Appendix 3-A

Desired Future Conditions and Modeled Available Groundwater Reports

The TWDB Groundwater Resources Division's Groundwater Availability Modeling Section has prepared GAM Run reports for each Groundwater Management Area (GMA) in Texas. The East Texas Regional Water Planning Area falls within two of these GMAs: GMA 11 and GMA 14. The reports related to these two GMAs are provided in this appendix.



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GAM RUN 16-024 MAG: MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 14

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Shirley C. Wade, Ph.D., P.G. Texas Water Development Board Groundwater Division Groundwater Availability Modeling Section (512) 936-0883 December 15, 2016

EXECUTIVE SUMMARY:

The modeled available groundwater for Groundwater Management Area 14 and the projected groundwater pumpage in subsidence districts for the Gulf Coast Aquifer System ranges from approximately 1,020,000 acre-feet per year in 2010 to 950,000 acre-feet per year in 2070. Table 1 presents the modeled available groundwater summarized by the decades 2010 to 2070 for groundwater conservation districts. Table 2 presents the projected groundwater pumpage in regulatory plans adopted by subsidence districts and factored into the development of desired future conditions adopted by groundwater conservation districts. Table 3 summarizes the modeled available groundwater for groundwater conservation districts and non-district counties, and the projected groundwater pumpage for subsidence districts by the decades 2020 to 2070 for use in the regional water planning process. The estimates are based on the desired future conditions for the Gulf Coast Aquifer System adopted by groundwater conservation districts in Groundwater Management Area 14 on April 29, 2016. The explanatory report and other materials submitted to the Texas Water Development Board (TWDB) were determined to be administratively complete on July 12, 2016.

REQUESTOR:

Ms. Kathy Turner Jones, chair of Groundwater Management Area 14.

DESCRIPTION OF REQUEST:

In a letter dated May 5, 2016, Ms. Kathy Turner Jones provided the TWDB with the desired future conditions of the Gulf Coast Aquifer System adopted by the groundwater

December 15, 2016

Page 4 of 30

conservation districts in Groundwater Management Area 14. The desired future conditions for the Gulf Coast Aquifer System, as described in Resolution No. 2016-01-01 and adopted April 29, 2016 by the groundwater conservation districts within Groundwater Management Area 14, are described below:

Groundwater Management Area 14 [all counties]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 28.3 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 23.6 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 18.5 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 66.2 feet after 61 years.

Austin County [Bluebonnet Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 39 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 23 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 23 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 76 feet after 61 years.
- From estimated year 1890 conditions, the maximum subsidence in Austin County should not exceed approximately 2.83 feet by the year 2070.

Brazoria County [Brazoria County Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 23 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 27 feet after 61 years.

December 15, 2016

Page 5 of 30

Chambers County

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 32 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 30 feet after 61 years.

Grimes County [Bluebonnet Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 5 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 5 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 6 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 52 feet after 61 years.
- From estimated year 1890 conditions, the maximum subsidence in Grimes County should not exceed approximately 0.12 feet by the year 2070.

Hardin County [Southeast Texas Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 21 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 27 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 29 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 89 feet after 61 years.

Jasper County [Southeast Texas Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 23 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 41 feet after 61 years.

December 15, 2016

Page 6 of 30

- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 46 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 40 feet after 61 years.

Jefferson County

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 15 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 17 feet after 61 years.

Liberty County

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 27 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 29 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 25 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 120 feet after 61 years.

Montgomery County [Lone Star Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 26 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately -4 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately -4 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 34 feet after 61 years.

Newton County [Southeast Texas Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 35 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 45 feet after 61 years.

December 15, 2016

Page 7 of 30

- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 44 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 37 feet after 61 years.

Orange County

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 14 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 16 feet after 61 years.

Polk County [Lower Trinity Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 26 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 10 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 15 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 73 feet after 61 years.

San Jacinto County [Lower Trinity Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 22 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 19 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 19 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 108 feet after 61 years.

Tyler County [Southeast Texas Groundwater Conservation District]

• From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 42 feet after 61 years.

December 15, 2016

Page 8 of 30

- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 35 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 30 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 62 feet after 61 years.

Walker County [Bluebonnet Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 9 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 4 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 42 feet after 61 years.
- From estimated year 1890 conditions, the maximum subsidence in Walker County should not exceed approximately 0.04 feet by the year 2070.

Waller County [Bluebonnet Groundwater Conservation District]

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 39 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 39 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 40 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 101 feet after 61 years.
- From estimated year 1890 conditions, the maximum subsidence in Waller County should not exceed approximately 4.73 feet by the year 2070.

Washington County

- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 1 foot after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 16 feet after 61 years.

December 15, 2016

Page 9 of 30

• From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 48 feet after 61 years.

Harris, Galveston, and Fort Bend Counties (Subsidence Districts)

Harris-Galveston Subsidence District and Fort Bend Subsidence District are not subject to the provisions of Section 36.108 of the Texas Water Code and therefore have not specified desired future conditions. Because desired future conditions were not adopted for the counties in the subsidence districts, modeled available groundwater values were not determined for those counties. The districts in Groundwater Management Area 14 incorporated the groundwater pumpage projections made by the subsidence districts in their regulatory plans so that all known regional groundwater pumpage projections are provided in Table 2 and are incorporated into the information relevant to regional water planning (Table 3).

METHODS:

The TWDB ran the groundwater availability model (version 3.01) for the northern part of the Gulf Coast Aquifer System (Figure 1) using the model files submitted with the explanatory report (GMA 14 and others, 2016; Appendix F) and an updated pumping file provided by the Groundwater Management Area 14 consultants on October 26, 2016. The modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Annual pumping rates were divided by county, river basin, regional water planning area, and groundwater conservation district within Groundwater Management Area 14 (Figure 2 and Tables 1 through 3).

As part of the process to calculate modeled available groundwater, the TWDB checked the model files submitted by Groundwater Management Area 14 to determine if the groundwater pumping scenarios were compatible with the adopted desired future conditions. The TWDB used these model files to extract model-calculated water levels for 2009 and 2070, and drawdown was calculated as the difference between water levels in 2009 and water levels in 2070. The results of this evaluation are provided in the Appendix. Drawdown averages were calculated for each county by aquifer and for the entire groundwater management area by aquifer. As specified in the explanatory report (GMA 14 and others, 2016; Appendix F), drawdown for cells which became dry during the simulation (water level dropped below the base of the cell) were excluded from the averaging. The calculated drawdown averages compared well with the desired future conditions and verified that the pumping scenarios defined by the districts achieved the desired future conditions. The subsidence values were also extracted from the model

December 15, 2016

Page 10 of 30

results and those were also compared to subsidence-based desired future conditions for the four counties where they were specified.

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the groundwater availability are described below:

- Version 3.01 of the groundwater availability model for the northern portion of the Gulf Coast Aquifer System was used for this analysis. See Kasmarek (2013) for assumptions and limitations of the model.
- The model has four layers which represent the Chicot Aquifer (Layer 1), the Evangeline Aquifer (Layer 2), the Burkeville Confining Unit (Layer 3), and the Jasper Aquifer and parts of the Catahoula Formation in direct hydrologic communication with the Jasper Aquifer (Layer 4).
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).
- Drawdown averages and modeled available groundwater values are based on the extent of the model area rather than official aquifer boundaries (Figures 1 and 2).
- Drawdown for cells with water levels below the base elevation of the cell ("dry" cells) were excluded from the averaging per Appendix F of the explanatory report.
- Cells with water levels below the base are "dry" in terms of water level. However, the transmissivity of those cells remains constant and pumping from those cells continues.
- For those cells where water levels have dropped below the base we include pumping in the modeled available groundwater values.
- Estimates of modeled available groundwater from the model simulation were rounded to whole numbers.

December 15, 2016

Page 11 of 30

- Starting conditions were assumed reasonable since 2009 was the final year of the calibrated model.
- A model tolerance of up to one foot was assumed when comparing desired future condition average drawdown values per county to model results (Appendix).
- A model tolerance of 0.1 foot was assumed when comparing desired future condition maximum subsidence values per county to model results (Appendix).
- Average drawdown per county may include some model cells that represent portions of surface water such as bays, reservoirs, and the Gulf of Mexico.

RESULTS:

The modeled available groundwater for the Gulf Coast Aquifer System that achieves the desired future conditions adopted by Groundwater Management Area 14 decreases from 571,007 to 544,220 acre-feet per year between 2010 and 2070 (Table 1). Projected groundwater pumpage from the three counties in the Harris Galveston Subsidence District and Fort Bend Subsidence District range between 325,226 and 545,246 acre-feet per year during the period 2010 to 2070 (Table 2). The combination of modeled available groundwater and projected groundwater pumpage has been summarized by county, river basin, and regional water planning area for use in the regional water planning process (Table 3). The modeled available groundwater is also summarized by groundwater conservation district and county (Table 1).

December 15, 2016

Page 12 of 30



FIGURE 1. MAP SHOWING THE AREAS COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PART OF THE GULF COAST AQUIFER SYSTEM.

December 15, 2016

Page 13 of 30



FIGURE 2. MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), SUBSIDENCE DISTRICTS, COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 14.

