November 19, 2024

Penny Hanson, General Manager
Neches and Trinity Valleys GCD
501 Devereaux Street
Jacksonville, TX 75766

RE: Addendum to Hydrogeological Report for the Neches and Trinity Valleys GCD Middle Wilcox Wellfield – Redtown Ranch Property, Anderson County, TX

Dear Ms. Hanson,

LRE Water ("LRE") is pleased to submit this Addendum to the Hydrogeological Report prepared for the Neches and Trinity Valleys Groundwater Conservation District ("NTVGCD" or District) on behalf of Redtown Ranch Holdings, LLC. The purpose of this Addendum is to provide the requested information as specified in the Letters from the District's consultant (Mr. James Beach, Advanced Groundwater Solutions "AGS") on October 28, 2024, and the District's attorney (Mr. John Stover) on October 21, 2024. For ease of reference, the letters with requested information are provided in Appendix A and the NTVGCD Hydrogeologic Report prepared by LRE (dated September 11, 2024) is provided in Appendix B of this Addendum. The proposed wellfield will be located on an approximately 7,465-acre property (herein referred to as the "Redtown Ranch Property") in Anderson and Houston County, Texas. The proposed wellfield will consist of eight (8) wells producing a total combined production capacity of 7,050 gallons per minute (gpm), or 11,401 acre-feet per year (ac-ft/yr) from the Middle Wilcox Aquifer in Anderson County. There are four (4) proposed wells located on the Redtown Ranch Property in Houston County (outside of the jurisdiction of the NTVGCD) that are planned to produce 3,700 gpm (5,984 ac-ft/yr) from the Middle Wilcox Aquifer. Therefore, the total combined production for the proposed wellfield is 10,750 gpm (17,385 ac-ft/yr) from the Middle Wilcox Aquifer on the Redtown Ranch Property.

Analytical Groundwater Modeling

LRE conducted analytical groundwater modeling using the Cooper-Jacob (1946) equation to assess local drawdown impacts within each proposed well and surrounding wells within 5-miles of the Redtown Ranch Property. To calculate drawdown, LRE developed proprietary excel-based software utilizing the Cooper-Jacob (1946) modified nonequilibrium equation:

$$s = \frac{264Q}{T}\log\left(\frac{0.3Tt}{r^2S}\right)\left(\frac{1}{WE}\right)$$

Where s is drawdown (in ft), Q is pumping rate (in gpm), r is the radial distance from the center of a pumped well to a point where drawdown is computed (in ft), S is storativity (dimensionless), T is transmissivity (in gallons per day per foot [gpd/ft]), t is elapsed time since pumping began (in days), and WE is well efficiency, expressed as a decimal (dimensionless). Table 1 summarizes the input parameters used to calculate drawdown in the analytical modeling, which are based on estimated hydraulic properties from surrounding well data and the Conceptual North QCSCW GAM Report by Schorr and others (2020). The modeling presented herein includes production of 7,050 gpm (11,401 ac-ft/yr) from wells in Anderson County and 3,700 gpm (5,984 ac-ft/yr) from wells in Houston County (Table 1). A well efficiency of 70% was applied to the drawdown calculations for only the pumping wells (Table 1). The radial distance between the proposed wells (r) are presented in Table 2.

Table 1. Input parameters for analytical modeling

Proposed Well	Pumping Rate, Q (gpm)	Storativity*, S	Transmissivity, T (gpd/ft)	Well Radius, r (ft)	Well Efficiency, WE (%)
MWLX-1	900	0.001	14,440	0.5	70
MWLX-2	900	0.001	15,425	0.5	70
MWLX-3	800	0.001	15,425	0.5	70
MWLX-4	900	0.001	15,095	0.5	70
MWLX-5	900	0.001	15,425	0.5	70
MWLX-10	900	0.001	14,110	0.5	70
MWLX-11	800	0.001	15,095	0.5	70
MWLX-12	950	0.001	16,735	0.5	70
MWLX-6	900	0.001	14,440	0.5	70
MWLX-7	900	0.001	15,095	0.5	70
MWLX-8	1,100	0.001	15,095	0.5	70
MWLX-9	800	0.001	15,095	0.5	70

