Appendix B
Aquifer Descriptions and Groundwater Availability

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Method of Determination for Groundwater Availability

When available, the amount of groundwater available for development is based on the TWDB's determination of modeled available groundwater (MAG), which is based on desired future conditions (DFC), as established by members of Groundwater Conservation Districts within a Groundwater Management Area (GMA). If a groundwater availability model (GAM) is available for an aquifer, it is to be used by the TWDB in making the MAG determination.

For aquifers without an adopted MAG, the TWDB provided "total availability" estimates that are based on results from groundwater modeling during the development of the MAGs for other aquifers. For other aquifers, Brazos G utilized the groundwater availability estimate carried forward from the 2016 Brazos G Regional Water Plan; these were determined based on a variety of sources, predominately information from historical TWDB groundwater reports and the TWDB groundwater database. The Brazos G technical consultant requested specific groundwater availability estimates based on the above information, and coordinated closely with the TWDB staff to finalize the non-MAG groundwater availability estimates for aquifers in counties and river basins for which an official MAG has not been adopted.

The MAG determination is based upon drought-of-record conditions which would occur simultaneously with increased, dry-year demands. For groundwater systems sensitive to annual hydrologic variability, this this is a ration approach. However, supplies from some aquifer systems, such as the Carrizo-Wilcox Aquifer, are not sensitive to annual or short-term fluctuations in hydrology. For these systems, simply applying the MAG has been found to be an overly conservative estimate of availability. With the realization that demands in many years will be substantially less than the dry-year demands, the Brazos G Regional Water Planning Group has adopted a MAG Peak Factor to increase planning supplies, which is based on developing an annual pumping pattern that reflects annual variation in pumping from an aquifer over a period while not exceeding the cumulative volume that would be pumped by the MAG in that same period. Any adjustments to the MAG, such as the MAG Peak Factor, must still honor the established DFCs for a given aquifer. A MAG Peak Factor is incorporated for the Carrizo-Wilcox Aquifer in Brazos County for this planning cycle. This peak factor is a composite factor representing the cumulative availability for the Carrizo-Wilcox Aquifer system from both the Carrizo and Simsboro Formations and represents an annual available groundwater supply which is 15 percent to 20 percent greater across the planning horizon than the MAG. The development of this MAG Peak Factor is presented in Appendix N-1 of the Brazos G technical memorandum for this plan.

Blaine Aquifer

Location

The Blaine Aquifer, a minor aquifer, occurs in the extreme western part of Brazos G and east of the High Plains of Texas (Figure B-1).

Geohydrology

The Blaine Formation of the Pease River Group of Permian Age consists of beds of gypsum, anhydrite, halite, dolomite, sandstone, and shale. Not all beds are found throughout the formation, however the individual beds of gypsum and dolomite are laterally continuous. Recharge primarily occurs from precipitation on the outcrop, which is along the eastern edge of the formation. Discharge is to the wells, seepage to streams, or leakage to other formations. Saturated thickness reaches 300 feet in the aquifer, but freshwater saturated thickness averages about 135 feet. Groundwater occurs primarily in solution channels and caverns within the beds of anhydrite and gypsum that contribute to the overall poor quality of the water. Although some wells contain slightly saline water, with total dissolved solids between 1,000 and 3,000 milligrams per liter, most contain moderately saline water, with total dissolved solids between 3,000 and 10,000 milligrams per liter, exceeding secondary drinking water standards for Texas. The aquifer is under water table conditions in the eastern part of the aquifer and under confined conditions to the west.

Development and Use

While the upper part of the Blaine provides irrigation supplies from solutioning of gypsum and dolomite beds in adjacent planning areas, Ogilbee (1962) reports that similar conditions are not present in Knox County. They probably do not exist in Fisher, Nolan and Stonewall Counties either. The TWDB data base shows only a few livestock and household wells in the Blaine Aquifer in the four counties. These data show inventoried Blaine wells be less than 200 ft deep. Water quality is highly variable. The TWDB estimated 2017 pumpage from Blaine Aquifer in Brazos G at 335 acft/yr, of which 6 acft/yr was for municipal use.

Availability

The Blaine Aquifer in Brazos G is in GMA-6. In a letter dated June 2017, the TWDB referenced a report titled GAM Run 16-031 MAG, which presents the MAG for the Blaine Aquifer in GMA-6. The MAG determination (Shi, 2017) utilized the Desired Future Conditions (DFC's provided by the GMA-6 representative) and groundwater model of the Seymour and Blaine aquifers (Ewing et. al, 2004) Using the approach outlined by the TWDB, aquifer MAG was calculated each county. The only county in Brazos G with an adopted MAG for the Blaine Aquifer is Fisher County. Availability of the Blaine Aquifer in Knox and Stonewall Counties is provided by the TWDB and is estimated based on modeling from GMA-6; availability in Nolan County is estimated based on previous Brazos G Regional Water Plans, historical TWDB groundwater reports, and data from the TWDB groundwater database.

Blaine Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
FISHER	12,855	12,820	12,855	12,820	12,855	12,820
KNOX [A]	700	700	700	700	700	700
NOLAN [A]	100	100	100	100	100	100
STONEWALL [A]	8,700	8,700	8,700	8,700	8,700	8,700
TOTAL	22,355	22,320	22,355	22,320	22,355	22,320

[A] Non-GAM estimate

Well Yields and Water Quality

Any extensive development of this aquifer is unlikely because of the frequent occurrence of poor-quality water and low well yields.

Resource Considerations

Counties in groundwater districts include: Knox (Rolling Plains Groundwater Conservation District (GCD)), Fisher (Clear Fork GCD), and Nolan (Wes-Tex GCD).

References

Duffin, G.L., and Beynon, B.E., 1992, Evaluation of water resources in parts of the Rolling Prairies region of North-Central Texas: TWDB Report 337.

Muller, Daniel A., and Price, Robert D., 1979, Ground-water availability in Texas: TDWR Report 238.

Ogilbee, William and Osborne, F.L., 1962, Ground-water resources of Haskell and Knox Counties, Texas: TWC Bulletin 6209.

Ewing, J.D., Jones, T.L., Pickens, J.F. and others, 2004, Groundwater Availability for the Seymour Aquifer: Texas Water Development Board Contract Report. http://www.twdb.state.tx.us/gam/symr/symr.htm

Shi, J., 2017, Gam Run 16-031 MAG: Modeled Available Groundwater for the Seymour, Blaine, Ogallala, and Dockum Aquifers in Groundwater Management Area 6, Texas Water Development Board Groundwater Division.

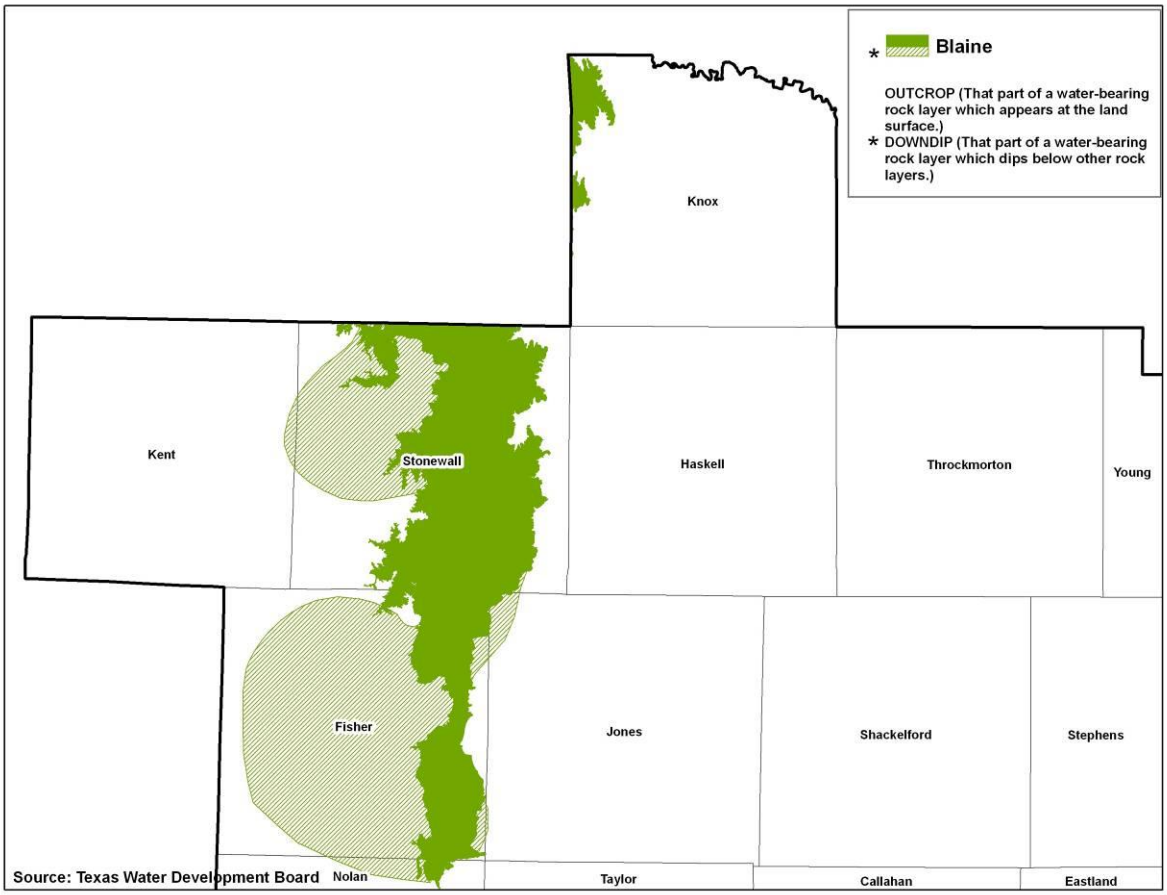

Figure B-1. Location of Blaine Aquifer in Brazos G

Brazos River Alluvium Aquifer

Location

The Brazos River Alluvium Aquifer is a minor aquifer and occurs along the floodplain and terrace deposits of the Brazos River downstream of Hill and Bosque Counties. The width of the aquifer ranges from less than one to almost seven miles. The Brazos River Alluvium Aquifer in Brazos G occurs in parts of Hill, Bosque, McLennan, Falls, Milam, Robertson, Burleson, Brazos, Washington and Grimes Counties. It is limited to the valley area along the Brazos River (Figure B-2).

Geohydrology

The river alluvium forms a floodplain and a series of terraces. The floodplain is of primary significance as a source of groundwater locally, however, groundwater also may occur in the terrace deposits that are outside the floodplain. The alluvium consists of layers of clay, silt, sand and various mixtures. The coarsest and best water-bearing zones are in the lower part of the aquifer. Water in the floodplain alluvium usually exists under water table conditions, although leaky artesian conditions may occur locally where there are extensive lenses of clay. The maximum saturated thickness of the alluvium is about 85 feet. The primary source of recharge is precipitation on the floodplain. Lesser amounts of recharge are losses of runoff in streams crossing the floodplain, groundwater discharge from adjacent aquifers and return flow from irrigation water. Discharge is mostly by seepage to the Brazos River, evapotranspiration, and wells.

Development and Use

The year 2017 Brazos G groundwater use for the Brazos River Alluvium Aquifer was estimated to be 133,065 acft with approximately 99 percent used for irrigation.

Availability

The Brazos River Alluvium Aquifer in Brazos G is in GMA-12. In a letter dated December 2017, the TWDB referenced a report titled GAM Run 17-030 MAG (Wade and Ballew, 2017), which presents the MAG for aquifers in the management area. The MAG volume for the Brazos River Alluvium Aquifer was determined using the groundwater availability model for the Brazos River Alluvium, version 1.01 (Ewing and Jigmond, 2016), which was developed to meet the Desired Future Conditions adopted by groundwater conservation district representatives of GMA-12. An adopted MAG is only available for Brazos, Burleson, Milam, and Robertson Counties. Non-MAG availability in Bosque, Falls, Hill, McLennan, and Washington Counties were provided by the TWDB and are estimated based average modeling for GMA-12. Non-MAG availability estimates for Grimes County are similarly based on modeling for GMA-14.

Brazos River Alluvium Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
BOSQUE [A]	830	830	830	830	830	830
BRAZOS	81,581	80,311	80,081	79,976	79,913	79,872
BURLESON	28,472	28,418	28,414	28,414	28,414	28,413
FALLS [A]	16,684	16,684	16,684	16,684	16,684	16,684
GRIMES [A]	5,112	5,112	5,112	5,112	5,112	5,112
HILL [A]	632	632	632	632	632	632
MCLENNAN [A]	15,023	15,023	15,023	15,023	15,023	15,023
MILAM	47,818	47,785	47,779	47,775	47,773	47,771
ROBERTSON	61,161	57,959	57,633	57,544	57,503	57,480
WASHINGTON [A]	5,770	5,770	5,770	5,770	5,770	5,770
TOTAL	263,083	258,524	257,958	257,760	257,654	257,587

[A] Non-GAM estimate

Well Yields

Yields from large supply wells are typically between 250 and 500 gallons per minute (gpm). Well yields are considerably less at the edges of the alluvium, and where there is minimal sand thickness or a considerable amount of silt and/or clay is present.

Water Quality

Water quality from the Brazos River Alluvium Aquifer varies widely, even within short distances. Concentrations of dissolved solids exceed 1,000 milligrams per liter (mg/L) in many areas; but, water is sufficiently fresh to meet drinking water standards in some areas. Data show the aquifer generally having 500 to 3,000 mg/L dissolved solids content. Areas with dissolved solids concentrations less than 500 mg/L or greater than 3,000 mg/L are of limited extent. Local groundwater contamination from agriculture chemicals is like1ly in intensively irrigated areas.

Resource Considerations

Any extensive development of this aquifer is likely to cause some reductions of streamflow in the Brazos and Little Brazos Rivers.

Counties with groundwater conservation districts in the Brazos G include: Bosque (Middle Trinity GCD, Grimes (Bluebonnet GCD), Hill (Prairielands GCD), Robertson and Brazos (Brazos Valley GCD), McLennan (McLennan County GCD) and Milam and Burleson (Post Oak Savannah GCD).

References

Cronin, J.G., and Wilson, C.A., 1967, Groundwater in the flood-plain alluvium of the Brazos River, Whitney Dam to vicinity of Richmond, Texas: TWDB Report 41.

Ewing, J.E., and Jigmond, M., 2016, Final Numerical Model Report for the Brazos River Alluvium Aquifer Groundwater Availability Model: Contract report to the Texas Water Development Board.

Wade, S.C., and Ballew, N., 2017, GAM Run 17-030 MAG: Modeled Available Groundwater for the Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Brazos River Alluvium Aquifers in Groundwater Management Area 12, Texas Water Development Board Groundwater Division.