December 15, 2016

Page 14 of 30

TABLE 1.MODELED AVAILABLE GROUNDWATER FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 14
SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2070.
VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater									
Conservation	County	Aquifor	2010	2020	2020	2040	2050	2060	2070
District	County	Aquiter	2010	2020	2030	2040	2050	2000	2070
Bluebonnet GCD	Austin	Chicot Aquifer	1,300	1,300	1,300	1,300	1,300	1,300	1,300
Bluebonnet GCD	Austin	Evangeline Aquifer	19,998	19,998	19,998	19,998	19,998	19,998	19,998
Bluebonnet GCD	Austin	Burkeville confining	0	0	0	0	0	0	0
Bluebonnet GCD	Austin	Jasper Aquifer	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Bluebonnet GCD	Grimes	Chicot Aquifer	0	0	0	0	0	0	0
Bluebonnet GCD	Grimes	Evangeline Aquifer	2,999	2,999	2,999	2,999	2,999	2,999	2,999
Bluebonnet GCD	Grimes	Burkeville confining	0	0	0	0	0	0	0
Bluebonnet GCD	Grimes	Jasper Aquifer	10,998	10,998	10,998	10,998	10,998	10,998	10,998
Bluebonnet GCD	Walker	Chicot Aquifer	0	0	0	0	0	0	0
Bluebonnet GCD	Walker	Evangeline Aquifer	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Bluebonnet GCD	Walker	Burkeville confining	0	0	0	0	0	0	0
Bluebonnet GCD	Walker	Jasper Aquifer	15,972	15,972	15,972	15,972	15,972	15,972	15,972
Bluebonnet GCD	Waller	Chicot Aquifer	300	300	300	300	300	300	300
Bluebonnet GCD	Waller	Evangeline Aquifer	40,994	40,994	40,994	40,994	40,994	40,994	40,994
Bluebonnet GCD	Waller	Burkeville confining	0	0	0	0	0	0	0
Bluebonnet GCD	Waller	Jasper Aquifer	300	300	300	300	300	300	300
Bluebonnet GCD		Gulf Coast Aquifer	05 850	05 850	05 850	05 850	05 850	05 850	05 850
Total		System	93,039	93,039	93,039	93,039	93,039	93,039	93,039
Brazoria County	Brazoria	Chicot Aquifer	38,994	39,042	39,164	39,208	39,251	39,295	39,345
Brazoria County	Brazoria	Evangeline Aquifer	11,376	11,376	11,376	11,376	11,376	11,375	11,376
Brazoria County		Gulf Coast Aquifer	50.369	50.418	50.540	50,583	50.626	50.670	50.721
GCD Total		System	00,000	55,110	00,010	00,000	00,010	55,57.0	
Lone Star GCD	Montgomery	Chicot Aquifer	11,922	12,600	13,870	13,944	15,026	14,717	14,175
Lone Star GCD	Montgomery	Evangeline Aquifer	37,734	27,525	27,553	27,773	26,575	26,615	26,529

December 15, 2016

Page 15 of 30

Groundwater									
District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
	, , , , , , , , , , , , , , , , , , ,	1							
Lone Star GCD	Montgomery	Burkeville confining	0	0	0	0	0	0	0
Lone Star GCD	Montgomery	Jasper Aquifer	41,491	23,880	22,582	22,288	22,404	22,673	23,301
Lone Star GCD		Gulf Coast Aquifer	91 146	64 004	64 004	64 004	64 004	64 004	64 004
Total		System	21,110	01,001	01,001	01,001	01,001	01,001	01,001
Lower Trinity GCD	Polk	Chicot Aquifer	0	0	0	0	0	0	0
Lower Trinity GCD	Polk	Evangeline Aquifer	8,302	8,302	8,302	8,302	8,302	8,302	8,302
Lower Trinity GCD	Polk	Burkeville confining	743	743	743	743	743	743	743
Lower Trinity GCD	Polk	Jasper Aquifer	27,663	27,663	27,663	27,663	27,663	27,663	27,663
Lower Trinity GCD	San Jacinto	Chicot Aquifer	0	0	0	0	0	0	0
Lower Trinity GCD	San Jacinto	Evangeline Aquifer	8,170	8,170	8,170	8,170	8,170	8,170	8,170
Lower Trinity GCD	San Jacinto	Burkeville confining	2,697	2,697	2,697	2,697	2,697	2,697	2,697
Lower Trinity GCD	San Jacinto	Jasper Aquifer	10,116	10,116	10,116	10,116	10,116	10,116	10,116
Lower Trinity		Gulf Coast Aquifer	57.691	57,691	57.691	57.691	57,691	57,691	57.691
GCD Total		System	0,,0,1	07,071	0,,071	5,,671	07,071	07,071	57,071
Southeast Texas	Hardin	Chicot Aquifer	1,262	1,262	1,262	1,262	1,262	1,262	1,262
Southeast Texas	Hardin	Evangeline Aquifer	33,665	33,665	33,665	33,665	33,665	33,665	33,665
Southeast Texas	Hardin	Burkeville confining	0	0	0	0	0	0	0
Southeast Texas	Hardin	Jasper Aquifer	0	0	0	0	0	0	0
Southeast Texas	Jasper	Chicot Aquifer	10,827	10,827	10,827	10,827	10,827	10,827	10,827
Southeast Texas	Jasper	Evangeline Aquifer	40,648	40,648	40,648	40,648	40,648	40,648	40,648
Southeast Texas	Jasper	Burkeville confining	1	1	1	1	1	1	1
Southeast Texas	Jasper	Jasper Aquifer	16,008	16,008	16,008	16,008	16,008	16,008	16,008
Southeast Texas	Newton	Chicot Aquifer	500	500	500	500	500	500	500
Southeast Texas	Newton	Evangeline Aquifer	21,343	21,343	21,343	21,343	21,343	21,343	21,343
Southeast Texas	Newton	Burkeville confining	0	0	0	0	0	0	0
Southeast Texas	Newton	Jasper Aquifer	12,376	12,376	12,376	12,376	12,376	12,376	12,376
Southeast Texas	Tyler	Chicot Aquifer	0	0	0	0	0	0	0

December 15, 2016

Page 16 of 30

Groundwater Conservation									
District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
Southeast Texas	Tyler	Evangeline Aquifer	20,576	20,576	20,576	20,576	20,576	20,576	20,576
Southeast Texas	Tyler	Burkeville confining	1	1	1	1	1	1	1
Southeast Texas	Tyler	Jasper Aquifer	17,634	17,634	17,634	17,634	17,634	17,634	17,634
Southeast Texas GCD Total		Gulf Coast Aquifer System	174,841	174,841	174,841	174,841	174,841	174,841	174,841
Total (groundwater conservation districts)		Gulf Coast Aquifer System	469,907	442,813	442936	442,979	443,022	443,066	443,117
No District-County	Chambers	Chicot Aquifer	22,573	22,573	22,573	22,573	22,573	22,573	22,573
No District-County	Chambers	Evangeline Aquifer	378	378	378	378	378	378	378
No District-County	Jefferson	Chicot Aquifer	2,426	2,426	2,426	2,426	2,426	2,426	2,426
No District-County	Jefferson	Evangeline Aquifer	100	100	100	100	100	100	100
No District-County	Liberty	Chicot Aquifer	14,571	14,571	14,572	14,572	14,572	14,572	14,572
No District-County	Liberty	Evangeline Aquifer	27,654	27,654	27,656	27,655	27,656	27,656	27,656
No District-County	Liberty	Burkeville confining	215	215	215	215	215	215	215
No District-County	Liberty	Jasper Aquifer	787	787	787	787	787	787	787
No District-County	Orange	Chicot Aquifer	18,162	18,162	18,162	18,162	18,162	18,162	18,162
No District-County	Orange	Evangeline Aquifer	1,202	1,202	1,202	1,202	1,202	1,202	1,202
No District-County	Washington	Evangeline Aquifer	3,236	3,236	3,236	3,236	3,236	3,236	3,236
No District-County	Washington	Burkeville confining	367	367	367	367	367	367	367
No District-County	Washington	Jasper Aquifer	9,428	9,428	9,428	9,428	9,428	9,428	9,428
No District- County Total		Gulf Coast Aquifer System	101,100	101,100	101,103	101,101	101,102	101,103	101,103

December 15, 2016

Page 17 of 30

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
GMA 14	Total (all areas except subsidence districts)	Gulf Coast Aquifer System	571,007	543,913	544,039	544,080	544,124	544,169	544,020

December 15, 2016

Page 18 of 30

TABLE 2.GROUNDWATER PUMPAGE PROJECTIONS FOR THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 14FOR SUBSIDENCE DISTRICT COUNTIES FOR EACH DECADE BETWEEN 2010 AND 2070.VALUES ARE IN ACRE-FEET PER YEAR.