Note: "gpm" indicates gallons per minute, "ft" indicates feet, "gpd/ft" indicates gallons per day per foot, "" indicates property obtained from the North QCSCW GAM Conceptual Report (Schorr and others, 2020), cells highlighted in gray indicate wells located in Houston County (outside NTVGCD boundary).*

Cumulative drawdown in each proposed well was calculated by superposition of drawdown effects and is equal to the sum of the individual drawdowns caused by each pumping well. The cumulative drawdown in the proposed wells after five years is presented in Table 3. A drawdown contour map after five years of pumping is provided in the Hydrogeologic Report (Appendix B). Cumulative drawdown in the proposed wells after 50 years of pumping is presented in Table 4. Illustrations showing the cone of depression depicting the contours for impacts for all wells listed in Appendix B of the LRE Report (Appendix B) after 50 years of pumping is presented in Figure 1 (as requested by Mr. John Stover – See Appendix A).

Table 2. Distance between proposed wells, r, in feet

Pumping Wells	MWLX-1	MWLX-2	MWLX-3	MWLX-4	MWLX-5	MWLX-10	MWLX-11	MWLX-12	MWLX-6	MWLX-7	MWLX-8	MWLX-9
MWLX-1	0.5	12,268	9,358	15,321	13,459	4,673	10,226	18,185	7,685	11,640	18,231	3,631
MWLX-2	12,268	0.5	11,328	5,277	10,928	7,597	6,171	11,770	18,631	19,096	21,863	13,850
MWLX-3	9,358	11,328	0.5	10,673	4,672	8,330	5,351	10,093	10,507	8,234	10,884	7,375
MWLX-4	15,321	5,277	10,673	0.5	8,119	11,023	5,735	6,922	20,179	18,903	19,701	15,768
MWLX-5	13,459	10,928	4,672	8,119	0.5	11,153	5,181	5,481	15,127	11,889	11,582	11,965
MWLX-10	4,673	7,597	8,330	11,023	11,153	0.5	6,700	14,985	11,594	13,773	18,875	6,818
MWLX-11	10,226	6,171	5,351	5,735	5,181	6,700	0.5	8,286	14,452	13,487	15,693	10,133
MWLX-12	18,185	11,770	10,093	6,922	5,481	14,985	8,286	0.5	20,590	17,179	15,262	17,196
MWLX-6	7,685	18,631	10,507	20,179	15,127	11,594	14,452	20,590	0.5	6,401	14,213	4,813
MWLX-7	11,640	19,096	8,234	18,903	11,889	13,773	13,487	17,179	6,401	0.5	7,820	8,014
MWLX-8	18,231	21,863	10,884	19,701	11,582	18,875	15,693	15,262	14,213	7,820	0.5	14,846
MWLX-9	3,631	13,850	7,375	15,768	11,965	6,818	10,133	17,196	4,813	8,014	14,846	0.5

Note: Distance in pumping well is equal to the well radius of 0.5 feet. Cells highlighted in gray indicate wells located in Houston County (outside NTVGCD boundary).

Table 3. Drawdown, s, after five years of pumping ($t = 1,825\ days$), in feet

Pumping Wells	MWLX-1	MWLX-2	MWLX-3	MWLX-4	MWLX-5	MWLX-10	MWLX-11	MWLX-12	MWLX-6	MWLX-7	MWLX-8	MWLX-9
MWLX-1	247	28	32	25	27	42	31	23	35	29	23	46
MWLX-2	27	232	28	38	28	33	36	27	21	21	19	25
MWLX-3	27	25	206	26	35	29	34	26	26	29	25	30
MWLX-4	24	39	29	237	33	29	38	35	21	21	21	24
MWLX-5	26	28	40	32	232	28	38	38	24	27	28	27
MWLX-10	40	33	32	28	28	232	35	24	28	25	21	35
MWLX-11	27	33	34	34	35	32	210	29	22	23	21	27
MWLX-12	23	30	32	37	41	26	35	250	21	24	26	24
MWLX-6	36	23	31	22	26	30	26	21	252	38	27	42
MWLX-7	28	21	33	21	28	26	26	23	36	237	34	33
MWLX-8	25	22	33	24	32	24	27	28	29	38	262	28
MWLX-9	41	24	32	22	25	33	28	21	37	31	23	219
s	**570**	**538**	**562**	**546**	**570**	**563**	**564**	**545**	**553**	**543**	**529**	**561**

Note: Cells highlighted in gray indicate wells located in Houston County (outside NTVGCD boundary).

