2.0 Hydrogeologic Conditions in Proximity to the Proposed Wells

This section describes the hydrogeologic conditions in proximity to the proposed Bryan Simsboro Aquifer wells #20 through #23. All four of the new wells will be completed in the Simsboro Aquifer, a formation within the Carrizo-Wilcox Aquifer. The following subsections discuss the hydrogeology and aquifer properties in the vicinity of the proposed wells.

2.1 Site Hydrogeology and Surficial Geology

The Carrizo-Wilcox aquifer is comprised of hydraulically connected sands from the Wilcox Group and the Carrizo Formation of the Claiborne Group (Ashworth and Hopkins, 1995). The sediments that form the Carrizo-Wilcox aquifer are part of a gulfward thickening wedge of Cenozoic sediments deposited in the Rio Grande Embayment of the northwest Gulf Coast Basin. **Figure 2** shows a representative stratigraphic section for the Carrizo-Wilcox Aquifer across Texas. In Central Texas between the Colorado and Trinity rivers, the Wilcox Group is formally subdivided into the Hooper, the Simsboro, and the Calvert Bluff formations. These formations correspond to deltaic, fluvial, and fluvial-deltaic facies, respectively, which occur throughout east-central Texas (Kaiser, 1974). The Hooper Formation represents the initial progradation of the Wilcox Group fluvial-deltaic systems into the Houston Embayment of the Gulf of Mexico basin and consists of interbedded shale and sandstones in subequal amounts, with minor amounts of lignite. The Simsboro Formation is predominantly a sand-rich formation composed of a multistory, multilateral sand deposit (Henry and others, 1980). The Calvert Bluff, like the Hooper Formation, consists mainly of low-permeability clays and lignite deposits (Ayers and Lewis, 1985), which function as confining layers that retard the vertical movement of water within the Carrizo–Wilcox aquifer across the area in the vicinity of the proposed wells.

