[1] Water rights held by the Brazos River Authority.
[2] Water rights held by the Brazos River Authority and the Department of the Army (Fort Hood).
[3] Millers Creek Lake is listed in Baylor County in Region B, but is used exclusively in the Brazos G Area.
[4] Storage authorization includes both Lake Stamford and College Lake
[5] Water rights held by the City of Waco.

### Table 1-6. Permitted Surface Water Diversions by Subregion

| Subregion | Permitted Diversion (acft/yr) [1] | | | | | |
|---|---|---|---|---|---|---|
| | Municipal | Industrial | Irrigation | Mining | Other[2] | Total |
| Rolling Plains | 505,047 | 46,058 | 62,023 | 9,249 | 75 | 622,451 |
| IH-35 Corridor | 467,025 | 109,181 | 21,286 | 1,121 | 5 | 598,618 |
| Lower Basin | 204,415 | 170,977 | 97,179 | 2,385 | 1,480 | 476,436 |
| **Region Total** | 1,176,487 | 326,216 | 180,488 | 12,755 | 1,560 | 1,697,506 |

[1] Available supply may be less than the permitted diversion based on hydrologic conditions and priority of individual water rights.
[2] Category includes consumptive amounts for recreation and other uses as classified by the TCEQ.

## 1.6 Wholesale Water Providers

Wholesale water providers are defined in 31 TAC §357 as any person or entity that sells wholesale water to water user groups or other wholesale water providers, or that the RWPG expects or recommends to deliver or sell water to water user groups or other wholesale water providers during the period covered by the regional water plan. It is the responsibility of the RWPG to identify wholesale water providers within the region to be evaluated for plan development. There are 12 identified wholesale water providers located primarily in the BGRWPA. These providers are listed in Table 1-7 and described below.

### Brazos River Authority

The largest provider of water in the BGRWPA is the BRA. The BRA also operates water and wastewater treatment systems, has programs to assess and protect water quality, does water supply planning, and supports water conservation efforts in the Brazos River Basin. The BRA provides water from three wholly owned and operated reservoirs: Lake Granbury, Possum Kingdom Lake, and Lake Limestone. The BRA also owns water rights for the proposed Allens Creek Reservoir in Region H. In addition to these sources, the BRA contracts for conservation storage space in the eight U.S. Army Corps of Engineers reservoirs in the region: Lakes Proctor, Belton, Stillhouse Hollow, Georgetown, Granger, Somerville, Whitney, and Aquilla. The total permitted capacity of the 12 constructed reservoirs in the BRA system is approximately 2.3 million acft. The BRA holds rights for diversion in the region totaling 661,901 acft, and contracts to supply water to municipal, industrial, and agricultural water customers in the BGRWPA and other regions. The BRA's largest current municipal customers, based on contracted supply, include Bell County Water Control and Improvement District No. 1, the City of Georgetown, and the City if Temple.

In 2016 the Brazos River Authority (BRA) obtained Water Use Permit No. 5851 (System Operations Permit) from the Texas Commission on Environmental Quality (TCEQ) for the diversion, impoundment, and use of (1) previously unappropriated state water in the Brazos River Basin, and (2) BRA owned return flows discharged into state watercourses not already authorized for use by other entities. The water right currently authorizes a maximum combined diversion of up to 334,345 acft/yr. Diversions are authorized in 40 individual stream segments basin-wide, with each stream segment assigned a specific maximum annual diversion amount.

**Table 1-7. Wholesale Water Providers in the Brazos G Area**

| Entity | Current Contracts (acft/yr) | Water Source |
|---|---|---|
| **Brazos G WWPs** | | |
| Aquilla WSD | 5,952 | Lake Aquilla |
| Bell County WCID #1 | 23,795 | Lake Belton |
| Bluebonnet WSC | 7,125 | Lake Belton |
| Brazos River Authority | 737,560[1,2] | Lakes Aquilla, Belton, Georgetown, Granbury, Granger, Limestone, Possum Kingdom, Proctor, Somerville, Stillhouse Hollow, Whitney and BRA System Operations Permit |
| Brazos River Authority | 22,128[3] | Highland Lakes Supply, Colorado Basin |
| Central Texas WSC | 10,537 | Lake Stillhouse Hollow |
| Eastland County WSD | 5,339 | Lake Leon |
| FHLM WSC | 1,934[4] | BRA System Operations Permit |
| North Central Texas MWA | 1,797[2] | Millers Creek Lake |
| Palo Pinto County MWD No. 1 | 4,250 | Lake Palo Pinto |
| Upper Leon MWD | 4,572 | Lake Proctor |
| Salt Fork Water Quality Corporation | - | Local saline groundwater |
| West Central Texas MWD | 17,900 | Hubbard Creek Reservoir |

[1] Includes 11,403 acft/yr in the Lake Aquilla System, 251,643 acft/yr in the Little River System, 379,515 acft/yr in the Main Stem/Lower Basin System, and 94,999 of System Operations Permit supply contracts (pending) (does not include GM Reserve or TPWD Trust) (based on contractual commitment list provided by BRA, dated 1/28/2020).

[2] Includes contracts in other regions.

[3] House Bill 1437 supplies from the Lower Colorado River Authority (based on contractual commitment list provided by BRA, dated 1/28/2020). 25,000 acft/yr is available, but not currently committed.

[4] Contract pending with BRA.

## Aquilla Water Supply District

Aquilla Water Supply District is located in Hill County, and obtains raw water from Lake Aquilla through a contract with the BRA. The district supplies treated water to five wholesale customers. The City of Hillsboro is the district's largest customer with a contract for 3,640 acft/yr. Total existing contracted sales for Aquilla Water Supply District are in the amount of 5,952 acft/yr.

## Bell County WCID No. 1

Bell County WCID No. 1 currently obtains raw water from Lake Belton for distribution to its customers and will soon also obtain water through new facilities at Lake Stillhouse Hollow. Major customers include and the U.S. Department of the Army (Fort Hood) and the Cities of Belton, Copperas Cove, Harker Heights, and Killeen. Bell County WCID No. 1 is currently contracted for a total treated water supply volume of 23,795 acft/yr, plus an additional supply to meet demands for Bell County WCID No. 3.

### Bluebonnet Water Supply Corporation

The Bluebonnet Water Supply Corporation (WSC) is located in Bell County. The WSC obtains raw water from Lake Belton, and sells treated water to nine entities in the BGRWPA. The largest customer is the City of McGregor, which holds a contract for 2,139 acft/yr. The total annual contracted supply to be provided by Bluebonnet WSC is 7,125 acft.

### Central Texas Water Supply Corporation

Central Texas WSC contracts with the BRA to obtain raw water from Lake Stillhouse Hollow and sells treated water under contract to 19 municipal water user groups; the largest of these contracts is with the Bell-Milam-Falls WSC for 2,327 acft/yr. Supply contracts by the Central Texas WSC total 10,537 acft/yr.

### Eastland County Water Supply District

The Eastland County Water Supply District owns and operates Lake Leon and has a water right to divert 5,800 acft for municipal and industrial purposes and 500 acft for irrigation. The district currently provides treated water to entities in Eastland County through the Cities of Eastland and Ranger. Current supply contracts by the Eastland County WSD total 5,339 acft/yr plus an additional treated supply volume to meet demands for Eastland County-Manufacturing.

### FHLM Water Supply Corporation

Several Public Water Supply entities in Falls, Hill, Limestone, and McLennan Counties formed the FHLM Water Supply Corporation to address the elevated arsenic levels, groundwater compliance issues, Trinity Aquifer depletion, and exchange information concerning treatment technologies and operations and maintenance considerations among the member entities. The main purpose of creating the FHLM WSC was to serve as the financing vehicle to obtain funding to support regional water projects for the area. The FHLM WSC has contracted with the BRA for 1,934 acft/yr of surface water supplies to be used by member utilities for blending and/or replacing existing groundwater supply, and is currently pursuing an additional water supply contract with the City of Waco.

### North Central Texas Municipal Water Authority

North Central Texas Municipal Water Authority supplies treated water to entities in Knox, Haskell and Stonewall Counties. The district has water rights to divert 5,000 acft/yr of raw water from Millers Creek Reservoir for municipal, industrial, and mining purposes. Current supply contracts from the North Central Texas Municipal Water Authority, including contracts for out of region sales, total 1,797 acft/yr.

### Palo Pinto County Municipal Water District No. 1

Palo Pinto County Municipal Water District No. 1 owns and operates Lake Palo Pinto, which is used to supply water to entities in Palo Pinto and Parker Counties. The district has rights to 18,500 acft a year for municipal and steam electric power uses. Treated water is supplied to the City of Mineral Wells (and its customers), Lake Palo Pinto Water Supply Corporation, and steam-electric entities in Palo Pinto County. Current supply contracts form the Palo Pinto County MWD No. 1 total 4,250 acft/yr plus an additional treated water volume to meet demands for the City of Mineral Wells.

### Salt Fork Water Quality Corporation

The Salt Fork Water Quality Corporation (SFWQC) was formed to develop a project for reducing surface water salinity in the Brazos River Basin. The project concept involves constructing a series of wells to be used for intercepting highly saline water currently being discharged to waterways from a series of seeps and springs in the Upper Brazos Basin. Captured water would be treated and processed to remove the salt which could then be used for commercial application, while the resulting freshwater would be available to for use by local municipal utilities. This project has yet to be developed, and the SFWQC does not currently hold any supply contracts.

### Upper Leon Municipal Water District

The Upper Leon Municipal Water District obtains water from Lake Proctor through contracts with the BRA. The MWD provides treated water to the Cities of Comanche, De Leon, Dublin, Gorman, Hamilton, Stephenville, and the Comanche County WSC. Current supply contracts from the Upper Leon MWD total 4,572 acft/yr.

### West Central Texas Municipal Water District

The West Central Texas Municipal Water District diverts raw water from Hubbard Creek Reservoir, which it owns and operates, for distribution to the Cities of Abilene, Albany, Anson, and Breckenridge. This district has rights to 56,000 acft/yr of water for municipal, industrial, irrigation, and mining uses. Current supply contracts from the West Central Texas MWD total 17,900 acft/yr.

## 1.7 Major Water Providers

The Brazos G RWPG defines Major Water Providers (MWPs) to be:

- Any WWP that is not also a municipal WUG, or
- Any WUG with a total municipal demand in the Brazos G Area of at least 1,000 acft/yr, including contractual sales to other municipal utilities.

Based on the above definition, the Brazos G RWPG has identified 91 WUGs and WWPs as Major Water Providers for the 2021 Brazos G Plan, listed in Table 1-8. This 2021 Brazos G Plan includes data summaries specific to these MWPs.

**Table 1-8. Major Water Providers in the Brazos G Area**

| | | | | | |
|---|---|---|---|---|---|
| 439 WSC | City of Bruceville-Eddy | FHLM WSC | Johnson County SUD | City of Navasota | City of Temple |
| City of Abilene | Brushy Creek MUD | Fern Bluff MUD | Jonah Water SUD | North Bosque WSC | Texas A&M University |
| Acton MUD | City of Bryan | Fort Hood | Kempner WSC | North Central Texas Municipal Water Authority | Texas State Technical College |
| City of Anson | City of Burleson | City of Fort Worth | City of Killeen | Palo Pinto County MUD No. 1 | Upper Leon Municipal Water District |
| Aquilla WSD | City of Caldwell | City of Gatesville | City of Lampasas | Possum Kingdom WSC | City of Venus |
| City of Arlington | City of Cameron | City of Georgetown | City of Leander | City of Robinson | City of Waco |
| Bell County WCID No.1 | City of Cedar Park | City of Giddings | Lee County WSC | City of Rockdale | Wellborn SUD |
| Bell County WCID No.2 | Central Texas WSC | City of Graham | Lower Colorado River Authority | City of Round Rock | West Central Texas MWD |
| City of Bellmead | City of Cleburne | City of Granbury | City of Mansfield | Salado WSC | Wickson Creek SUD |
| City of Belton | City of College Station | City of Harker Heights | Manville WSC | Salt Fork Water Quality Corporation (SFWQC) | Williamson County WSID No 3 |
| Bethesda WSC | Colorado River Municipal Water District | City of Hearne | City of Marlin | Southwest Milam WSC | City of Woodway |
| Bistone Municipal Water Supply District | City of Copperas Cove | City of Hewitt | City of McGregor | City of Stamford | |
| Bluebonnet WSC | Corix Utilities Texas, Inc | City of Hillsboro | City of Mexia | City of Stephenville | |

**Table 1-8. Major Water Providers in the Brazos G Area**

| | | | | | |
|---|---|---|---|---|---|
| Brazos River Authority (BRA) | Coryell City Water Supply District | City of Huntsville | City of Mineral Wells | City of Sweetwater | |
| City of Breckenridge | Dog Ridge WSC | City of Hutto | Morgans Point Resort | Tarrant Regional Water District | |
| City of Brenham | Eastland County WSC | Jarrell-Schwertner WSC | Mountain Peak SUD | City of Taylor | |

# 1.8 Current Water Users and Demand Centers

## 1.8.1 Regional Water Use

Total water use by each county in the BGRWPA is summarized in Figure 1-12 for 2017. Water use can be classified into four general types of use: municipal, industrial, agricultural, and non-consumptive. Figure 1-13 shows historical water use by municipalities, industries, and agriculture in the BGRWPA. Industrial use can be further broken down into three sub-categories: manufacturing, steam-electric cooling, and mining. Agricultural use consists of the subcategories of water used for irrigation and livestock. Historical water use in the planning area for six categories is summarized in Table 1-9.

In Appendix A, Table A-7 gives historical water-use data for all counties in the BGRWPA, and Table A-8 gives historical water-use data by category of use. Historical surface water use greater than or equal to 1,000 acft is given in Appendix D by each water-right holder.

## 1.8.2 Municipal Use

Municipal water use includes water consumed for residential and commercial enterprises and institutions. Residential and commercial uses are categorized together because they are similar types of uses (i.e., they both use water primarily for drinking, cleaning, sanitation, air-conditioning, and landscape watering). Generally, municipal use does not include water use by large industries. Projections for future municipal use account for population growth and anticipated efforts at water conservation. Municipal use of 362,506 acft accounted for about 40 percent of the region’s total water use in 2017. Figure 1-14 shows municipal water use in each BGRWPA county in 2017.