Table 4. Approximate drawdown, s, after 50 years of pumping ($t = 18,250\ days$), in feet

Pumping Wells	MWLX-1	MWLX-2	MWLX-3	MWLX-4	MWLX-5	MWLX-10	MWLX-11	MWLX-12	MWLX-6	MWLX-7	MWLX-8	MWLX-9
MWLX-1	270	45	49	42	43	59	47	39	51	46	39	62
MWLX-2	42	254	43	54	44	49	52	43	37	36	35	41
MWLX-3	41	39	226	39	49	42	48	40	39	42	39	44
MWLX-4	40	55	45	259	49	45	54	51	36	37	37	40
MWLX-5	41	44	55	48	254	44	54	53	40	43	43	43
MWLX-10	55	49	48	44	44	254	50	40	43	41	37	50
MWLX-11	41	47	48	48	49	46	230	43	36	37	35	41
MWLX-12	40	46	48	54	57	43	51	273	38	41	42	41
MWLX-6	52	40	48	38	43	46	43	38	276	55	43	59
MWLX-7	44	37	49	37	44	42	42	39	52	259	49	49
MWLX-8	42	40	50	41	49	42	45	45	46	55	287	45
MWLX-9	55	38	46	37	40	47	42	35	52	45	37	240
s	**764**	**732**	**755**	**740**	**764**	**757**	**758**	**739**	**747**	**737**	**724**	**754**

Note: Cells highlighted in gray indicate wells located in Houston County (outside NTVGCD boundary).