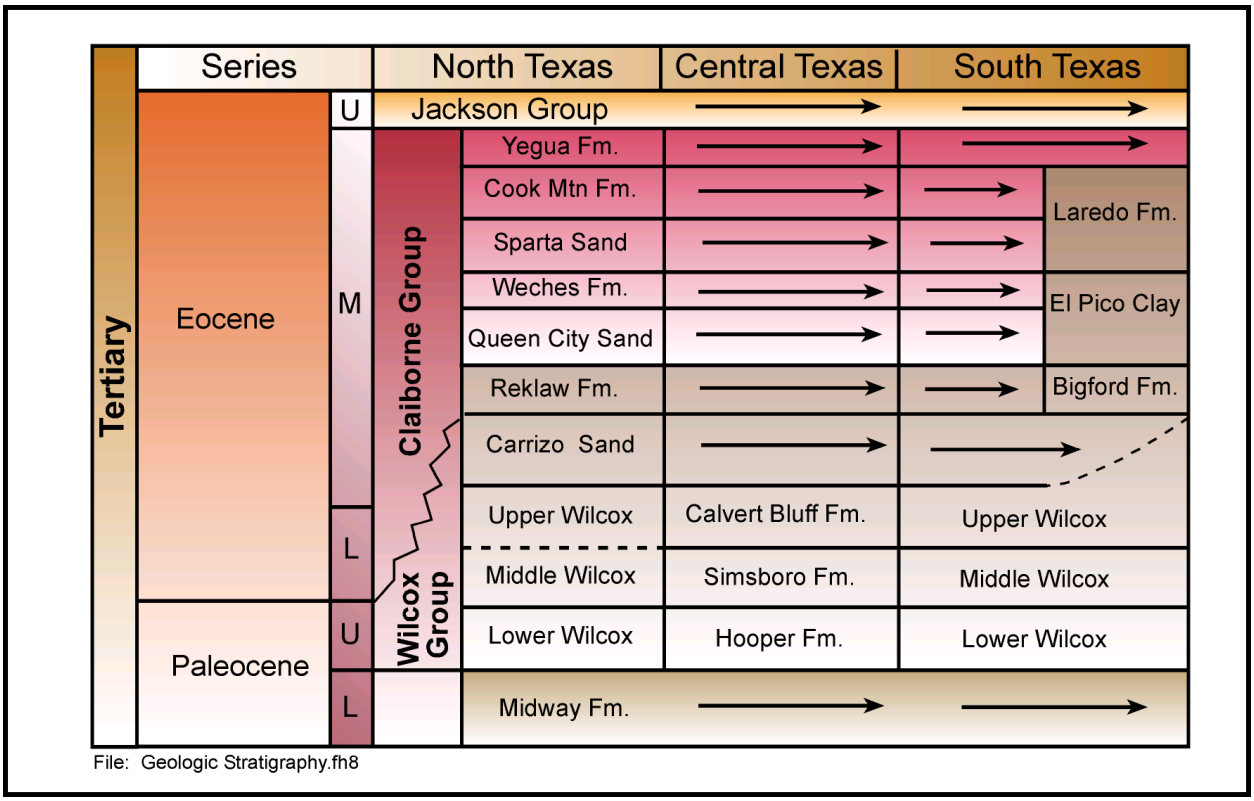

Figure 2. **Generalized stratigraphic section for the Carrizo-Wilcox aquifer in Texas (after Ayers and Lewis, 1985; Hamlin, 1988; Kaiser, 1978).**

Between the Colorado and Trinity rivers, the Carrizo–Wilcox aquifer system is composed of four hydrostratigraphic units with distinct hydraulic properties: the Hooper, Simsboro, and Calvert Bluff Formations of the Wilcox Group and the Carrizo Sand of the Claiborne Group. The Simsboro and Carrizo Formations contain thick, laterally continuous, permeable sands and are generally more important hydrostratigraphic units for water supply development than the Calvert Bluff and Hooper formations. The Calvert Bluff and Hooper formations are mostly comprised of clay, silt, and sand mixtures, as well as lignite deposits. Because of their relatively low vertical permeability, the Hooper and Calvert Bluff formations act as leaky aquitards that confine fluid pressures in the Simsboro and Carrizo aquifers and restrict groundwater movement between the layers. Although the Hooper and Calvert Bluff formations contain sand units, they are generally finer and less continuous than the sands of the Simsboro and Carrizo formations. Above the Carrizo Formation, the low-permeability marine shale of the Reklaw Formation restricts vertical groundwater movement to the overlying Queen City Formation in the Claiborne Group.

Figure 3 provides a surface geology map in the vicinity of the proposed wells. The Cook Mountain Formation of the Claiborne Group is present at ground surface (outcrop) where the proposed new wells are located. The Cook Mountain is younger than the Carrizo-Wilcox and therefore is above that aquifer in stratigraphic sequence (see Figure 2). The Tertiary units comprising the Carrizo-Wilcox, Queen City, and Sparta aquifers dip into the subsurface from their outcrops in a southeast direction from 20 to

180 feet per mile (Dutton and others, 2003). The Carrizo-Wilcox formations, including the Simsboro, outcrop updip from the proposed wells in Robertson County. The formations outcrop in a northeast to southwest direction which can be seen by the contact between the Cook Mountain and the Yegua formations in **Figure 3**.