Subsidence District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
Fort Bend	Fort Bend	Chicot Aquifer	46,789	58,200	52,663	62,635	72,957	84,002	95,430
Fort Bend	Fort Bend	Evangeline Aquifer	75,249	71,572	51,072	56,656	61,875	66,942	71,651
Fort Bend	Fort Bend	Burkeville confining	0	0	0	0	0	0	0
Fort Bend	Fort Bend	Jasper Aquifer	0	0	0	0	0	0	0
Fort Bend Subsidence District Total		Gulf Coast Aquifer System	122,038	129,772	103,735	119,291	134,832	150,944	167,081
Harris-Galveston	Galveston	Chicot Aquifer	4,850	5,819	6,537	7,153	7,748	8,303	8,759
Harris-Galveston	Galveston	Evangeline Aquifer	167	215	254	284	314	346	371
Harris-Galveston	Harris	Chicot Aquifer	92,348	136,640	108,694	80,512	86,842	90,290	93,457
Harris-Galveston	Harris	Evangeline Aquifer	224,465	264,588	176,427	114,821	121,148	126,231	130,840
Harris-Galveston	Harris	Burkeville confining	0	0	0	0	0	0	0
Harris-Galveston	Harris	Jasper Aquifer	6,067	8,212	5,432	3,164	3,368	3,519	3,644
Harris-Galveston Subsidence District Total		Gulf Coast Aquifer System	327,897	415,474	297,343	205,935	219,420	228,688	237,071
GMA 14	Total (subsidence districts)	Gulf Coast Aquifer System	449,935	545,246	401,078	325,226	354,252	379,632	404,152

December 15, 2016

Page 19 of 30

TABLE 3.MODELED AVAILABLE GROUNDWATER AND PROJECTED GROUNDWATER PUMPAGE VALUES (IN ITALICS) BY DECADE FOR THE
GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 14. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE
SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER.

County	RWPA	River Basin	Gulf Coast Aquifer System	2020	2030	2040	2050	2060	2070
Austin	Н	Brazos-Colorado	Chicot Aquifer	1,005	1,005	1,005	1,005	1,005	1,005
Austin	Η	Brazos-Colorado	Evangeline Aquifer	14,517	14,517	14,517	14,517	14,517	14,517
Austin	Η	Brazos-Colorado	Burkeville confining unit	0	0	0	0	0	0
Austin	Η	Brazos-Colorado	Jasper Aquifer	76	76	76	76	76	76
Austin	Н	Brazos	Chicot Aquifer	295	295	295	295	295	295
Austin	Н	Brazos	Evangeline Aquifer	5,458	5,458	5,458	5,458	5,458	5,458
Austin	Н	Brazos	Burkeville confining unit	0	0	0	0	0	0
Austin	Η	Brazos	Jasper Aquifer	826	826	826	826	826	826
Austin	Н	Colorado	Chicot Aquifer	0	0	0	0	0	0
Austin	Η	Colorado	Evangeline Aquifer	23	23	23	23	23	23
Austin	Η	Colorado	Burkeville confining unit	0	0	0	0	0	0
Austin	Η	Colorado	Jasper Aquifer	98	98	98	98	98	98
Brazoria	Η	Brazos-Colorado	Chicot Aquifer	9,134	8,929	8,735	8,474	8,217	7,986
Brazoria	Η	Brazos-Colorado	Evangeline Aquifer	1	1	2	2	2	2
Brazoria	Η	Brazos	Chicot Aquifer	3,223	3,057	2,992	2,923	2,865	2,821
Brazoria	Η	Brazos	Evangeline Aquifer	0	0	0	0	0	0
Brazoria	Η	San Jacinto-Brazos	Chicot Aquifer	26,684	27,178	27,481	27,854	28,213	28,537
Brazoria	Η	San Jacinto-Brazos	Evangeline Aquifer	11,375	11,374	11,374	11,374	11,374	11,374
Chambers	Η	Neches-Trinity	Chicot Aquifer	10,798	10,798	10,798	10,798	10,798	10,798
Chambers	Η	Neches-Trinity	Evangeline Aquifer	0	0	0	0	0	0
Chambers	Η	Trinity-San Jacinto	Chicot Aquifer	1,671	1,671	1,671	1,671	1,671	1,671
Chambers	Η	Trinity-San Jacinto	Evangeline Aquifer	378	378	378	378	378	378
Chambers	Η	Trinity	Chicot Aquifer	10,104	10,104	10,104	10,104	10,104	10,104
Chambers	Η	Trinity	Evangeline Aquifer	0	0	0	0	0	0
Fort Bend	Н	Brazos-Colorado	Chicot Aquifer	6,338	7,157	8,493	10,447	13,307	17,077
Fort Bend	Н	Brazos-Colorado	Evangeline Aquifer	563	728	1,079	1,584	2,310	<i>3,25</i> 6

December 15, 2016

Page 20 of 30

County	RWPA	River Basin	Gulf Coast Aquifer System	2020	2030	2040	2050	2060	2070
Fort Bend	Н	Brazos-Colorado	Burkeville confining unit	0	0	0	0	0	0
Fort Bend	Н	Brazos-Colorado	Jasper Aquifer	0	0	0	0	0	0
Fort Bend	Н	Brazos	Chicot Aquifer	25,117	24,308	30,446	36,552	42,837	49,006
Fort Bend	Н	Brazos	Evangeline Aquifer	17,216	13,537	16,080	18,582	21,174	23,754
Fort Bend	Н	Brazos	Burkeville confining unit	0	0	0	0	0	0
Fort Bend	Н	Brazos	Jasper Aquifer	0	0	0	0	0	0
Fort Bend	Н	San Jacinto-Brazos	Chicot Aquifer	17,810	15,117	17,542	19,801	21,707	23,191
Fort Bend	Н	San Jacinto-Brazos	Evangeline Aquifer	35,680	25,524	28,118	30,370	32,165	<i>33,3</i> 66
Fort Bend	Н	San Jacinto-Brazos	Burkeville confining unit	0	0	0	0	0	0
Fort Bend	Н	San Jacinto-Brazos	Jasper Aquifer	0	0	0	0	0	0
Fort Bend	Н	San Jacinto	Chicot Aquifer	8,936	6,081	6,153	6,157	6,151	6,156
Fort Bend	Н	San Jacinto	Evangeline Aquifer	18,113	11,282	11,379	11,340	11,293	11,275
Fort Bend	Н	San Jacinto	Burkeville confining unit	0	0	0	0	0	0
Fort Bend	Н	San Jacinto	Jasper Aquifer	0	0	0	0	0	0
Galveston	Н	Neches-Trinity	Chicot Aquifer	0	0	0	0	0	1
Galveston	H	San Jacinto-Brazos	Chicot Aquifer	5,819	6,537	7,153	7,748	8,303	8,759
Galveston	H	San Jacinto-Brazos	Evangeline Aquifer	215	254	284	314	346	371
Grimes	G	Brazos	Chicot Aquifer	0	0	0	0	0	0
Grimes	G	Brazos	Evangeline Aquifer	2,256	2,256	2,256	2,256	2,256	2,256
Grimes	G	Brazos	Burkeville confining unit	0	0	0	0	0	0
Grimes	G	Brazos	Jasper Aquifer	8,624	8,624	8,624	8,624	8,624	8,624
Grimes	G	San Jacinto	Chicot Aquifer	0	0	0	0	0	0
Grimes	G	San Jacinto	Evangeline Aquifer	743	743	743	743	743	743
Grimes	G	San Jacinto	Burkeville confining unit	0	0	0	0	0	0
Grimes	G	San Jacinto	Jasper Aquifer	1,451	1,451	1,451	1,451	1,451	1,451
Grimes	G	Trinity	Jasper Aquifer	922	922	922	922	922	922
Hardin	Ι	Neches	Chicot Aquifer	1,262	1,262	1,262	1,262	1,262	1,262
Hardin	Ι	Neches	Evangeline Aquifer	33,527	33,527	33,527	33,527	33,527	33,527
Hardin	I	Neches	Burkeville confining unit	0	0	0	0	0	0

December 15, 2016

Page 21 of 30

County	RWPA	River Basin	Gulf Coast Aquifer System	2020	2030	2040	2050	2060	2070
Hardin	I.	Neches	Jasper Aquifer	0	0	0	0	0	0
Hardin	\mathbf{I}_{p}	Trinity	Chicot Aquifer	0	0	0	0	0	0
Hardin	I	Trinity	Evangeline Aquifer	138	138	138	138	138	138
Hardin	I	Trinity	Burkeville confining unit	0	0	0	0	0	0
Hardin	I	Trinity	Jasper Aquifer	0	0	0	0	0	0
Harris	Н	San Jacinto-Brazos	Chicot Aquifer	4,331	4,858	5,405	5,959	6,383	6,853
Harris	Н	San Jacinto-Brazos	Evangeline Aquifer	1,975	2,096	2,211	2,323	2,435	2,544
Harris	Н	San Jacinto	Chicot Aquifer	129,749	101,232	72,499	78,104	81,042	83,662
Harris	Н	San Jacinto	Evangeline Aquifer	262,218	173,938	112,257	118,444	12 <i>3,</i> 397	127,883
Harris	Н	San Jacinto	Burkeville confining unit	0	0	0	0	0	0
Harris	Н	San Jacinto	Jasper Aquifer	8,212	5,432	3,164	<i>3,</i> 368	<i>3,5</i> 19	3,644
Harris	Н	Trinity-San Jacinto	Chicot Aquifer	2,560	2,604	2,609	2,779	2,865	2,942
Harris	Н	Trinity-San Jacinto	Evangeline Aquifer	395	393	353	382	398	412
Harris	Н	Trinity-San Jacinto	B Burkeville confining unit	0	0	0	0	0	0
Harris	Н	Trinity-San Jacinto	Jasper Aquifer	0	0	0	0	0	0
Jasper	I	Neches	Chicot Aquifer	7,717	7,717	7,717	7,717	7,717	7,717
Jasper	I	Neches	Evangeline Aquifer	17,407	17,407	17,407	17,407	17,407	17,407
Jasper	I	Neches	Burkeville confining unit	0	0	0	0	0	0
Jasper	Ι	Neches	Jasper Aquifer	12,506	12,506	12,506	12,506	12,506	12,506
Jasper	I	Sabine	Chicot Aquifer	3,110	3,110	3,110	3,110	3,110	3,110
Jasper	Ι	Sabine	Evangeline Aquifer	23,241	23,241	23,241	23,241	23,241	23,241
Jasper	I	Sabine	Burkeville confining unit	1	1	1	1	1	1
Jasper	I	Sabine	Jasper Aquifer	3,502	3,502	3,502	3,502	3,502	3,502
Jefferson	Ι	Neches-Trinity	Chicot Aquifer	1,722	1,722	1,722	1,722	1,722	1,722
Jefferson	I	Neches-Trinity	Evangeline Aquifer	0	0	0	0	0	0
Jefferson	I	Neches	Chicot Aquifer	703	703	703	703	703	703
Jefferson	I	Neches	Evangeline Aquifer	100	100	100	100	100	100
Liberty	Η	Neches-Trinity	Chicot Aquifer	327	327	327	327	327	327
Liberty	Η	Neches-Trinity	Evangeline Aquifer	37	37	37	37	37	37