## Figure 1-12. 2017 Total Water Use by County

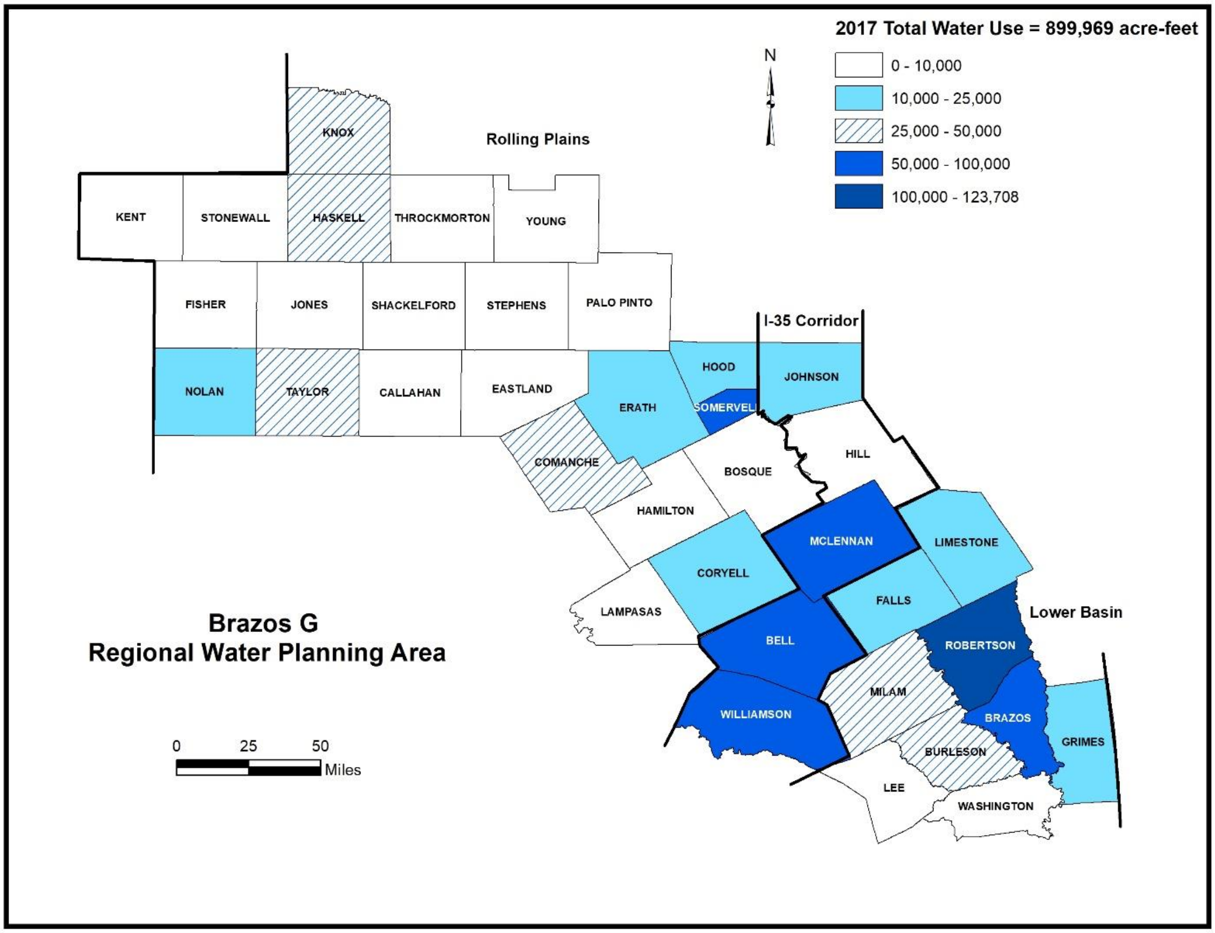


**Figure 1-13. Historical Water Use by Type**

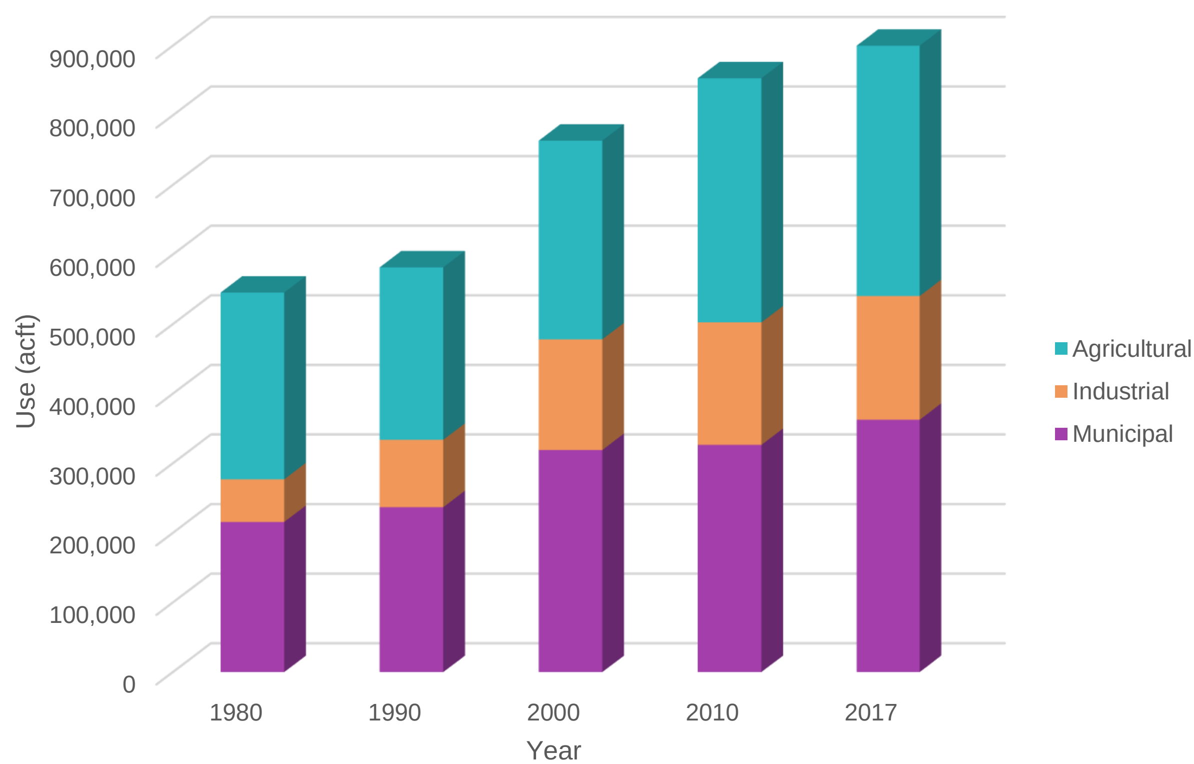
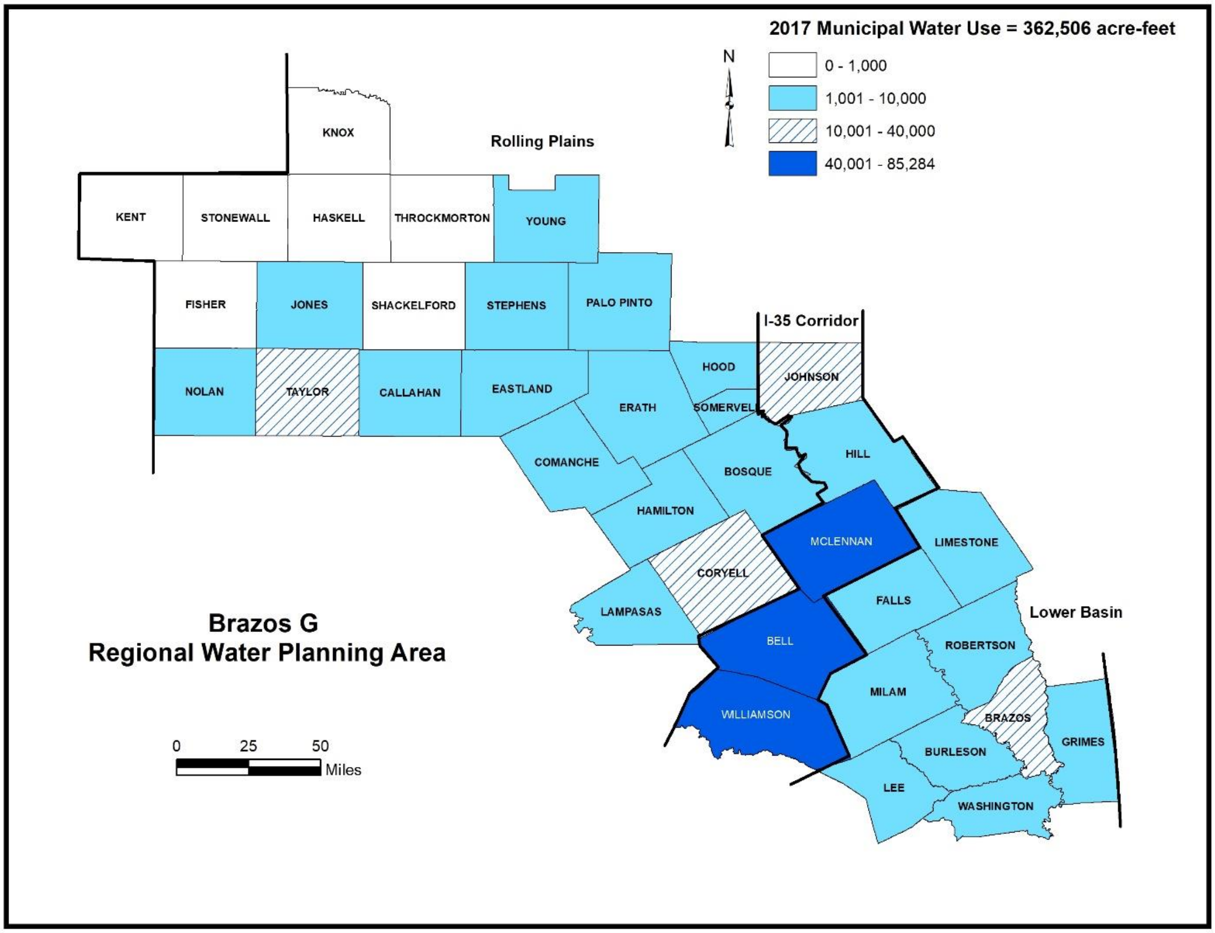



**Table 1-9. Historical Water Use[1] (acft/yr)**

| Category | 1980 | 1990 | 2000 | 2010 | 2017 |
|---|---|---|---|---|---|
| Municipal Use | 215,744 | 236,955 | 312,169 | 332,760 | 362,506 |
| Manufacturing Use | 21,124 | 32,240 | 60,522 | 9,124 | 10,821 |
| Steam-Electric Use | 28,686 | 57,657 | 97,921 | 113,553 | 153,229 |
| Mining Use | 11,413 | 6,944 | 4,143 | 57,644 | 13,730 |
| Irrigation Use | 229,387 | 200,954 | 232,911 | 298,754 | 315,648 |
| Livestock Use | 38,915 | 46,770 | 53,222 | 55,208 | 44,035 |
| Total Use | 545,269 | 581,520 | 760,888 | 867,043 | 899,969 |
| **Percent of State Total** | 3.06% | 3.70% | 4.69% | 6.24% | 6.50% |

[1] Historical data obtained from TWDB.

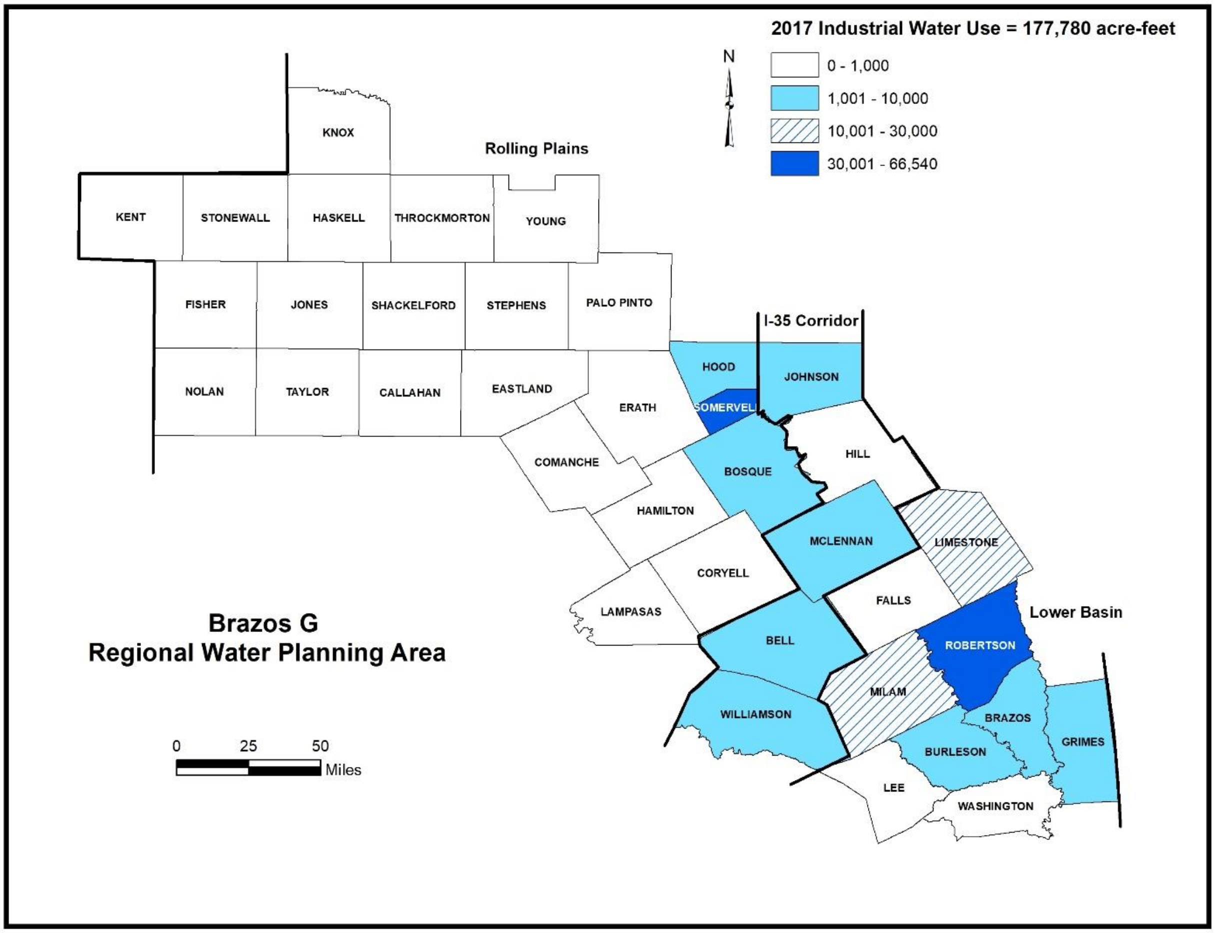
**Figure 1-14. 2017 Municipal Water Use**




## 1.8.3 Industrial Use

Industrial use consists of water used for manufacturing, for steam-electric cooling during power generation, and for mining operations. Projections for industrial use account for expected growth of industries, population changes, available mineral reserves, and production rates. In 2017, industrial use was 177,780 acft, or about 20 percent of the total water used in the BGRWPA. Refer to Figure 1-15 for 2017 industrial water use by county.

**Figure 1-15. 2017 Industrial Water Use (Manufacturing, Steam-Electric Cooling, and Mining)**




## Manufacturing

Manufacturing use is water used for producing finished goods. Manufacturing use was 10,821 acft in 2017, or 6 percent of total industrial water usage that year.

## Steam-Electric Cooling

This category is water used during the power-generation process and is typically losses due to forced evaporation during cooling. Water that is diverted and not consumed (i.e., return flow) is not included in the power-generation total. Water use for steam-electric cooling in 2017 was 153,229 acft, or 86 percent of total industrial water use.

## Mining

Mining use is water consumed for exploration and production of oil and gas, and for mining of lignite, sand, gravel, and such. Mining use in 2017 was 13,730 acft, or 8 percent of the total industrial water use.

## 1.8.4 Agricultural Use

Agricultural use is water used for irrigation and for watering livestock. Agricultural use was 359,683 acft in 2017 or 40 percent of the BGRWPA's total water use. Agricultural water use by each county in the planning area in 2017 is summarized in Figure 1-16.