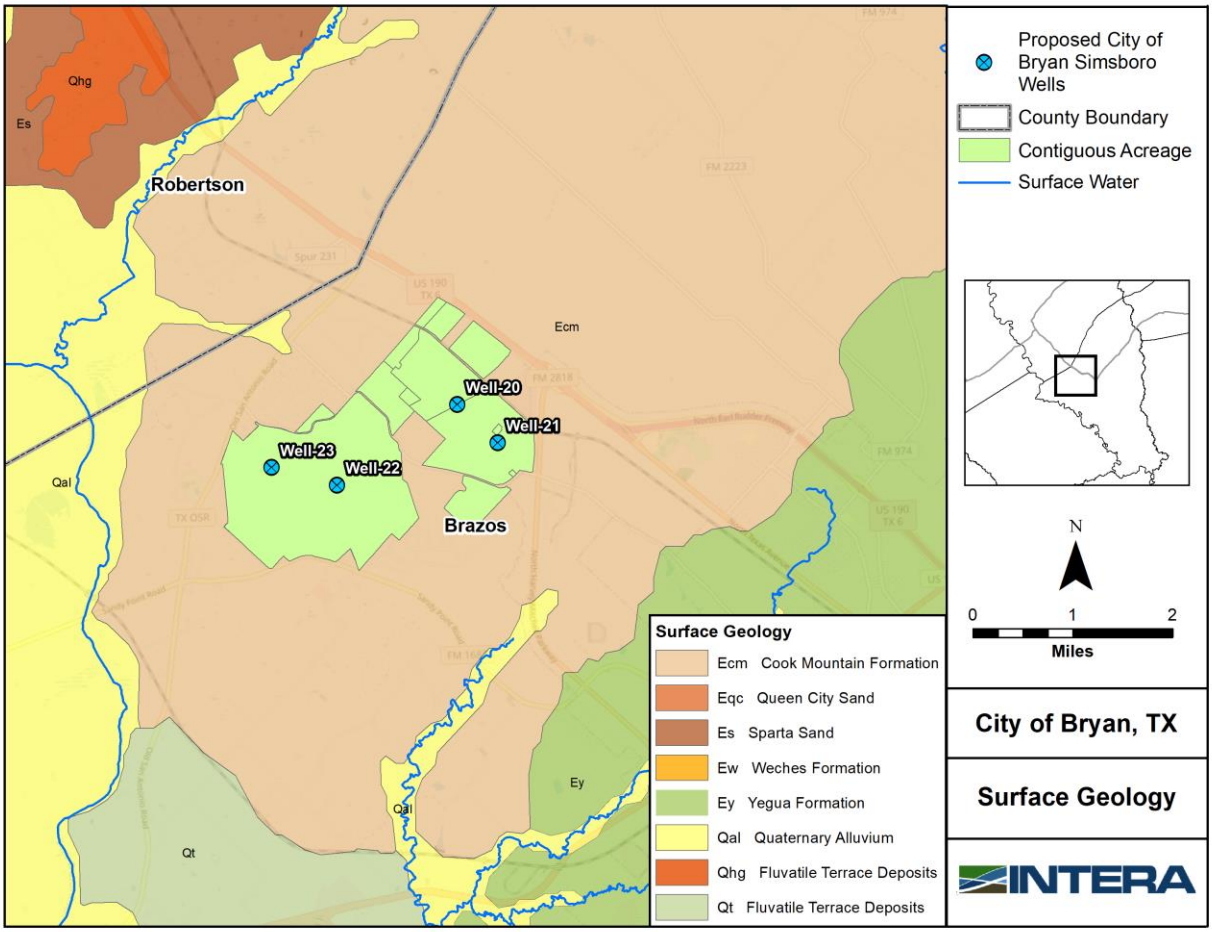

Figure 3. Surface Geology Map in the vicinity of the newly proposed Simsboro Wells (Geologic Atlas of Texas, Austin Sheet Barnes, 1981).

INTERA reviewed four geophysical logs from City of Bryan wells to estimate the aquifer thickness and sand percent in the vicinity of the new wells. In the vicinity of the wells, the top of the Simsboro Formation of the Carrizo-Wilcox Aquifer is 2,300 to 2,500 feet below ground surface (ft bgs). **Table 2** provides INTERA picks and the Groundwater Availability Model (GAM) top elevation, bottom elevations, and thicknesses for the Simsboro at Bryan wells 12, 14, 15 and 18. The table provides our estimate of percent (%) sand in the Simsboro which ranges from 80 to 82% sand.

Table 2. Geophysical Log picks in Simsboro in vicinity to the proposed new wells.

Well Number	Latitude	Longitude	Surface Elevation (ft asl)	INTERA Log Analysis		Thickness (ft)	Sand Percent (%)	GAM Depth to Top Simsboro (ft)	GAM Depth to Bottom Simsboro (ft)	GAM Simsboro Thickness (ft)
				Depth to Top Simsboro (ft)	Depth to Bottom Simsboro (ft)					
Bryan Well 12	30.7293	-96.4296	321	2,385	2,902	517	83	2,393	2,849	456
Bryan Well 14	30.74411	-96.4537	295	2,224	2,711	487	80	2,093	2,687	594
Bryan Well 15	30.7214	-96.4623	362	2,389	2,867	478	80	2,307	2,750	443
Bryan Well 18	30.7266	-96.4776	367	2,324	2,834	512	82	2,060	2,547	487