December 15, 2016

Page 22 of 30

County	RWPA	River Basin	Gulf Coast Aquifer System	2020	2030	2040	2050	2060	2070
Liberty	Н	Neches	Chicot Aquifer	2,804	2,804	2,804	2,804	2,804	2,804
Liberty	Η	Neches	Evangeline Aquifer	2,267	2,267	2,267	2,267	2,267	2,267
Liberty	Η	Neches	Burkeville confining unit	0	0	0	0	0	0
Liberty	Η	Neches	Jasper Aquifer	0	0	0	0	0	0
Liberty	Η	San Jacinto	Chicot Aquifer	753	754	753	754	754	754
Liberty	Η	San Jacinto	Evangeline Aquifer	4,322	4,323	4,322	4,323	4,323	4,323
Liberty	Η	San Jacinto	Burkeville confining unit	215	215	215	215	215	215
Liberty	Η	San Jacinto	Jasper Aquifer	787	787	787	787	787	787
Liberty	Η	Trinity-San Jacinto	Chicot Aquifer	3,160	3,160	3,160	3,160	3,160	3,160
Liberty	Η	Trinity-San Jacinto	Evangeline Aquifer	5,690	5,690	5,690	5,690	5,690	5,690
Liberty	Η	Trinity-San Jacinto	Burkeville confining unit	0	0	0	0	0	0
Liberty	Η	Trinity-San Jacinto	Jasper Aquifer	0	0	0	0	0	0
Liberty	Η	Trinity	Chicot Aquifer	7,528	7,528	7,528	7,528	7,528	7,528
Liberty	Η	Trinity	Evangeline Aquifer	15,339	15,339	15,339	15,339	15,339	15,339
Liberty	Η	Trinity	Burkeville confining unit	0	0	0	0	0	0
Liberty	Η	Trinity	Jasper Aquifer	0	0	0	0	0	0
Montgomery	Η	San Jacinto	Chicot Aquifer	12,600	13,870	13,944	15,026	14,717	14,175
Montgomery	Η	San Jacinto	Evangeline Aquifer	27,525	27,553	27,773	26,575	26,615	26,529
Montgomery	Η	San Jacinto	Burkeville confining unit	0	0	0	0	0	0
Montgomery	Η	San Jacinto	Jasper Aquifer	23,880	22,582	22,288	22,404	22,673	23,301
Newton	Ι	Neches	Jasper Aquifer	176	176	176	176	176	176
Newton		Sabine	Chicot Aquifer	500	500	500	500	500	500
Newton	Ι	Sabine	Evangeline Aquifer	21,343	21,343	21,343	21,343	21,343	21,343
Newton	I	Sabine	Burkeville confining unit	0	0	0	0	0	0
Newton	I	Sabine	Jasper Aquifer	12,200	12,200	12,200	12,200	12,200	12,200
Orange	Ι	Neches-Trinity	Chicot Aquifer	256	256	256	256	256	256
Orange	I	Neches-Trinity	Evangeline Aquifer	0	0	0	0	0	0
Orange	I.	Neches	Chicot Aquifer	2,162	2,162	2,162	2,162	2,162	2,162
Orange	I.	Neches	Evangeline Aquifer	1,125	1,125	1,125	1,125	1,125	1,125

December 15, 2016

Page 23 of 30

County	RWPA	River Basin	Gulf Coast Aquifer System	2020	2030	2040	2050	2060	2070
Orange	I	Sabine	Chicot Aquifer	15,744	15,744	15,744	15,744	15,744	15,744
Orange	I	Sabine	Evangeline Aquifer	77	77	77	77	77	77
Polk	Ι	Neches	Chicot Aquifer	0	0	0	0	0	0
Polk	Ι	Neches	Evangeline Aquifer	3,582	3,582	3,582	3,582	3,582	3,582
Polk	Ι	Neches	Burkeville confining unit	118	118	118	118	118	118
Polk	Ι	Neches	Jasper Aquifer	11,197	11,197	11,197	11,197	11,197	11,197
Polk	Η	Trinity	Chicot Aquifer	0	0	0	0	0	0
Polk	Η	Trinity	Evangeline Aquifer	4,720	4,720	4,720	4,720	4,720	4,720
Polk	Η	Trinity	Burkeville confining unit	625	625	625	625	625	625
Polk	Η	Trinity	Jasper Aquifer	16,465	16,465	16,465	16,465	16,465	16,465
San Jacinto	Н	San Jacinto	Chicot Aquifer	0	0	0	0	0	0
San Jacinto	Η	San Jacinto	Evangeline Aquifer	5,744	5,744	5,744	5,744	5,744	5,744
San Jacinto	Н	San Jacinto	Burkeville confining unit	0	0	0	0	0	0
San Jacinto	Η	San Jacinto	Jasper Aquifer	4,636	4,636	4,636	4,636	4,636	4,636
San Jacinto	Н	Trinity	Chicot Aquifer	0	0	0	0	0	0
San Jacinto	Η	Trinity	Evangeline Aquifer	2,426	2,426	2,426	2,426	2,426	2,426
San Jacinto	Η	Trinity	Burkeville confining unit	2,697	2,697	2,697	2,697	2,697	2,697
San Jacinto	Η	Trinity	Jasper Aquifer	5,480	5,480	5,480	5,480	5,480	5,480
Tyler	I	Neches	Chicot Aquifer	0	0	0	0	0	0
Tyler	Ι	Neches	Evangeline Aquifer	20,576	20,576	20,576	20,576	20,576	20,576
Tyler	Ι	Neches	Burkeville confining unit	1	1	1	1	1	1
Tyler	Ι	Neches	Jasper Aquifer	17,634	17,634	17,634	17,634	17,634	17,634
Walker	Η	San Jacinto	Chicot Aquifer	0	0	0	0	0	0
Walker	Η	San Jacinto	Evangeline Aquifer	2,000	2,000	2,000	2,000	2,000	2,000
Walker	Н	San Jacinto	Burkeville confining unit	0	0	0	0	0	0
Walker	Η	San Jacinto	Jasper Aquifer	7,107	7,107	7,107	7,107	7,107	7,107
Walker	Н	Trinity	Jasper Aquifer	8,866	8,866	8,866	8,866	8,866	8,866
Waller	Η	Brazos	Chicot Aquifer	256	256	256	256	256	256
Waller	H	Brazos	Evangeline Aquifer	14,363	14,363	14,363	14,363	14,363	14,363

December 15, 2016

Page 24 of 30

County	RWPA	River Basin	Gulf Coast Aquifer System	2020	2030	2040	2050	2060	2070
				-					
Waller	Η	Brazos	Burkeville confining unit	0	0	0	0	0	0
Waller	Η	Brazos	Jasper Aquifer	300	300	300	300	300	300
Waller	Η	San Jacinto	Chicot Aquifer	44	44	44	44	44	44
Waller	Η	San Jacinto	Evangeline Aquifer	26,630	26,630	26,630	26,630	26,630	26,630
Waller	Η	San Jacinto	Burkeville confining unit	0	0	0	0	0	0
Waller	Η	San Jacinto	Jasper Aquifer	0	0	0	0	0	0
Washington	G	Brazos	Evangeline Aquifer	3,236	3,236	3,236	3,236	3,236	3,236
Washington	G	Brazos	Burkeville confining unit	367	367	367	367	367	367
Washington	G	Brazos	Jasper Aquifer	9,356	9,356	9,356	9,356	9,356	9,356
Washington	G	Colorado	Jasper Aquifer	72	72	72	72	72	72
GMA 14			Gulf Coast Aquifer System	1,089,160	945,116	869,306	898,377	923,801	948,373
Total			nan namann - zaannaaaanan namanna - armanna 1988 - 198 - Chingson Namais	nu er • contentrationel • SEP districtions			verses and Dubble of	, canana a mining co s tiling di Madala di	12 100000000000000000000000000000000000

December 15, 2016

Page 25 of 30

LIMITATIONS:

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historic time period.