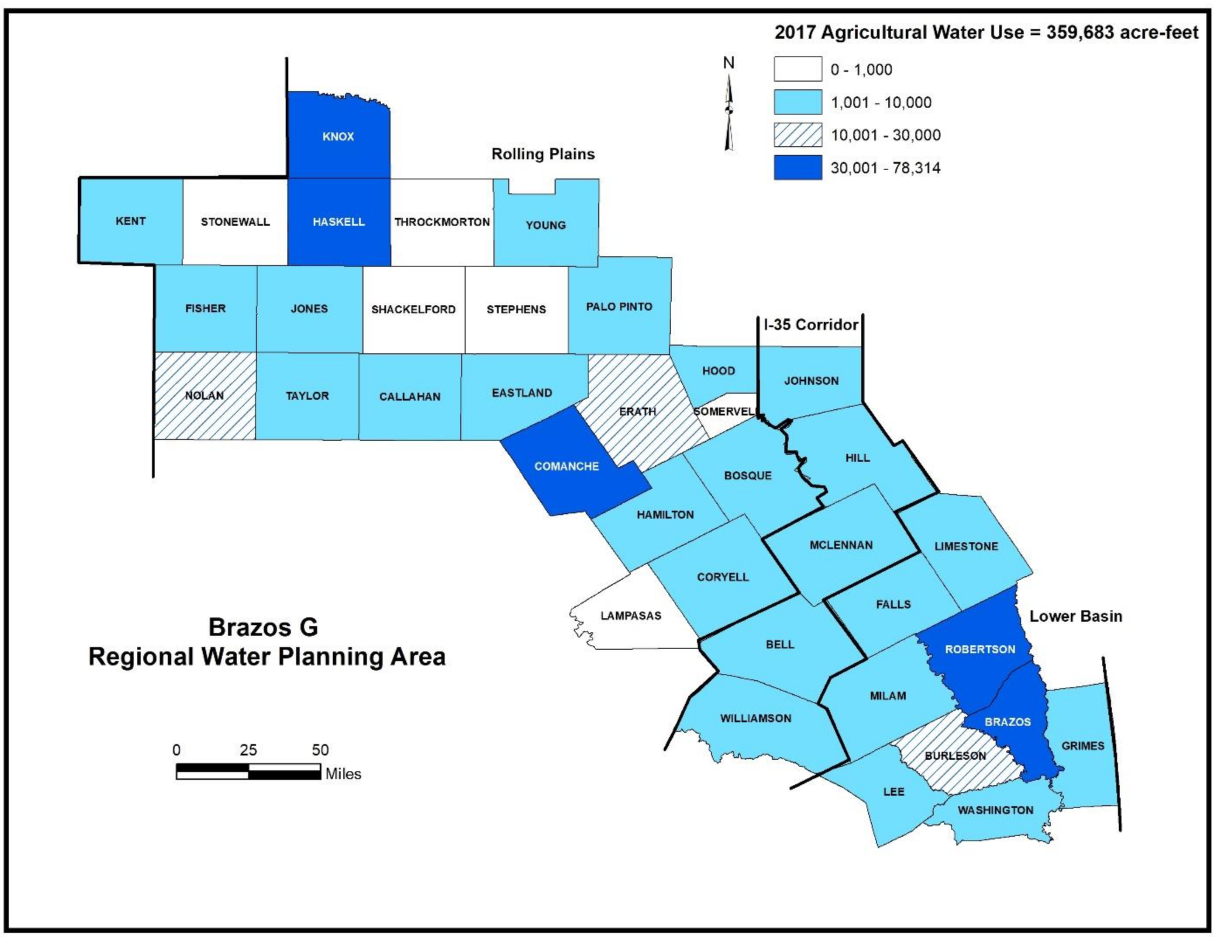
### Irrigation

Irrigation use in 2017 totaled 315,648 acft, or about 88 percent of the total agricultural water use. Refer to Appendix F for more detailed information about irrigation use in the BGRWPA.

### Livestock Watering

The estimate of use for livestock watering is based on a determination of the total number of livestock in the region. A uniform water-consumption rate for each type of animal is applied to this total number. The categories of livestock considered are cattle and calves, poultry, sheep and lambs, and hogs and pigs. Livestock watering totaled 44,035 acft, or 12 percent of agricultural use in 2017. Refer to Appendix F for more detailed information on water used for livestock.

**Figure 1-16. 2017 Agricultural Water Use (Livestock and Irrigation)**



### 1.8.5 Non-Consumptive Use

Non-consumptive use is water that is diverted and then returned to the river basin with minimal change in volume and temperature, or is used but never leaves the river system. The majority of non-consumptive water use in the BGRWPA is associated with recreational use and the return flow from power generation. Water-related recreational activities include boating, camping, fishing, and swimming. Recreational use in the BGRWPA is supported by numerous state parks and by public facilities for boating and camping at various lakes and reservoirs.

Navigation is another form of non-consumptive use. Other than small watercraft used primarily for recreation on lakes and rivers, the BGRWPA includes no use of water for navigation. No water management strategy considered by the BGRWPG will affect navigation, either in the BGRWPA or in adjacent regions.

Power generation demands large amounts of water for cooling equipment. Twenty steam-electric power-generating facilities were operating in the BGRWPA in 2008 (BEG, 2008). Most of the diverted water was returned to the Brazos River Basin. Water that is lost to evaporation during the cooling process is considered industrial use and is discussed in Section 1.5.3.

## 1.9 Natural Resources

### 1.9.1 Regional Vegetation

The BGRWPA lies within several different vegetational areas, or ecoregions.[13] Figure 1-17 shows the locations of these ecoregions, which are relatively homogenous areas in terms of geography, hydrology, and land use. The five ecoregions in the BGRWPA are the Rolling Plains, Blackland Prairies, Post Oak Savannah, Cross Timbers and Prairies, and Edwards Plateau. A general description for each ecoregion is provided below. More detailed information is provided in Appendix E.

#### Rolling Plains

The Rolling Plains are part of the Great Plains of the central United States. The Rolling Plains region covers about 24 million acres of gently rolling to moderately rough terrain. The region is bordered on the west by the Caprock Escarpment, on the south by the Edwards Plateau, and on the east by the Cross Timbers and Prairies region. Annual precipitation averages about 22 to 30 inches, and elevations range from 800 to 3,000 feet above sea level. The eastern part of the Rolling Plains is called the Reddish Prairie. Soils vary from coarse sands in outwash terraces near streams to tight clays or red-bed clays and shales.

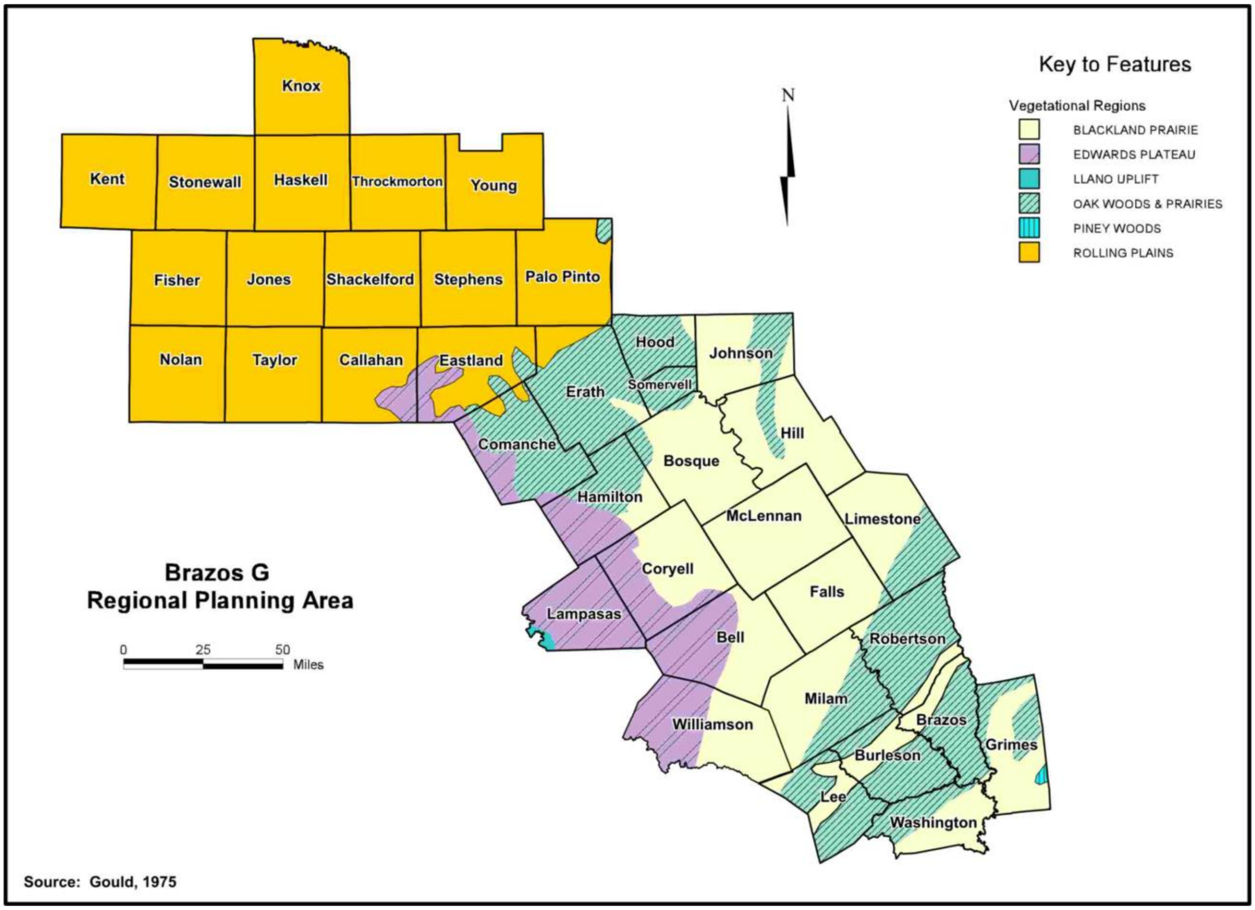
#### Blackland Prairies

The Blackland Prairies region consists of nearly level to gently rolling topography. It covers about 11.5 million acres from Grayson and Red River Counties in northeast Texas to Bexar County in the south-central part of the State where it merges with the brush land of the Rio

[13] Gould, F.W., *The Grasses of Texas*, Texas A&M University Press, College Station, Texas, 1975.

Grande Plains. Annual precipitation is 30 to 45 inches, and elevations range from 300 to 800 feet above sea level. The term blackland comes from the uniformly dark-colored, calcareous clays in the Alfisols (fertile mineral soils). Soils in the Blackland Prairies are interspersed with gray-colored, acidic sandy loams. This highly fertile region has widely been used for agriculture, but it is increasingly used for ranching.[14] Experts estimate that less than one percent of the Blackland Prairies remain in a near-natural condition.[15]

**Figure 1-17. Vegetational Areas of the Brazos G Area**




## Post Oak Savannah

The Post Oak Savannah covers about 8.5 million acres in east-central Texas and consists of closely associated and intermingled prairies and woodlands on slightly acidic sandy or clay loams. Topography in this region is gently rolling to hilly, with moderate to deeply dissected drainage paths. Soils in uplands are generally light-colored, acidic sandy loams or sands, and soils in bottomlands are light-brown to dark-gray acidic sandy loams or clays. Much of this vegetational area is used for crops and grazing.

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[14] Gould, F.W. and Schuster, J.L. and Hatch, S.L., *Texas Plants B, An Ecological Summary*, Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas, 1990.

[15] Smeins and Diamond, 1986.

#### Cross Timbers and Prairies

The Cross Timbers and Prairies vegetational area covers about 17 million acres in north-central Texas. Geology in this area is diverse, and the topography varies from gently rolling to hilly to deeply dissected. Rapid surface drainage is typical throughout the region. Soils are typically brown, neutral-to-slightly acidic, sandy or clay loams.

#### Edwards Plateau

The Edwards Plateau area covers about 24 million acres. This includes a large portion of the Hill Country in west-central Texas, the Llano Uplift, and the Stockton Plateau. Average annual precipitation increases from west to east across this region. Limestone or caliche typically underlie the shallow, variably-textured soils, although granitic rock underlies soil in the Llano Uplift. Land use in this vegetational area is dominated by ranching of cattle, sheep, and goats. This region reportedly once was dominated by a grassland or an open savannah climax community, except in steep canyons and slopes where junipers and oaks were dominant. The widespread disturbance associated with grazing livestock eventually allowed brush and tree species to spread widely throughout the original grasslands and savannahs.

### 1.9.2 Regional Geology

Figure 1-18 shows the varied geology of the planning area. Generally, the formations in the northwest part of the planning area are the older Blaine and San Angelo Formations of the Paleozoic era. The central part of the planning area is typically dominated by younger formations from the Cretaceous era, such as the Trinity Group; the Navarro and Taylor Groups; and the Austin, Eagle Ford, Woodbine, and U. Washita Groups. The youngest formations are in the southern part of the planning area. These formations include the Cook Mountain, Weches, Sparta, and Yegua, among others. Many areas near streams and rivers are dominated by alluvial deposits.

### 1.9.3 Soils

The soils of the upper Brazos River Basin are agriculturally and ecologically important. Throughout the Brazos G Area, soils are varied and are influenced by both geology and surface drainage. Figure 1-19 shows the locations of different orders of soil in the BGRWPA. These soil types are briefly described in the following subsections.