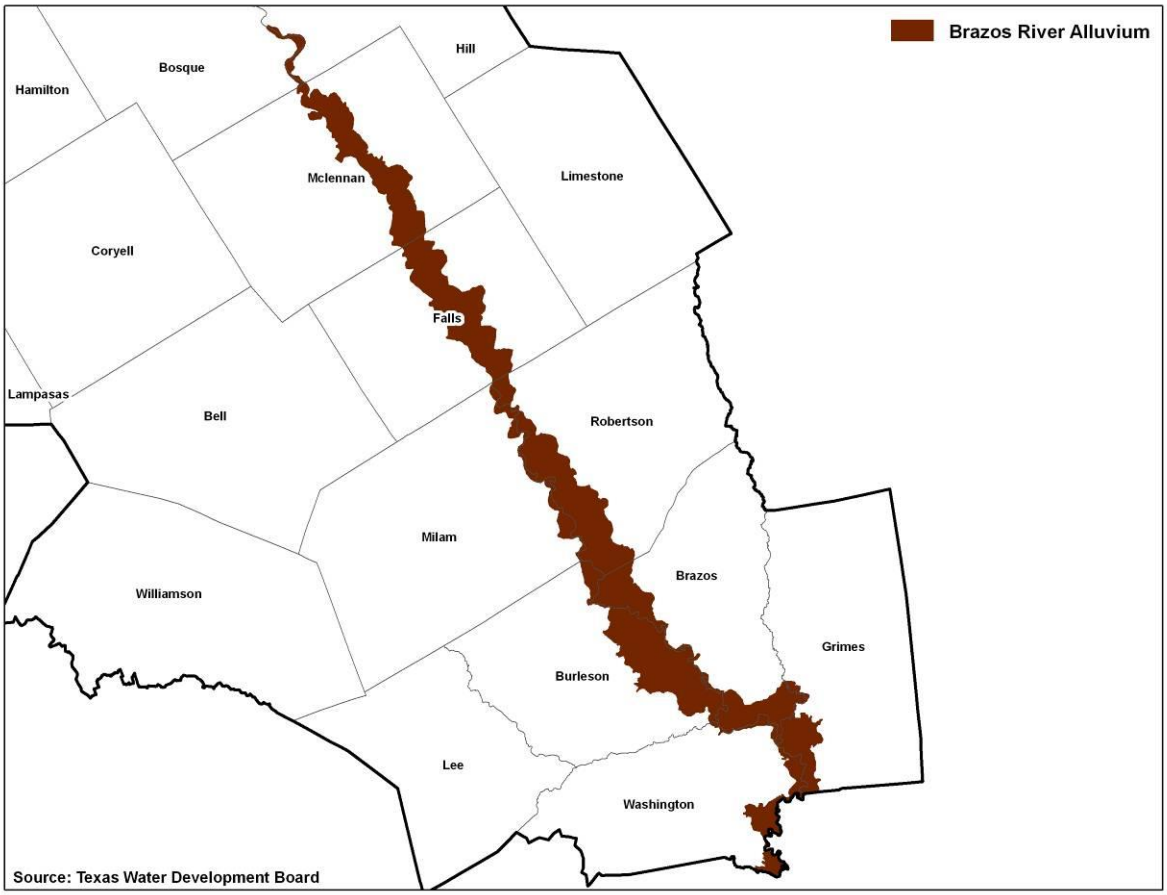

Figure B-2. Location of Brazos River Alluvium Aquifer in Brazos G

Carrizo-Wilcox Aquifer

Location

The Carrizo-Wilcox, a major aquifer within the Brazos G, is of major significance in water planning due to a relatively large supply of undeveloped water. It traverses a southeastern part of the Brazos G in a northeast-southwest-trending band and extends into adjoining planning areas (Figure B-3). It occurs within the Brazos G primarily in parts of Brazos, Burleson, Lee, Limestone, Milam, and Robertson Counties.

Geohydrology

The Carrizo Formation and the underlying Wilcox Group, which is divided into the Calvert Bluff, Simsboro, and Hooper units, form the Carrizo-Wilcox Aquifer. The Simsboro is a major water-bearing unit across the Brazos G and also in neighboring planning areas. Between the Colorado and Trinity Rivers, the Simsboro sands are uniquely productive and are largely separated from overlying and underlying geologic units by clays of low permeability. The sands in the Simsboro and Carrizo are overwhelmingly the two most significant water-bearing zones in the Carrizo-Wilcox. The Calvert Bluff and Hooper are generally tapped only by shallow wells.

The Carrizo-Wilcox consists of a thick sequence of ancient river and delta deposits, consisting mostly of sand, silt, and clay. Total thickness is typically between 2,000 and 3,000 feet, and net sand thickness can exceed 50 percent of the total thickness. Some important coal (lignite) deposits occur primarily within the Calvert Bluff. From surface outcrops (recharge areas) the members of the Carrizo-Wilcox dip coastward beneath younger strata. Water table conditions occur in recharge areas, and artesian conditions occur in downdip areas. Precipitation is the main source of recharge. A substantial, but unknown, amount of potential recharge is lost through evapotranspiration in areas of the outcrop. Freshwater sands occur up to 30 miles south of recharge areas and to depths up to about 3,000 feet in the most permeable sands. Slightly saline water occurs just to the southeast (coastward) of the fresh water. Faulting within the Mexia-Talco Fault Zone occurs in an approximately 5-mile wide belt across parts of Lee, Burleson, Milam, and Robertson Counties. The faults affect position, continuity, and possibly water quality within the Carrizo-Wilcox zones in variable and mostly unknown ways.

Development and Use

The year 2017 Brazos G groundwater use for the Brazos River Alluvium Aquifer was estimated to be 40,089 acft with approximately 57 percent used for municipal purposes. Relatively large amounts of municipal water use is by Bryan, College Station, Texas A&M, Hearne and Rockdale. Most of the irrigation use occurs in Milam and Robertson Counties.

Availability

The Carrizo-Wilcox in Brazos G primarily lies within the boundary of GMA-12; however, a portion does extend across the northern part of Grimes County in GMA-14. In a letter dated December 2017 to GMA-12, the TWDB referenced a report titled GAM Run 17-030 MAG (Wade and Ballew, 2017) which presents the MAG within the management area. The MAG was determined using the groundwater availability model for the central part of the Carrizo-Wilcox,

Queen City, and Sparta aquifers, version 2.02 (Kelley and others, 2004), which was developed to meet the Desired Future Conditions adopted by groundwater conservation district representatives of GMA-12. No MAG has been adopted for the Carrizo-Wilcox within GMA-14; the groundwater availability values for Grimes County, as provided by the TWDB, are estimated based on from groundwater modeling from GMA-14. The results are presented in the following table.

Carrizo-Wilcox Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070 [A]**
BRAZOS	44,832	47,844	49,418	53,969	57,167	57,167
BRAZOS (MAG PEAK FACTOR)	53,350	55,977	59,302	63,683	65,742	65,742
BURLESON	23,242	28,039	32,511	36,485	38,694	38,694
FALLS	867	875	884	895	895	895
GRIMES [B]	8,274	8,274	8,274	8,274	8,274	8,274
LEE	21,142	20,516	20,558	21,466	19,069	19,069
LIMESTONE	11,353	11,483	11,664	11,966	11,966	11,966
MILAM	23,928	20,211	19,119	21,366	22,327	22,327
ROBERTSON	46,590	47,400	47,881	48,281	48,282	48,282
WILLIAMSON	9	9	9	10	9	9
TOTAL [C]	188,755	192,784	200,202	212,426	215,258	215,258

[A] – Adopted MAG does not include a MAG determination for 2070; 2070 value extrapolated based on 2060 volume.
[B] - Non-GAM Estimate
[C] – Values calculated using MAG Peak Factor for the Carrizo-Wilcox Aquifer in Brazos County.

Well Yields

Wide variations occur in individual well yields for the four Carrizo-Wilcox hydrogeologic units, mostly depending on well depth and local sand thickness. Estimated ranges for maximum individual well yields are from 500 to 2,000 gpm for the Carrizo, from 100 to 300 gpm for the Calvert Bluff, from 500 to 3,000 gpm for the Simsboro, and from 100 to 300 gpm for the Hooper.

Water Quality

Water generally meets drinking water standards, but local exceptions occur. Excessive iron concentrations are the most common water quality problem, and some water supplies must be treated. Hydrogen sulfide and methane occurrences are occasionally reported. Water obtained near the outcrops of the water-bearing zones generally is higher in hardness and lower in total dissolved solids content. In downdip areas the water is commonly a sodium-bicarbonate-type water, with total dissolved solids content ranging from about 300 to 800 mg/L and averaging 400

to 500 mg/L. The dissolved solid concentrations tend to be greater at the downdip limit of the aquifer.

Resource Considerations

Few development problems have occurred to date, and water-level declines have been relatively small or restricted to pumping centers near larger developments. No important pollution problems are evident. One potential impact of significant drawdown is dewatering existing wells due to the wells being too shallow or have casing diameters which restrict setting pumps at lower depths.

There are four groundwater conservation districts that oversee the development and management of the Carrizo-Wilcox Aquifer within the Brazos G. The counties with a groundwater conservation district include: Lee (Lost Pines GCD), Robertson and Brazos (Brazos Valley GCD), Milam and Burleson (Post Oak Savannah GCD), and Grimes (Bluebonnet GCD).

References

Dutton, A.R., 1999, Assessment of groundwater availability in the Carrizo-Wilcox Aquifer in Central Texas--Results of numerical simulations of six groundwater-withdrawal projections (2000-2050), The University of Texas at Austin, Bureau of Economic Geology.

Dutton, A.R., Harden, B., Nicot, J.P., and O'Rourke, D., 2003. Groundwater availability model for the central part of the Carrizo-Wilcox Aquifer in Texas. TWDB Contract Report.

Follett, C.R., 1970, Ground-water resources of Bastrop County, Texas: TWDB Report 109.

Follett, C.R., 1974, Ground-water resources of Brazos and Burleson Counties, Texas: TWDB Report 185.

Harden, R.W. & Associates, Inc., 1986, The most suitable areas for management of the Carrizo/Wilcox aquifer in Central Texas.

Kelley, V.A., Deeds, N.E., Fryar, D.G., and Nicot, J.P., 2004, Groundwater availability models for the Queen City and Sparta Aquifers: TWDB Contract Report, http://www.twdb.state.tx.us/gam/czwx_c/czwx_c.htm

Rettman, P.L., 1987, Ground-water resources of Limestone County, Texas: TWDB Report 299.

Thompson, G.L., 1966, Ground-water resources of Lee County, Texas: TWDB Report 20.

Thorkildsen, D., and Price, R.D., 1991, Ground-water resources of the Carrizo-Wilcox aquifer in the Central Texas region: TWDB Report 332.

Wade, S.C., and Ballew, N., 2017, GAM Run 17-030 MAG: Modeled Available Groundwater for the Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Brazos River Alluvium Aquifers in Groundwater Management Area 12, Texas Water Development Board Groundwater Division.

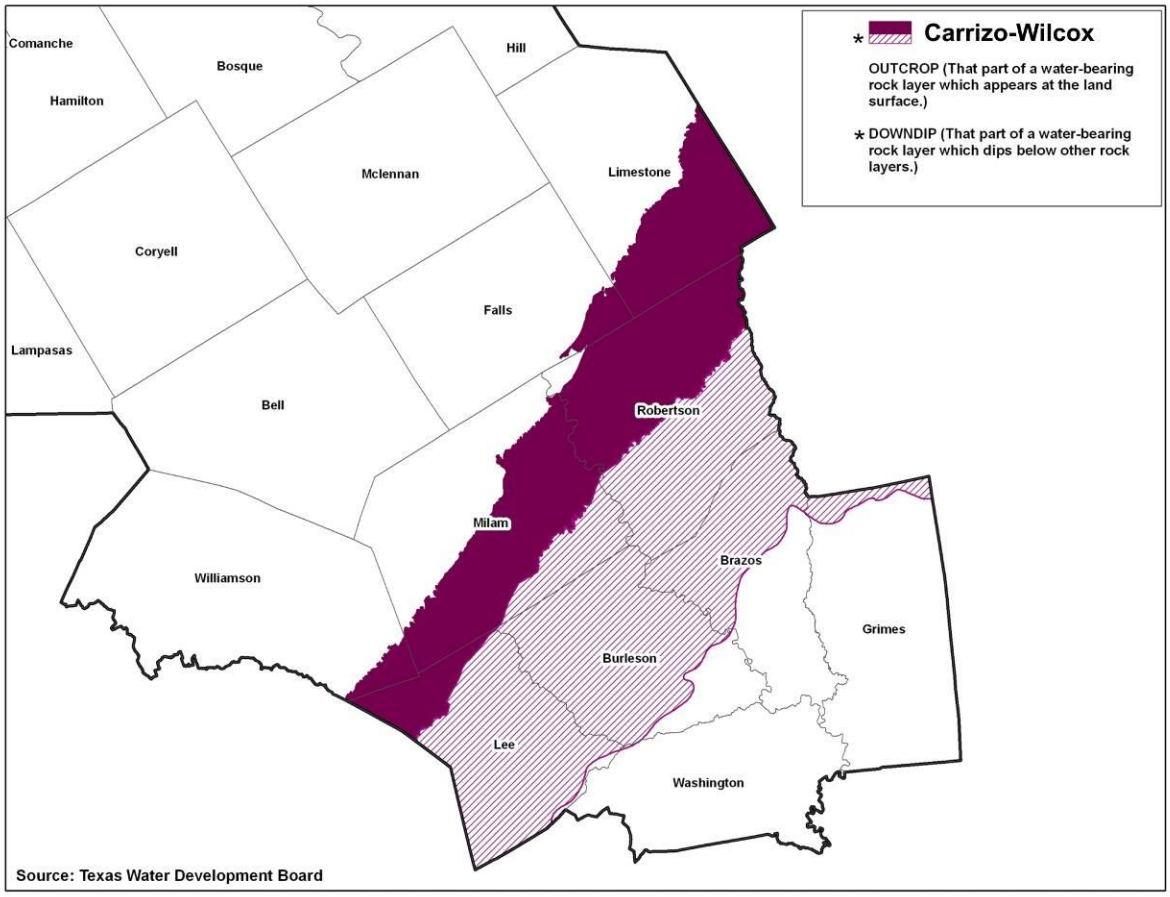

Figure B-3. Location of Carrizo-Wilcox Aquifer in Brazos G

Cross-Timbers Aquifer

Location

The Cross Timbers Aquifer was newly-designated as a minor aquifer in December 2017. The aquifer occurs in a band ranging in thickness from approximately 75 to 90 miles wide extending from the Red River at the Oklahoma-Texas border to the Colorado River in central Texas. With the exception of the westernmost counties, the Cross Timbers Aquifer is shown to underlay the counties of the Brazos G Upper Basin as well as portions of Hood and Lampasas County in the Brazos G Middle Basin (Figure B-16).

Geohydrology

Four separate formation groups comprise the Cross Timbers Aquifer: the Strawn, Canyon, Cisco-Bowie, and Wichita-Albany Groups. In general, the formation groups of the Cross Timbers Aquifer consist of limestone, shale, and sandstone which occur in layers or lenses indicating riverine and deltaic depositional environments (Ballew and French, 2019). The Strawn Group consists of shale, limestone, and sandstone with conglomerate and thin beds of coal. The Canyon Group overlays the Strawn Group and is comprised of massive too thin-bedded limestone, interbedded with shale, thin sandstone, and conglomerate. The Cisco Group, overlaying the Canyon Group, consists of shale, siltstone, sandstone, limestone, conglomerate, and some coal. The youngest of the formations, those in the Wichita Group, consists primarily of thin beds of limestone and fine grained sandstone; however, massive saturated limestone beds have been located near the top of the group (Ballew and French, 2019). Total aquifer thickness within the Brazos G is anticipated to be one the order of 3,000 to 5,000 ft thick based on generalized cross sections (Nicot and others, 2013).