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and groundwater levels in the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

December 15, 2016

Page 26 of 30

Model "Dry" Cells

The predictive model run for this analysis results in water levels in some model cells dropping below the base elevation of the cell during the simulation. In terms of water level the cells have gone dry. However, as noted in the model assumptions the transmissivity of the cell remains constant and will produce water.

A total of 591cells out of 10,968 cells (five percent) go "dry" in the Chicot Aquifer (Layer 1) along the thinnest part of the outcrop. There are 19 dry cells out of 8,184 total cells (0.02 percent) in the thinnest part of the Burkeville confining unit (Layer 3), and 18 dry cells out of 10,815 total cells (0.02 percent) in the thinnest part of the Jasper Aquifer (Layer 4) outcrop. As noted in the model assumptions pumping from dry cells is included in the modeled available groundwater values. Total pumping from dry cells in the Chicot Aquifer in model year 2070 is 77 acre-feet in Montgomery County. There are no dry cells for the model run in the Evangeline Aquifer. Total pumping from dry cells in the Burkeville Confining unit in model year 2070 is 2,697 acre-feet in San Jacinto County. The total pumping from dry cells in the Jasper Aquifer in model year 2070 is 5,084 acre-feet in Grimes, Jasper, Newton, Polk, Trinity, Tyler, and Walker counties.

December 15, 2016

Page 27 of 30

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December 15, 2016

Page 28 of 30

APPENDIX

December 15, 2016

Page 29 of 30

TABLE A.1 MODEL-CALCULATED AVERAGE DRAWDOWN VALUES (DDN) AND MODELED MAXIMUM SUBSIDENCE COMPARED WITH DESIRED FUTURE CONDITIONS (DFCS) BY COUNTY FOR THE NORTHERN PORTION OF THE GULF COAST AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 14. ALL VALUES ARE IN FEET.

County	Chicot Aquifer DDN	Evangeline Aquifer DDN	Burkeville Confining Unit DDN	Jasper Aquifer DDN	Maximum Subsidence (model estimate)	Chicot Aquifer DFC	Evangeline Aquifer DFC	Burkeville Unit DFC	Jasper Aquifer DFC	Maximum Subsidence DFC
Austin	40	23	23	76	2.82	39	23	23	76	2.83
Brazoria	23	28	na	na	na	23	27	na	na	ns
Chambers	33	30	na	na	na	32	30	na	na	ns
Fort Bend*	54	56	60	108	na	ns	ns	ns	ns	ns
Galveston*	34	31	na	na	na	ns	ns	ns	ns	ns
Grimes	5	5	6	53	0.10	5	5	6	52	0.12
Hardin	21	27	29	90	na	21	27	29	89	ns
Harris*	30	5	-15	63	na	ns	ns	ns	ns	ns
Jasper	24	42	46	40	na	23	41	46	40	ns
Jefferson	16	17	na	na	na	15	17	na	na	ns
Liberty	28	29	25	121	na	27	29	25	120	ns
Montgomery	26	-4	-4	35	na	26	-4	-4	34	ns
Newton	35	45	45	37	na	35	45	44	37	ns

December 15, 2016

Page 30 of 30

County	Chicot Aquifer DDN	Evangeline Aquifer DDN	Burkeville Confining Unit DDN	Jasper Aquifer DDN	Maximum Subsidence (model estimate)	Chicot Aquifer DFC	Evangeline Aquifer DFC	Burkeville Unit DFC	Jasper Aquifer DFC	Maximum Subsidence DFC
Orange	14	16	na	na	na	14	16	na	na	ns
Polk	26	10	16	73	na	26	10	15	73	ns
San Jacinto	22	19	20	109	na	22	19	19	108	ns
Tyler	42	36	30	62	na	42	35	30	62	ns
Walker	0	9	4	42	0.10	na	9	4	42	0.04
Waller	39	40	40	102	4.71	39	39	40	101	4.73
Washington	na	1	16	48	na	na	1	16	48	ns
GMA average	28.7	23.9	18.7	66.7	na	28.3	23.6	18.5	66.2	ns

*Desired Future Conditions were not specified for counties located in the subsidence districts

na = not applicable

ns = not specified

DFC = adopted desired future condition

DDN = average model calculated drawdown based on pumping scenario provided by districts in GMA 14

GAM RUN 17-024 MAG: MODELED AVAILABLE GROUNDWATER FOR THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS IN GROUNDWATER MANAGEMENT AREA 11

Shirley C. Wade, Ph.D., P.G. Texas Water Development Board Groundwater Division Groundwater Availability Modeling Department (512) 936-0883 June 19, 2017



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Shirley C. Wade, Ph.D., P.G. Texas Water Development Board Groundwater Division Groundwater Availability Modeling Department (512) 936-0883 June 19, 2017

EXECUTIVE SUMMARY:

The modeled available groundwater for Groundwater Management Area 11 for the Carrizo-Wilcox, Queen City, and Sparta aquifers is summarized by decade for the groundwater conservation districts (Tables 2 through 4 respectively) and for use in the regional water planning process (Tables 5 through 7 respectively). The modeled available groundwater estimates for the Carrizo-Wilcox Aquifer range from approximately 349,000 acre-feet per year in 2010 to approximately 341,000 acre-feet per year in 2070 (Table 2). The modeled available groundwater estimates for the Queen City Aquifer range from approximately 223,000 acre-feet per year in 2010 to approximately 222,000 acre-feet per year in 2070 (Table 3). The modeled available groundwater estimate for the Sparta Aquifer is approximately 2,700 acre-feet per year for each decade from 2010 to 2070 (Table 4). The estimates were extracted from results of a model run using the groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (version 2.01). The model run files, which meet the desired future conditions adopted by district representatives of Groundwater Management Area 11, were submitted to the Texas Water Development Board (TWDB) on February 15, 2017, as part of the Desired Future Conditions Explanatory Report for Groundwater Management Area 11. The explanatory report and other materials submitted to the Texas Water Development Board (TWDB) were determined to be administratively complete on March 13, 2017.

REQUESTOR:

Ms. Leah Adams, coordinator of Groundwater Management Area 11.

June 19, 2017 Page 4 of 24

DESCRIPTION OF REQUEST:

In a letter dated February 15, 2017, Dr. William R. Hutchison, on behalf of Groundwater Management Area 11, provided the TWDB with the desired future conditions of the Carrizo-Wilcox, Queen City, and Sparta aquifers adopted by the groundwater conservation districts in Groundwater Management Area 11. The desired future conditions for the Carrizo-Wilcox, Queen City, and Sparta aquifers are described in Attachment B of the Resolution to Adopt Desired Future Conditions for Aquifers in Groundwater Management Area 11, adopted January 11, 2017, by the groundwater conservation districts within Groundwater Management Area 11. The desired future conditions, excerpted from Attachment B, are presented below:

"Table 5 [Table 1 below] from GMA 11 Technical Memorandum 16-02 (Draft 2), dated March 25, 2016 lists the proposed desired future conditions, and is presented below [Table 1]. As described in the technical memorandum, the proposed desired future conditions are average drawdowns (in feet) from year 2000 conditions to 2070 conditions were largely based on GAM Scenario 4. Based on an analysis of model output and model limitations, the output from the model was modified to develop the proposed desired future conditions as follows:

- Layers 2 and 4 (the confining units) were eliminated, and Table 5 includes only aquifer units. Areas that have no active cells are designated as NP (for not present).
- Layers 5, 6, 7, and 8 are combined, and a single drawdown value for the Carrizo-Wilcox Aquifer are [sic] listed.
- All areas that are less than 200 square miles are eliminated (noted as NRS, or not relevant for purposes of joint planning due to size of area).
- Areas with negative drawdown that are greater than 200 square miles have had the negative drawdown cells eliminated from the average drawdown calculation, effectively assuming that those cells have a zero drawdown, and that the negative drawdown areas are a result of model limitations, as discussed (designated in yellow).
- The desired future condition in Panola County for the Carrizo-Wilcox Aquifer is listed as 3 feet. The actual average using all data from the model is 2 feet. If the areas with negative drawdown are assumed to be zero, the revised average is 4 feet. As presented at the March 22, 2016 GMA 11 meeting, Mr. Wade Oliver (representing the Panola County GCD) evaluated the average drawdown under Scenario 4 using an alternative analytical modeling approach and concluded that the drawdown was 3 feet. Thus, Mr. Oliver's result is consistent with the midpoint between the two GAM-based drawdown approaches."

June 19, 2017 Page 5 of 24

TABLE 1.DRAWDOWN FOR USE AS DESIRED FUTURE CONDITIONS (2000 TO 2070 IN FEET)[TABLE 5 FROM GMA 11 TECHNICAL MEMORANDUM 16-02 (DRAFT 2), DATED MARCH25, 2016].).