Figure 1-18. Geology of the Brazos G Area

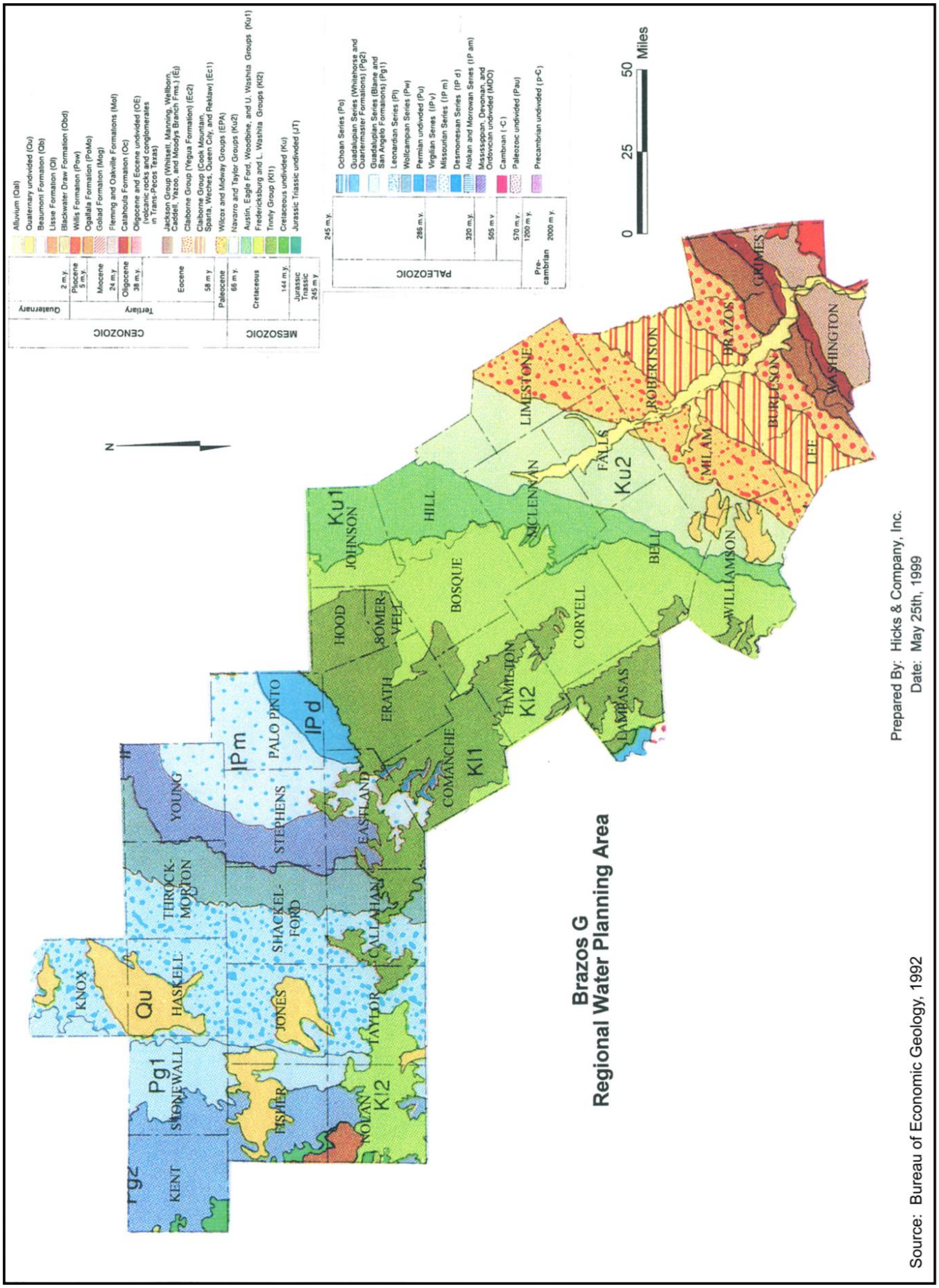
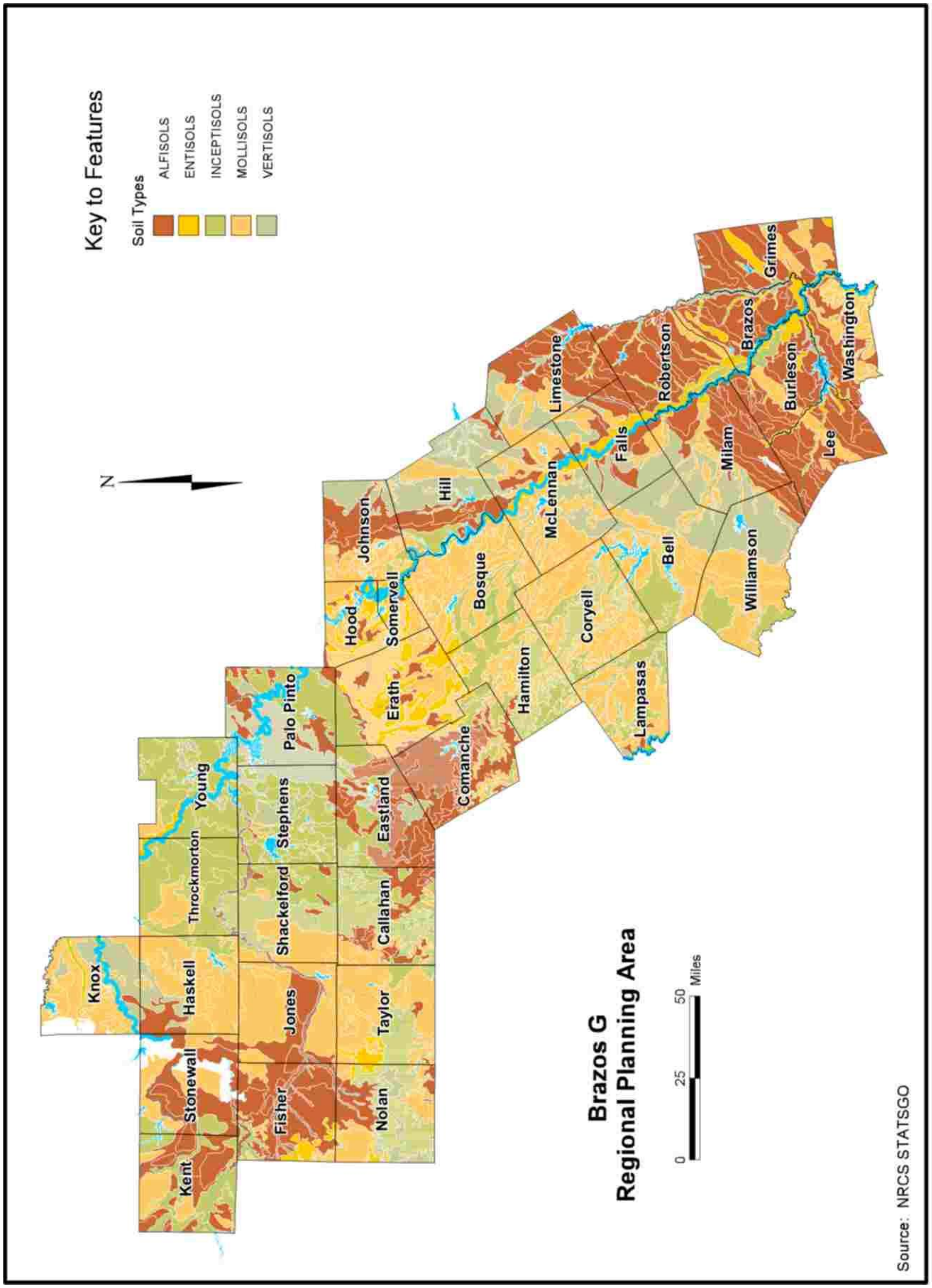


**Figure 1-19. Soils of the Brazos G Area**



#### Alfisols

Alfisols are mineral soils with a gray-to-brown surface horizon. These soils form under humid, cool-to-hot areas of native grasslands. They are productive and favor good crop yields.

#### Entisols

Entisols are typical of rangeland in west and southwest Texas. In this order, soils range from infertile sands and bedrock to highly productive soils on recent alluvium. A characteristic common to all Entisols is the lack of significant profile development.

#### Inceptisols

Inceptisols are thought to form relatively quickly from the alteration of parent material. Productivity varies among soils in this order, and it is affected by factors such as levels of organic matter and drainage. Typically, Inceptisols have slightly higher profile development than Entisols.

#### Mollisols

Mollisols are considered important agriculturally and are characterized by a thick, dark surface horizon. These soils develop under grassland-prairie vegetation typical of the central United States. Mollisols cover more land area in the United States than any other soil order.

#### Vertisols

Vertisols have a high clay content and therefore may develop deep cracks from shrinking during dry periods. The fine texture of Vertisols and their tendency to shrink excessively makes them generally unstable for building foundations and even for some agricultural uses.

### 1.9.4 Wetlands

Wetlands are defined by the U.S. Army Corps of Engineers as areas that, due to a combination of hydrologic and soil conditions, are capable of supporting hydrophytic vegetation. In the Brazos G Area, wetlands are found primarily in narrow strips along rivers and streams.

As a natural resource, wetlands are especially valued because of their location on the landscape, the wide variety of ecological functions they perform, and the uniqueness of their plant and animal communities. Many wetlands are also valued for their aesthetic qualities, as sites for educational research, as sites of historic and archaeological importance, and as locations for storing or conveying floodwaters. Wetlands provide high-quality habitats for wildlife, including foraging and nesting areas for birds and spawning and nursery areas for fish.

### 1.9.5 Water Resources

Rivers and reservoirs are important ecological resources for the Brazos G Area. These support diverse aquatic plants and animals as well as terrestrial wildlife living along the banks. Important rivers and creeks in the planning area include the Brazos, Leon, Bosque, Lampasas, San Gabriel, South Wichita, Little, Clear Fork of the Brazos, and Yegua Creek. These rivers contribute to unique vegetational communities that provide habitat for wildlife. There are more than 40 species of aquatic amphibians, reptiles, and mammals in the planning area. Waterfowl heavily use the mature, hardwood, bottomland forests and forested wetlands often associated with rivers. Aquatic habitats include riffles and pools, which support both invertebrates and fish.

Reservoirs (Figure 1-20) provide habitat for inland fish stocks and waterfowl. Many reservoirs in the planning area provide habitat for fish stocks and waterfowl including Lake Stamford, Hubbard Creek Reservoir, Possum Kingdom Lake, Lake Leon, Lake Proctor, Lake Whitney, Lake Stillhouse Hollow, Lake Belton, Lake Waco, and Lake Somerville.

Although few in number, the major springs and seeps in the planning area that produce frequent flows are often rich in wildlife habitat and ecological diversity. Springs represent a transition from groundwater to surface water. Where frequent springflow occurs, an abundance of moisture is provided, resulting in diverse vegetational communities unique to such areas. Typical vegetation includes willows, cottonwoods, hackberry, elms, rushes, sedges, and smartweed. These vegetational communities often provide optimal habitat for native wildlife.

## 1.9.6 Wildlife Resources

### Biotic Provinces

Just as Texas has been divided into major plant zones,[16] the State has also been classified into biotic provinces based on the distribution of topographic features, climate, vegetation types, and terrestrial vertebrates[17] (Figure 1-21). The BGRWPA includes the Kansan, Austroriparian, Balconian, and Texan biotic provinces.

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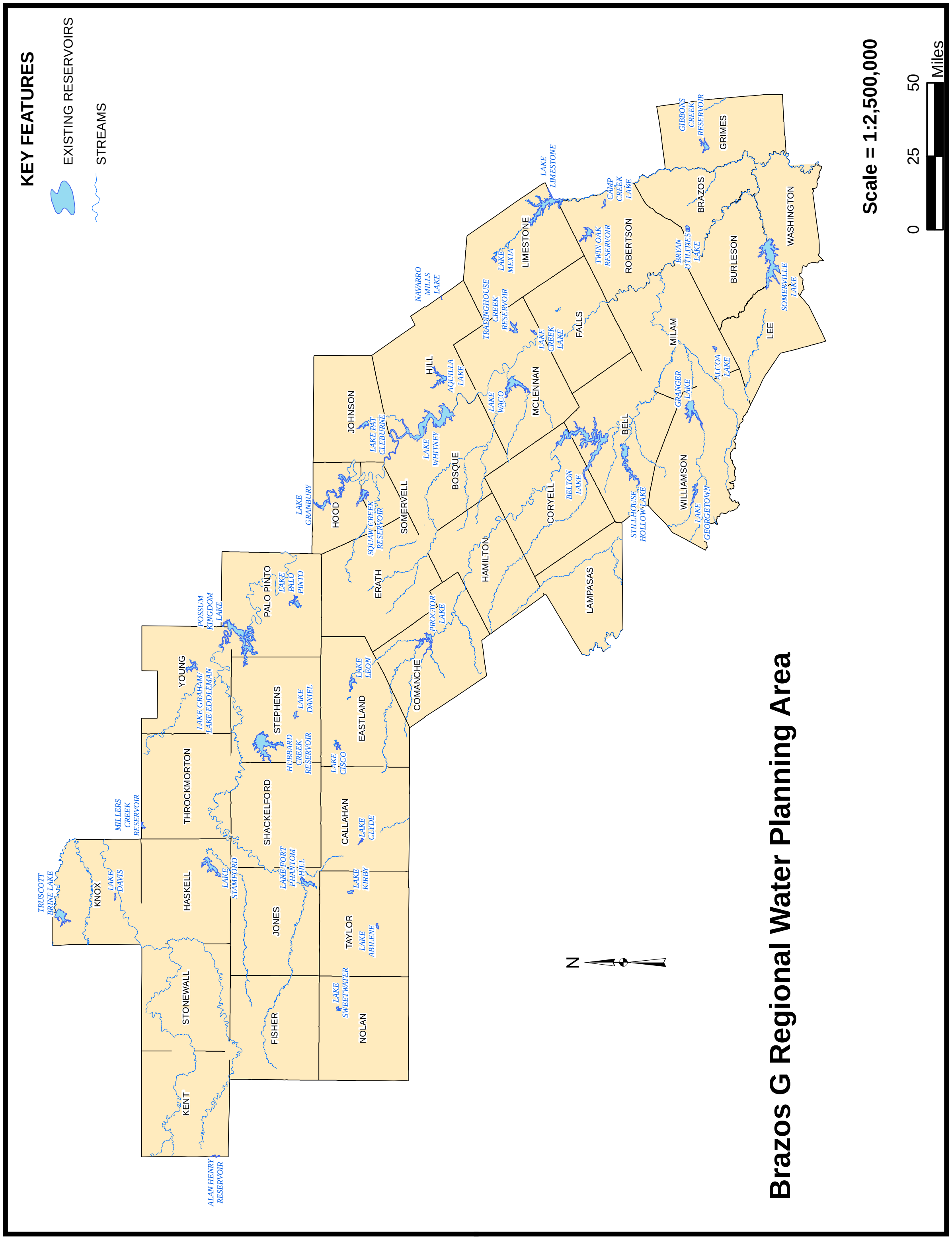
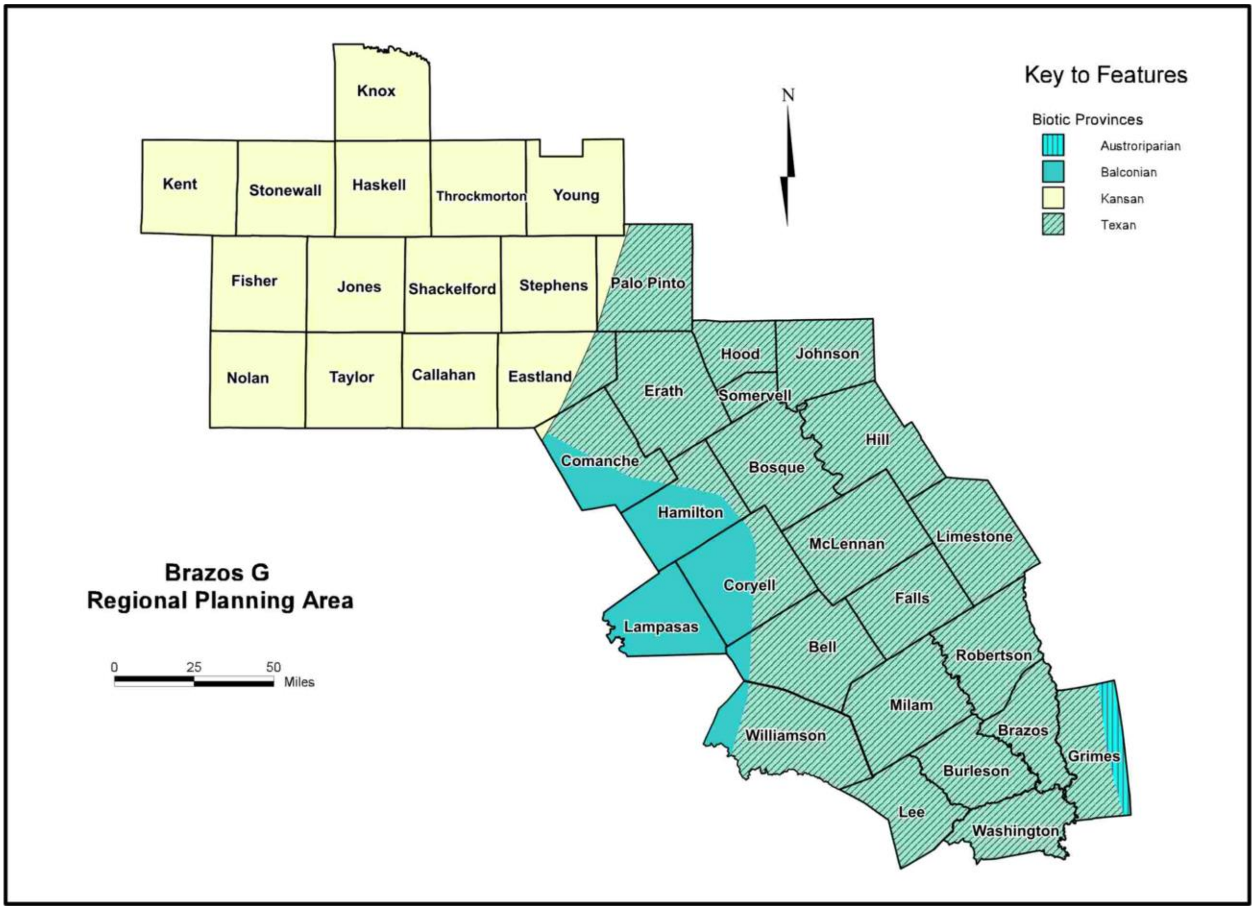
[16] Gould, Op. Cit., 1975.

[17] Blair, 1950.

Figure 1-20. Water Resources of the Brazos G Area



### Figure 1-21. Biotic Provinces of the Brazos G Area




## Kansan

The Kansan province runs southward from the Texas panhandle and across the Rolling Plains area of the Brazos G Area. It meets the Texan biotic province at the western boundary of the Cross Timbers and Prairies vegetational area. There is little available moisture in the province, and moisture that is available decreases from east to west. The plant associations vary. However, they fall into three general categories of associations: the mixed-grass plains, the mesquite-grass association, and the short-grass plains.