Development and Use

Development is mostly limited to local use for household and livestock purposes. Approximately 75 percent of the well completed in the Cross Timbers formation are domestic wells and approximately 20 percent are stock wells (Ballew and French, 2019). Pumpage estimates for the Cross Timbers Aquifer was not included specifically in the TWDB's 2017 estimates; however, review of literature indicates that pumpage from 'Other Aquifers' identified by the TWDB within the same area as the Cross Timber Aquifer extent is likely from the Cross Timbers Aquifer (Ballew and French, 2019). The TWDB reports a usage from Other Aquifers in the region of the Cross Timbers Aquifer extent within Brazos G of 5,521 acft/yr with approximately 53 percent used for irrigation and 33 percent for municipal use.

Availability

The Cross Timbers Aquifer lies within the boundaries of GMA-6. The most recent round of planning and selection of Desired Future Conditions by each groundwater management area did not include an adopted MAG for the Cross Timbers Aquifer. This is a newly designated aquifer by the TWDB; groundwater availability estimates in Shackelford and Stephens Counties are based on the availability provided for Other Aquifers in the 2016 Brazos G Regional Water Plan.

Cross-Timbers Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2030**	**2050**	**2060**	**2070**
SHACKELFORD [A]	712	712	712	712	712	712
STEPHENS [A]	620	620	620	620	620	620
TOTAL	1,332	1,332	1,332	1,332	1,332	1,332

[A] – Non-MAG estimate.

Well Yields

The geometry and aquifer properties vary widely within the Cross Timbers Aquifer and contribute to variability in well yields. Reported yield range as high as 57 to 189 gpm among the four formation groups with the Strawn Group being the most prolific; however, the majority of reported yields range are less than 30 to 45 gpm (Ballew and French, 2019).

Water Quality

Groundwater produced from the Cross Timbers Aquifer ranges from fresh to brackish with high variability of water quality within and between individual formations. The majority of wells sampled are completed in the Cisco Group and were found to have total dissolved solids concentrations less than 3,000 milligrams per liter with a median concentration of 839 milligrams per liter (Ballew and French, 2019). Samples analyses from all formations in the Cross Timbers Aquifer indicate the native groundwater is mostly fresh to slightly saline. Evaluations concerning chloride concentrations (Nicot and others, 2013) indicate an average chloride concentration in the Cross Timbers Aquifer approximately twice as much as that in the adjacent Trinity Aquifer, likely influenced by surface contamination of halite dissolution.

Resource Considerations

Counties with groundwater conservation districts include: Lampasas (Saratoga UWCD), Erath and Comanche (Middle Trinity GCD), Hood (Upper Trinity GCD), and Haskell (Rolling Plains GCD).

References

Ballew, N., and French, L.N., 2019, Groundwater Conditions in the Cross Timbers Aquifer, Texas Water Development Board Groundwater Management Report 19-01.

Nicot, J.P., Huang, Y., Wolaver, B.D., and Costley, R.A., 2013, Flow and Salinity Patters in Low-Transmissivity Upper Paleozoic Aquifer of North-Central Texas: Gulf Coast Association of Geological Societies Journal, V. 2.

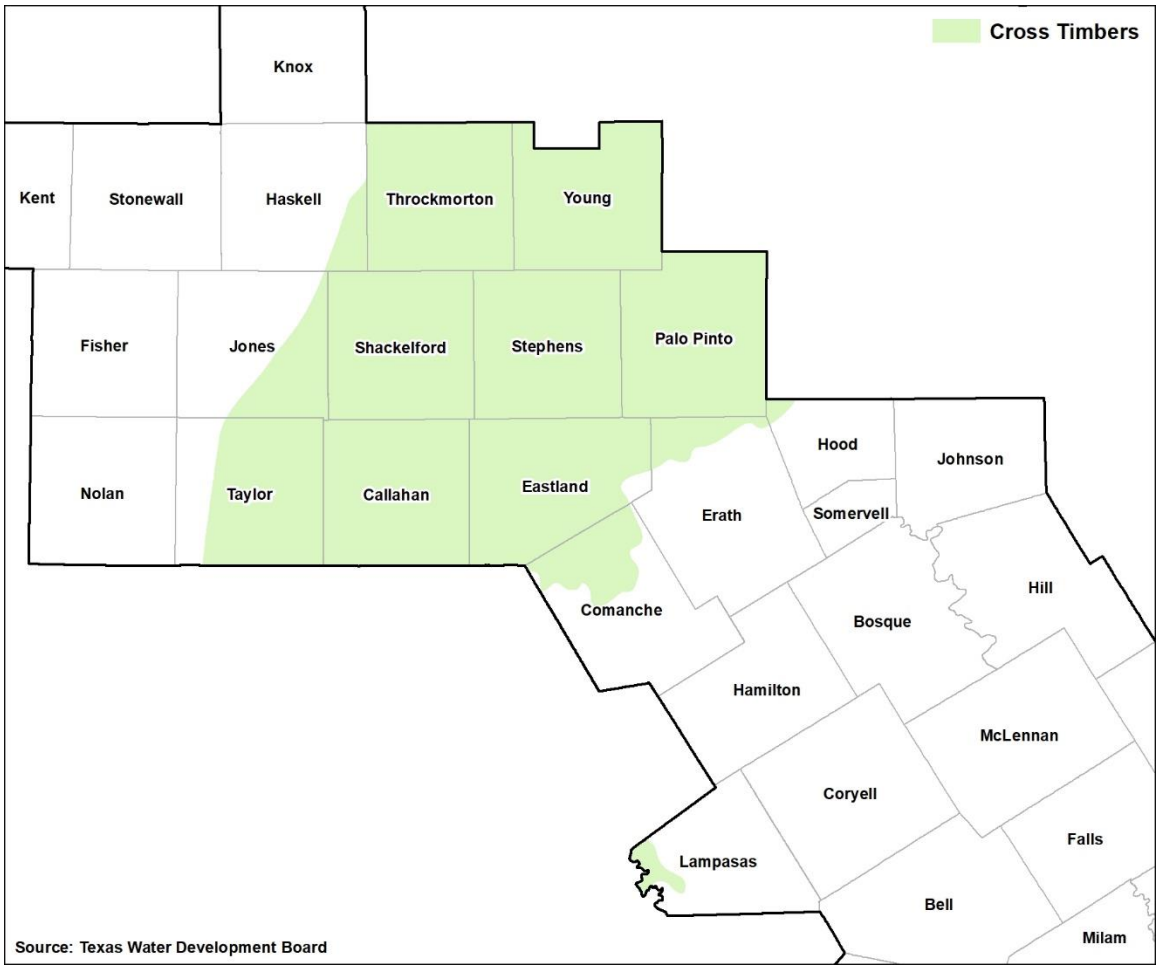

Figure B-4. Location of Cross-Timbers Aquifer in Brazos G

Dockum Aquifer

Location

The Dockum, a minor aquifer, occurs only along in the western parts of Nolan, Fisher, and Kent Counties within the Brazos G (Figure B-4). It's important to note that there is a discrepancy in the occurrence of the Dockum as shown in Figure B-4 and in the Shamburger, 1967 report. The Shamburger report shows the Dockum extending into the mid-part of Nolan County, while the TWDB delineation is limited to the extreme western edge of the county.

Geohydrology

Water is derived largely from sands and gravels in the Santa Rosa Formation of Permian age or from the Santa Rosa and the overlying Trinity Sands in a western Nolan County. Water table conditions mostly prevail.

Development and Use

The year 2017 groundwater use within the Brazos G totaled 14,326 acft. Over 97 percent of the water produced from the Dockum Aquifer is for irrigation in Nolan County.

Availability

The Dockum in Brazos G is divided between GMA-6 and GMA-7. In letter dated December June 2017 to GMA-6, the TWDB referenced a report titled GAM Run 16-031 MAG (Shi, 2017) which presents the modeled available groundwater for Kent and Fisher Counties. In letter dated September 2018 to GMA-7, the TWDB referenced a report titled GAM Run 16-026 MAG Version 2 (Jones, 2018) which presents the MAG for Nolan County. The MAG within both groundwater management areas was determined using the groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015) and the specified Desired Future Conditions provided by the GMA-6 and GMA-7 representatives. Of the three counties in which the Dockum Aquifer is present, a MAG volume was only adopted for Fisher County. Availability of the Dockum Aquifer in Kent County, as provided by the TWDB, was estimated based on modeling from GMA-1; availability in Nolan County was estimated based on previous Brazos G Regional Water Plans, historical TWDB groundwater reports, and data from the TWDB groundwater database.

Dockum Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
FISHER	79	79	79	79	79	79
KENT [A]	6,250	6,250	6,250	6,250	6,250	6,250
NOLAN [A]	5,750	5,750	5,750	5,750	5,750	5,750
TOTAL	12,079	12,079	12,079	12,079	12,079	12,079

[A] – Non-MAG estimate

Well Yields and Water Quality

Well yields vary widely, ranging from less than 10 gpm to 400 gpm and averaging 200 gpm.

Water from the aquifer typically meets drinking water standards and contains 500 to 600 mg/L dissolved solids content. However, in heavily irrigated areas, elevated concentrations of nitrates have been reported.

Resource Considerations

There are three groundwater conservation districts in Brazos G counties where the Dockum Aquifer is present. Groundwater management in Nolan County is by Wes-Tex GCD. There is little pumpage from the Dockum in the Kent County (Salt Fork UWCD) and Fisher County (Clear Fork GCD).

References

Duffin, G.L., and Beynon, B.E., 1992, Evaluation of water resources in parts of the Rolling Prairies region of North-Central Texas: TWDB Report 337.

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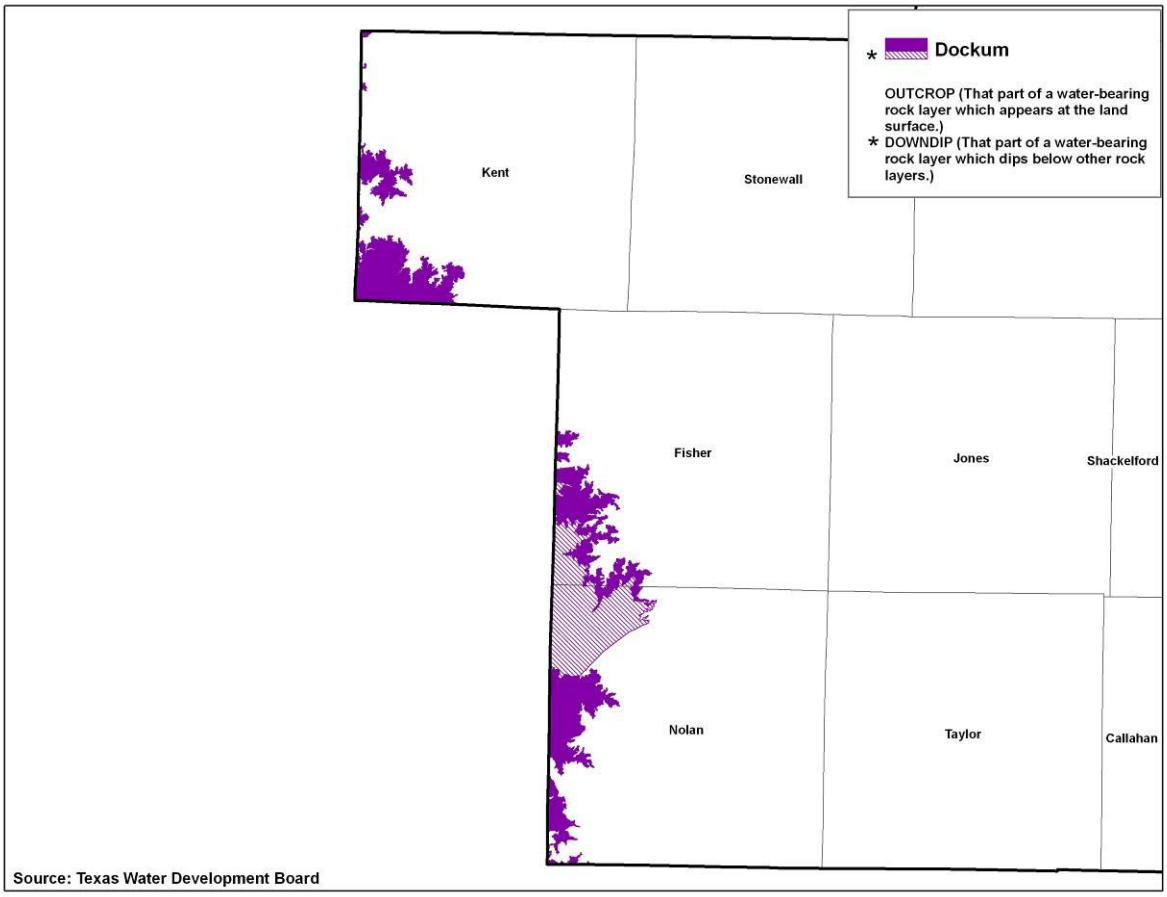

Figure B-5. Location of Dockum Aquifer in Brazos G

Edwards (Balcones Fault Zone) Aquifer

Location

The northern segment of the Edwards (Balcones Fault Zone (BFZ)) Aquifer is a major aquifer and occurs in the southern part of the central Brazos G region. This segment of the aquifer also extends into the adjacent Region K planning area to the south, but only to the Colorado River. The northern segment of the Edwards (BFZ) is hydraulically separate from the Edwards (BFZ) occurring south of the Colorado River, referred to as the Barton Springs segment, and the San Antonio segment of the Edwards (BFZ) even further south. The northern segment of the Edwards (BFZ) appears to be overdeveloped except during average and wet times, and some supplies are subject to shortages in larger droughts.

The Edwards (BFZ) in the Brazos G occurs in a narrow north-south-trending belt across parts of Williamson and Bell Counties (Figure B-5), essentially extending from Round Rock to Salado.

Geohydrology

The Edwards (BFZ) Aquifer consists of the Edwards and associated limestone, including the Comanche Peak, Kiamichi and Georgetown. However, significant water-bearing zones are normally restricted to the Edwards (BFZ), with associated limestone commonly yielding little to no water according to test drilling records (Harden, 1999). The source of the water is infiltration of rainfall and seepage from streams. The water moves primarily in honeycombed, solution-enlarged voids and other enlarged secondary porosity zones along joints and faults. The formation dips to the east beneath younger strata. Water table conditions occur in recharge areas (mostly west of IH-35), and artesian conditions occur further east. At the eastern boundary of the aquifer the water quality becomes more mineralized and eventually unusable for most purposes. The water moves from recharge areas to natural spring discharge points and to wells. The three largest springs (and their approximate high and low flows) include San Gabriel Springs at Georgetown (zero to 25 cubic feet per second (cfs)), Berry Springs north of Georgetown (zero to 48 cfs) and Salado Springs at Salado (5 to 59 cfs). The Edwards (BFZ) responds more quickly than most other aquifers to drought and wet cycles. With adequate rainfall, the aquifer is able to supply substantial water to current users and sustain substantial springflow at the three main locations. In times of below-average rainfall or drought, discharge exceeds recharge with the result being most springflow decreases greatly or dries up and some wells begin to fail. Over the years more and more wells have been drilled and increasingly diminished springflow has occurred. Introduction of surface water supplies has slowed the trend, but competition for Edwards (BFZ) water in the area is continuing.