County	Sparta	Queen City	Carrizo-Wilcox
Anderson	NRS	9	90
Angelina	16	NRS	48
Bowie	NP	NP	5
Camp	NP	NRS	33
Cass	NP	10	68
Cherokee	NRS	14	99
Franklin	NP	NP	14
Gregg	NP	NRS	58
Harrison	NP	1	18
Henderson	NP	5	50
Hopkins	NP	NP	3
Houston	3	6	80
Marion	NP	24	45
Morris	NP	NRS	46
Nacogdoches	5	4	29
Panola	NP	NP	3
Rains	NP	NP	1
Rusk	NP	NRS	23
Sabine	1	NP	9
San Augustine	2	NP	7
Shelby	NP	NP	1
Smith	NP	17	119
Titus	NP	NRS	11
Trinity	9	NRS	51
Upshur	NP	9	77
Van Zandt	NP	NRS	21
Wood	NP	5	89
Grand Total	4	10	56

Notes: NP = Not present

NRS = Not relevant due to size (less than 200 square miles)

Yellow Cells represent average drawdown calculations that assume negative drawdown is zero (model artifact and model limitation)

Green Cell represents the recommended DFC for Panola County as described above

June 19, 2017

Page 6 of 24

TWDB staff reviewed the model files associated with the desired future conditions and received clarification on procedures and assumptions from the Groundwater Management Area 11 Technical Coordinator on March 13 and 15, 2017. Questions included whether drawdown averages and modeled available groundwater values are based on official aquifer extent or model extent, whether to include dry cells in drawdown averaging, methods for calculating Panola County drawdown, and how to re-calculate average drawdowns for counties with net negative average drawdowns. The clarifications are included in the Parameters and Assumptions Section of this report.

The Groundwater Management Area 11 Technical Coordinator was notified on May 3, 2017 that the modeled available groundwater values for several counties would not necessarily match the pumping values presented in Technical Memorandum 16-02 (Hutchison, 2016). The pumping values presented in Technical Memorandum 16-02 appear to be based on the model extent, while the modeled available groundwater values have been extracted based on the official aquifer.

METHODS:

The groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Figures 1 through 4) was run using the model files submitted with the explanatory report (Hutchison, 2017). Model-calculated drawdowns were extracted for the year 2070. Drawdown averages were calculated for each county by aquifer and for the entire Groundwater Management Area 11 by aquifer. As specified in the desired future condition resolution and further clarification, drawdown for cells that became dry during the simulation (water level dropped below the base of the cell) were excluded from the averaging. The calculated drawdown averages were compared with the desired future conditions to verify that the pumping scenario achieved the desired future conditions within one foot.

The modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Annual pumping rates by aquifer are presented by county and groundwater conservation district, subtotaled by groundwater conservation district, and then summed for Groundwater Management Area 11 (Tables 2 through 4). Annual pumping rates by aquifer are also presented by county, river basin, and regional water planning area within Groundwater Management Area 11 (Tables 5 through 7).

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code (2011), "modeled available groundwater" is the estimated average amount of water that may be produced annually to

June 19, 2017 Page 7 of 24

achieve a desired future condition. Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the modeled available groundwater estimates are described below:

- We used Version 2.01 of the groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. See Fryar and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers.
- This groundwater availability model includes eight layers, which generally represent the Sparta Aquifer (Layer 1), the Weches Confining Unit (Layer 2), the Queen City Aquifer (Layer 3), the Reklaw Confining Unit (Layer 4), the Carrizo (Layer 5), the Upper Wilcox (Layer 6), the Middle Wilcox (Layer 7), and the Lower Wilcox (Layer 8). Layers represent equivalent geologic units outside of the official aquifer extents. In the case of Layers 6 through 8 in areas where the Upper, Middle, or Lower Wilcox are not distinct, then the corresponding layer represents part of an adjoining Wilcox unit.
- In the Sabine Uplift area, the Simsboro Formation (Middle Wilcox Aquifer) is not distinguishable and the Wilcox Group is informally divided into the Upper Wilcox and the Lower Wilcox aquifers (Fryar and others, 2003). In the current version of the groundwater availability model, layers 6 and 7 represent the Upper Wilcox and Lower Wilcox aquifers in this area. Layer 8 is included in the model in this area, but it is of nominal thickness.
- The model was run with MODFLOW-96 (Harbaugh and others, 1996).
- Drawdown averages and modeled available groundwater values were based on the official aquifer boundaries rather than the extent of the model area (Figures 2, 3, and 4).
- Drawdown for cells where water levels dropped below the base elevation of the cell causing the cell to become inactive (dry cells) were excluded from the averaging.

June 19, 2017 Page 8 of 24

- If a county with an area greater than 200 square miles had a net negative drawdown average the average was re-calculated by assuming all negative drawdowns were zero. The zero values were included in the averaging. This assumption applies to San Augustine County in the Sparta Aquifer and Wood County in the Queen City Aquifer as noted in Table 1. It also applies to Hopkins and Rains counties in the Carrizo-Wilcox Aquifer although those counties were not noted in Table 1 (Table 1 of the Resolution).
- A tolerance of one foot was assumed when comparing desired future conditions (Table 1, average drawdown values per county) to model drawdown results.
- Drawdown for Panola County was estimated from the groundwater availability modeling results and the average drawdown is within the one foot tolerance of the desired future condition for Panola County (model results drawdown = 2 feet and desired future condition drawdown= 3 feet).
- Estimates of modeled available groundwater from the model simulation were rounded to whole numbers.

RESULTS:

The modeled available groundwater estimates for the Carrizo-Wilcox Aquifer range from approximately 349,000 acre-feet per year in 2010 to approximately 341,000 acre-feet per year in 2070 (Table 2). The modeled available groundwater estimates for the Queen City Aquifer range from approximately 223,000 acre-feet per year in 2010 to approximately 222,000 acre-feet per year in 2070 (Table 3). The modeled available groundwater estimate for the Sparta Aquifer is approximately 2,700 acre-feet per year for each decade from 2010 to 2070 (Table 4). The modeled available groundwater is summarized by groundwater conservation district and county for the Carrizo-Wilcox, Queen City, and Sparta aquifers (Tables 2, 3, and 4 respectively). The modeled available groundwater has also been summarized by county, river basin, and regional water planning area for use in the regional water planning process for the Carrizo-Wilcox, Queen City, and Sparta aquifers (Tables 5, 6, and 7 respectively). Small differences of values between table summaries are due to rounding.

The Gulf Coast, Nacatoch, Trinity, and Yegua-Jackson aquifers were declared non-relevant for the purpose of adopting desired future conditions by the Groundwater Management Area 11 Districts; therefore, modeled available groundwater values were not calculated for those aquifers. June 19, 2017 Page 9 of 24



FIGURE 1. GROUNDWATER MANAGEMENT AREA (GMA) 11 BOUNDARY, RIVER BASINS, AND COUNTIES OVERLAIN ON THE EXTENT OF THE CARRIZO-WILCOX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS.

June 19, 2017 Page 10 of 24



FIGURE 2. REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE CARRIZO-WILCOX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS. June 19, 2017 Page 11 of 24



FIGURE 3. REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE QUEEN CITY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS.

June 19, 2017 Page 12 of 24



FIGURE 4. REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE SPARTA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS.

June 19, 2017

Page 13 of 24

TABLE 2.MODELED AVAILABLE GROUNDWATER FOR THE CARRIZO-WILCOX AQUIFER IN GROUNDWATER MANAGEMENT AREA 11
SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2010 AND
2070. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
Neches & Trinity									
Valleys GCD	Anderson	Carrizo-Wilcox	29,088	29,088	29,088	29,088	29,088	29,088	29,088
Neches & Trinity									
Valleys GCD	Cherokee	Carrizo-Wilcox	20,933	20,933	20,933	20,933	20,933	20,933	20,470
Neches & Trinity			10.044	10.011	10.011	10011	10 5 10	10 (11)	10 505
Valleys GCD	Henderson	Carrizo-Wilcox	13,866	13,866	13,866	13,866	13,768	13,614	13,585
Neches & Trinity		C	(2004	(2.00/	(2.00)	(2.00/	(2 500	(2 (24	(2442
Valleys GCD Total		Carrizo-Wilcox	63,886	63,886	63,886	63,886	63,789	63,634	63,143
GCD	Panola	Carrizo-Wilcox	8,376	8,376	8,218	8,218	8,218	8,068	8,068
Pineywoods GCD	Angelina	Carrizo-Wilcox	27,591	27,591	27,591	27,591	27,591	27,591	27,591
Pineywoods GCD	Nacogdoches	Carrizo-Wilcox	24,181	24,181	24,181	24,181	24,181	24,181	24,181
Pineywoods GCD									
Total		Carrizo-Wilcox	51,773	51,773	51,773	51,773	51,773	51,773	51,773
Rusk County GCD									
Total	Rusk	Carrizo-Wilcox	20,847	20,837	20,837	20,837	20,818	20,818	20,818
Total (GCDs)		Carrizo-Wilcox	144,882	144,872	144,714	144,714	144,598	144,293	143,801
No District-County	Bowie	Carrizo-Wilcox	10,845	9,872	9,558	9,278	9,278	8,999	8,999
No District-County	Camp	Carrizo-Wilcox	4,050	4,050	4,050	4,050	4,050	4,050	4,050
No District-County	Cass	Carrizo-Wilcox	18,078	18,023	17,925	17,863	17,786	17,702	17,626
No District-County	Franklin	Carrizo-Wilcox	9,786	9,786	9,786	9,786	9,786	9,786	9,786
No District-County	Gregg	Carrizo-Wilcox	8,041	8,041	8,041	8,041	8,041	8,041	8,041
No District-County	Harrison	Carrizo-Wilcox	11,165	11,035	10,961	10,921	10,873	10,853	10,827
No District-County	Hopkins	Carrizo-Wilcox	6,392	6,392	6,392	6,392	6,392	6,392	6,392
No District-County	Houston	Carrizo-Wilcox	26,294	26,294	26,294	26,294	26,294	26,294	26,294
No District-County	Marion	Carrizo-Wilcox	2,729	2,726	2,726	2,726	2,726	2,726	2,726