## Austroriparian

The western fringe of the Austroriparian province extends into the southeastern rim of the Brazos G Area. This province comprises the pine and hardwood forests of the eastern Gulf Coastal plain. The province is limited to the west due to low moisture. However, vegetational communities found in the westward extensions of the province occur along drainageways where environmental conditions allow.

## Balconian

The Balconian province includes most of the Edwards Plateau excluding the region west of the Pecos River. The Edwards Plateau is a physio-graphically discrete unit. It has a variety of wildlife, and its vegetation is different from that found in adjacent provinces. The abundant vertebrate species are a mixture of Austroriparian, Tamaulipan, Chihuahuan, and Kansan.

Most of the Balconian province lies on Cretaceous limestone, but igneous intrusives and sediments of Precambrian age are exposed in the Llano Uplift. Limestone caverns and springs are common features of this province. Massive outcrops of limestone are characteristic of the stream canyons, and limestone fragments occur at the surface over almost the entire area.

Rainfall amounts typically decrease from east to west. The most characteristic plant association is the juniper-oak scrub. Mesquite is also distributed throughout the province.

#### Texan

The Texan biotic province has no true endemic species of vertebrates. In this area, western species tend to encroach into open habitats, and eastern species encroach along the many wooded drainageways extending through the landscape. The Texan province has supported 49 species of mammals, 39 species of snakes, 16 species of lizards, 2 types of land turtles, 18 types of toads and frogs (anurans), and 5 species of salamander (urodeles).

### Threatened and Endangered Species

In planning water-management strategies, one major consideration is the potential impact on threatened and endangered species. Table E-1 in Appendix E gives a complete list of threatened and endangered species in each county in the BGRWPA. Some of the more widely seen of these are the golden-cheeked warbler (Dendroica chrysoparia), the black-capped vireo (Vireo atricapillus), and the bald eagle (Haliaeetus leucocephalus).

## 1.9.7 Agricultural Resources

Agriculture is a mainstay of the BGRWPA rural economy. Among livestock, cattle were the most significant component, approaching 2.01 million head with an additional 96,000 dairy cows in 2017. Over 17 million acres, or about 85 percent of BGRWPA's total area, were classified as farmland in 2017. Of the 17 million acres of farmland, about 4.6 million acres were classified as cropland, of which about 2.8 million acres were harvested. Refer to Appendix F for detailed listings of agricultural information for the BGRWPA.

The Texas Department of Agriculture has specified several Agricultural Statistics Districts for the purpose of keeping records. The districts within the BGRWPA are 2N and 2S (Rolling Plains), 3 (Cross Timbers), 4 (Blacklands), 5S (South East), 7 (Lampasas County), and 8N (South Central).

### Rolling Plains

Counties in the Rolling Plains (Districts 2N and 2S) are Fisher, Haskell, Jones, Kent, Knox, Nolan, Stonewall, and Taylor. The major dryland products are extensive row-crops, such as cotton, and wheat. Irrigation comes from the Seymour Aquifer where available. Major crops include wheat and cotton. Hay and silage are also produced, but because of low rainfall, their acreage is much less than in other districts in the BGRWPA.

### Cross Timbers

The Cross Timbers counties (District 3) are Callahan, Comanche, Eastland, Erath, Hood, Palo Pinto, Shackelford, Somervell, Stephens, Throckmorton, and Young. Combined, these counties lead the State in dairy production. This is due to several factors such as available groundwater from the Trinity Aquifer, soils suitable for forage production, topography conducive to dairy operation, and an existing infrastructure. The major crops produced in the Cross Timbers are hay and silage, with smaller amounts of peanuts, pecans, and vegetables irrigated from the Trinity Aquifer.

### Blacklands

The Blacklands counties (District 4) are Bell, Bosque, Coryell, Falls, Hamilton, Hill, Johnson, Limestone, McLennan, Milam, and Williamson. Lampasas County (District 7) is included for the purposes of this analysis. The Blacklands is noted for dryland production of corn for grain, grain sorghum, wheat for grazing and grain, cotton, and hay. Irrigation in the Blacklands is limited by lack of sufficient groundwater supply.

### South East and South Central Texas

South East and South Central Texas counties (District 5S and 8N) are Brazos, Burleson, Grimes, Lee, Robertson, and Washington. This subregion has limited row-crop agriculture because suitable topography and soils are limited. Hay and silage are the major agricultural products. The Brazos River Bottoms counties (Brazos, Burleson, and Robertson) produce most of the crops in the subregion, including corn for grain, grain sorghum, and cotton. The Brazos River Alluvium is the major source of groundwater for the Brazos River Bottoms.

## 1.10 Threats and Constraints to Water Supply

Projected population growth in the region, particularly along the IH-35 Corridor, will strain existing municipal supplies. The population of Williamson County within Region G, for example, is projected to increase more than 150% between 2020 and 2070 to about 1,490,951 people. Water will become even more valuable, especially in the western and central parts of the BGRWPA, due to limited options for new reservoirs and because the aquifers in these areas have limited potential for further development.

Other concerns include the high content of chloride in surface-water runoff from the upper Brazos River Basin. Water with high chloride content is more expensive to treat and therefore places capital constraints on suppliers who obtain surface water from affected streams and reservoirs.

Zebra mussels are an invasive species impacting water quality in reservoirs and impairing the operation of water supply infrastructure. The Texas Parks and Wildlife Department maintains an up-to-date list of the occurrences of zebra mussels at the following web site:

https://tpwd.texas.gov/huntwild/wild/species/exotic/zebramusselmap.phtml

According to the website, as of September 1, 2020, the following reservoirs in the Brazos G Area are either “infested”, i.e., established reproducing populations, or “positive”, i.e., zebra mussels or their larvae have been detected: Lake Belton, Lake Georgetown, Lake Granger, Lake Stillhouse Hollow, and Lake Waco. The Little River, downstream of Lakes

Belton, Stillhouse Hollow, Georgetown and Granger is also positive for zebra mussels. Several reservoirs in the adjacent Trinity and Colorado River Basins are also infested or positive.

## 1.10.1 Susceptibility of Water Supplies to Drought

### Groundwater

The 16 aquifers within the BGRWPA vary in drought resistance, but all tend to have more resistance than most surface-water reservoirs. Most of the thick, deep, and extensive sand aquifers with moderate to high transmissivity react very slowly to droughts. Their supplies are virtually drought-proof even during long droughts. These aquifers, such as the Carrizo-Wilcox and Gulf Coast Aquifers, store enormous amounts of water. Somewhat thinner, yet still extensive, sand aquifers with low to moderate transmissivity commonly are only slightly less drought resistant. These aquifers include the Trinity, Woodbine, Queen City, Sparta, and Hickory.

During long droughts, shallow alluvial aquifers from which large withdrawals are made experience water level declines that are relatively large in comparison to total saturated thickness. Supplies from these aquifers, such as the Seymour and Brazos River Alluvium Aquifers, can be affected by drought but generally only by extended droughts. In extended droughts, available well yields are typically reduced, and pumps must run longer for a given level of supply.

In thin aquifers with shallow supplies, drought resistance may not be adequate. Such aquifers in the BGRWPA include the Dockum, Blaine, and Edwards-Trinity (Plateau). Also, shallow supplies in or near outcrop areas of aquifers, even of major aquifers, may have limited drought resistance.

Aquifers composed of limestone and/or dolomite are commonly the least drought-resistant. This is because these aquifers typically have only about one-tenth as much storage per cubic foot as sand aquifers. For limestone aquifers, the amount of well development is also an important factor in drought resistance. Thus, the Edwards (BFZ) Aquifer, with more developed well capacity than is available in extended droughts, is the least drought-resistant of all the aquifers in the BGRWPA. Depending on location and exact local conditions, springflows and some Edwards (BFZ) well supplies are substantially reduced in only moderate droughts. In contrast, the Marble Falls and Ellenburger-San Saba Aquifers, which are relatively undeveloped by wells, can more slowly discharge a part of their stored water during long droughts.

In the Brazos G Area, for supplies drawing from the Edwards (BFZ) Aquifer, drought planning is critical. All of the other aquifers in the region are drought resistant due to their inherent characteristics.

### Surface Water

Surface water supplies in the region vary greatly, as annual rainfall ranges from 20 to 24 inches in Kent County in the northwest, to 40 to 48 inches in Grimes County in the southeast. Evaporation rates show a similarly wide variation, with the highest rates occurring in the northwestern part of the region.

Drought originates from a deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector. Drought should be considered relative to some long-term average condition of balance between precipitation and evapotranspiration (i.e., evaporation + transpiration). It is also related to the timing (i.e., principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness of the rains. Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with drought and can significantly aggravate its severity.

Hydrological drought is associated with the effects of periods of precipitation shortfalls on surface water supply. The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency affects the water supply. Firm yields of reservoirs are estimated based on water that would be available through a repeat of the historic drought of record, which includes the effects of reduced runoff and high evaporation rates during the drought period. Water supply from run-of-the-river diversions are estimated based on water that would be available[18] through a repeat of the drought of record as well, but without the benefit of using stored water. The water supply estimates throughout this water plan are reliable through a repeat of the drought of record and are therefore not particularly susceptible to drought-induced shortages. However, the northwestern counties of the Brazos G Area are currently suffering through a particularly dry spell and data indicate new record drought conditions.

In 2009, 2011, 2012, and 2013 priority calls were made in the Brazos Basin. In July 2013 TCEQ issued an Order for the Brazos Basin including Possum Kingdom Lake and below Possum Kingdom Lake. The Order suspended or modified approximately 900 water rights in the Brazos Basin in 21 counties. The Order required the owners of larger reservoirs affected by the Order to submit pass-through plans, detailing their response to the priority call. The priority call was rescinded on October 10, 2013.

On April 9, 2014 the TCEQ directed that a new Watermaster be appointed for the Brazos River Basin including Possum Kingdom Lake and the watershed below the lake. The purpose of the Watermaster is to maintain compliance with water rights by monitoring stream flows, reservoir levels and water use. It is also the responsibility of the Watermaster to mediate the curtailment of water use if a priority call is initiated.

### 1.10.2 Identified Water Quality Problems

Water quality varies throughout the upper, middle and lower portions of the BGRWPA. Water quality is generally good in aquifers and in the tributaries of the Brazos River. However, high concentrations of chloride are found in the main stem of the Brazos River. Three factors affecting water quality in the Brazos G Area are wastewater disposal, high-density agricultural activities, and natural saline contamination.[19] Except for the third factor,

[18] Estimates of municipal and industrial run-of-river diversions are for 100 percent reliability. For irrigation uses, run-of-river reliability less than 100 percent is often acceptable.

[19] Texas Natural Resource Conservation Commission (TNRCC), *Summary Report: Regional Assessments of Water Quality Pursuant to the Texas Clean Rivers Act (Senate Bill 818)*, 1992.

these threats are associated with the growth of both population and the economy, which are expected to continue in the future.

Water quality data collection and assessment studies have been conducted since 1991 through the Texas Clean Rivers Program (CRP). Through collaborative efforts with other agencies and basin residents, the BRA identifies and evaluates water quality and watershed management issues, establishes priorities for corrective actions, and implements activities to improve and protect the Brazos River basin. Identified surface water quality problems within the BGRWPA are summarized according to specific regions in the basin, and are based on information from the Texas Clean Rivers Program 2004 Basin Highlights Report.[20]

### Upper Basin Region

The Upper Basin Region includes the Salt and Double Mountain Forks and the Clear Fork of the Brazos River. Water quality data reveal water quality impacts represented by high conductivity levels, along with high total dissolved solids and chloride concentrations. While this region contributes only 14 to 18 percent of the total Brazos River flow, the area contributes 45 to 55 percent of the total dissolved minerals and about 75 to 85 percent of the dissolved salts.

### Upper Central Basin Activity Region

The Upper Central Basin of the Brazos River includes eight lakes, five watersheds, and a variety of land uses interconnected throughout the watersheds. The Upper Central Basin Region generally covers from Bell County north to Hood County. Numerous watershed protection and management projects are being conducted in this region to address declining water quality due to impacts from industrial, agricultural, municipal, and natural causes. On-going activities and water quality issues in this area include:

- In 2002, the BRA began a special study on Lake Granbury to assess impacts from septic systems in the coves throughout the lake.
- The BRA currently monitors Aquilla Creek at FM 933 in this watershed. TCEQ has been monitoring Lake Aquilla as a result of its placement on the State's 303 (d) list for impairments due to high concentrations of atrazine.
- The Bosque River Watershed drains approximately 1,652 square miles and discharges into Lake Waco. Elevated bacteria, nutrient and algal growth are concerns for this watershed, due to high non-point source pollution activity generally attributed to confined animal feeding operations. There are several on-going activities undertaken by the State, BRA, City of Waco, and local entities to monitor and reduce pollution in this watershed.
- A number of sites in the Leon River watershed show concerns for elevated bacteria and nutrient concentrations, as well as depressed dissolved oxygen.
- Lake Stillhouse Hollow experiences above average water quality conditions and remains primarily undeveloped. Discharging into the Lampasas river downstream

[20] Brazos River Authority (BRA), Texas Clean Rivers Program 2004 Highlights Report, available online at http://www.brazos.org/CleanRiversProgram/BasinReport/Executive_Summary.pdf, 2004.

of the lake, Salado Creek is experiencing concerns from elevated nutrient concentrations.

#### Lower Central Basin Activity Region

Portions of the Lower Central Basin are subject to non-point source discharges and nutrient loading from agricultural activities. Data collected to date show that Cottonwood Branch in Brazos County near Bryan has very high concentrations of nutrients and elevated bacteria levels. Lakes Limestone and Granger also show concerns for nutrient loading that is contributing to increased aquatic plant growth.

Additionally, elevated naturally occurring arsenic levels have been experienced in Trinity Aquifer groundwater produced from certain areas of Falls, Hill, Limestone, and Milam Counties which has created compliance issues with USEPA drinking water standards.

#### Lower Basin Activity Region

The BRA monitors eight sites in Yegua Creek watershed, including two sites on Lake Somerville. The lake, which spans 11,460 acres, has experienced several fish kills. Lake Somerville has experienced both elevated and depressed pH levels, which may be attributed to fluctuations in blue-green algae populations.

### 1.10.3 Identified Threats to Agricultural and Natural Resources

Drought and water quality are the two primary threats to agricultural and natural resources in the Brazos G Area.

#### Threats to Agricultural Resources

Drought is the primary threat to agricultural resources in the Brazos G Area. During long droughts, surface water supplies for unconfined livestock are diminished. If the drought extends through the season for growing forages, production is reduced due to the lack of forageable food. Additional threats to livestock arise from the reduced water supply for rural water systems that are not interconnected or that are not supplied by a reliable source. This is especially true in the northwest part of the region. Water for confined livestock (e.g., dairy cattle and poultry) and for crop irrigation typically comes from groundwater.

Water quality can also pose a threat to agricultural resources. Increased levels of salts and total dissolved solids may damage certain crops and require additional water for irrigation. High levels of salts can accumulate on the surface soils, creating a hardpan effect that impedes percolation of irrigated water. As water quality degrades, crop selection and production may be limited. An additional threat to crop production is the migration into agricultural land of municipal well fields to supply groundwater to growing cities. Groundwater Conservation Districts and Underground Water Conservation Districts have been created in part to manage groundwater supplies that may have competing interests.