Development and Use

The year 2017 groundwater use within the Brazos G totaled 13,696 acft. Approximately 86 percent of the water is used for municipal supply, of which about 72 percent occurs in Williamson County.

Availability

The Northern Edwards (BFZ) Aquifer in Brazos G is within GMA-8. In letter dated January 2018 to GMA-8, the TWDB referenced a report titled GAM Run 17-029 MAG (Shi, 2018) which presents the MAG for the aquifers in the groundwater management area. The MAG volumes were determined using the groundwater availability model for the northern segment of the Edwards (BFZ) Aquifer, version 1.01 (Jones, 2003) and previous GAM run results (Anaya, 2008) based on the specified Desired Future Conditions provided by the GMA-8 representative. The results are presented in the following table.

Edwards (BFZ) Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
BELL	6,469	6,469	6,469	6,469	6,469	6,469
WILLIAMSON	3,452	3,452	3,452	3,452	3,452	3,452
TOTAL	9,921	9,921	9,921	9,921	9,921	9,921

Well Yields

Wide variations occur in individual well yields obtainable from the Edwards (BFZ). Well yields depend upon boreholes encountering secondary, solution-enlarged openings in the limestone. Wells used for public supply range from 200 to about 2,000 gpm.

Water Quality

Water, although hard, meets drinking water standards with dissolved solids content mostly less than 500 mg/L in developed areas. Further east, the water becomes more mineralized. The fluoride content is high in some of the downdip eastern areas.

Resource Considerations

Groundwater resources appear to be overdeveloped during record drought conditions. Existing local plans of the larger users have long included conjunctive use plans with surface waters from Lakes Georgetown, Travis, and/or Stillhouse Hollow. Significant groundwater pumpage can reduce springflow, and the aquifer is locally subject to pollution from surface sources. The higher withdrawals by wells can directly affect springflow and downstream surface water supplies. A groundwater district exists in Bell County (Clearwater UWCD).

References

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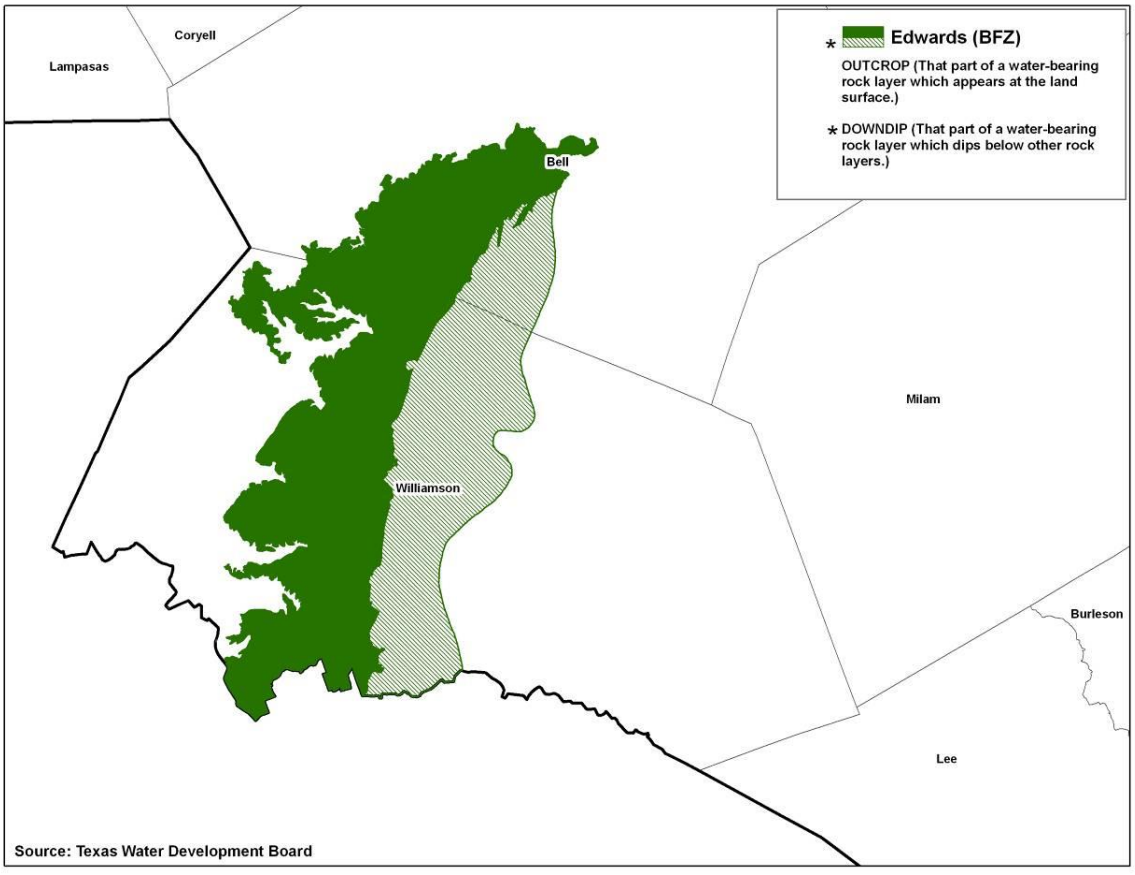

Figure B-7. Location of Edwards (BFZ) Aquifer (northern segment) in Brazos G

Edwards-Trinity (Plateau) Aquifer

Location

The Edwards-Trinity (Plateau) Aquifer is a major aquifer in Texas due to its expansive coverage and available water supplies. In the Brazos G, this aquifer is found only in parts of Nolan and Taylor Counties (Figure B-6). It provides only a very small water supply to the planning region.

Geohydrology

Water from the Edwards-Trinity (Plateau) is derived largely from Cretaceous sands (Trinity) in Nolan County in combination with the underlying Dockum, where present. Water-table conditions are typical. Maximum well yields typically are less than 50 gallons per minute. In western Nolan County, much of the water production is associated with the Edwards-Trinity (Plateau) because of the surface geology, but the major water-bearing zone of higher capacity wells is the underlying Dockum.

Development and Use

The year 2017 groundwater use within the Brazos G totaled 2,166 acft. Approximately 87 percent of the water is used for municipal supply, of which about 82 percent occurs in Nolan County.

Availability

The Edwards-Trinity (Plateau) Aquifer in Brazos G is divided between GMA-7 and GMA-8. In a letter dated September 2018 to GMA-7, the TWDB referenced a report titled GAM Run 16-026 MAG Version 2 (Jones, 2018) which presents the MAG for the aquifers in the management area. Similarly, a letter dated January 2018 to GMA-8 from the TWDB referenced a report titled GAM Run 17-029 MAG (Shi, 2018) which provides the MAG volumes for this management area. The MAG volume for Edwards-Trinity (Plateau) Aquifer in GMA-7 was developed using the single-layer alternative groundwater flow model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Hutchinson an Others, 2011) which is an update to the previously developed groundwater availability model (Anaya and Jones, 2009). No MAG has been adopted for the Edwards-Trinity (Plateau) Aquifer in GMA-8. In lieu of this, groundwater availability in Nolan County is estimated based on previous Brazos G Regional Water Plans, historical TWDB groundwater reports, and data from the TWDB groundwater database. Groundwater availability in Taylor County was estimated based on the availability utilized in the 2016 Brazos G Regional Water Plan.

Edwards-Trinity (Plateau) Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
NOLAN [A]	693	693	693	693	693	693
TAYLOR [A]	489	489	489	489	489	489
TOTAL	1,182	1,182	1,182	1,182	1,182	1,182

[A] – Non-MAG estimate

Well Yields and Water Quality

Potential well yields are generally less than 100 gpm. Typical waters meet drinking water standards and contain 400 to 500 mg/L dissolved solids content.

Resource Consideration

In 2012, the TWDB estimated the total pumpage from the aquifer to be 2,631 acft. Most of the usage was for municipal purposes in Nolan County. Few undeveloped supplies appear available. Existing supplies appear to be susceptible to droughts.

Groundwater in Nolan County is regulated by Wes-Tex GCD.

References

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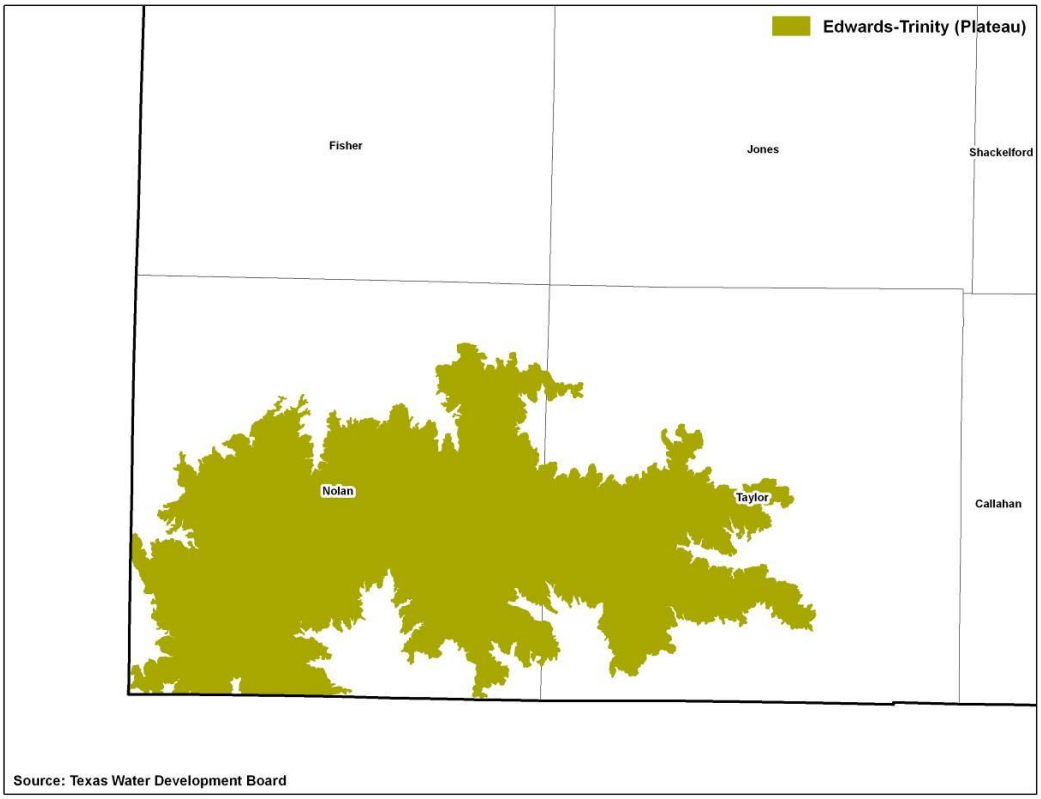

Figure B-8. Location of Edwards-Trinity (Plateau) Aquifer in Brazos G

Ellenburger-San Saba Aquifer

Location

The Ellenburger-San Saba Aquifer, a minor aquifer, occurs in the Brazos G, but only in the southwestern part of Lampasas County (Figure B-7). It primarily occurs in adjacent planning area to the south and west.

Geohydrology

The aquifer consists of limestone and dolomites with secondary solutioning along fractures and faults. The aquifer extends from outcrops and dips to depths of perhaps 2,000 feet. Little is known about conditions in the deeper parts of the aquifer. In some areas the aquifer is believed to be connected to the Marble Falls Aquifer. Faults are believed to function as an important part in controlling groundwater flow and water levels. The aquifer supports numerous springs, is lightly used, and usually has less than 1,000 mg/L dissolved solids.

Development and Use

In 2017, the TWDB estimated pumpage in Brazos G to be about 18 acft with approximately 61 percent of the use being for livestock and the remaining 39 percent for municipal use.

Availability

In a letter dated January 2018 to GMA-8, the TWDB referenced a report titled GAM Run 17-029 MAG (Shi, 2018) which provides the MAG volumes for the aquifers in GMA-8. The MAG for the Ellenburger-San Saba Aquifer was developed using the groundwater availability model for the minor aquifers in the Llano Uplift region of Texas (Shi and Others, 2016) and Desired Future Conditions provided by GMA-8 representative. The results are presented in the following table.

Ellenburger-San Saba

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
LAMPASAS	2,601	2,593	2,601	2,593	2,601	2,593
TOTAL	2,601	2,593	2,601	2,593	2,601	2,593

Resource Considerations

Groundwater resources are large in relation to current use and future local demand. The Saratoga Underground Water Conservation District has jurisdiction in Lampasas County.

References

Bluntzer, R.L., 1992, Evaluation of the ground-water resources of the Paleozoic and Cretaceous aquifers in the Hill Country of Central Texas: TWDB Report 339.

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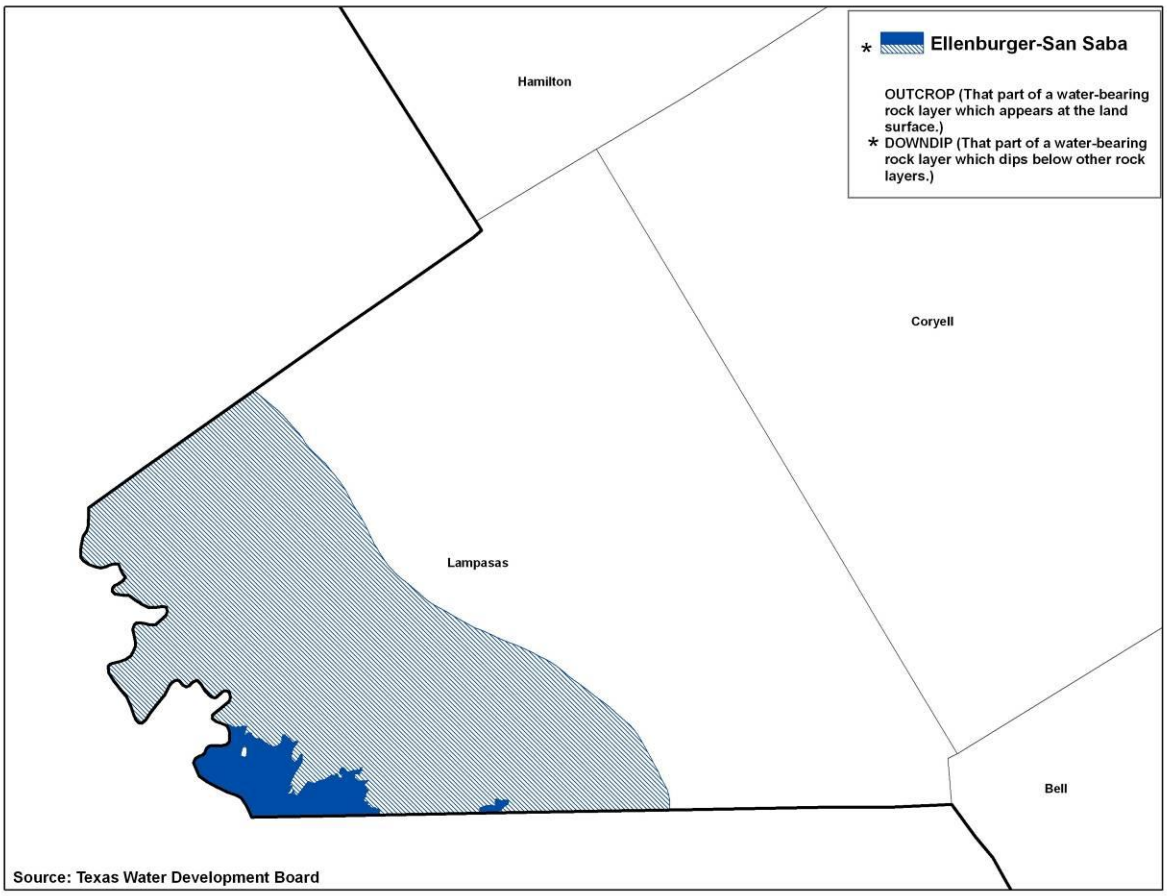

Figure B-8. Location of Ellenburger-San Saba Aquifer in Brazos G

Gulf Coast Aquifer

Location

The Gulf Coast Aquifer, a major aquifer, occurs in a limited area in the southeastern part of the Brazos G. It occurs in a northeast-southwest-trending band and extends into adjoining planning areas (Figure B-8). In the Brazos G the aquifer is present primarily in Washington and in the southern two-thirds of Grimes Counties. A small part of the aquifer exists in the extreme southernmost part of Brazos County, but is not considered to be sufficiently productive for regional planning purposes.