June 19, 2017

Page 14 of 24

Groundwater Conservation	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
District		1							
No District-County	Morris	Carrizo-Wilcox	2,627	2,569	2,569	2,569	2,569	2,569	2,569
No District-County	Rains	Carrizo-Wilcox	1,922	1,839	1,839	1,839	1,802	1,802	1,745
No District-County	Red River	Carrizo-Wilcox	NULL ¹						
No District-County	Sabine	Carrizo-Wilcox	3,606	3,606	3,606	3,606	3,606	3,606	3,606
No District-County	San Augustine	Carrizo-Wilcox	1,439	1,439	1,439	1,439	1,439	1,439	1,439
No District-County	Shelby	Carrizo-Wilcox	11,210	10,894	10,441	10,305	9,723	9,287	9,100
No District-County	Smith	Carrizo-Wilcox	35,951	35,951	35,925	35,925	35,925	35,912	35,889
No District-County	Titus	Carrizo-Wilcox	10,354	10,052	9,902	9,672	9,624	9,573	9,472
No District-County	Trinity	Carrizo-Wilcox	368	368	368	368	368	368	368
No District-County	Upshur	Carrizo-Wilcox	7,132	7,132	7,132	7,132	7,132	7,132	7,132
No District-County	Van Zandt	Carrizo-Wilcox	10,330	10,330	10,330	10,157	10,098	10,098	9,971
No District-County	Wood	Carrizo-Wilcox	21,544	21,457	21,413	21,338	21,316	21,292	21,237
No District- County Total		Carrizo-Wilcox	203,863	201,856	200,696	199,700	198,827	197,920	197,268
Total for GMA 11		Carrizo-Wilcox	348,745	346,728	345,410	344,414	343,424	342,213	341,069

¹A desired future condition was not specified for the Carrizo-Wilcox Aquifer in Red River County; however, other counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater.

June 19, 2017

Page 15 of 24

TABLE 3.MODELED AVAILABLE GROUNDWATER FOR THE QUEEN CITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 11
SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2010 AND
2070. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
Neches & Trinity									
Valleys GCD	Anderson	Queen City	19,101	19,101	19,101	19,101	19,101	19,101	19,101
Neches & Trinity									
Valleys GCD	Cherokee	Queen City	23,211	23,211	23,211	23,211	23,211	23,039	22,866
Neches & Trinity									
Valleys GCD	Henderson	Queen City	15,412	15,412	15,412	15,412	15,412	15,412	15,412
Neches & Trinity		125 (1276)							
Valleys GCD Total		Queen City	57,725	57,725	57,725	57,725	57,725	57,552	57,380
Pineywoods GCD	Angelina	Queen City	NULL ¹	NULL ¹	NULL ¹				
Pineywoods GCD	Nacogdoches	Queen City	2,985	2,985	2,985	2,985	2,985	2,985	2,985
Pineywoods GCD									
Total		Queen City	2,985	2,985	2,985	2,985	2,985	2,985	2,985
Rusk County GCD		126,023					2011 TO CARD 10 10		
Total	Rusk	Queen City	NULL ¹	NULL ¹	NULL ¹				
Total (GCDs)		Queen City	60,710	60,710	60,710	60,710	60,710	60,537	60,365
No District-County	Camp	Queen City	NULL ¹	NULL ¹	NULL ¹				
No District-County	Cass	Queen City	38,509	38,509	38,509	38,509	38,509	38,509	38,509
No District-County	Gregg	Queen City	NULL ¹	NULL ¹	NULL ¹				
No District-County	Harrison	Queen City	10,071	10,071	10,071	10,071	10,071	10,071	10,071
No District-County	Houston	Queen City	2,301	2,301	2,301	2,301	2,301	2,301	2,301
No District-County	Marion	Queen City	15,407	15,407	15,407	15,407	15,407	15,338	15,271
No District-County	Morris	Queen City	NULL ¹	NULL ¹	NULL ¹				
No District-County	Smith	Queen City	59,034	59,034	59,034	59,034	58,904	58,709	58,578
No District-County	Titus	Queen City	NULL ¹	NULL ¹	NULL ¹				
No District-County	Trinity	Queen City	NULL ¹	NULL ¹	NULL ¹				
No District-County	Upshur	Queen City	27,391	27,391	27,391	27,197	27,197	27,197	27,145

June 19, 2017 Page 16 of 24

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
No District-County	Van Zandt	Queen City	NULL ¹						
No District-County	Wood	Queen City	10,046	10,046	10,046	10,046	10,046	10,046	10,046
No District- County Total		Queen City	162,759	162,759	162,759	162,566	162,435	162,172	161,922
Total for GMA 11		Queen City	223,469	223,469	223,469	223,275	223,145	222,709	222,287

¹Counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater. For additional information in pumping in the model run see Table 6 from Technical Memorandum 16-02 (Hutchison, 2016).

June 19, 2017

Page 17 of 24

TABLE 4.MODELED AVAILABLE GROUNDWATER FOR THE SPARTA AQUIFER IN GROUNDWATER MANAGEMENT AREA 11 SUMMARIZED
BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2070. VALUES
ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
Neches & Trinity Valleys GCD	Anderson	Sparta	NULL ¹						
Neches & Trinity Valleys GCD	Cherokee	Sparta	NULL ¹						
Neches & Trinity Valleys GCD Total		Sparta	NULL ¹						
Pineywoods GCD	Angelina	Sparta	371	371	371	371	371	371	371
Pineywoods GCD	Nacogdoches	Sparta	365	365	365	365	365	365	365
Pineywoods GCD Total		Sparta	737	737	737	737	737	737	737
Total (GCDs)		Sparta	737	737	737	737	737	737	737
No District-County	Houston	Sparta	1,454	1,454	1,454	1,454	1,454	1,454	1,454
No District-County	Sabine	Sparta	197	197	197	197	197	197	197
No District-County	San Augustine	Sparta	166	166	166	166	166	166	166
No District-County	Trinity	Sparta	182	182	182	182	182	182	182
No District-County Total		Sparta	1,999	1,999	1,999	1,999	1,999	1,999	1,999
Total for GMA 11		Sparta	2,736	2,736	2,736	2,736	2,736	2,736	2,736

¹Counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater. For additional information in pumping in the model run see Table 6 from Technical Memorandum 16-02 (Hutchison, 2016).

June 19, 2017

Page 18 of 24

TABLE 5.

5. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE CARRIZO-WILCOX AQUIFER IN GROUNDWATER MANAGEMENT AREA 11. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER.

County	RWPA	River Basin	Aquifer	2020	2030	2040	2050	2060	2070
Anderson	I	Neches	Carrizo-Wilcox	23,335	23,335	23,335	23,335	23,335	23,335
Anderson	I	Trinity	Carrizo-Wilcox	5,753	5,753	5,753	5,753	5,753	5,753
Angelina	Ι	Neches	Carrizo-Wilcox	27,591	27,591	27,591	27,591	27,591	27,591
Bowie	D	Sulphur	Carrizo-Wilcox	9,872	9,558	9,278	9,278	8,999	8,999
Camp	D	Cypress	Carrizo-Wilcox	4,050	4,050	4,050	4,050	4,050	4,050
Cass	D	Cypress	Carrizo-Wilcox	15,159	15,132	15,132	15,119	15,106	15,094
Cass	D	Sulphur	Carrizo-Wilcox	2,864	2,794	2,731	2,667	2,596	2,532
Cherokee	I	Neches	Carrizo-Wilcox	20,933	20,933	20,933	20,933	20,933	20,470
Franklin	D	Cypress	Carrizo-Wilcox	7,765	7,765	7,765	7,765	7,765	7,765
Franklin	D	Sulphur	Carrizo-Wilcox	2,021	2,021	2,021	2,021	2,021	2,021
Gregg	D	Cypress	Carrizo-Wilcox	862	862	862	862	862	862
Gregg	D	Sabine	Carrizo-Wilcox	7,179	7,179	7,179	7,179	7,179	7,179
Harrison	D	Cypress	Carrizo-Wilcox	6,183	6,109	6,070	6,036	6,016	5,990
Harrison	D	Sabine	Carrizo-Wilcox	4,851	4,851	4,851	4,837	4,837	4,837
Henderson	C	Trinity	Carrizo-Wilcox	7,829	7,829	7,829	7,732	7,577	7,548
Henderson	I	Neches	Carrizo-Wilcox	6,036	6,036	6,036	6,036	6,036	6,036
Hopkins	D	Cypress	Carrizo-Wilcox	313	313	313	313	313	313
Hopkins	D	Sabine	Carrizo-Wilcox	2,842	2,842	2,842	2,842	2,842	2,842
Hopkins	D	Sulphur	Carrizo-Wilcox	3,237	3,237	3,237	3,237	3,237	3,237
Houston	I	Neches	Carrizo-Wilcox	22,488	22,488	22,488	22,488	22,488	22,488
Houston	I	Trinity	Carrizo-Wilcox	3,806	3,806	3,806	3,806	3,806	3,806
Marion	D	Cypress	Carrizo-Wilcox	2,726	2,726	2,726	2,726	2,726	2,726
Morris	D	Cypress	Carrizo-Wilcox	2,166	2,166	2,166	2,166	2,166	2,166
Morris	D	Sulphur	Carrizo-Wilcox	402	402	402	402	402	402
Nacogdoches	I	Neches	Carrizo-Wilcox	24,181	24,181	24,181	24,181	24,181	24,181
Panola	Ι	Cypress	Carrizo-Wilcox	6	6	6	6	6	6