#### Threats to Natural Resources

The Brazos River Basin within the BGRWPA is a freshwater eco-region that is defined as primarily temperate coastal rivers and lakes habitat, with high ranking habitats for fish, reptiles and amphibian species.[21] Identified threats to these biological resources stem from the combined effects of land use disturbance, reduced stream flow from prolonged droughts as well as current and future water diversions from water supply projects, lower lake levels, and impacted quality of surface and groundwater. Declining flows can affect the availability and quality of aquatic habitats and streamside vegetation and also contribute to changes in water temperature and chemistry. As discussed in Section 1.7.2, water quality in the Brazos River Basin has been degraded by increased concentrations of chlorides, dissolved metals, ammonia, nitrates, and phosphates, pesticides, algae, and fecal coliform bacteria. Under lower flow conditions, greater effects from pesticide contamination could occur through higher concentrations of chlorinated hydrocarbons and organic phosphates. A summary of potential effects that identified threats would have on biological resources is presented in Table 1-10. The water resources impacted by water quality concerns identified in Section 1.7.2 within the Brazos River Basin are presented in Table 1-11.

Reduced stream flows and reservoir levels, which are brought on by drought and increases in water use, pose the greatest potential threat to aquatic species in the region. Lower stream flows would alter the proportion of stream runs, riffles, pools, and backwater sloughs and decrease the wetted perimeter (total available habitat). These changes in habitat may benefit some species, primarily hardy, generalist species, but would negatively impact most species and result in reduced species richness. Riparian vegetation is also threatened by less over bank flooding and a shift to more mesic (drier) conditions with a decline in those species that are dependent on flooding processes (cottonwood, willow, and pecan) and an increase in species tolerating drier conditions (hackberry and mesquite).

**Table 1-10. Summary of Regional Threats to Biological Resources in the Brazos River Basin**

| Threat | Potential Effects to Aquatic Organisms | Potential Effects to Riparian Vegetation |
|---|---|---|
| ***Rivers & Streams*** | | |
| Lower Streamflows | Decreased stream runs, riffles, pools, and backwater sloughs resulting in lower habitat diversity and species richness. | Less overbank flooding and shift to more mesic (drier) conditions with decline in species dependent on flooding processes and increase in species tolerating drier conditions. |
| Lower Water Quality | Lower habitat suitability; lower habitat diversity, species richness, and abundance; possible direct and indirect adverse effects from point and non-point source contaminants. | Potentially enhanced growth from higher concentrations of phosphorus, nitrates, and other nutrients; but increased growth could be suppressed by lower water tables from declining flows, increased salinities or exposure to contaminants. |

[21] Abell, R.A, D.M. Olson, E. Dinerstein, P.T. Hurley, J.T. Diggs, W. Eichbaum, S. Walters, W. Wettengel, T. Allnutt, C.J. Loucks, and P. Hedao. 2000. Freshwater Eco-regions of North America – A Conservation Assessment. World Wildlife Fund. Island Press. Washington D.C. 320 pp.

### Table 1-10. Summary of Regional Threats to Biological Resources in the Brazos River Basin

| Threat | Potential Effects to Aquatic Organisms | Potential Effects to Riparian Vegetation |
|---|---|---|
| ***Reservoirs*** | | |
| Lower Reservoir Levels | If prolonged, less available habitat resulting in lower species diversity & species abundance. If seasonal, potential positive effects through enhanced fishery production, depending on timing and duration of subsequent rising lake levels. | Increase in growth of shoreline herbaceous and woody vegetation during lower lake levels, but growth suppressed or reversed by rising lake levels and seasonal inundation. |
| Lower Water Quality | Lower habitat suitability; lower habitat diversity, species richness, and species abundance. | Potentially enhanced growth from higher concentrations of phosphorus, nitrates, and other nutrients; but growth suppressed or reversed through lower water tables from declining flows, increased salinities or exposure to contaminants. |
| ***Bays & Estuaries*** | | |
| Reduced freshwater inflows | Possible change in hydrological dynamics of estuary. Projected effects would be minimal due to limited coastal marsh habitats associated with the Brazos River Estuary. | Effects considered minimal due to limited coverage resulting from previous levee construction and river channelization. |

### Table 1-11. Location of Threats to Biological Resources Related to Water Quality in the Brazos Basin

| Identified Threats | Upper Basin | Upper Central Basin | Lower Central Basin | Lower Basin |
|---|---|---|---|---|
| Increased Chlorides | Salt and Double Mountain Forks; Clear Fork; White River Lake. | Upper Brazos River | Lake Limestone | |
| Fecal Coliform Bacteria | Millers Creek; | Upper Brazos River; Possum Kingdom Lake; Lake Granbury; Lake Whitney; Bosque River; Lake Waco; Lake Proctor; Leon River; Lake Belton | Central Brazos River | Lower Brazos River |
| Dissolved Oxygen | | | | Lower Brazos River |
| Increased Nutrients[1] | Clear Fork of the Brazos; Deadman Creek; California Creek | Bosque River; Lake Waco; Lake Proctor, Leon River; Lake Belton; Salado Creek | Central Brazos River; Still Creek/Thompson Creek; Lake Limestone; Lake Granger | Lower Brazos River |
| Algae | | Upper Brazos River; Bosque River; Lake Waco | | Lower Brazos River |
| Pesticides & Heavy Metals | Upper Brazos River | Upper Brazos River; Aquilla Creek | | |

[1] Includes: Ammonia, Phosphorus, Nitrogen, Nitrate-Nitrogen

## 1.11 Drought Preparations

With the significant historical growth across the state and considering the current projections for future growth in the Brazos G area, the demand for water is expected to continue increasing. Preparation and planning for potential future drought(s) is critical to ensuring a sufficient water supply is available to meet user demands. Refer to Chapter 7 of this plan for detailed information concerning the drought of record in the Brazos G area, current drought preparation and considerations, and recommendations for additional regional level drought response planning tools.

Drought contingency plans are required by the State for wholesale water suppliers, irrigation districts, and retail water suppliers. For surface water right-holders that supply 1,000 acft/yr or more for non-irrigation use and 10,000 acft/yr for irrigation use, SB1 requires a water conservation plan. To aid entities in the region with the development of these plans, example water conservation and drought management plans are provided in Appendices J and K.

In addition, conservation plans are commonly included in the management plans of Groundwater Conservation Districts or Underground Water Conservation Districts.

# 1.12 Existing Programs and Goals

## 1.12.1 Groundwater Regulation

### Priority Groundwater Management Areas (PGMAs)

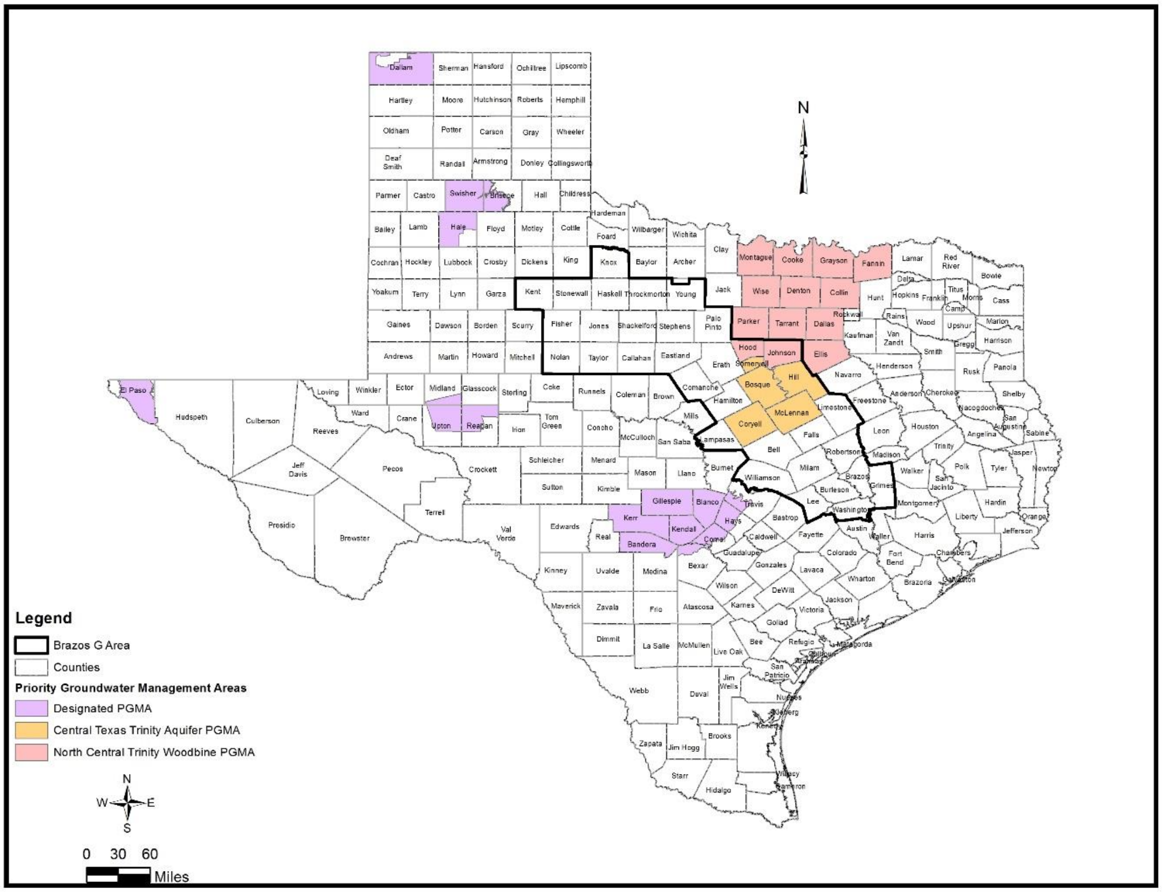
The Texas Legislature authorized the TCEQ to identify and delineate priority groundwater management areas (PGMAs) as "those areas of the state that are experiencing or that are expected to experience, within the immediately following 25-year period, critical groundwater problems, including shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, and contamination of groundwater supplies" (§Section 35.007, Chapter 35, Title 2, Texas Water Code).

Following a PGMA designation, TCEQ may recommend creating a groundwater conservation district. Citizens in the PGMA have two years to establish a Groundwater Conservation District (GCD). If a GCD is not established in the required timeframe, a GCD will be established that is consistent with the original TCEQ recommendation, which will be governed by a locally elected board of directors.

TCEQ designated two PGMA areas in the BGRWPA, the Central Texas-Trinity Aquifer PGMA and the Northern Trinity and Woodbine Aquifers PGMA, shown on Figure 1-22. TCEQ designated the Central Texas-Trinity Aquifer PGMA on October 31, 2008. Counties in this PGMA include Bosque, Coryell, Hill, McLennan, and Somervell. The Northern Trinity and Woodbine Aquifers PGMA was designated on February 11, 2009. This PGMA includes Collin, Cooke, Dallas, Denton, Ellis, Fannin, Grayson, Hood, Johnson, Montague, Parker, Tarrant, and Wise counties. Only Hood and Johnson counties are in the Brazos G Area.

At the time of this plan, all affected counties in the PGMA areas are part of GCDs. In 2007 the Upper Trinity GCD was formed, which includes Hood County. In May 2009, Bosque County joined the Middle Trinity GCD. The Tablerock GCD, which included Coryell County, was dissolved by the Legislature; Coryell County joined the Middle Trinity GCD in 2009. In 2009, the Texas Legislature created the Prairielands GCD and the Southern Trinity GCD. The Prairieland GCD includes Johnson, Hill and Somervell counties. At this time, only McLennan County is part of the Southern Trinity GCD. A map of groundwater conservation districts is presented in Figure 1-23.

**Figure 1-22. Priority Groundwater Management Areas**




## Groundwater Conservation Districts and Groundwater Management Areas

There are thirteen GCDs in the BGRPA, as shown on Figure 1-23 and listed in Table 1-12. All GCDs are required to develop and implement a management plan to manage groundwater resources. A list of the GCDs' management plan approval dates are shown on Table 1-12 and are available through the TWDB website.

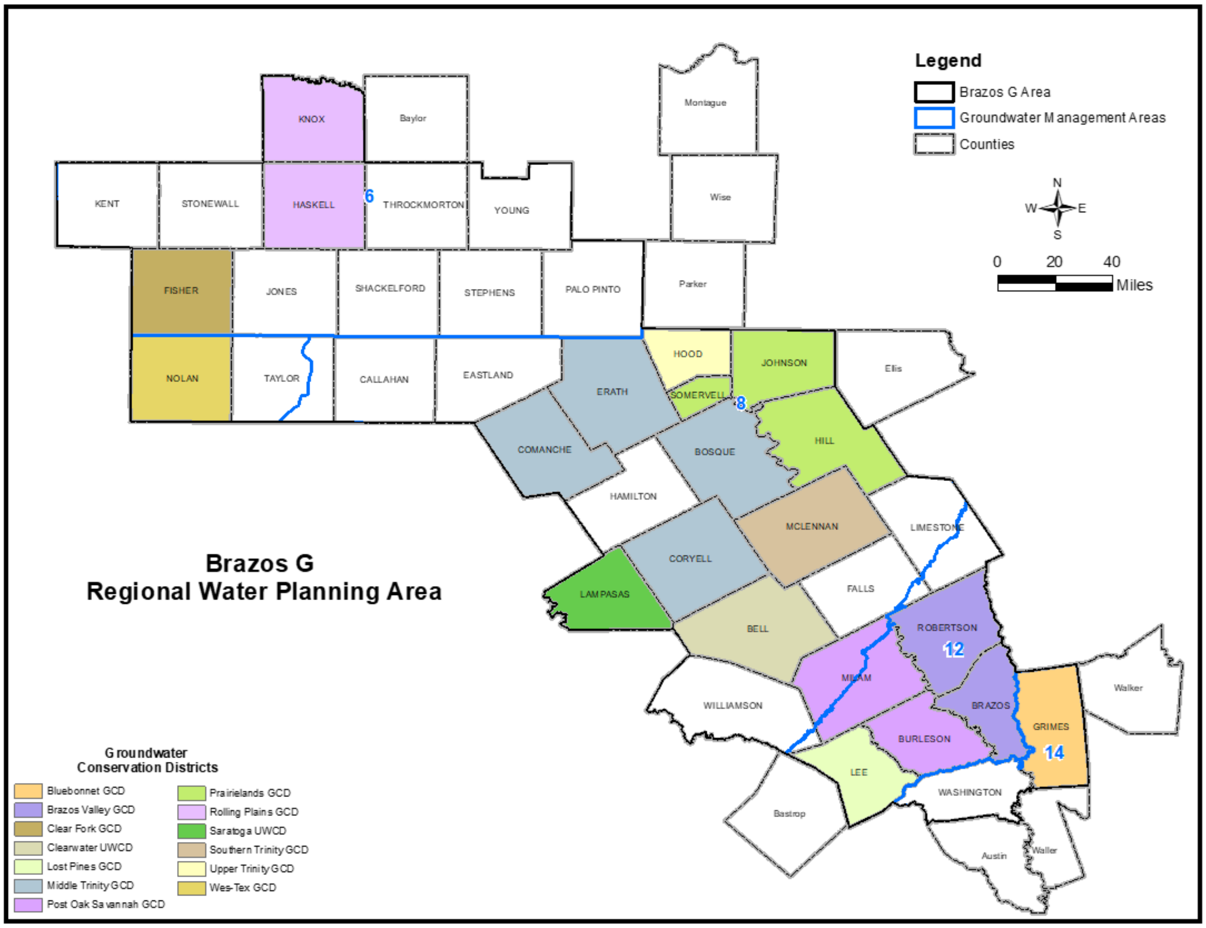
In 2001, Senate Bill 2 of the 77th Texas Legislature authorized the TWDB to designate Groundwater Management Areas (GMAs) that would include all major and minor aquifers of the state. Sixteen GMAs were delineated and adopted by the TWDB in 2002 and cover all major and minor aquifers in Texas. The BGRWPA intersects GMA 6, 7, 8, 12, and 14. These GMAs are shown on Figure 1-23 and are listed in Table 1-13.

In 2005, House Bill 1763 of the 79th Texas Legislature required GCDs in groundwater management areas to meet and define the Desired Future Conditions (DFCs) of the groundwater resources within the groundwater management area. The legislation requires that the DFCs be defined by September 1, 2010 and every 5 years thereafter. This requires joint planning among the GCDs in each GMA to determine Desired Future Conditions.