ft asl = feet above sea level

Depositional patterns of Claiborne Group sedimentation were influenced by the tectonic evolution of the Gulf of Mexico Basin. Early Mesozoic history of the basin included rifting and creation of numerous subbasins. During the Jurassic, marine flooding and restricted circulation resulted in accumulation of halite beds in these subbasins (Jackson, 1982). Subsidence continued as the rifted continental crust cooled. The sediment column records the effects of changes in relative rates of sediment progradation, basin subsidence, and sea level change. More than 50,000 feet of sediment has accumulated in the Gulf of Mexico Basin (Salvador, 1991). Various fault zones are associated with the basin history of crustal warping, subsidence, and sediment loading. From coastward to inland, these include (1) the Wilcox Growth Fault Zone, (2) the Karnes-Milano-Mexia Fault Zone, (3) the Elkhart-Mt. Enterprise Fault Zone, and (4) the Balcones Fault Zone. Recently, Young and others (2018) studied the location, displacement, and hydrologic character of the faults in the Carrizo-Wilcox of Central Texas. **Figure 4** shows the location of faults included in the current Carrizo-Wilcox GAM. There are no known mapped faults in the Carrizo-Wilcox within a five-mile radius of the proposed new wells. Minor faults may exist in this area, but none have been mapped to our knowledge. The closest faults are associated with the Karnes-Milano-Mexia Fault Zone to the north-northwest in Robertson and Milano counties.