Geohydrology

The Gulf Coast Aquifer consists primarily of four water-bearing zones, the deepest being the Catahoula. The Catahoula is overlain by the Jasper Aquifer (mostly within the Oakville Sandstone). The Burkeville confining layer separates the Jasper from the overlying Evangeline Aquifer, which is contained within the Fleming and Goliad Sands. The Chicot Aquifer overlies the Evangeline and is the uppermost component of the Gulf Coast Aquifer. The Chicot consists of the Lissie, Willis and younger formations.

The water-bearing zones present consist of a complex sequence of ancient river and delta deposits, consisting mostly of interbedded and interfingering sands, silts and clays which thicken coastward. The strata form a leaky artesian aquifer system of large extent along the Texas Coastal Plain. Total thickness in the Brazos G is up to 1,200 feet, and net sand thickness is about 20 percent of the total thickness. From surface outcrops (recharge areas) the sand zones dip coastward beneath younger strata. Water table conditions occur in recharge areas, and artesian conditions occur in downdip areas. Precipitation is the main source of recharge, and large amounts of recharge are rejected by evapotranspiration in the outcrop. Mostly only freshwater sands occur in the Brazos G, and they extend to depths as great as 1,200 feet. However, some slightly saline water sands occur in the deeper extents of the Catahoula.

Development and Use

The year 2017 groundwater use within the Brazos G totaled 2,708 acft. Approximately 75 percent of the water was used for municipal and manufacturing supply.

Availability

The Gulf Coast Aquifer in Brazos G is primarily within GMA-14, though a small portion of the aquifer extends into southern most part of Brazos County in GMA-12. In letter dated December 2016 to GMA-14, the TWDB referenced a report titled GAM Run 16-024 MAG (Wade, 2016) which presents the MAG for the aquifers in GMA-14. The MAG for the Gulf Coast Aquifer in GMA-14 was determined using the groundwater availability model for the northern part of the Gulf Coast Aquifer System, Version 3.01 (Kasmarek, 2013) Desired Future Conditions provided by the GMA-14 representative.

A letter from the TWDB to GMA-12, dated December 2017, referenced a report titled GAM Run 17-030 MAG (Wade and Ballew, 2017) which provides the MAG volumes for the aquifers in GMA-12. No MAG has been adopted for the Gulf Coast Aquifer in GMA-12. In lieu of an adopted MAG, the Gulf Coast Aquifer MAG estimates are as provided by the TWDB and are based on modeling from GMA-14.

Gulf Coast Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
BRAZOS [A]	1,189	1,189	1,189	1,189	1,189	1,189
GRIMES	13,996	13,996	13,996	13,996	13,996	13,996
WASHINGTON	13,031	13,031	13,031	13,031	13,031	13,031
TOTAL	28,216	28,216	28,216	28,216	28,216	28,216

[A] – Non-MAG estimate

Well Yields

Wide variations occur in individual well yields obtainable from the primary water-bearing sands, depending on area, depth, and local sand thickness. Estimated ranges for maximum individual well yields are 300 to 800 gpm.

Water Quality

Water generally meets drinking water standards, but local exceptions occur. Iron content is occasionally a problem. Waters obtained near the outcrops of the water-bearing zones are generally higher in hardness and lower in total dissolved solids content. In downdip areas the water is commonly a calcium-bicarbonate-type water, with total dissolved solids content ranging up to 1,000 mg/L.

Resource Considerations

Groundwater resources are largely undeveloped, few development problems have occurred to date and water-level declines are minimal to none. Few and limited water pollution problems are apparent. Counties with groundwater conservation districts include: Grimes (Bluebonnet GCD) and Robertson and Brazos (Brazos Valley GCD).

References

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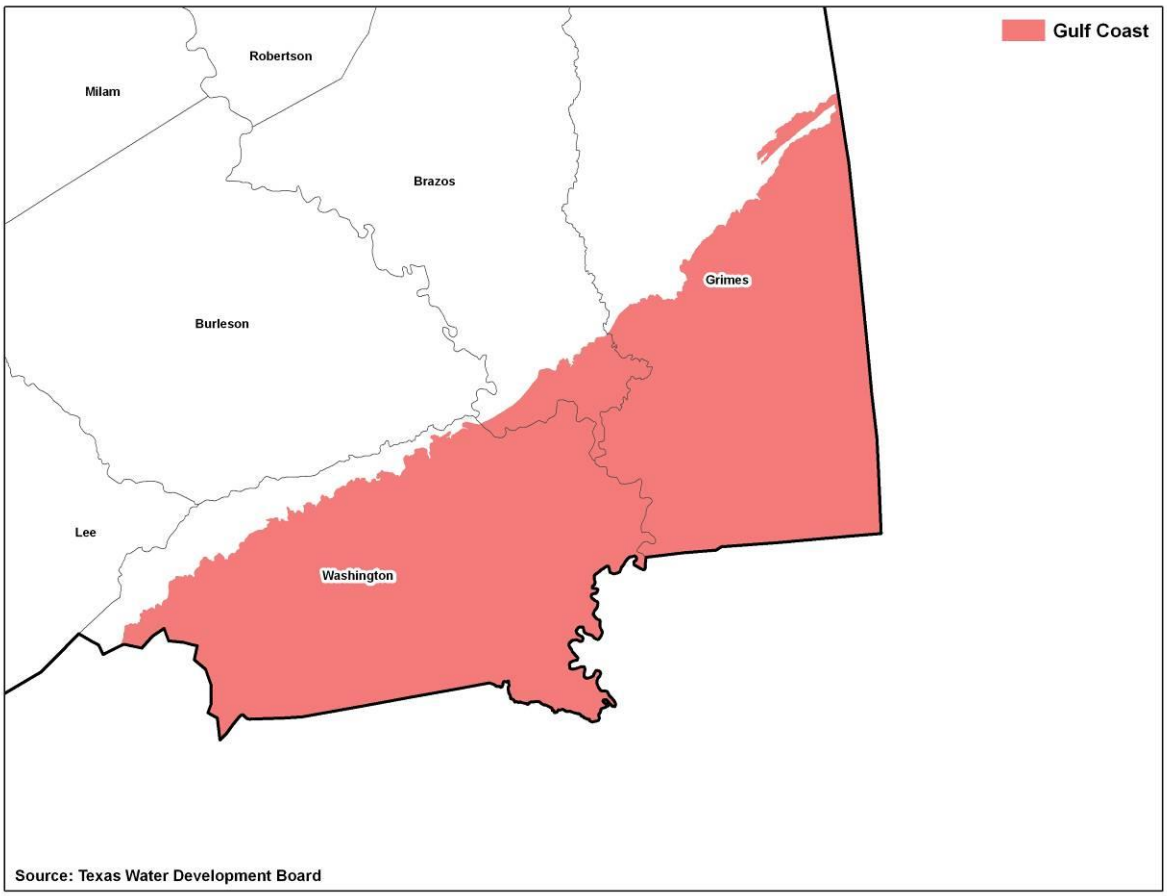

Figure B-9. Location of Gulf Coast Aquifer in Brazos G

Hickory Aquifer

Location

The Hickory Aquifer, a minor aquifer, occurs in the southwest half of Lampasas County and the western tip of Williamson County in the Brazos G. The aquifer primarily occurs in an adjacent planning area to the south and west of Brazos G.

Geohydrology

The aquifer consists of sandstones which dip northeast away from the Llano Uplift. No pumpage is listed in Brazos G in TWDB data files for year 2017, and no Hickory wells are known to exist within the Brazos G. Geophysical log data suggest that the aquifer is deeper than 3,500 feet.

Development and Use

Water-bearing properties are unknown, and water quality with excessive radiological parameters is likely. For these reasons, it is not considered in planning for the Brazos G.

Availability

The Saratoga Underground Water Conservation District encompasses Lampasas County.

In a letter dated January 2018 to GMA-8, the TWDB referenced a report titled GAM Run 17-029 MAG (Shi, 2018) which provides the MAG volumes for the aquifers in GMA-8. The MAG for the Hickory Aquifer was developed using the groundwater availability model for the minor aquifers in the Llano Uplift region of Texas (Shi and Others, 2016) and Desired Future Conditions provided by GMA-8 representative. The results are presented in the following table.

Hickory Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
LAMPASAS	114	113	114	113	114	113
WILLIAMSON	0	0	0	0	0	0
TOTAL	114	113	114	113	114	113

References

Bluntzer, R.L., 1992, Evaluation of the ground-water resources of the Paleozoic and Cretaceous aquifers in the Hill Country of Central Texas: TWDB Report 339.

Preston, R.D., Pavlicek, D.J., Bluntzer, R.L., Derton, J., 1996, The Paleozoic and related aquifers of Central Texas: TWDB Report 346.

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Marble Falls Aquifer

Location

The Marble Falls Aquifer, a minor aquifer, occurs in the Brazos G only in Lampasas County (Figure B-9). It primarily occurs in an adjacent planning area to the south and west.

Geohydrology

The Marble Falls Aquifer occurs in discontinuous outcrops in the southwestern part of Lampasas County. Water occurs in secondary solution fractures, cavities and channels in the Marble Falls Limestone. The aquifer is connected to the Ellenburger-San Saba Aquifer where intervening beds are thin or absent and via faults. The aquifer supports numerous springs. The larger ones include the springs at Lampasas, which average about 9 cfs.

Development and Use

The TWDB estimates pumpage within Brazos G for year 2017 at 23 acft, of which 11 acft was for municipal use.

Availability

In a letter dated January 2018 to GMA-8, the TWDB referenced a report titled GAM Run 17-029 MAG (Shi, 2018) which provides the MAG volumes for the aquifers in GMA-8. The MAG for the Marble Falls Aquifer was developed using the groundwater availability model for the minor aquifers in the Llano Uplift region of Texas (Shi and Others, 2016) and Desired Future Conditions provided by GMA-8 representative. The results are presented in the following table.

Marble Falls Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2030**	**2050**	**2060**	**2070**
LAMPASAS	2,845	2,837	2,845	2,837	2,845	2,837
TOTAL	2,845	2,837	2,845	2,837	2,845	2,837

Well Yields and Water Quality

Aquifer use is limited to shallow, small wells. Water quality is suitable for most purposes near the outcrop area.

Resource Considerations

Groundwater resources are large in relation to current use and future local demand. Regulation is provided by the Saratoga Underground Water Conservation District for Lampasas County.

References

Bluntzer, R.L., 1992, Evaluation of the ground-water resources of the Paleozoic and Cretaceous aquifers in the Hill Country of Central Texas: TWDB Report 339.

Muller, Daniel A., and Price, Robert D., 1979, Ground-water availability in Texas: TDWR Report 238.

Preston, R.D., Pavlicek, D.J., Bluntzer, R.L., Derton, J., 1996, The Paleozoic and related aquifers of Central Texas: TWDB Report 346.

Shi, J., Boghici, R., Kohlrenken, W., and Hutchinson, W.R., 20216, Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory).

Shi, J., 2018, GAM Run 17-029 MAG: Modeled Available Groundwater for the Trinity, Woodbine, Edwards (Balcones Fault Zone), Marble Falls, Ellenburger-San Saba, and Hickory Aquifers in Groundwater Management Area 8, Texas Water Development Board Groundwater Division.

Williams, C.R., 2008. Adopted desired future conditions of the Ellenburger-San Saba, Hickory, and Marble Falls Aquifers: Memorandum dated June 9, 2008 and directed to Cheryl Maxwell, Administrative Agent for Groundwater Management Area 8.

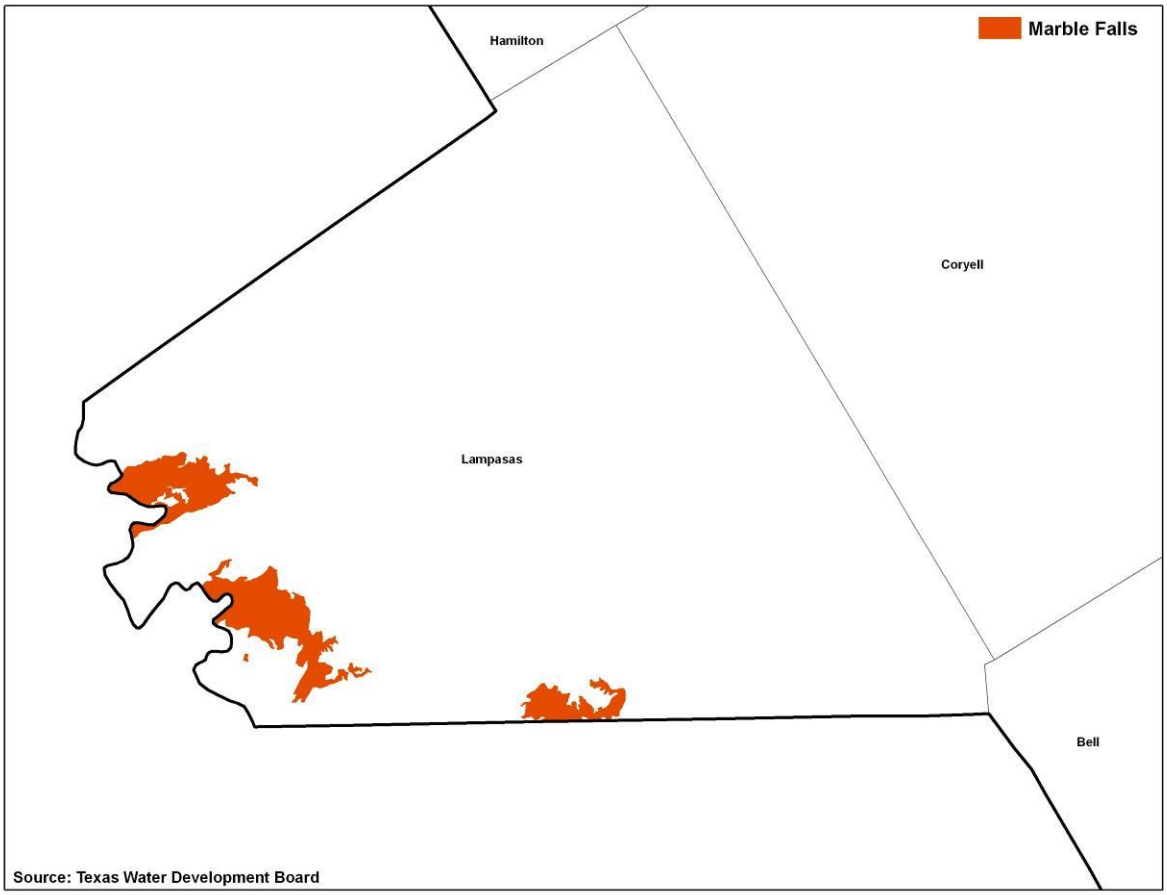

Figure B-10. Location of Marble Falls Aquifer in Brazos G

Queen City Aquifer

Location

The Queen City Aquifer, a minor aquifer, occurs in the southeastern part of the Brazos G and in adjoining planning areas. It forms a northeast-southwest-trending band primarily across parts of Robertson, Brazos, Grimes, Milam, Burleson and Lee Counties (Figure B-10).