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." 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).

After the DFCs are determined by the GMAs, the TWDB performs quantitative analysis to determine the amount of groundwater available for production that does not exceed the DFC. For aquifers where a Groundwater Availability Model (GAM) exists, the GAM is used to develop the MAG (Available Groundwater). The MAG estimated through this process is then used by RWPGs as the available groundwater for the planning period. For aquifers or local groundwater that are not listed as a minor or major aquifer, the water availability is based on historical use and available hydrogeological records. Table 1-13 shows the status of the Desired Future Conditions development, and the status of the determination of Modeled Available Groundwater (MAG) for each GMA in the BGRWPA.

## Figure 1-23. Groundwater Conservation Districts and Groundwater Management Areas Located Wholly or Partially within the Brazos G Area




## Table 1-12. Groundwater Conservation District Management Plan Approval Dates

| Name of District | Date Plan Approved |
|---|---|
| Bluebonnet Groundwater Conservation District | 12/31/2018 |
| Brazos Valley Groundwater Conservation District | 05/13/2019 |
| Clear Fork Groundwater Conservation District | 01/15/2015 |
| Clearwater Groundwater Conservation District | 03/12/2019 |
| Lost Pines Groundwater Conservation District | 01/24/2018 |
| Middle Trinity Groundwater Conservation District | 02/08/2019 |
| Post Oak Savannah Groundwater Conservation District | 12/29/2017 |
| Prairielands Groundwater Conservation District | 05/31/2019 |
| Rolling Plans Groundwater Conservation District | 09/15/2015 |
| Saratoga Groundwater Conservation District | 08/31/2020 |
| Southern Trinity Groundwater Conservation District | 09/15/2015 |
| Upper Trinity Groundwater Conservation District | 12/10/2018 |
| Wes-Tex Conservation District | 03/18/2020 |

**Table 1-13. Groundwater Conservation Districts, Aquifers, Desired Future Conditions (DFCs), and Modeled Available Groundwater (MAG) Status by GMA for the Brazos G Area**

| Groundwater Management Area 6 | | | |
|---|---|---|---|
| Clear Fork GCD, Rolling Plains GCD | | | |
| **Aquifer** | **Major or Minor Aquifer?** | **Desired Future Conditions Status** | **Modeled Available Groundwater Status** |
| Seymour | Major | Adopted 11/17/2016 | Submitted 06/30/2017. GR 16-031 MAG |
| Dockum | Minor | Adopted 11/17/2016 | Submitted 06/30/2017. GR 16-031 MAG |
| Blaine | Minor | Adopted 11/17/2016 | Submitted 06/30/2017. GR 16-031 MAG |
| Cross Timbers | Minor | No DFC Adopted[1] | - |
| **Groundwater Management Area 7** | | | |
| Wes-Tex GCD | | | |
| **Aquifer** | **Major or Minor Aquifer?** | **Desired Future Conditions Status** | **Modeled Available Groundwater Status** |
| Edwards-Trinity(Plateau) | Major | Adopted 03/22/2018 | Submitted 09/21/2018. GR 16-026 MAG Version 2 |
| Dockum | Minor | No DFC Adopted[1] | - |
| **Groundwater Management Area 8** | | | |
| Clearwater UWCD, Middle Trinity GCD, Post Oak Savannah GCD[2], Prairielands GCD, Saratoga UWCD, Southern Trinity GCD, Upper Trinity GCD | | | |
| **Aquifer** | **Major or Minor Aquifer?** | **Desired Future Conditions Status** | **Modeled Available Groundwater Status** |
| Trinity | Major | Adopted 01/31/2017 | Submitted 01/19/2018. GR 17-029 MAG |
| Edwards (BFZ) | Major | Adopted 01/31/2017 | Submitted 01/19/2018. GR 17-029 MAG |
| Brazos River Alluvium | Minor | No DFC Adopted[1] | - |
| Ellenburger-San Saba | Minor | Adopted 01/31/2017 | Submitted 01/19/2018. GR 17-029 MAG |
| Hickory | Minor | Adopted 01/31/2017 | Submitted 01/19/2018. GR 17-029 MAG |
| Marble Falls | Minor | Adopted 01/31/2017 | Submitted 01/19/2018. GR 17-029 MAG |
| Woodbine | Minor | Adopted 01/31/2017 | Submitted 01/19/2018. GR 17-029 MAG |
| **Groundwater Management Area 12** | | | |
| Brazos Valley GCD, Post Oak Savannah GCD[2], Lost Pines GCD | | | |
| **Aquifer** | **Major or Minor Aquifer?** | **Desired Future Conditions Status** | **Modeled Available Groundwater Status** |
| Carrizo-Wilcox | Major | Adopted 05/25/2017 | Submitted 12/15/2017. GR 17-030 MAG |
| Brazos River Alluvium | Minor | Adopted 05/25/2017 | Submitted 12/15/2017. GR 17-030 MAG |
| Queen City | Minor | Adopted 05/25/2017 | Submitted 12/15/2017. GR 17-030 MAG |
| Sparta | Minor | Adopted 05/25/2017 | Submitted 12/15/2017. GR 17-030 MAG |
| Yegua-Jackson | Minor | Adopted 05/25/2017 | Submitted 12/15/2017. GR 17-030 MAG |

| Groundwater Management Area 14 | | | |
|---|---|---|---|
| Bluebonnet GCD | | | |
| **Aquifer** | **Major or Minor Aquifer?** | **Desired Future Conditions Status** | **Modeled Available Groundwater Status** |
| Carrizo-Wilcox | Major | No DFC Adopted[1] | - |
| Gulf Coast | Major | Adopted 04/29/02016 | Submitted 12/15/2016. GR 16-024 MAG |
| Brazos River Alluvium | Minor | No DFC Adopted[1] | - |
| Queen City | Minor | No DFC Adopted[1] | - |
| Sparta | Minor | No DFC Adopted[1] | - |
| Yegua-Jackson | Minor | No DFC Adopted[1] | - |

[1] No DFC is currently adopted by GMA for this aquifer and no corresponding MAG has been published by the GMA. Availability estimates presented elsewhere in this plan are based on historic modeling and/or modeling during MAG development for other aquifers. [2] Post Oak Savannah GCD is in GMA 8 and GMA 12.

Texas Clean Rivers Act

In 1991, the 72nd Legislature passed the Texas Clean Rivers Act [22] to establish for the first time a watershed basis for water quality planning in Texas.[23,24] The Act requires each river basin in the State to be assessed for water quality and management strategies on an on-going basis. It also requires reports to be provided to the TCEQ every even-numbered year.[25] The Act provides specific guidelines for accomplishing the water quality assessments, including: (1) comprehensive assessments on a watershed basis with emphasis on non-point sources, nutrients, and toxic materials; (2) delegation of responsibility for assessments to river authorities; (3) formation of river basin steering committees; (4) discharge permitting on a basin-wide basis; and (5) assessment fees charged to wastewater- and water-rights permittees.

The BRA is a partner with the TCEQ in the Clean Rivers Program for the BGRWPA. The program provides funding for BRA staff to assess water quality in the Brazos River Basin and to document local problems. Also, the program provides fee payers with site-specific information on water quality such as receiving water assessments and flow data. The 2004 Report[26] for the Brazos River Basin provides an assessment of water quality for the basin, drawing attention to: (1) the need for more long-term data on water quality, (2) a continued emphasis on the Basin Steering Committee for direction and comment on the water quality assessment program, (3) continued assistance in water quality monitoring from local partners in the Basin Monitoring Program, (4) emphasis on assessing and maintaining data, and (5) development of a geographical information system for the basin. The 2004 Report provides detailed findings about water quality and related items for selected sub-

[22] Senate Bill 818, amending the Texas Water Code, Sections 5.103, 5.105, 26.011; T.A.C. Sections 320.1-320.9

[23] TNRCC, Op. Cit., 1992.

[24] TNRCC, Op. Cit., 1999.

[25] BRA, “Planning and Environmental Division”, [Online] Available URL: http://www.brazos.org/home.htm, 1999.

[26] BRA, Op. Cit., 2004.

watersheds of the basin. The findings most relevant to the BGRWPA were summarized in Section 1.7.2.

### 1.12.2 Clean Water Act

The 1972 Federal Water Pollution Control Act, which as amended is called the Clean Water Act, is the federal law with the most impact on water quality protection in the BGRWPA. As amended in 1977 and again in 1987, the Clean Water Act: (1) establishes the framework for monitoring and controlling industrial and municipal point-source discharges through the National Pollutant Discharge Elimination System (NPDES), (2) authorizes federal assistance for the construction of municipal wastewater treatment facilities, and (3) requires cities to obtain permits for stormwater or non-point-source discharges.[27] The Clean Water Act also includes provisions to protect specific aquatic resources. Section 303 establishes a non-degradation policy for high quality waters and provides for establishment of state standards for receiving water quality. Section 401 allows states to enforce water quality requirements for federal projects such as dams. Section 404 provides safeguards for wetlands and other waters from the discharge of dredged or fill material. Section 305 calls for the TCEQ to prepare and submit a water quality inventory to the U.S. Environmental Protection Agency.[28] Other provisions protect particular types of ecosystems such as lakes (Section 314), estuaries (Section 320), and oceans (Section 403).[29] Several of these provisions are relevant to specific water quality concerns in the BGRWPA.

### 1.12.3 Safe Drinking Water Act

The Safe Drinking Water Act, passed in 1974 and amended in 1986 and 1996, allows the U.S. Environmental Protection Agency to set standards for drinking water quality. These standards are divided into two categories: National Primary Drinking Water Regulations (primary standards that must be met by all public water suppliers) and National Secondary Water Regulations (secondary standards that are not enforceable, but are recommended). Primary standards protect water quality by limiting levels of contaminants that are known to adversely affect public health and that are anticipated to occur in water. Secondary standards have been set for contaminants that may affect cosmetic or aesthetic qualities of water (e.g., taste, odor, or color). For some constituents, the State of Texas has secondary standards that differ from the National standards.

### 1.12.4 Source Water Assessment and Protection Program

The TCEQ’s Source Water Assessment and Protection (SWAP) Program can be an important part of water resource management. The SWAP Program, authorized by the Safe Drinking Water Act, assists local jurisdictions in preventing contamination of drinking water supplies. It identifies sources of public drinking water, determines potential contaminants, assesses water systems’ susceptibility to contamination, and informs the

[27] 33 USCA, Sections 1251 through 1387.

[28] TWDB, 1997.

[29] Adler, R.W., Landman, J. and Cameron, D., *The Clean Water Act: Twenty Years Later*, Island Press, Washington D.C., 1993.

public of the results. It is part of a comprehensive, integrated approach to clean ground and surface water undertaken by the TCEQ.

The centerpiece of the SWAP Program is a focus on prevention. Water can be easily contaminated, but it is difficult and expensive to clean up. Through the SWAP Program, by preventing contamination, jurisdictions are able to avoid the cost of removing contamination and maintain clean, reliable sources for drinking water.

The SWAP Program is designed to assist Texas communities in protecting their drinking water sources. Its goal is to increase public awareness of the importance of protecting drinking water sources and actions that can be taken to protect those sources. The SWAP Process involves seven steps:

1. Delineation (or mapping) of source water protection areas, any areas surrounding a drinking water source, whether from ground or surface water;
2. Conducting an inventory of actual or potential sources of contamination in the delineated area;
3. Conducting an analysis of the relative susceptibility of the water supply to those contamination sources and presenting the results to the public water supply in the form of a Source Water Susceptibility Assessment Report. These results provide insights into activities near your water sources and serve as the starting point for implementing source water protection.
4. Working with selected local communities to make information available to the public;
5. Voluntary application of best management practices to prevent contamination, such as land use practices, regulations and permits, structural measures, good housekeeping practices, public education and emergency response planning;
6. Monitoring and continually assessing source water supplies; and,
7. Conducting triennial sampling and continually monitoring, assessing and conducting protection activities.

By conducting continual monitoring, assessment and protection activities, communities can minimize potential sources of contamination and protect source water supplies over the long-term.

## 1.12.5 State Water Availability Modeling Initiatives

### TCEQ Water Availability Models (WAMs)

Water Availability Models (WAMs) are computer-based simulation models used to determine water availability for surface water rights under Texas' priority system. These models are used to evaluate water availability for newly requested water rights or water right amendments. The models are also used for regional water planning. There are twenty individual WAMs that cover the twenty-three river basins in Texas, including coastal basins. The period of record most WAMs is approximately 1940 to 1997, although the hydrology has been extended for the Colorado WAM through 2016. The TCEQ has initiated an update of the Brazos WAM to extend the hydrologic data in the model through 2018.

There are two WAM scenarios used and maintained by TCEQ staff:

- Full Authorization (Run3) – In the Full Authorization scenario all water rights utilize their full authorized amounts. This scenario is used to evaluate perpetual water rights and amendments.
- Current Conditions (Run 8) – The Current Conditions scenario Includes return flows, current reservoir conditions and has water rights diversions based on historical use. This scenario is used to evaluate term water rights.

Most of the Brazos G Planning Area falls within the area covered by the Brazos WAM. Existing supplies and future water management strategies were evaluated using a modified WAM Run 3. The modified WAM Run3 includes existing and future sediment conditions for reservoirs.

### TWDB Groundwater Availability Models (GAMs)

Groundwater Availability Models (GAMs) were developed under the direction of the TWDB. The GAMs cover most of the major and minor aquifers within Texas. The GAMs are used in the regional planning process as discussed in 1.11.1. Based on the agreed upon Desired Future Condition (DFC) the GAMs are run to develop the MAG for each aquifer to be used in the Regional Planning Process.

## 1.13 Previous Water Supply Planning in the Brazos G Area

As discussed in previous sections, the Brazos G Area is a large and diverse with varying needs of water users in the different parts of the region. In response to these different needs, the region has a history of successful local water supply planning and development. These studies are too numerous to identify and list in entirety here. Some of the more recent studies include:

- Bosque County water treatment and distribution study to address water needs in Bosque County in the central Brazos River Basin. The study was completed in March 2004.[30]
- The Brazos River Authority and Tarrant Regional Water District sponsored a water supply study for Parker and Johnson Counties in the central Brazos River Basin to meet the growing needs of this area. Phase 1 of the study was completed in April 2004.[31]
- The West Central Brazos River Basin Regional Water Treatment and Distribution Facility Study evaluated water needs in the upper Brazos River Basin. This study was completed in August 2004.[32]

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[30] Carter-Burgess, March 2004, Bosque County Regional Water Treatment and Distribution Facilities Plan, Final Report to the Brazos River Authority.

[31] Freese and Nichols, April 2004, Regional Water Supply and Wastewater Service Study for Johnson and Parker Counties, Phase I.

[32] Freese and Nichols, August 2004, West Central Brazos River Basin Regional Water Treatment and Distribution Facility Plan.

- Bell/Williamson Regional Water Supply Facility Plan – Included eight participants in southern Bell County and Northern Williamson County. The study recommended the cooperation of these eight participants in development of infrastructure and water supply projects.
- The City of Abilene and the Cities of Midland and San Angelo (Region F) have formed the West Texas Water Partnership (WTWP) to identify and secure long-range water supplies for the three cities and the surrounding region. Results from ongoing studies will be reflected in future regional water plans.
- The Falls, Hill, Limestone, and McLennan Counties (FHLM)-TWDB Regional Water Facility Planning Study evaluated the feasibility of a regional water system to replace and/or supplement multiple smaller water systems currently providing service within the FHLM area. The study addresses elevated arsenic concentrations experienced by study participants and also evaluates water treatment and transmission alternatives to meet the arsenic Maximum Contaminant Level (MCL). [33]

Brief summaries of the *Brazos G Regional and State Water Plans* and several studies completed recently are presented in the following sections.