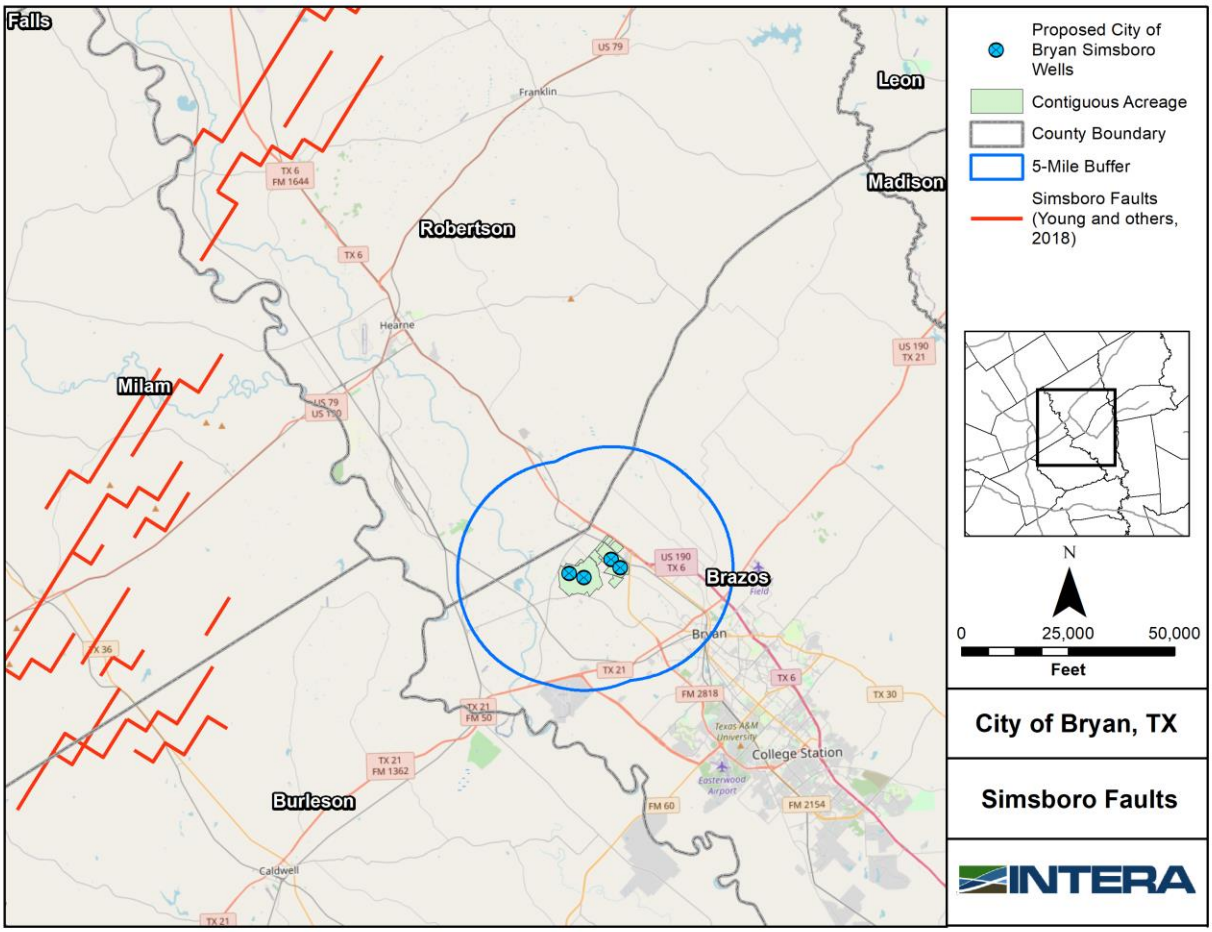

Figure 4. Location of Carrizo-Wilcox fault systems in the vicinity of the proposed wells (Young and others, 2018).

2.2 Depth Interval of Proposed Wells and Aquifer Conditions

The proposed wells will be completed in the Simsboro Formation of the Carrizo-Wilcox Aquifer. In the vicinity of the proposed wells, the top of the Simsboro is at an approximate depth of 2,300 to 2,500 ft bgs and is approximately 500 to 600 feet in thickness. **Table 1** provides an estimate of the expected total depth of each of the proposed new wells.

Static water levels measured by the City of Bryan staff last year averaged approximately 311 ft bgs demonstrating the deeply confined aquifer conditions in the Simsboro in the vicinity of the proposed wells. Current heads in the vicinity of the proposed wells are estimated to range from 2,000 to 2,200 feet above the top of the Simsboro.

Figure 5 plots water levels measured at Bryan Well # 16 and College Station Well #2, both of which are located within the one-mile buffer surrounding the proposed wells. Simsboro water levels in the vicinity of the proposed wells have declined 150 to 200 feet since 1975.