June 19, 2017 Page 19 of 24

County	RWPA	River Basin	Aquifer	2020	2030	2040	2050	2060	2070
Panola	I	Sabine	Carrizo-Wilcox	8,370	8,212	8,212	8,212	8,062	8,062
Rains	D	Sabine	Carrizo-Wilcox	1,839	1,839	1,839	1,802	1,802	1,745
Red River	D	Sulphur	Carrizo-Wilcox	NULL ¹					
Rusk	Ι	Neches	Carrizo-Wilcox	11,769	11,769	11,769	11,750	11,750	11,750
Rusk	Ι	Sabine	Carrizo-Wilcox	9,068	9,068	9,068	9,068	9,068	9,068
Sabine	Ι	Neches	Carrizo-Wilcox	356	356	356	356	356	356
Sabine	I	Sabine	Carrizo-Wilcox	3,249	3,249	3,249	3,249	3,249	3,249
San Augustine	Ι	Neches	Carrizo-Wilcox	1,149	1,149	1,149	1,149	1,149	1,149
San Augustine	I	Sabine	Carrizo-Wilcox	290	290	290	290	290	290
Shelby	Ι	Neches	Carrizo-Wilcox	2,577	2,288	2,151	2,018	2,018	2,018
Shelby	Ι	Sabine	Carrizo-Wilcox	8,317	8,154	8,154	7,705	7,269	7,081
Smith	D	Sabine	Carrizo-Wilcox	13,246	13,220	13,220	13,220	13,206	13,196
Smith	Ι	Neches	Carrizo-Wilcox	22,705	22,705	22,705	22,705	22,705	22,693
Titus	D	Cypress	Carrizo-Wilcox	7,215	7,064	6,834	6,786	6,735	6,634
Titus	D	Sulphur	Carrizo-Wilcox	2,838	2,838	2,838	2,838	2,838	2,838
Trinity	H	Trinity	Carrizo-Wilcox	99	99	99	99	99	99
Trinity	Ι	Neches	Carrizo-Wilcox	269	269	269	269	269	269
Upshur	D	Cypress	Carrizo-Wilcox	5,442	5,442	5,442	5,442	5,442	5,442
Upshur	D	Sabine	Carrizo-Wilcox	1,689	1,689	1,689	1,689	1,689	1,689
Van Zandt	D	Neches	Carrizo-Wilcox	4,317	4,317	4,317	4,317	4,317	4,317
Van Zandt	D	Sabine	Carrizo-Wilcox	4,629	4,629	4,456	4,397	4,397	4,270
Van Zandt	D	Trinity	Carrizo-Wilcox	1,384	1,384	1,384	1,384	1,384	1,384
Wood	D	Cypress	Carrizo-Wilcox	2,053	2,053	2,053	2,053	2,053	2,053
Wood	D	Sabine	Carrizo-Wilcox	19,404	19,360	19,285	19,263	19,239	19,184
GMA 11 Total			Carrizo-Wilcox	346,728	345,410	344,414	343,424	342,213	341,069

¹ A desired future condition was not specified for the Carrizo-Wilcox Aquifer in Red River County; however, other counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater.

June 19, 2017 Page 20 of 24

TABLE 6.MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE QUEEN CITY AQUIFER IN GROUNDWATER MANAGEMENT AREA
11. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA),
RIVER BASIN, AND AQUIFER.

County	RWPA	River Basin	Aquifer	2020	2030	2040	2050	2060	2070
Anderson	I	Neches	Queen City	11,828	11,828	11,828	11,828	11,828	11,828
Anderson	I	Trinity	Queen City	7,274	7,274	7,274	7,274	7,274	7,274
Angelina	I	Neches	Queen City	NULL ¹					
Camp	D	Cypress	Queen City	NULL ¹					
Cass	D	Cypress	Queen City	35,499	35,499	35,499	35,499	35,499	35,499
Cass	D	Sulphur	Queen City	3,010	3,010	3,010	3,010	3,010	3,010
Cherokee	I	Neches	Queen City	23,211	23,211	23,211	23,211	23,039	22,866
Gregg	D	Cypress	Queen City	NULL ¹					
Gregg	D	Sabine	Queen City	NULL ¹					
Harrison	D	Cypress	Queen City	7,762	7,762	7,762	7,762	7,762	7,762
Harrison	D	Sabine	Queen City	2,310	2,310	2,310	2,310	2,310	2,310
Henderson	С	Trinity	Queen City	3,345	3,345	3,345	3,345	3,345	3,345
Henderson	I	Neches	Queen City	12,067	12,067	12,067	12,067	12,067	12,067
Houston	I	Neches	Queen City	2,043	2,043	2,043	2,043	2,043	2,043
Houston	I	Trinity	Queen City	258	258	258	258	258	258
Marion	D	Cypress	Queen City	15,407	15,407	15,407	15,407	15,338	15,271
Morris	D	Cypress	Queen City	NULL ¹					
Nacogdoches	I	Neches	Queen City	2,985	2,985	2,985	2,985	2,985	2,985
Rusk	I	Neches	Queen City	NULL ¹					
Rusk	I	Sabine	Queen City	NULL ¹					
Smith	D	Sabine	Queen City	28,343	28,343	28,343	28,213	28,018	27,887
Smith	Ι	Neches	Queen City	30,692	30,692	30,692	30,692	30,692	30,692
Titus	D	Cypress	Queen City	NULL ¹					
Trinity	H	Trinity	Queen City	0	0	0	0	0	0
Trinity	I	Neches	Queen City	NULL ¹					

June 19, 2017 Page 21 of 24

County	RWPA	River Basin	Aquifer	2020	2030	2040	2050	2060	2070
Upshur	D	Cypress	Queen City	19,642	19,642	19,448	19,448	19,448	19,396
Upshur	D	Sabine	Queen City	7,749	7,749	7,749	7,749	7,749	7,749
Van Zandt	D	Neches	Queen City	NULL ¹					
Wood	D	Cypress	Queen City	986	986	986	986	986	986
Wood	D	Sabine	Queen City	9,060	9,060	9,060	9,060	9,060	9,060
GMA 11 Total			Queen City	223,469	223,469	223,276	223,145	222,709	222,287

¹Counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater. For additional information in pumping in the model run see Table 6 from Technical Memorandum 16-02 (Hutchison, 2016).

June 19, 2017

Page 22 of 24

TABLE 7.MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE SPARTA AQUIFER IN GROUNDWATER MANAGEMENT AREA 11.
RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA),
RIVER BASIN, AND AQUIFER.

County	RWP A	River Basin	Aquifer	2020	2030	2040	2050	2060	2070
Anderson	I	Neches	Sparta Aquifer	NULL ¹					
Anderson	I	Trinity	Sparta Aquifer	NULL ¹					
Angelina	I	Neches	Sparta Aquifer	371	371	371	371	371	371
Cherokee	I	Neches	Sparta Aquifer	NULL ¹					
Houston	Ι	Neches	Sparta Aquifer	477	477	477	477	477	477
Houston	I	Trinity	Sparta Aquifer	977	977	977	977	977	977
Nacogdoches	I	Neches	Sparta Aquifer	365	365	365	365	365	365
Sabine	I	Neches	Sparta Aquifer	37	37	37	37	37	37
Sabine	I	Sabine	Sparta Aquifer	160	160	160	160	160	160
San Augustine	I	Neches	Sparta Aquifer	163	163	163	163	163	163
San Augustine	Ι	Sabine	Sparta Aquifer	3	3	3	3	3	3
Trinity	H	Trinity	Sparta Aquifer	29	29	29	29	29	29
Trinity	I	Neches	Sparta Aquifer	154	154	154	154	154	154
GMA 11 Total	·		Sparta Aquifer	2,736	2,736	2,736	2,736	2,736	2,736

¹ Counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater. For additional information in pumping in the model run see Table 6 from Technical Memorandum 16-02 (Hutchison, 2016).

June 19, 2017 Page 23 of 24

LIMITATIONS:

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historic time period.

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and groundwater levels in the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

June 19, 2017 Page 24 of 24 **REFERENCES:**

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