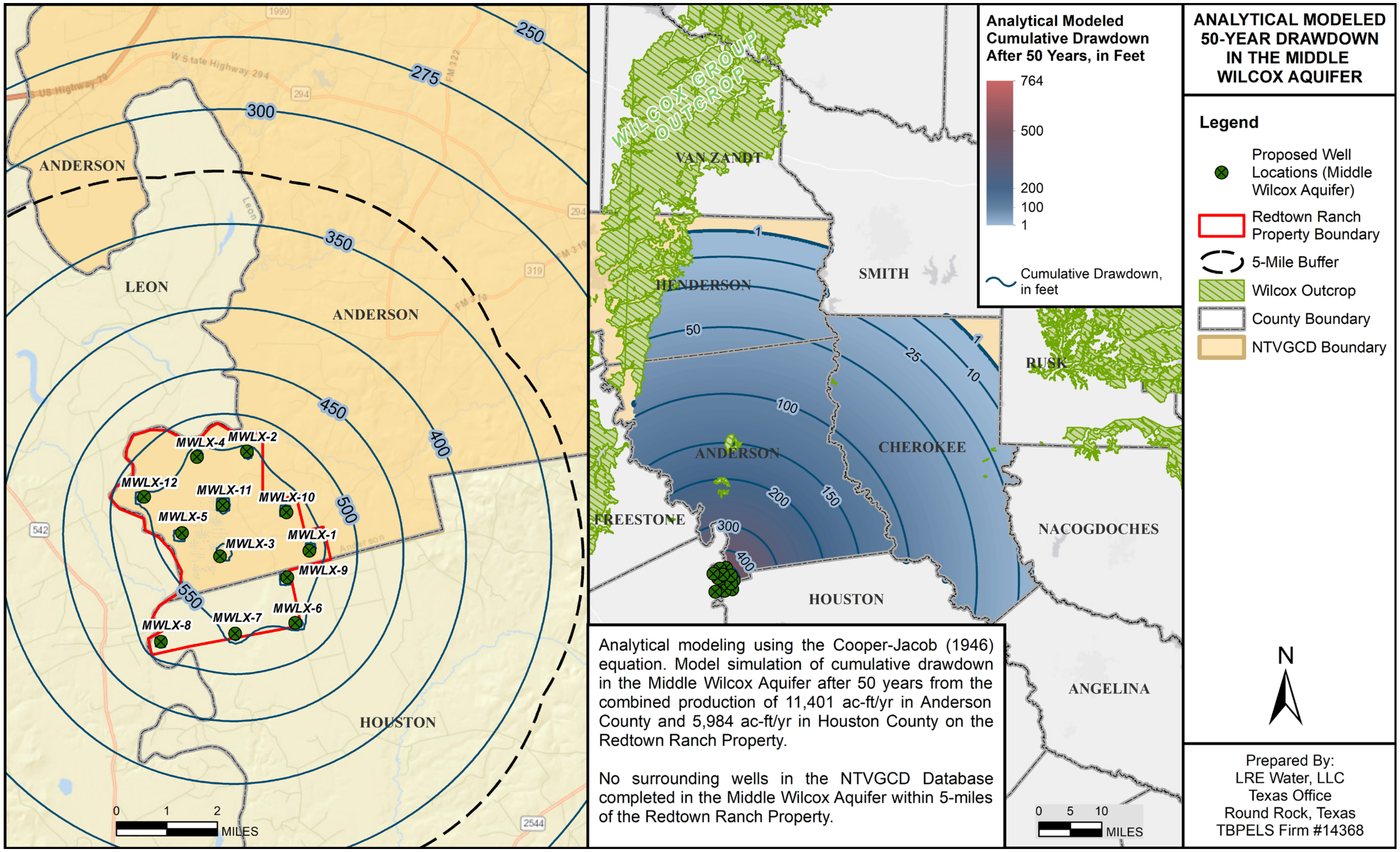

Figure 1. Analytical modeled cumulative 50-year drawdown in the Middle Wilcox Aquifer

The use of the Cooper-Jacob (1946) equation to calculate drawdown is appropriate where the value of u in the Theis (1935) well function, $W(u)$, is sufficiently small (Driscoll, 1986). To verify the appropriateness of using the Cooper-Jacob (1946) equation in the analytical modeling (as requested by AGS – See Appendix A), the critical value of u was solved using the following equation (Theis, 1935):

$$u = \frac{1.87\ r^2 S}{Tt}$$

Where r is the radial distance from the center of a pumped well to a point where drawdown is computed (in ft), S is storativity (dimensionless), T is transmissivity (gpd/ft), and t is elapsed time since pumping began (in days). Table 1 provides the values of transmissivity (T) and storativity (S) values and Table 2 provides the distances between the proposed wells (r). The determinations of u after pumping for five years (t = 1,825 days) and 50 years (t = 18,250 days) are presented in Table 5 and Table 6, respectively.

According to Kruseman and de Ridder (1994), the Cooper-Jacob (1946) approximation is appropriate where the value of u is less than 0.01. Driscoll (1986) suggests that the Cooper-Jacob (1946) approximation can be used where the value of u is less than approximately 0.05. Table 5 and Table 6 show that all determinations of u are less than 0.05 and 0.01, and therefore the methodology presented herein is appropriate for use in the analytical modeling. However, it is important to note that at a certain distance from the pumping well, where u becomes greater than 0.05, the Cooper-Jacob (1946) modified nonequilibrium equation is no longer applicable. This occurs approximately 10 miles from the proposed wellfield after five years of pumping, and approximately 32 miles from the proposed wellfield after 50 years of pumping. Therefore, drawdown calculations beyond these distances from the proposed wellfield are not valid.

Table 5. Determination of u for 5 years of pumping (t = 1,825 days)