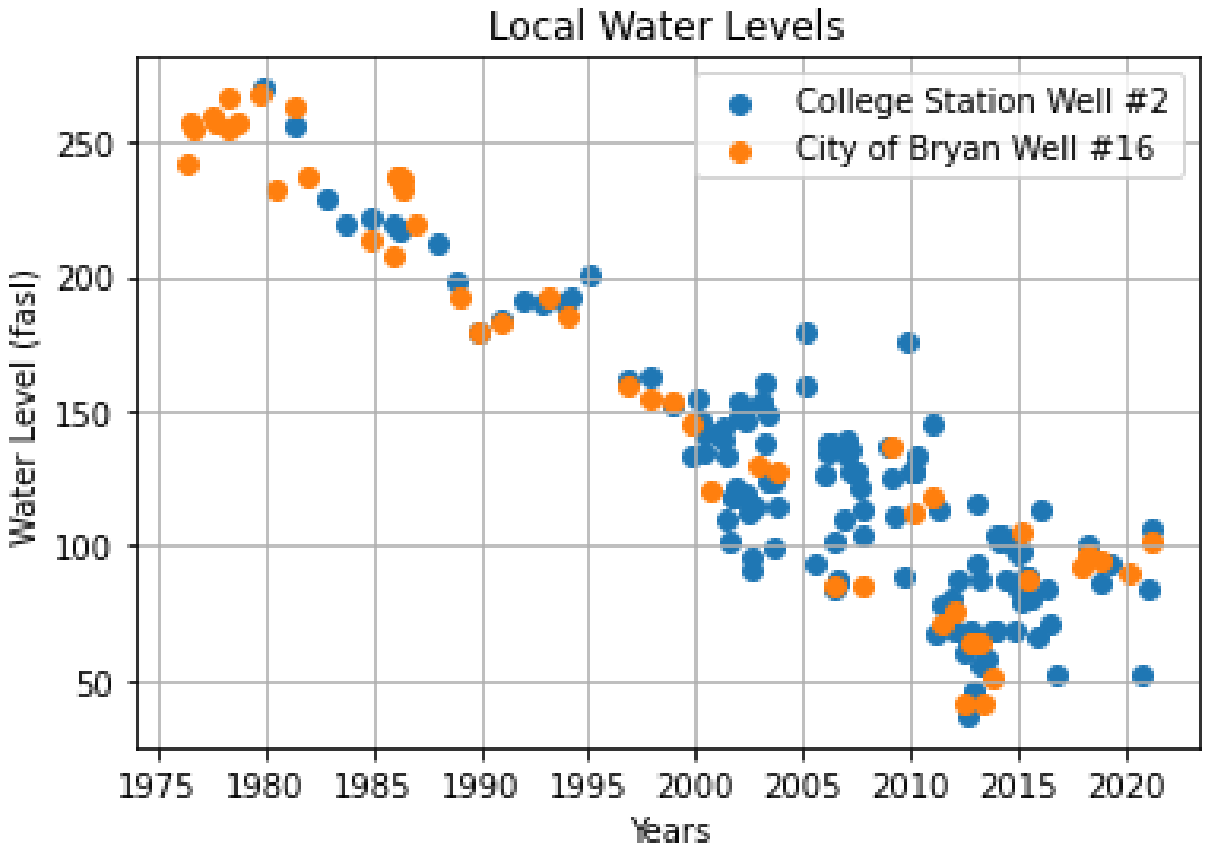

Figure 5. Water elevation hydrographs within the one-mile buffer of the proposed new wells (TWDB Groundwater Database).

2.3 Aquifer Properties in Proximity to Proposed Wells

INTERA reviewed the available well records from the Texas Water Development Board (TWDB) groundwater database, available literature, and the state approved Central Carrizo-Wilcox GAM to characterize the aquifer properties in the vicinity of the proposed wells. Our search for well test data was confined to a radius of five miles surrounding the proposed wells.

A review of the TWDB groundwater database records provided data (pumping rate, drawdown, and time of drawdown measurements) that was used to calculate a specific capacity and estimate a transmissivity for 12 wells. **Appendix A** provides the links to the well reports from which these data were derived. **Table 3** provides estimates of transmissivity and hydraulic conductivity from these 12 tests. The transmissivity was estimated using the Cooper-Jacobs closed form equation and the hydraulic conductivity was estimated from the transmissivity divided by the screen length. The average transmissivity from these tests is 10,263 square feet per day (ft^2/day) with a hydraulic conductivity average of 24.7 feet per day (ft/day). The City of Bryan also estimated specific capacity in eight wells based upon 24-hour pumping events in late 2022. The estimated transmissivity and hydraulic

conductivity from these eight well tests are also shown in **Table 3**. These tests provide an average transmissivity of 13,367 ft^2/day with a hydraulic conductivity average of 32.9 ft/day.

We also reviewed results from five Simsboro wells with available drawdown-rate data with a formal Cooper-Jacob straight line fit for transmissivity. **Table 4** provides the reported transmissivity and hydraulic conductivity estimates from these five tests as well as the source of the data. The test results for Bryan Well #18 are from an LBG-Guyton 2005 technical memorandum (see **Appendix B**). The test interpretations for College Station Wells 1 and 2, Texas A&M Well #7 and #A7 are from Young and others (2018) and the page from that report is included in **Appendix B**. The average transmissivity from these tests is 15,753 ft^2/day with a hydraulic conductivity average of 43 ft/day. This average uses the recovery data estimate for Bryan Well #18 and the early time fit for Texas A&M Well #7. The data in **Table 4** show that it is common to get a different transmissivity estimate depending on whether the data are early time or late time, as the volume of aquifer being integrated in the pumping well response increases with time.

We also looked at the average properties from the Central Carrizo-Wilcox GAM in all grid blocks within a five-mile area of the proposed wells. **Table 5** summarizes these data for the GAM for model layers corresponding to the Reklaw Formation through the base of the Wilcox Group (the Hooper Formation). The average Simsboro transmissivity in the five-mile area surrounding the proposed wells is 14,229 ft^2/day.

In summary, the range of transmissivity estimates from specific capacity data averaged 10,263 ft^2/day from the driller reports and 13,367 ft^2/day from the City of Bryan data collected in fall of 2022. The good pump tests averaged 15,753 ft^2/day and ranged from 9,226 to 24,885 ft^2/day. The average from a five miles area surrounding the proposed wells is 14,229 ft^2/day. The GAM provides an estimate consistent with the available data and a conservative estimate of transmissivity in the vicinity of the proposed wells. For this reason, we used the GAM average transmissivity in the analytic drawdown calculations presented in Section 4.2.