## 1.13.1 Brazos G Regional and State Water Plans

Since SB1 was passed in 1997, the Brazos G Regional Planning Group has completed four rounds of planning, with regional plans adopted in 2001, 2006, 2011, and 2016. These regional plans have been rolled up with 15 other regional plans into the State Water Plan in 2002, 2007, 2012, and 2017 respectively. Each successive plan has been updated to reflect the most relevant information at the time. This section provides a brief summary of each of the Brazos G Regional water Plans and the State Water Plans.

### 2001 Brazos G Regional Water Plan[34]

The 2001 Brazos G Regional Water Plan found that on a regional basis, there are sufficient water supplies to meet the projected demands. In year 2050, the region was projected to have a surplus of about 500,000 acre-feet per year, yet there were some entities that did not have enough water to meet projected needs. The highest growth areas were identified along the I-35 corridor in the central part of the region, straining existing groundwater supplies. Slower economic growth and implementation of previous long-term planning in the upper Brazos G Area resulted in fewer municipal needs in this part of the region. However, water quality concerns in the upper Brazos River Basin can limit water supplies.

The major recommended strategies in the 2001 plan included four new major reservoirs, reallocation of hydropower storage in Lake Whitney, coordinated operation of reservoir systems for the Brazos River Authority and the City of Abilene, chloride control in the upper Brazos River Basin, and further development of groundwater from the Carrizo-Wilcox aquifer. Since the plan was completed, the California Creek Diversion Project, a recommended strategy in the 2001 plan for the City of Stamford to supplement supplies

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[33] Susan Roth, 2015, Final Draft Report – FHLM Regional Water Facility Planning Study

[34] Brazos G Regional Planning Group, January 2001, Regional Water Plan

from Lake Stamford, has been constructed and is operational. Other smaller projects also have been completed or are in the design phase.

The recommended new major reservoirs include:

- Millican Reservoir (Bundic Dam Site):
- Little River Reservoir:
- South Bend Reservoir (long-term strategy):
- Breckenridge Reservoir (long-term strategy):

### 2006 Brazos G Regional Water Plan[35]

In the 2006 plan, a comparison of total supplies available in the region with demand for all use categories in the region shows a surplus past the year 2050. These mask shortages that are projected to occur to individual water supply entities and water user groups. Shortages were shown for entities in 32 of the 37 counties in the Brazos G Area. The recommended water strategies included advanced water conservation, wastewater reuse, system operation of Brazos River Authority Reservoirs, conjunctive use, desalination, aquifer storage and recovery, brush management, weather modification, six new on-channel and five new off-channel reservoirs, regional interconnection, Carrizo-Wilcox aquifer development and voluntary redistribution. The total supply from these recommended water supplies is over 590,000 acre-feet per year at an estimated cost of over $1 billion.

### 2011 Brazos G Regional Water Plan[36]

In the 2011 plan, a comparison of total supplies available in the region (developed groundwater supplies and firm surface water) with demand for all use categories in the region shows a surplus past the year 2040. These mask shortages that are projected to occur to individual water supply entities and water user groups. Shortages are projected for Williamson County starting at about the year 2020, while overall regional supplies are projected to exceed regional demands until past the year 2040. Even within most counties that have projected overall surpluses, there are individual entities that do not have sufficient supply to meet projected needs. Shortages were shown for entities in 31 of the 37 counties in the Brazos G Area. The recommended water strategies included advanced water conservation, wastewater reuse, system operation of Brazos River Authority Reservoirs, conjunctive use, desalination, aquifer storage and recovery, brush management, weather modification, nine new on-channel and six new off-channel reservoirs, regional interconnection, Carrizo-Wilcox aquifer development, voluntary redistribution, storage reallocation of federal reservoirs and reservoir connections. The total supply from these recommended water supplies is over 587,000 acre-feet per year at an estimated cost of over $3 billion.

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[35] Brazos G Regional Planning Group, January 2006, Regional Water Plan

[36] Brazos G Regional Planning Group, January 2011, Regional Water Plan

## 2016 Brazos G Regional Water Plan[37]

Municipal demands are developed assuming a hot, dry year, with 2011 typically selected as the basis for estimating daily per capita use values (GPCD) for each WUG. Conservation is considered first as a water management.

The 2016 Brazos G Regional Water Plan includes recommendations for 99,573 acft/yr of municipal conservation savings and another 46,662 acft/yr for wastewater reuse. The conservation savings are in excess of those already included in the TWDB demand projections. Conservation recommendations for several entities in Williamson County go beyond this and call for a reduction to a target of 120 GPCD by 2070.

Total new supplies of water into the Brazos G Area total 397,655 acft/yr, comprised of newly developed groundwater, supply transferred from other regions, newly developed surface water supplies, or supplies made available through conservation or augmentation of existing facilities. Total project costs for these new supplies exceed $2.5 billion.

System operation of the Brazos River Authority's reservoirs can increase supplies in the Brazos G Area by nearly 167,000 acft/yr (assuming interruptible supplies can be firmed up through conjunctive operation with other sources), with additional supplies available to the Region H Area in the lower basin. This strategy would more efficiently utilize the existing resources of the BRA by expanding the supply that can be developed from the BRA's existing reservoirs, thus delaying the need for new reservoirs to meet growing needs in the basin. Related to this, overdrafting of Lake Granger when the reservoir is nearly full and injecting part of this supply into the Trinity Aquifer through an Aquifer Storage and Recovery (ASR) project can yield an additional 9,050 acft/yr of supply when the ASR well field is operated in conjunction with Lake Granger to meet demands.

During the Brazos G regional water planning process, water management strategies such as additional development of Carrizo-Wilcox Aquifer groundwater and the Lake Granger Augmentation Project were preferred options to include in the 2016 Brazos G Regional Water Plan. When confronted by the Modeled Available Groundwater (MAG) limitations of these two options, the BGRWPG had little alternative but to make the Little River Off-Channel Reservoir a recommended strategy.

## Water for Texas 2002[38]

This was the first State Water Plan to be adopted by the TWDB after the passage of SB1 in 1997. It was estimated that by 2050, almost 900 cities statewide (representing 38 percent of the projected population) and other water users will need either to reduce demand (through conservation and/or drought management) or develop additional sources of water beyond those currently available to meet their needs during droughts. The proposed water management strategies had an estimated cost of $17.9 billion.

[37] Brazos G Regional Planning Group, January 2016, Regional Water Plan

[38] Texas Water Development Board, January 2002, Texas State Water Plan.

### Water for Texas 2007[39]

The state was projected to grow from 21 million people in 2000 to approximately 46 million people in 2060. It was estimated that Texas would need 8.8 million acre-feet of water by 2060 to meet this growth. The 16 Regional Water Planning Groups identified 4,500 water management strategies to provide an additional 9.0 million acre-feet of water. The estimated cost of these strategies was approximately $30.7 billion. Without this investment there would be a potential $9.1 billion impact to businesses and workers by 2020 with increased impact of $98.4 billion by 2060.

### Water for Texas 2012[40]

The 16 Regional Water Planning Groups (Planning Groups) identified a total of 2,569 water user groups. Of those groups, 895 (35 percent) in 2020 would have water supply needs if the state were facing drought conditions, increasing to 1,085 (42 percent) in 2060. The Water Planning groups recommended feasible water management strategies to meet most of those needs. Solutions proposed by the Planning Groups include strategies such as the use of currently developed surface water and groundwater sources, conservation, reuse, new interbasin transfers, and development of additional groundwater and surface water resources. 26 new reservoirs were recommended by the Planning Groups to meet identified needs of the water user groups. The Planning Groups estimated total capital costs over the next 50 years to meet needs for additional water supplies at $53 billion, including $27 billion to implement strategies for municipal water user groups. Meeting these costs will require a long-term financial commitment from local political subdivisions, regional authorities, and the State of Texas.

### Water for Texas 2017[41]

The 16 Regional Water Planning Groups (Planning Groups) identified a total of 4.76 million acre-feet per year of water needs in 2020, increasing to 8.89 million acre-feet/year by 2070. These needs include 511,000 acre-feet/year of municipal needs in 2020 and 3.41 million acre-feet/year in 2070, a 568 percent increase. The 16 regional water planning groups recommended about 5,500 water management strategies. The principal strategies to address those needs include demand management (mostly in the form of conservation) (30 percent of the supply recommended), reuse of wastewater (14 percent), additional groundwater development (10 percent), and surface water strategies (45 percent). Planning groups recommended 26 new major reservoir that would provide about 1.1 million acre-feet per year of new supplies. About 2,500 individual projects are associated with the recommended water management strategies, with an estimated implementation cost of $63 billion.

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[39] Texas Water Development Board, January 2007, Texas State Water Plan.

[40] Texas Water Development Board, January 2012, Texas State Water Plan.

[41] Texas Water Development Board, January 2017, Texas State Water Plan.

### 1.13.2 Bosque County Regional Water Treatment and Distribution Facilities Plan

The *2001 Brazos G Regional Water Plan* identified several water users in Bosque County with shortages over the planning period. In an attempt to address this widely known shortage, the Brazos River Authority, Texas Water Development Board, and the Cities of Clifton and Meridian jointly sponsored a study to determine the regional water needs and to evaluate existing and proposed water facilities.

The study evaluated four alternatives to supply water to the different users, including individual treatment and delivery systems to a regional facility that would serve all participants. The study recommended the regional facility, which would include expansion of the City of Clifton's water treatment plant and interconnections to the other participants, including Clifton, Childress WSC, Meridian, Valley Mills and Walnut Springs.

### 1.13.3 Falls, Hill, Limestone, and McLennan Counties (FHLM) – TWDB Regional Water Facility Planning Study

FHLM WSC, in conjunction with 26 other entities, commissioned this study to evaluate the feasibility of developing a regional water infrastructure plan to serve existing and future populations through 2040 in the study area within Falls, Hill, Limestone, and McLennan Counties. Changes to the Maximum Contaminant Level (MCL) for arsenic published by the United States Environmental Protection Agency (USEPA) in 2001 caused a number of water systems to be non-compliant ue to naturally-occuring and elevated arsenic levels in local groundwater supplies. Additionally, regional declines in the Trinity Aquifer also created supply concerns beyond that of just the arsenic concentrations.

The study evaluated different alternatives for meeting the projects goals including blending of water with elevated arsenic concentrations, individual treatment systems violating the arsenic MCL, a new regional surface water treatment plant, and Carrizo-Aquifer development. The study recommended that the Carrizo-Wilcox Aquifer development project be implemented since it diversifies the water supply portfolio in a cost-effective manner for the member utilities while also securing long term water supplies. The study noted that individual treatment by affected utilities would provide the shortest development time period, and if a negotiated Agreed Order with the USEPA couldn't not be obtained for implementing the recommended Carrizo-Wilcox Regional Groundwater Project, individual treatment or blending should be pursued to satisfy USEPA requirements related to the arsenic MCL.

### 1.13.4 Regional Water Supply and Wastewater Service Study for Johnson and Parker Counties, Phase I

The Brazos River Authority and Tarrant Regional Water District (TRWD) jointly commissioned a study to investigate the feasibility of developing regional water supply and wastewater treatment facilities to serve the unmet needs of the two counties. The first phase of an anticipated two-phase study was completed in April 2004. The primary objective of the first phase was to identify and evaluate raw water supply and water and wastewater treatment concepts of mutual interest to the Authority, TRWD and their primary wholesale customers. Subject to the Phase I identification of concepts deemed worthy of additional study, a Phase II study may further study those options that show promise from an engineering, economic, water quality and institutional standpoint.

Phase I of the study identified several water supply scenarios to serve water user groups with projected shortages in each county. The study focused on concepts that would blend the higher TDS water from the Brazos Basin with lower TDS water from the Trinity River Basin to reduce the need to desalinate the Brazos Basin water. The study concluded that a regional water treatment plant in northwest Johnson County treating a blend of BRA and TRWD water could economically serve a large area of northwest Johnson, southwest Tarrant and southeast Parker counties, including the new growth in Fort Worth's extraterritorial jurisdiction. A second option involved a plant in northeast Johnson County which could supply a large area with unmet needs including the rapidly growing areas around Mansfield and Burleson. Phase II of the study is intended to provide more detailed information required by stakeholders to allow them to further evaluate these concepts in relation to their own interests and potential participation in a regional system. Phase II has not been initiated to date.

### 1.13.5 West Central Brazos River Basin Regional Water Treatment and Distribution Facility Study

The Brazos River Authority, Texas Water Development Board, and the U.S. Economic Development Administration sponsored a water treatment and distribution study for water users in the upper Brazos River Basin. This study was initiated in response to the significant drought that occurred in the late 1990s and subsequent years, and developed a plan to meet demands 25 percent greater than projected needs in order to account for the future uncertainties of droughts.

The West Central Brazos River Basin Regional Water Treatment and Distribution Facility Plan evaluated the water needs in an 18-county area, assessed the economic impacts of water shortages and identified a plan to develop and efficiently utilize the water resources in the area. Specific concerns identified in the study included water quality of surface water sources, limited groundwater sources, and limited existing infrastructure to move water from areas with supply to areas with needs.

Recognizing the vulnerability of small surface lakes and the uncertainty of groundwater, this study focused on interconnecting existing supply sources and developing new supplies to provide a safe level of supply to water users and increase the reliability of existing sources to promote economic growth in the region. Collectively, over 25 potential water management strategies were evaluated to meet specific needs in the region. In addition, three general strategies (brush control, weather modification and salt water control) were reviewed as potential means to improve water quality and quantity in the region.

The study conducted numerous hydraulic analyses to evaluate the possibility of moving water through existing and improved infrastructure, including the West Central Brazos Distribution System in Stephens County (formerly the Kerr-McKee pipeline). Two scenarios demonstrated the greatest potential impact to the region:

- Interconnection between Abilene and North Central Texas MWA
- Interconnections among Shackelford WSC, Stephens County Rural WSC and the City of Throckmorton using the West Central Brazos Distribution System

Other major strategies recommended in this study include:

- Regional water treatment plant to treat water from Possum Kingdom Lake
- Connection from Lake Stamford to Throckmorton
- Turkey Peak Reservoir in Palo Pinto County
- Diverting water from the Clear Fork of the Brazos River to Hubbard Creek Lake and increasing the capacity to transport water to Abilene

## 1.14 Summary of Water Loss Audits in Brazos G Area

Retail public water utilities are required to complete and submit a water loss audit form to the Texas Water Development Board. The first water loss audit reports were submitted to the TWDB by March 31, 2006. Entities with greater than 3,300 connections are required to submit their water loss audit to TWDB on an annual basis. In addition, all other retail public suppliers are required to submit a water loss audit once every five years with the next scheduled audit due May 1, 2021. Recently passed legislation requires that water loss audits be completed by a person trained to conduct water loss auditing. The TWDB offers in-person training across the State and also offers the training through an online Water Loss Auditor Training Video. The water audit reporting requirements follow the International Water Association (IWA) and American Water Works Association (AWWA) Water Loss Control Committee methodology.

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

In the Brazos G Area in 2017, sixty public water suppliers submitted a water loss audit to TWDB. Table 1-14 summarizes the water loss audit information that was collected by the TWDB for the 2017 calendar year. The average total water loss was nearly 19%, which is higher than the 2017 statewide average of 14.56%. The region encourages the reduction in water loss where feasible.

**Table 1-14. Summary of Water Loss Audits in the Brazos G Area**

| Statistic | Real Loss for WUGs with Less than 32 Connections per Mile (gal/mi/day) | Real Loss for WUGs with 32 or More Connections per Mile (gal/mi/day) | Apparent Daily Loss (gal/connection /day) | Total Water Use (GPCD) | Water Loss (GPCD) | Total Water Loss (%) |
|---|---|---|---|---|---|---|
| Median | 473.08 | 33.42 | 6.04 | 115.14 | 18.91 | 16.42 |
| Average | 776.21 | 42.96 | 9.19 | 119.16 | 22.63 | 18.99 |