Pumping Wells	MWLX-1	MWLX-2	MWLX-3	MWLX-4	MWLX-5	MWLX-10	MWLX-11	MWLX-12	MWLX-6	MWLX-7	MWLX-8	MWLX-9
MWLX-1	0.0000	0.0107	0.0062	0.0167	0.0129	0.0015	0.0074	0.0235	0.0042	0.0096	0.0236	0.0009
MWLX-2	0.0100	0.0000	0.0085	0.0018	0.0079	0.0038	0.0025	0.0092	0.0231	0.0242	0.0318	0.0127
MWLX-3	0.0058	0.0085	0.0000	0.0076	0.0014	0.0046	0.0019	0.0068	0.0073	0.0045	0.0079	0.0036
MWLX-4	0.0159	0.0019	0.0077	0.0000	0.0045	0.0082	0.0022	0.0033	0.0276	0.0243	0.0263	0.0169
MWLX-5	0.0120	0.0079	0.0014	0.0044	0.0000	0.0083	0.0018	0.0020	0.0152	0.0094	0.0089	0.0095
MWLX-10	0.0015	0.0038	0.0046	0.0081	0.0083	0.0000	0.0030	0.0149	0.0089	0.0126	0.0237	0.0031
MWLX-11	0.0071	0.0026	0.0019	0.0022	0.0018	0.0030	0.0000	0.0047	0.0142	0.0123	0.0167	0.0070
MWLX-12	0.0224	0.0094	0.0069	0.0033	0.0020	0.0152	0.0047	0.0000	0.0288	0.0200	0.0158	0.0201
MWLX-6	0.0043	0.0252	0.0080	0.0296	0.0166	0.0098	0.0152	0.0308	0.0000	0.0030	0.0147	0.0017
MWLX-7	0.0092	0.0248	0.0046	0.0243	0.0096	0.0129	0.0123	0.0200	0.0028	0.0000	0.0042	0.0044
MWLX-8	0.0203	0.0293	0.0073	0.0238	0.0082	0.0218	0.0151	0.0143	0.0124	0.0037	0.0000	0.0135
MWLX-9	0.0009	0.0136	0.0039	0.0176	0.0102	0.0033	0.0073	0.0210	0.0016	0.0046	0.0156	0.0000

Note: Cells highlighted in gray indicate wells located in Houston County (outside NTVGCD boundary).

Table 6. Determination of u for 50 years of pumping (t = 18,250 days)

Pumping Wells	MWLX-1	MWLX-2	MWLX-3	MWLX-4	MWLX-5	MWLX-10	MWLX-11	MWLX-12	MWLX-6	MWLX-7	MWLX-8	MWLX-9
MWLX-1	0.0000	0.0011	0.0006	0.0017	0.0013	0.0002	0.0007	0.0023	0.0004	0.0010	0.0024	0.0001
MWLX-2	0.0010	0.0000	0.0009	0.0002	0.0008	0.0004	0.0003	0.0009	0.0023	0.0024	0.0032	0.0013
MWLX-3	0.0006	0.0009	0.0000	0.0008	0.0001	0.0005	0.0002	0.0007	0.0007	0.0005	0.0008	0.0004
MWLX-4	0.0016	0.0002	0.0008	0.0000	0.0004	0.0008	0.0002	0.0003	0.0028	0.0024	0.0026	0.0017
MWLX-5	0.0012	0.0008	0.0001	0.0004	0.0000	0.0008	0.0002	0.0002	0.0015	0.0009	0.0009	0.0010
MWLX-10	0.0001	0.0004	0.0005	0.0008	0.0008	0.0000	0.0003	0.0015	0.0009	0.0013	0.0024	0.0003
MWLX-11	0.0007	0.0003	0.0002	0.0002	0.0002	0.0003	0.0000	0.0005	0.0014	0.0012	0.0017	0.0007
MWLX-12	0.0022	0.0009	0.0007	0.0003	0.0002	0.0015	0.0005	0.0000	0.0029	0.0020	0.0016	0.0020
MWLX-6	0.0004	0.0025	0.0008	0.0030	0.0017	0.0010	0.0015	0.0031	0.0000	0.0003	0.0015	0.0002
MWLX-7	0.0009	0.0025	0.0005	0.0024	0.0010	0.0013	0.0012	0.0020	0.0003	0.0000	0.0004	0.0004
MWLX-8	0.0020	0.0029	0.0007	0.0024	0.0008	0.0022	0.0015	0.0014	0.0012	0.0004	0.0000	0.0013
MWLX-9	0.0001	0.0014	0.0004	0.0018	0.0010	0.0003	0.0007	0.0021	0.0002	0.0005	0.0016	0.0000

Note: Cells highlighted in gray indicate wells located in Houston County (outside NTVGCD boundary).

Numerical Groundwater Modeling

The purpose of the numerical modeling was to assess the regional impacts of the combined production of 7,050 gpm (11,401 ac-ft/yr) from the Middle Wilcox Aquifer (North QCSCW GAM; Layer 8) in Anderson County and 3,700 gpm (5,984 ac-ft/yr) from the Middle Wilcox Aquifer in Houston County. The information requested for the numerical modeling by AGS is provided in Appendix A. Additional email correspondence with AGS providing clarification for the numerical modeling is also provided in Appendix A of this Addendum. Based on the requested information, LRE modeled the impacts of the proposed production for 50 years from 2025 through December 31, 2074 (2075), and recovery for five years after modeled pumping was discontinued, from 2075 through December 31, 2079 (2080).