Geohydrology

The water-bearing zones consist of sands interbedded with silts and clays. Total sand thickness ranges up to 300 feet. From their surface outcrop (recharge area) the sands dip coastward beneath younger strata. Freshwater occurs to depths up to 2,000 feet or more. Water table conditions occur in recharge areas, and artesian conditions exist in downdip areas. Precipitation and vertical leakage are the main sources of recharge. A large amount of recharge is rejected by evapotranspiration in the outcrop.

Development and Use

The year 2017 groundwater use within the Brazos G totaled 2,676 acft. About 29 percent of that use occurred in Milam County followed by 24 percent, 23 percent, and 21 percent in Lee, Milam, and Robertson Counties, respectively. Total use was about 60 percent for irrigation and 26 percent for municipal use. The relatively small use is partly due to the presence and development of the Sparta Aquifer at shallower depths over most of the area where the Queen City is present.

Availability

The Queen City Aquifer in Brazos G is primarily in GMA-12, though a portion of the aquifer extends into the northern parts of Grimes and Washington Counties in GMA-14. In a letter dated December 2017 to GMA-12, the TWDB referenced a report titled GAM Run 17-030 MAG (Wade and Ballew, 2017) which presents the MAG within the management area. The MAG for the Queen City Aquifer was determined using the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers, version 2.02 (Kelley and others, 2004), which was developed to meet the Desired Future Conditions adopted by groundwater conservation district representatives of GMA-12. No MAG has been adopted for the Queen City within GMA-14; the non-MAG groundwater availability for Grimes County, as provided by the TWDB, are based on modeling from GMA-14.

Queen City Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070** [A]
BRAZOS	836	883	887	891	891	891
BURLESON	416	447	447	447	447	447
GRIMES [B]	637	637	637	637	637	637
LEE	757	774	791	810	829	829
MILAM	53	56	56	56	56	56
ROBERTSON	368	309	309	309	309	309
TOTAL	3,067	3,106	3,127	3,150	3,169	3,169

[A] – Adopted MAG does not include a MAG determination for 2070; 2070 value extrapolated based on 2060 volume.

[B] – Non-MAG estimate

Well Yields

Estimated ranges for maximum individual well yields are 200 to 500 gpm. Wide variations can occur in individual well yields obtainable from the Queen City sands, depending on area, depth and local sand thickness.

Water Quality

Water typically meets drinking water standards, except for iron. High iron content is a common, but treatable, problem. Hydrogen sulfide or methane gas is reported occasionally. Waters obtained near the outcrops of the water-bearing zones generally are higher in hardness and lower in total dissolved solids content. In downdip areas the water is commonly a calcium/sodium- or sodium-bicarbonate-type water with total dissolved solids content ranging from 300 mg/L up to 1,000 mg/L or more.

Resource Considerations

Groundwater resources are partly undeveloped, and few development problems have occurred to date. Water level declines are minimal to none. Few and limited water pollution problems are apparent.

Counties with groundwater districts include: Grimes (Bluebonnet GCD), Robertson and Brazos (Brazos Valley GCD), Lee (Lost Pines GCD), and Milam and Burleson (Post Oak Savannah GCD).

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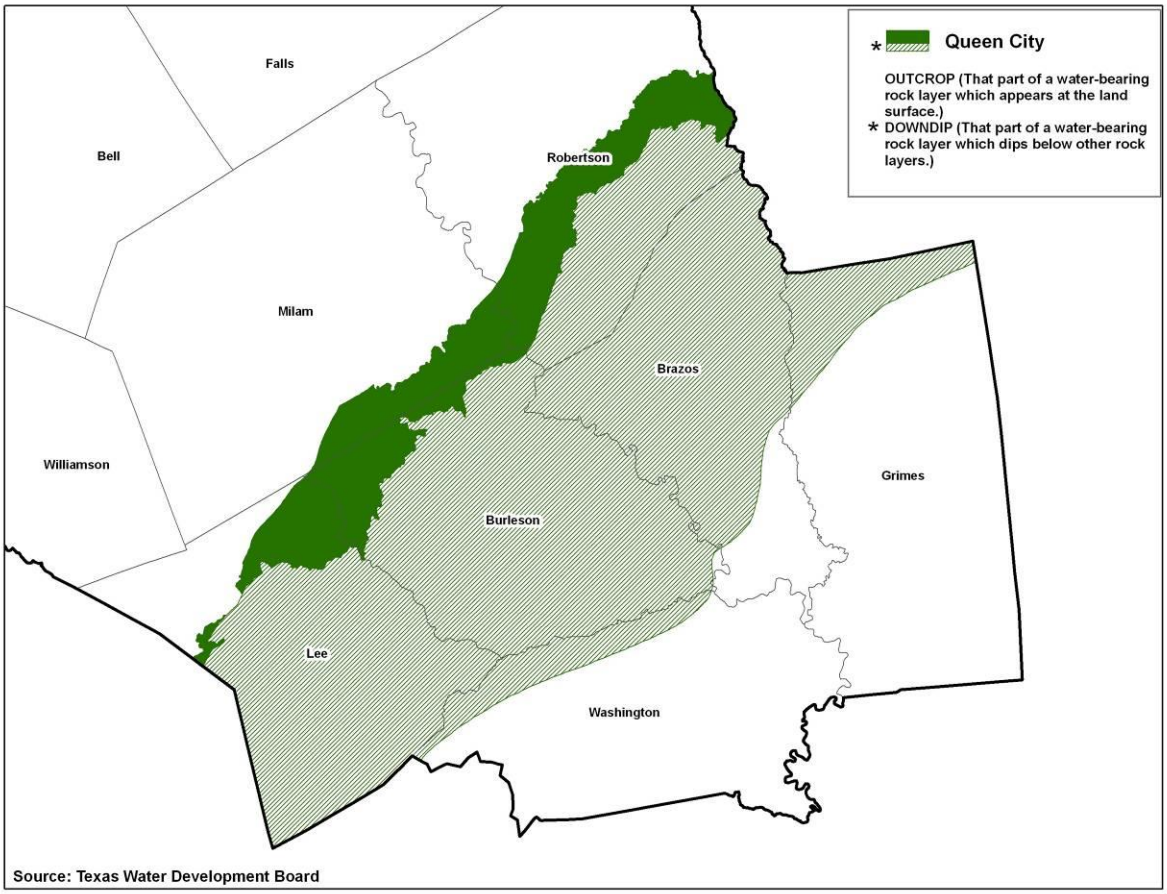

Figure B-11. Location of Queen City Aquifer in Brazos G

Seymour Aquifer

Location

The Seymour Aquifer is classified as a major aquifer in Texas and occurs in scattered, isolated areas in the western part of the Brazos G and in three other planning areas to the north. The Seymour is a shallow, alluvial aquifer used almost exclusively for irrigation.

The largest area of the Seymour Aquifer is in Haskell and Knox Counties where nearly 90 percent of the Seymour pumpage in Brazos G occurs. Other scattered areas of the aquifer extend over parts of Jones, Fisher, Kent, Stonewall, and Throckmorton Counties (Figure B-11). While the Seymour has a large surficial extent in these four counties, the aquifer generally has a relatively thin saturated thickness, is less productive and does not support widespread irrigation as it does in Knox and Haskell Counties.

Geohydrology

The Seymour consists of isolated areas of alluvium and is composed of gravel, sand and silty clay. The gravels, deposited by eastward flowing streams in geologic times, are mostly in the lower part of the Seymour. Total formation thickness is generally less than 100 feet. Water table conditions predominate. Direct infiltration of precipitation is the main source of recharge and is reasonably high. The historical pumpage in Knox and Haskell Counties is equivalent to capturing about 2.0 inches, or over 8 percent, of the annual precipitation. Recharge amounting of over 20 percent of precipitation has been observed for some seasons near Rochester in Haskell County. Water levels have fluctuated mostly in response to variations in rainfall and irrigation pumpage. Continuing water level declines have not occurred in most areas in Haskell and Knox Counties, and some rises have been noted. In all the other counties most water levels show a level or declining trend; and, few rises have been noted.

Development and Use

Within the Brazos G, the TWDB estimates total groundwater pumpage in 2017 to be 76,405 acft. About 98 percent was used for irrigation. However, this aquifer is an important resource for several municipal water users in the northern part of the region. In Kent County, groundwater from the Seymour accounts for nearly all of the municipal supplies. Haskell and Knox Counties accounted for about 96 percent of the total withdrawals in year 2017.

Availability

The Seymour Aquifer in Brazos G is in GMA-6. In a letter dated June 2017, the TWDB referenced a report titled GAM Run 16-031 MAG (Shi, 2017) which presents the MAG for the aquifers in GMA-6. The GAM run report notes that the MAG for the Seymour Aquifer in Knox and Haskell Counties was determined using a refined groundwater availability model for the Seymour Aquifer (Jigmund and others, 2014); the Seymour MAG for Fisher County was determined using the groundwater availability model for the Seymour and Blaine Aquifers (Ewing and others, 2004). Both determinations incorporated Desired Future Conditions provided by the GMA-6 representative.

The 16-031 GAM results did not include a MAG determination for Jones, Kent, Stonewall, Throckmorton, and Young Counties. In lieu of an adopted MAG, the Seymour Aquifer MAG in these counties are estimates, as provided by the TWDB, based on modeling from GMA-6.

Seymour Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
FISHER	6,718	6,132	6,149	6,472	6,490	6,131
HASKELL	41,750	41,636	41,750	41,636	41,750	41,636
JONES [A]	2,918	2,918	2,918	2,918	2,918	2,918
KENT [A]	1,181	1,180	1,180	1,179	1,179	1,179
KNOX	29,036	26,640	26,224	26,530	29,166	26,973
STONEWALL [A]	233	230	224	215	214	214
THROCKMORTON [A]	115	115	115	115	115	115
YOUNG [A]	309	258	258	258	258	258
TOTAL	82,260	79,109	78,818	79,323	82,090	79,424

[A] – Non-MAG estimate

Well Yields

Well yields average 270 gpm and are as high as 1,300 gpm. Wide variations occur in individual well yields obtainable from the Seymour, depending on area, depth and local character and thickness of gravels.

Water Quality

Water quality is variable for many reasons. The dissolved solids content of natural water ranges from 300 to 3,000 mg/L with most values between 400 and 1,000 mg/L. Most water meets drinking water standards, except for nitrate content which typically ranges from 30 to 90 mg/L and commonly exceeds the limit of 45 mg/L for public supplies. Past oil field practices have impacted water quality locally. Many detailed maps of individual water quality parameters for Haskell and Knox Counties are in included in the TDWR Report 226 (Harden, 1978).

Resource Considerations

Groundwater resources, while significant, are essentially fully developed, although some added supplies could be developed in some areas of water level rises or in other areas in average to wet times. Counties with groundwater conservation districts include: Kent (Salt Fork UWCD) and Haskell and Knox (Rolling Plains GCD). There may be additional opportunities for conjunctive use or for recharge and conservation projects in the region, depending on surface water availability and cost effectiveness.

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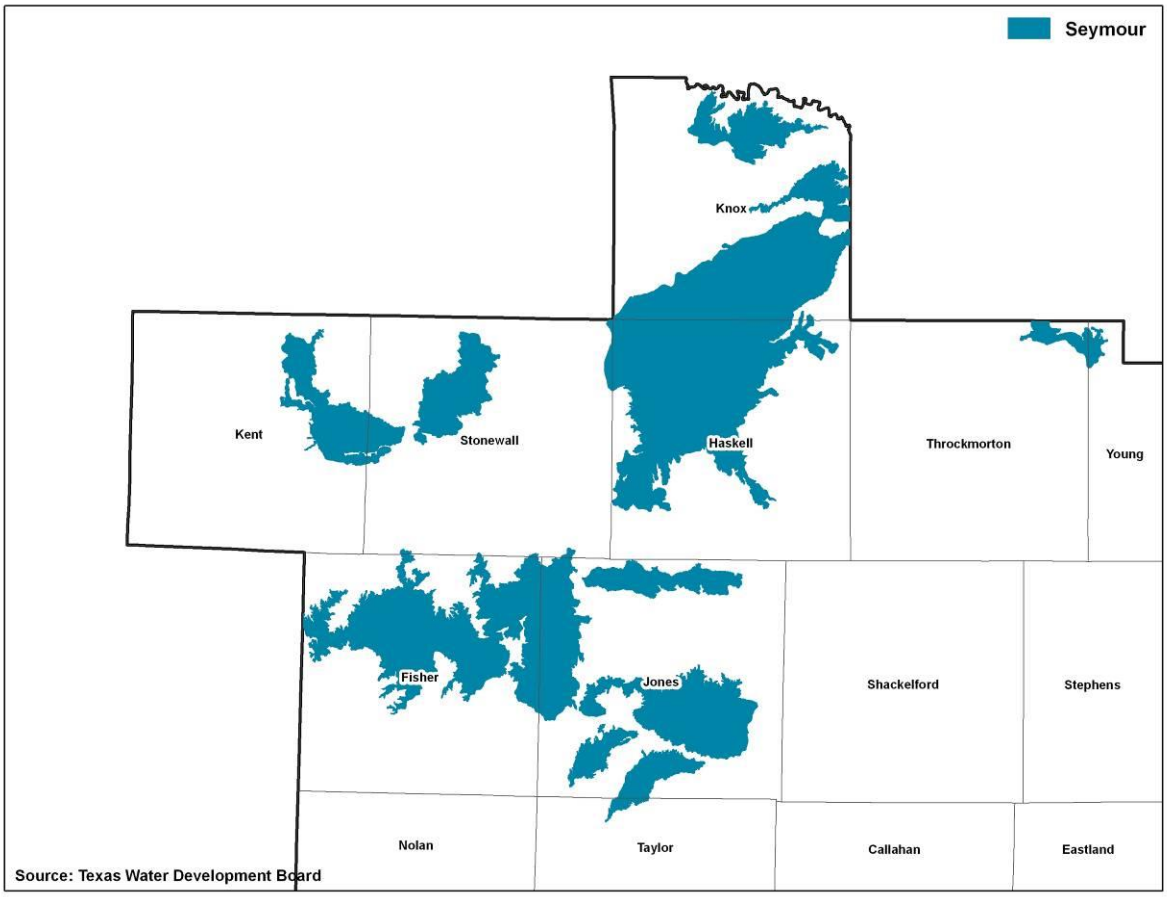

Figure B-12. Location of Seymour Aquifer in Brazos G

Sparta Aquifer

Location

The Sparta Aquifer, a minor aquifer, occurs in the southeastern part of the Brazos G and in adjoining planning areas. It occurs in a northeast-southwest-trending band primarily across parts of Brazos, Burleson, Grimes, Lee, Milam and Robertson Counties (Figure B-12). Its location is a short distance southeast of the Queen City Aquifer. Some users have wells screened across both zones.