Table 3 Analysis of Production Rate Data from the TWDB Groundwater Database for wells within 5 miles of the proposed wells

Label	State Well #	BVGCD Permit #	Aquifer	Screen Dia. (in)	Total Screen thickness (ft)	GAM thickness (ft)	TWDB GWDB Data		2022 City of Bryan 24 Hour Specific Capacity Tests	
							Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)
City of Bryan - Well #10	5921303	BVHU-0003	Simsboro	20	270	613.3			6,264	23.2
City of Bryan - Well #12	5921205	BVHU-0005	Simsboro	20	368	596.7			12,144	33
City of Bryan - Well #13	5921208	BVHU-0006	Simsboro	20	470	607.8			18,095	38.5
City of Bryan - Well #14	5921207	BVHU-0007	Simsboro	20	484	607.8			22,070	45.6
City of Bryan - Well #15	5921107	BVHU-0008	Simsboro	20	410	435.2	10,947	26.7	13,735	33.5
City of Bryan - Well #16	5921209	BVHU-0009	Simsboro	20	375	591.7			8,700	23.2
City of Bryan - Well #17	5921210	BVHU-0010	Simsboro	20	420	591.7	12,600	30	9,954	23.7
City of Bryan - Well #18	5921108	BVDO-0003	Simsboro	24	375	547.2	12,338	32.9	15,975	42.6
City of Bryan - Well #19 (CS #4)	5921412	BVHU-0041	Simsboro	16	392	442.8	8,859	22.6		
City of College Station - Well #1	5921410	BVHU-0038	Simsboro	10	460	430.3	5,336	11.6		
City of College Station - Well #2	5921409	BVHU-0039	Simsboro	10	390	442.8	6,552	16.8		
City of College Station - Well #3	5921411	BVHU-0040	Simsboro	9	490	519.4	5,537	11.3		
City of College Station - Well #5	5921413	BVHU-0042	Simsboro	10	456	519.4	11,400	25		
City of College Station - Well #7	5921415	BVDO-0013	Simsboro	10	432	525.9	15,466	35.8		
Texas A&M - Well #7	5921732	BVHU-0455	Simsboro	10	436	609.1	12,644	29		
Wellborn SUD - OSR #1	5913707	BVHU-0058	Simsboro	9	470	574.5	6,486	13.8		
Unnamed_GWDB_well_1	5921804		Simsboro	11	372		14,992	40.3		
						AVERAGE	10,263	24.7	13,367	32.9

Table 4 Aquifer Properties from Good Pump Tests for wells within 5 miles of the proposed wells.

Label	State Well #	BVGCD Permit #	Aquifer	Total Screen thickness (ft)	Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Source
City of Bryan - Well #18	5921108	BVDO-0003	Simsboro	375			LBG-Guyton, 2005
Pumping Early Time Fit					14,157		
Pumping Late Time Fit					9,226		
Recovery Fit					14,375	38.3	
City of College Station - Well #1	5921410	BVHU-0038	Simsboro	460	18,192	39.5	Young and others (2018)
City of College Station - Well #2	5921409	BVHU-0039	Simsboro	390	17,556	45.0	Young and others (2018)
Texas A&M - Well #7	5921732	BVHU-0455	Simsboro	436			Young and others (2018)
Early Time Fit					14,331	32.9	
Late Time Fit					24,855		
Texas A&M - Well #A-7			Simsboro	248	14,313	57.7	Young and others (2018)
AVERAGE					15,753	43	

Table 5 GAM Aquifer properties for grid cells within 5 miles of the proposed wells.

Layer	Kh (ft/day)	Kv (ft/day)	Thickness (ft)	Specific Storage (1/ft)	Transmissivity (ft^2/day)	Storativity
Reklaw	0.48	4.31E-05	103.5	7.12E-07	48	7.15E-05
Carrizo	11.34	3.22E-03	284.8	3.48E-07	3,197	9.71E-05
Calvert Bluff	0.94	1.39E-04	962.0	4.13E-07	884	3.94E-04
Simsboro	24.32	2.46E-04	600.0	2.10E-07	14,229	1.25E-04
Hooper	1.52	2.52E-05	939.9	2.71E-07	1,429	2.55E-04

T and S calculated using the properties in each cell and then averaged
All cells within 5 miles