Due to current model constraints, the proposed combined production of 7,050 gpm (11,401 ac-ft/yr) from the Middle Wilcox Aquifer (QCSCW GAM; Layer 8) in Anderson County and 3,700 gpm (5,984 ac-ft/yr) from the Middle Wilcox Aquifer in Houston County could not be sustained for the requested pumping periods. Therefore, the total combined annual production of 17,385 ac-ft/yr was automatically reduced in MODFLOW to prevent cell depletion. Table 7 shows the auto-flow reduced production rates used in the numerical modeling, which were reduced by 6-11% from 2025 to 2075.

Table 7. Auto-flow reductions in the Middle Wilcox (Layer 8) in the numerical modeling

Pumping Time (Years)	Model Time (Year)	Combined Pumping Rates (gpm)	Combined Annual Production (ac-ft)	Percent Reduction (%)
0	2025	10,750	17,385	0%
1	2026	10,124	16,372	6%
2	2027	9,755	15,776	9%
3	2029	9,659	15,620	10%
4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50	2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074	9617, 9594, 9580, 9569, 9562, 9556, 9551, 9548, 9545, 9542, 9540, 9539, 9537, 9536, 9535, 9534, 9534, 9533, 9533, 9532, 9532, 9531, 9531, 9531, 9530, 9530, 9530, 9530, 9530, 9529, 9529, 9529, 9529, 9529, 9529, 9529, 9529, 9529, 9529, 9528, 9528, 9528, 9528, 9528, 9528, 9528	15553, 15516, 15492, 15476, 15463, 15454 15446, 15440, 15436, 15432, 15429, 15426 15424, 15422, 15420, 15419, 15418, 15417 15416, 15415, 15415 15414, 15414, 15413 15413, 15412, 15412 15412, 15411, 15411 15411, 15411, 15410 15410, 15410, 15410 15410, 15410, 15410 15409, 15409, 15409 15409, 15409, 15409 15409	11%

Note: "gpm" indicates gallons per minute, "ac-ft" indicates acre-feet.

For the numerical modeling, LRE used predictive Scenario 33, as documented in Technical Memo 21-01 (Hutchinson, 2021b), to assess the regional impacts to the aquifer. Drawdown was calculated for Scenario 33 TM 21-01 ("Base Run") and proposed pumping from the Middle Wilcox Aquifer (North QCSCW GAM; Layer 8) using the auto-flow reduced production in Table 7 ("Proposed MWLX"). LRE calculated "marginal drawdown" from the "Proposed MWLX" as the difference in head between the "Base Run" and the combined "Base Run" and "Proposed MWLX" pumping.

As requested by AGS (Appendix A), LRE modeled drawdown for the following scenarios:

- Drawdown from the "Proposed MWLX" after five years from 2025 to 2030 (Figure 2)
- Drawdown from the "Proposed MWLX" after 50 years from 2025 to 2075 (Figure 3)
- Residual drawdown (recovery) five years after "Proposed MWLX" stopped from 2075-2080 (Figure 4).

The most recent DFCs were approved by GMA-11 on August 11, 2021, based on Scenario 33, TM 21-01 (Hutchinson, 2021a). As described in the GMA-11 Desired Future Conditions Explanatory Report (Hutchinson, 2021c), average drawdown across the county represents the regional average drawdown occurring due to pumping during the period of interest. The recently adopted DFC for Anderson County is an average drawdown of 155 feet in the Carrizo-Wilcox Aquifer (Layers 6-9) from 2013 to 2080 (Hutchinson, 2021a). Cumulative drawdown from the numerical modeling was computed and compared to the average drawdown in the Middle Wilcox Aquifer (Layer 8) in Anderson County. Table 8 summarizes the average drawdown in the Carrizo-Wilcox Aquifer in Anderson County from the "Base Run" and the "Proposed MWLX" pumping for five years (2025 to 2030) and 50 years (2025 to 2075). Table 8 presents the average recovery in the Carrizo-Wilcox Aquifer in Anderson County five years after the "Proposed MWLX" pumping stops (2075-2080). The additional drawdown due to the "Proposed MWLX" pumping only, averaged across the Carrizo-Wilcox Aquifer in Anderson County, is approximately 52.83 feet after five years (2025-2030) and 57.64 feet after 50 years (2025-2075), as shown in Table 8. Recovery in the Carrizo-Wilcox Aquifer averaged across Anderson County after the "Proposed MWLX" pumping stops is approximately 38.45 feet after five years (2075-2080) (Table 9).