Geohydrology

The water-bearing zones consist of sands interbedded with silts and clays. Total sand thickness ranges from about 100 to 200 feet. From their surface outcrop (recharge area) the sands dip coastward beneath younger strata. Freshwater occurs to depths up to 2,000 feet or more. Water table conditions occur in recharge areas, and artesian conditions occur in downdip areas. Precipitation and vertical leakage are the main sources of recharge. A large amount of recharge is rejected by evapotranspiration in the outcrop.

Development and Use

The year 2017 groundwater use within the Brazos G totaled 4,529 acft. About 60 percent that use was for municipal purposes, the majority of which occurred in Brazos County.

Availability

The Sparta Aquifer in Brazos G is primarily within GMA-12, though a portion of the aquifer extends into the northern parts of Grimes and Washington Counties in GMA-14. In a letter dated December 2017 to GMA-12, the TWDB referenced a report titled GAM Run 17-030 MAG (Wade and Ballew, 2017) which presents the MAG within the management area. The MAG for the Sparta Aquifer was determined using the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers, version 2.02 (Kelley and others, 2004) and Desired Future Conditions provided by the GMA-12 representative.

No MAG has been adopted for the Sparta Aquifer in GMA-14; the groundwater availability for Grimes County are estimates, as provided by the TWDB, based on modeling from GMA-14. The resulting MAG volumes for the Sparta Aquifer in Brazos G are presented in the table below.

Sparta Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070 [A]**
BRAZOS	5,404	6,505	7,507	8,509	8,509	8,509
BURLESON	2,246	4,042	5,613	6,735	6,735	6,735
GRIMES [B]	2,571	2,571	2,571	2,571	2,571	2,571
LEE	1,483	1,487	1,490	1,493	1,494	1,494
ROBERTSON	510	510	510	510	510	510
TOTAL	12,214	15,115	17,691	19,818	19,819	19,819

[A] - Adopted MAG does not include a MAG determination for 2070; 2070 value extrapolated based on 2060 volume.

[B] – Non-MAG estimate.

Well Yields

Estimated ranges for maximum individual well yields are 200 to 600 gpm. Wide variations can occur in individual well yields obtainable from the Sparta, depending on area, depth and local sand thickness.

Water Quality

Water typically meets drinking water standards, except for iron. High iron content is a common problem, and hydrogen sulfide gas is reported occasionally. Waters obtained near the outcrops of the water-bearing zones generally are higher in hardness and lower in total dissolved solids content. In downdip areas the water is commonly a calcium/sodium- or sodium-bicarbonate-type water with total dissolved solids content ranging from about 300 up to 1,000 mg/L or more.

Well Yields

Estimated ranges for maximum individual well yields are 200 to 600 gpm. Wide variations can occur in individual well yields obtainable from the Sparta, depending on area, depth and local sand thickness.

Water Quality

Water typically meets drinking water standards, except for iron. High iron content is a common problem, and hydrogen sulfide gas is reported occasionally. Waters obtained near the outcrops of the water-bearing zones generally are higher in hardness and lower in total dissolved solids content. In downdip areas the water is commonly a calcium/sodium- or sodium-bicarbonate-type water with total dissolved solids content ranging from about 300 up to 1,000 mg/L or more.

Resource Considerations

Groundwater resources are largely undeveloped, except in the vicinity of College Station and Texas A&M well fields. Few development problems have occurred to date, and water level declines have been limited except near these well fields and the former Bryan well fields. Few

and limited water pollution problems are apparent. Counties with groundwater conservation districts include: Lee (Lost Pines GCD), Robertson and Brazos (Brazos Valley GCD) and Milam and Burleson (Post Oak Savannah GCD).

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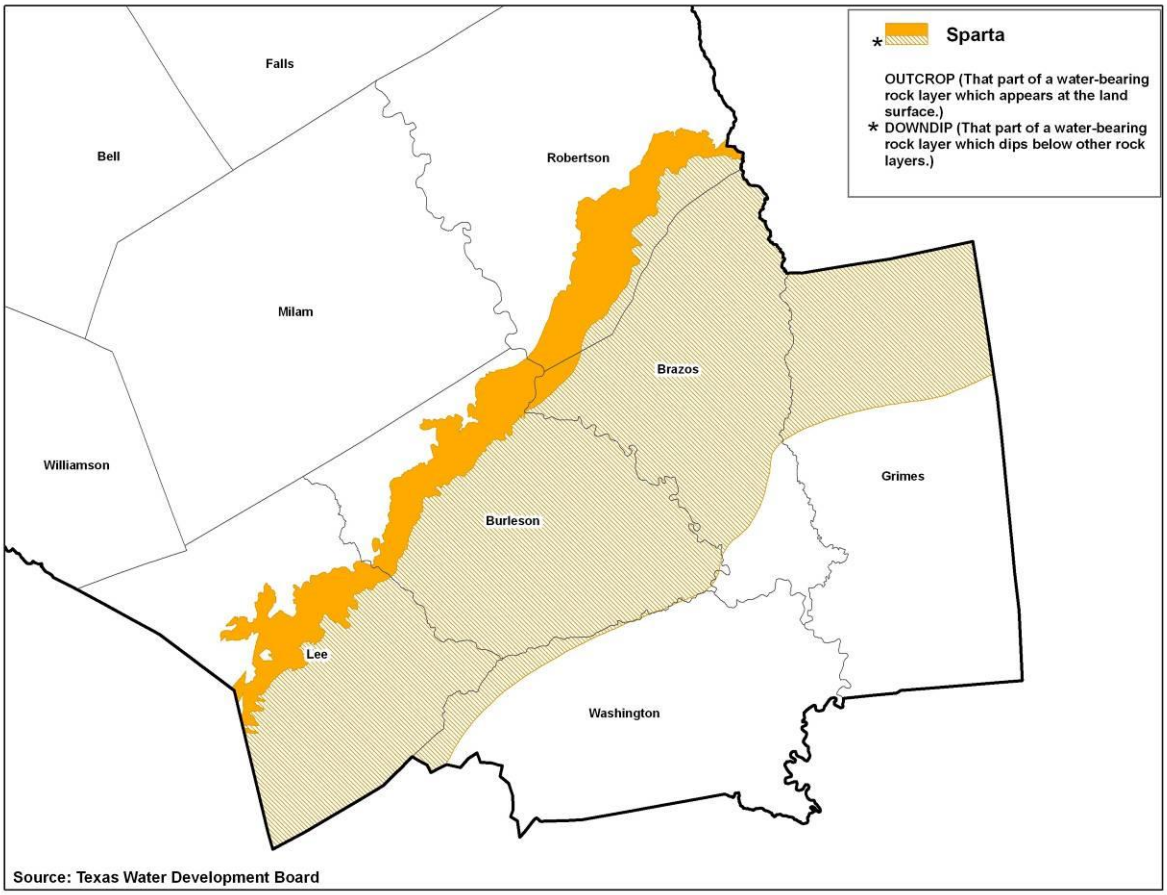

Figure B-13. Location of Sparta Aquifer in Brazos G

Trinity Aquifer

Location

The Trinity Aquifer, a major aquifer, occurs in a north-south-trending band that extends in Brazos G from Williamson County in the south to Hood and Johnson Counties in the north. The aquifer supplies drinking water to numerous communities, homes and farms in Central Texas and irrigation water to many farms, especially in Comanche and Erath Counties. Considering the trends in water level declines as a reference, the aquifer appears to be overdeveloped in a large part of the confined area.

The outcrop of the Trinity Aquifer in Brazos G occurs mostly in Callahan, Eastland, Erath, Hood, Somervell, Comanche, Hamilton, Coryell and Lampasas Counties. The confined area is mostly in Johnson, Hill, Bosque, McLennan, Coryell, Bell and Williamson Counties (Figure B-13).

Geohydrology

The aquifer is composed of the Paluxy, Glen Rose and Travis Peak Formations. The Travis Peak Formation is subdivided into the Hensell, Pearsall/CowCreek/Hamett, and Hosston/Sligo members. Updip where the Glen Rose thins or is missing, the Paluxy and Travis Peak Formations coalesce to form the Antlers Formation. The uppermost water-bearing zone is the Paluxy Formation. The lower water-bearing zone consists of Travis Peak Formation and is divided into the Hensell and Hosston Members in much of the eastern part of Brazos G. Groundwater is much more abundant in the lower zones than the upper zone.

The water-bearing zones consist of a sand and limestone and are often interbedded with clay and shale. The aquifer outcrops in the western part of the north-south-trending band and is confined in the eastern part. The rocks dip east-southeast at a rate of about 15 feet per mile in the northwest part of Brazos G, gradually increase in dip to 40 feet per mile in the central part, and then rapidly increase in dip to 80 to 100 feet per mile east of the Luling-Mexia-Talco Fault Zone. Water table conditions occur in outcrop (recharge) areas, and confined (artesian) conditions occur in downdip areas. The aquifer is naturally recharged by precipitation in the outcrop area where soils have layers of sand and sandy loam. In the downdip area, some recharge to the heavily pumped water-bearing zones probably includes a very modest amount of leakage from over- and underlying formations. Discharge is mostly to wells, springs, seeps and evapotranspiration in the outcrop area, and to wells in the confined zone.

Development and Use

The year 2017 Brazos G groundwater use totaled 71,284 acft, of which 42 percent was municipal use and 49 percent irrigation. Comanche, Erath, and McLennan Counties account for the highest percentage of total pumpage at 26 percent, 18 percent, and 15 percent, respectively.

Availability

The Trinity Aquifer in Brazos G is primarily located within GMA-8, though a small portion extends into Palo Pinto County in GMA-6. In letter dated January 2018 to GMA-8, the TWDB referenced a report titled GAM Run 17-029 MAG (Shi, 2018), which presents the MAG for the aquifers in the management area. The Trinity Aquifer MAG volume in GMA-8 was determined using the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (Kelley and others, 2014) and Desired Future Conditions provided by the GMA-8 representative. No MAG has been adopted for the Trinity Aquifer in GMA-6; the groundwater availability estimate used for Palo Pinto County was taken from previous Brazos G Regional Water Plans and is based on historical TWDB reports and data included in the TWDB groundwater database.

In addition, some municipal or county authorities in the North - Central Texas Trinity and Woodbine Aquifers and Central Texas -Trinity Aquifer in Priority Groundwater Management Areas (PGMAs) may require groundwater availability certification at a subdivision level. If these authorities choose to require a certification, the developer of a new subdivision plat is to follow TCEQ Chapter 230 - Groundwater Availability Certification for Platting rules. It is unknown how many, if any, of the authorities in these PGMAs require certifications.

Well Yields

Well yields have a wide variation in the Trinity Aquifer. In general, yields for large supply wells in the western part of the aquifer where the outcrop occurs are between 50 and 250 gpm. In the confined part, large wells usually produce between 200 and 700 gpm. Well yields are mostly related to the cumulative thickness of sand layers and water level in the water-bearing zone at the well. Potential well yields have declined substantially in areas with large declines in water levels from a combination of increased lift and the inability to create a cone of depression around the well.

Water Quality

Water quality from the Trinity Aquifer is acceptable for most municipal and industrial purposes; however, excess concentrations of certain constituents in some areas exceed drinking water standards. One concern is relatively high concentrations of bacteria and nutrients that have been found in some wells in Callahan, Eastland, Erath and Comanche Counties. Another concern is contamination from brines associated with oil and gas operations. Finally, limited areas are impacted by leakage of poor-quality water from overlying formations.

Resource Considerations

Groundwater resources are considered to be within or less than development limits in the outcrop area and generally overdeveloped in the confined areas. The Trinity Aquifer in Brazos G is overseen by seven groundwater conservation districts, but these districts do not cover the entire aquifer area within the Brazos G. Counties with groundwater conservation districts include: Lampasas (Saratoga UWCD), Bell (Clearwater UWCD), Bosque, Comanche and Erath (Middle Trinity GCD), McLennan (McLennan County GCD), and Coryell (Tablerock GCD), Somerville, Johnson and Hill (Prairielands GCD) and Hood (Upper Trinity GCD).

Trinity Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
BELL	9,267	9,241	9,267	9,241	9,267	9,241
BOSQUE	8,788	8,762	8,788	8,762	8,788	8,762
CALLAHAN	1,729	1,725	1,729	1,725	1,729	1,725
COMANCHE	12,072	12,039	12,072	12,039	12,072	12,039
CORYELL	4,503	4,491	4,503	4,491	4,503	4,491
EASTLAND	5,747	5,732	5,747	5,732	5,747	5,732
ERATH	20,658	20,599	20,658	20,599	20,658	20,599
FALLS	1,438	1,434	1,438	1,434	1,438	1,434
HAMILTON	2,431	2,425	2,431	2,425	2,431	2,425
HILL	4,029	4,017	4,029	4,017	4,029	4,017
HOOD	12,458	12,424	12,458	12,424	12,458	12,424
JOHNSON	9,422	9,396	9,422	9,396	9,422	9,396
LAMPASAS	1,672	1,666	1,672	1,666	1,672	1,666
LEE	0	0	0	0	0	0
LIMESTONE	0	0	0	0	0	0
MCLENNAN	20,691	20,635	20,691	20,635	20,691	20,635
MILAM	0	0	0	0	0	0
PALO PINTO [A]	12	12	12	12	12	12
SOMERVELL	3,188	3,181	3,188	3,181	3,188	3,181
TAYLOR	14	14	14	14	14	14
WILLIAMSON	3,513	3,503	3,513	3,503	3,513	3,503
TOTAL	121,632	121,296	121,632	121,296	121,632	121,296