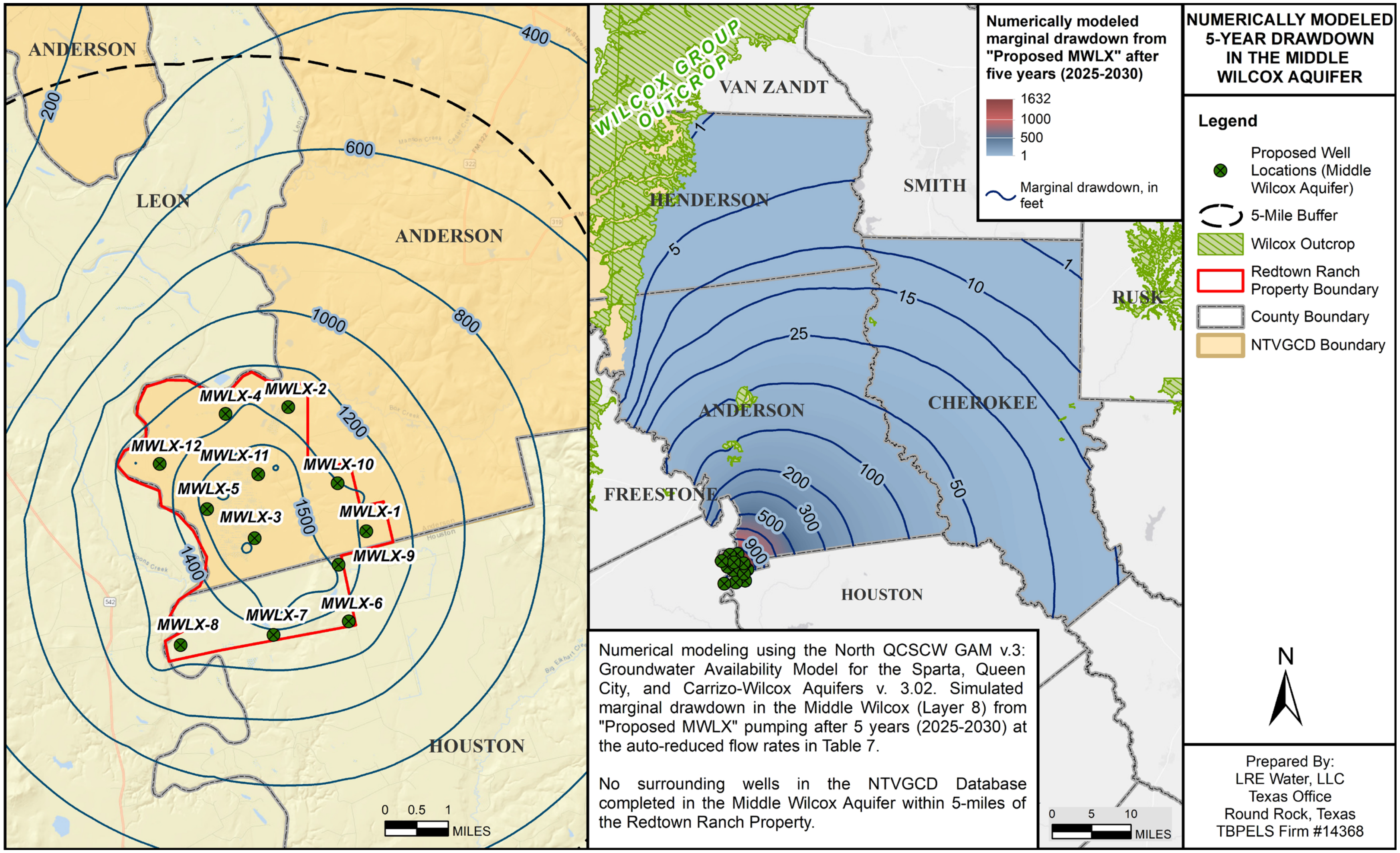

Figure 2. Numerically modeled marginal drawdown in the Middle Wilcox Aquifer (Layer 8) from "Proposed MWLX" after 5 years (2025-2030)