[A] – Non-MAG estimate

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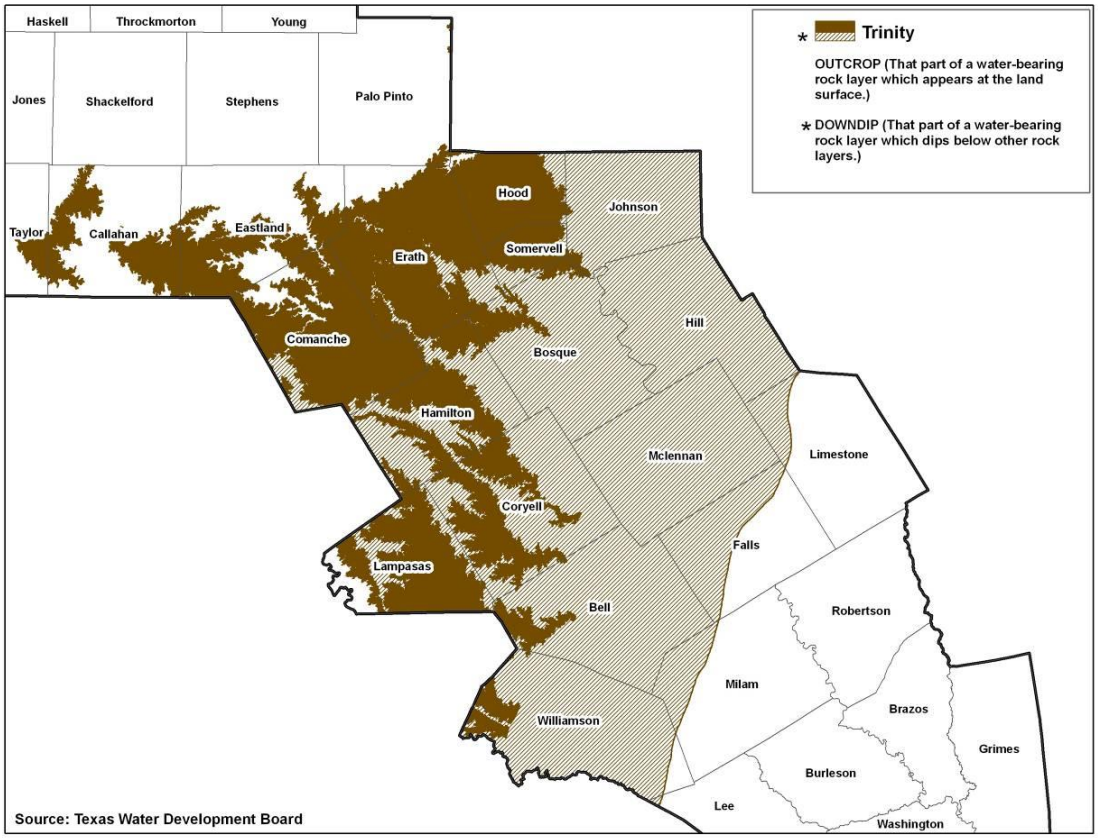

Figure B-14. Location of Trinity Aquifer in Brazos G

Woodbine Aquifer

Location

The Woodbine Aquifer, a minor aquifer, is in the north-central part of the Brazos G and in adjacent planning areas to the north. It occurs in a north-south-trending belt primarily across parts of Johnson and Hill Counties (Figure B-14).

Geohydrology

The Woodbine consists of water-bearing sandstone interbedded with shale. The sandstone tends to be thicker in the lower part of the formation. The upper part of the Woodbine has distinctly poorer water quality. Total formation thickness ranges up to slightly over 200 feet and sand thickness up to 100 feet. From their surface outcrop (recharge area) the water-bearing sands dip eastward beneath younger strata. Water table conditions occur in recharge areas, and artesian conditions occur in downdip areas. Precipitation is the main source of recharge. Maximum estimated transmissivities for the best yielding zones in the lower Woodbine are about 250 to 500 square ft per day.

Development and Use

Development is mostly limited to local use for household and livestock purposes. The TWDB estimates the total pumpage to be 405 acft in 2017. About 58 percent of the pumpage was for municipal purposes.

Availability

The Woodbine Aquifer in Brazos G is located in GMA-8. In a letter dated January 2018 to GMA-8, the TWDB referenced a report titled GAM Run 17-029 MAG (Shi, 2018) which provides the MAG volumes for the aquifers in GMA-8. The MAG for the Woodbine Aquifer in GMA-8 was determined using the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (Kelley and others, 2014) and Desired Future Conditions provided by the GMA-8 representative. The MAG volume for the Woodbine Aquifer in Brazos G is presented in the following table.

In addition, some municipal or county authorities in the North - Central Texas Trinity and Woodbine Aquifers in Priority Groundwater Management Areas (PGMAs) may require groundwater availability certification at a subdivision level. If these authorities choose to require a certification, the developer of a new subdivision plat is to follow TCEQ Chapter 230 - Groundwater Availability Certification for Platting rules. It is unknown how many, if any, of the authorities in these PGMAs require subdivision certifications.

Woodbine Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
HILL	588	586	588	586	588	586
JOHNSON	1,985	1,980	1,985	1,980	1,985	1,980
MCLENNAN	0	0	0	0	0	0
TOTAL	2,573	2,566	2,573	2,566	2,573	2,566

Well Yields

Estimated ranges for maximum individual well yields are 50 to 150 gpm. Wide variations occur in individual well yields obtainable from Woodbine sands, depending on area, depth, and local sand thickness.

Water Quality

Water typically meets drinking water standards. Waters obtained near the outcrop of the water-bearing zones generally are higher in hardness and lower in total dissolved solids content. In confined areas the water is commonly a sodium-bicarbonate-type water with total dissolved solids content ranging from 500 to over 1,000 mg/L. The higher mineralized waters contain appreciably higher sulfate content. High iron concentrations are common in the outcrop areas.

Resource Considerations

The Woodbine is a relatively weak aquifer, supports little development and has minimal potential within the Brazos G. Few development problems have occurred to date, but large water level declines can be expected from any significant added development. Care must be taken in well construction to seal off the higher mineralized water in the upper part of the formation and to screen the best water-bearing zones in the lower part. No existing local plans are known. The groundwater conservation districts regulating the Woodbine in the Brazos G are McLennan County GCD and Prairielands GCD (Hill, Johnson Counties).

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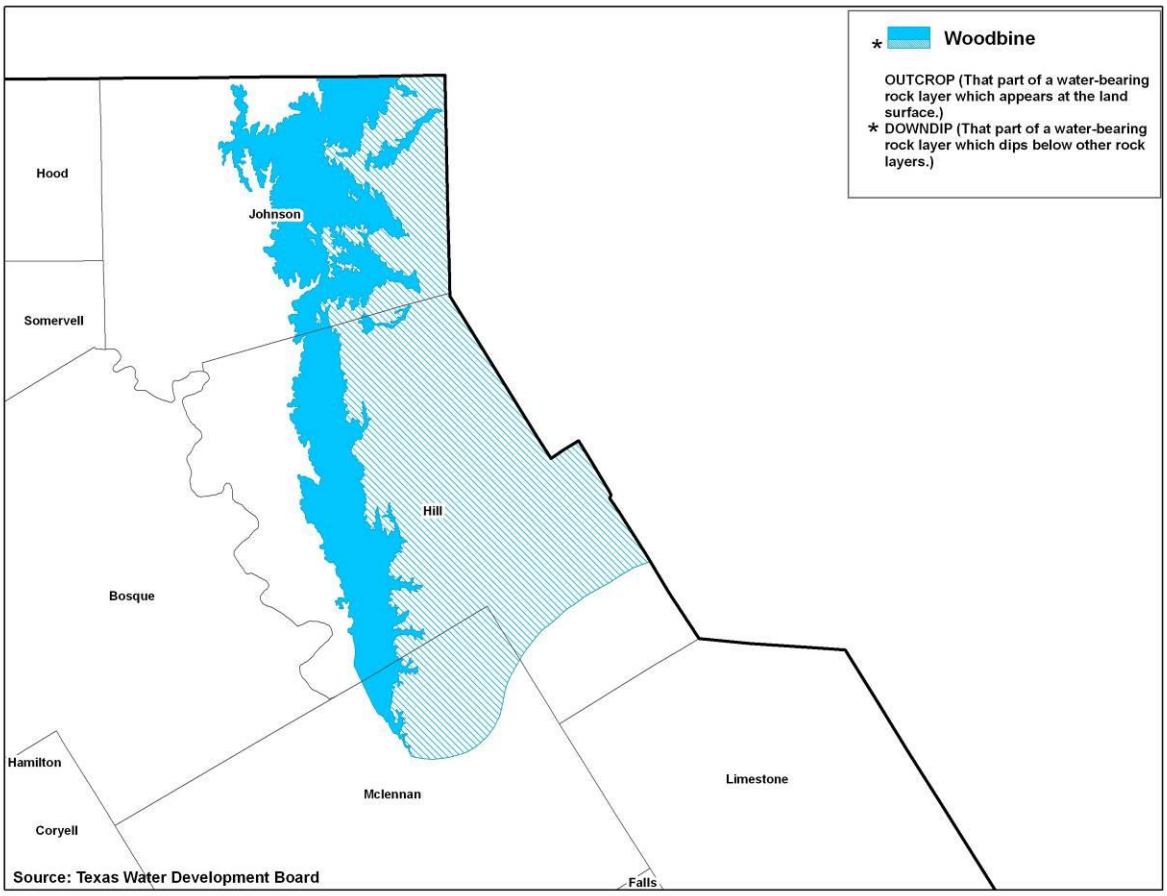

Figure B-15. Location of Woodbine Aquifer in Brazos G

Yegua-Jackson Aquifer

Location

The Yegua-Jackson Aquifer occurs in the southeastern part of the Brazos G and in adjoining planning areas. It occurs in a northeast-southwest-trending band that is 15-20 miles wide and primarily cuts across parts of Brazos, Burleson, Grimes, Lee, and Washington Counties (Figure B-15). Its location is a short distance downdip of the Sparta Aquifer and is covered by younger sediments in much of the area.

Geohydrology

The Yegua Formation consists of fine to medium sand that is interbedded with indurated fine-grained sandstone and clay. It has a maximum thickness in Grimes County of nearly 1,200 ft. The Jackson Group consists of fine to medium sand, clay, and siltstone. Its maximum thickness is about 1,600 ft. From their surface outcrop (recharge area) the sands dip coastward beneath younger strata. Water table conditions occur in recharge areas, and artesian conditions occur in downdip areas. Precipitation is the main source of recharge. A large amount of recharge is rejected by evapotranspiration in the outcrop.

Development and Use

Development is mostly limited to local use for household and livestock purposes. The TWDB estimates the total pumpage to be 3, 079 acft in 2017. Over two-thirds of the pumpage occurred in Brazos County, the majority of which was for irrigation purposes.

Availability

The Yegua-Jackson Aquifer in Brazos G is in GMA-12 and 14. In a letter dated December 2017, the TWDB referenced a report titled GAM Run 17-030 MAG (Wade and Ballew, 2017) which provides the MAG volumes for the aquifers in GMA-12. The MAG for the Yegua-Jackson in GMA-12 was determined using version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer (Deeds and others, 2010) and Desired Future Conditions provided by the GMA-12 representative.

The Yegua-Jackson Aquifer was not included in the most recent modeling and Desired Future Condition evaluation for GMA-14. Correspondingly, no MAG has been adopted for the Yegua-Jackson in Grimes and Washington Counties. In lieu of a published MAG by the GMA, the groundwater availability in Grimes, Lee, and Washington Counties are estimates, as provided by the TWDB, based on modeling from GMAs -14, 13, and -12, respectively.

Well Yields

Estimated maximum individual well yields are about 500 gpm. Wide variations can occur in individual well yields, depending on area, depth and local sand thickness.

Water Quality

Relatively shallow wells yield water that typically meets drinking water standards.. Waters obtained near the outcrops of the water-bearing zones generally are higher in hardness and lower in total dissolved solids content. In downdip areas, water with total dissolved solids content ranges from about 300 up to 1,000 mg/L or more.

Resource Considerations

Counties with groundwater conservation districts include: Lee (Lost Pines GCD), Robertson and Brazos (Brazos Valley GCD), and Grimes (Bluebonnet GCD).

Yegua-Jackson Aquifer

Modeled Available Groundwater (acft/yr)						
COUNTY	**2020**	**2030**	**2040**	**2050**	**2060**	**2070***
BRAZOS	6,856	6,854	6,854	6,854	6,854	6,854
BURLESON	14,544	12,576	12,564	12,478	12,326	12326
GRIMES [A]	3,278	3,278	3,278	3,278	3,278	3,278
LEE [A]	635	635	635	635	635	635
WASHINGTON [A]	291	291	291	291	291	291
TOTAL	25,604	23,634	23,622	23,536	23,384	23,384

[A] – Non-MAG estimate

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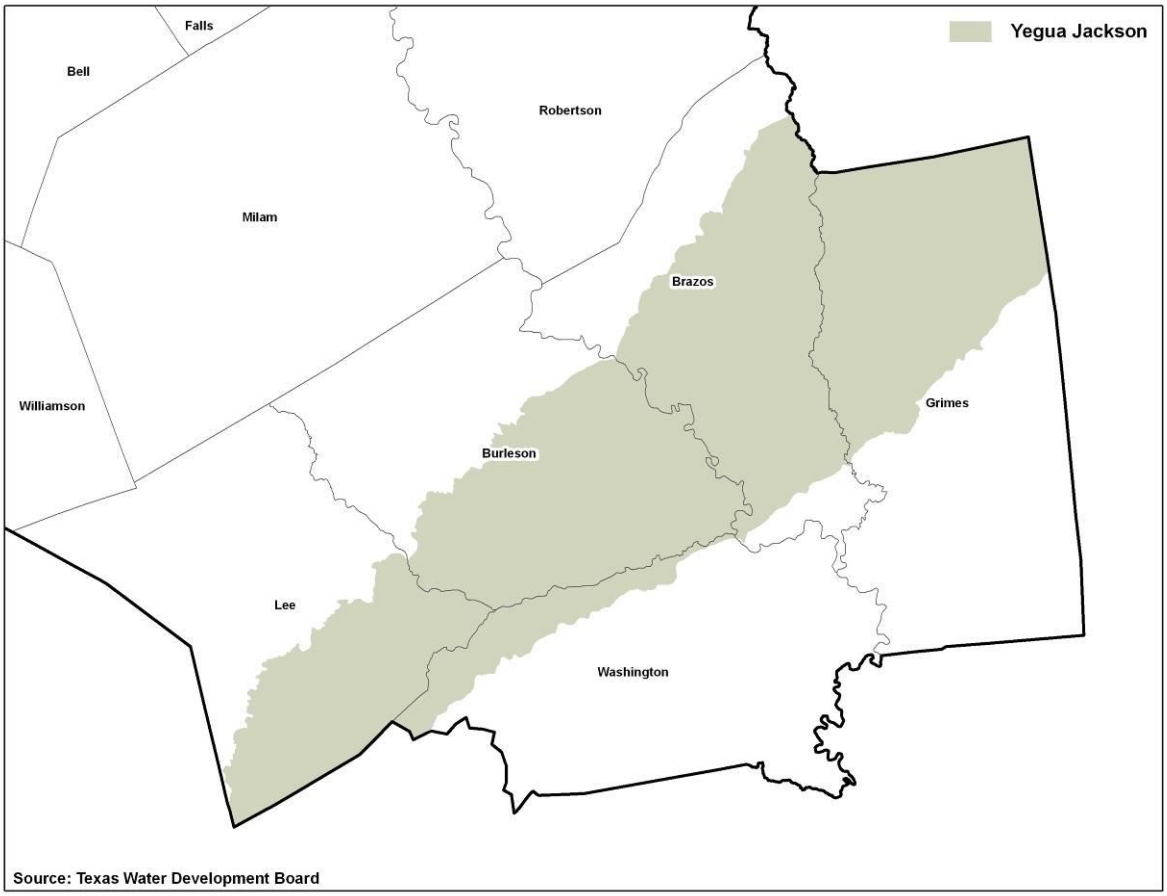

Figure B-16. Location of Yegua-Jackson Aquifer in Brazos G