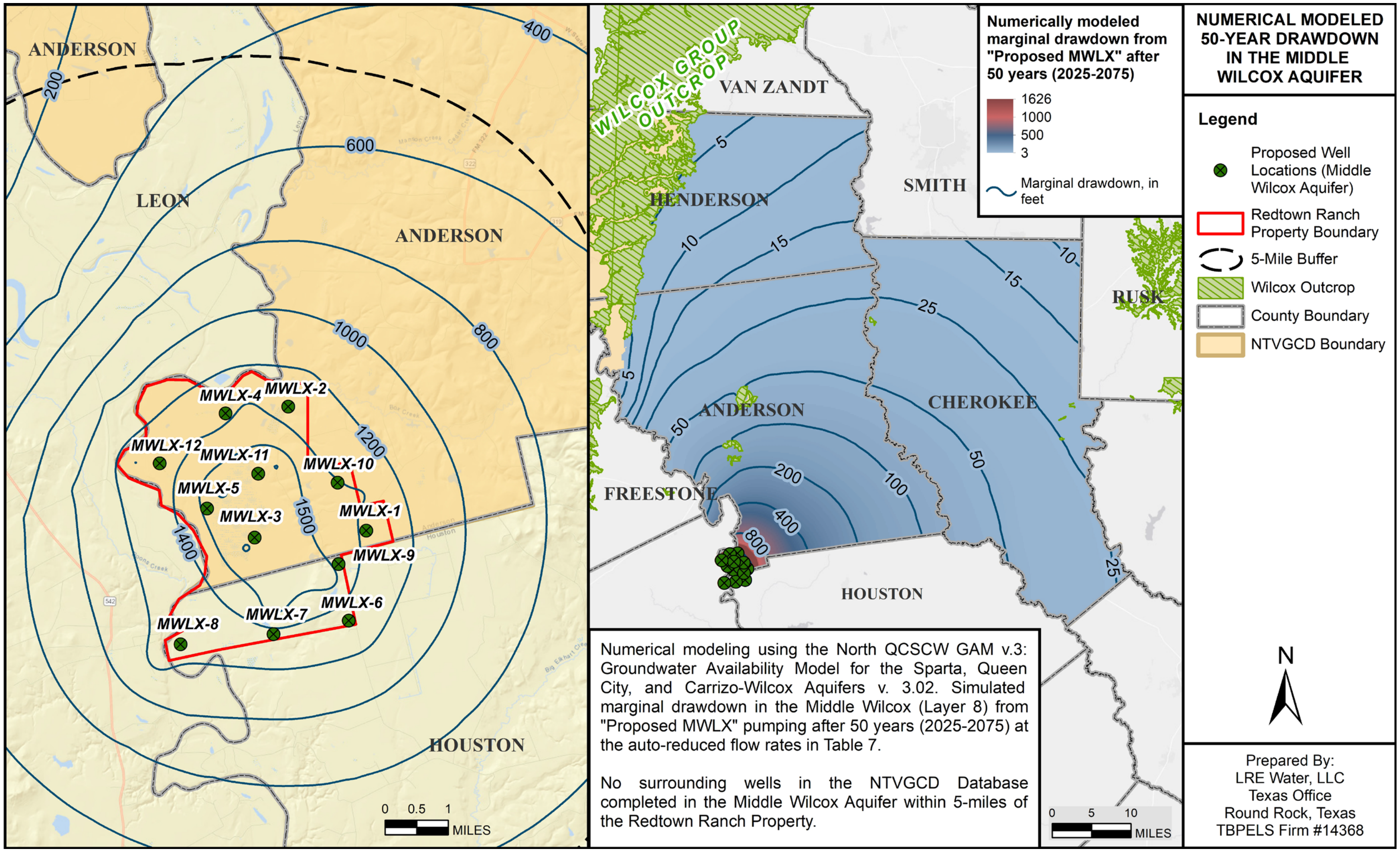

Figure 3. Numerically modeled marginal drawdown in the Middle Wilcox Aquifer (Layer 8) from "Proposed MWLX" after 50 years (2025-2075)

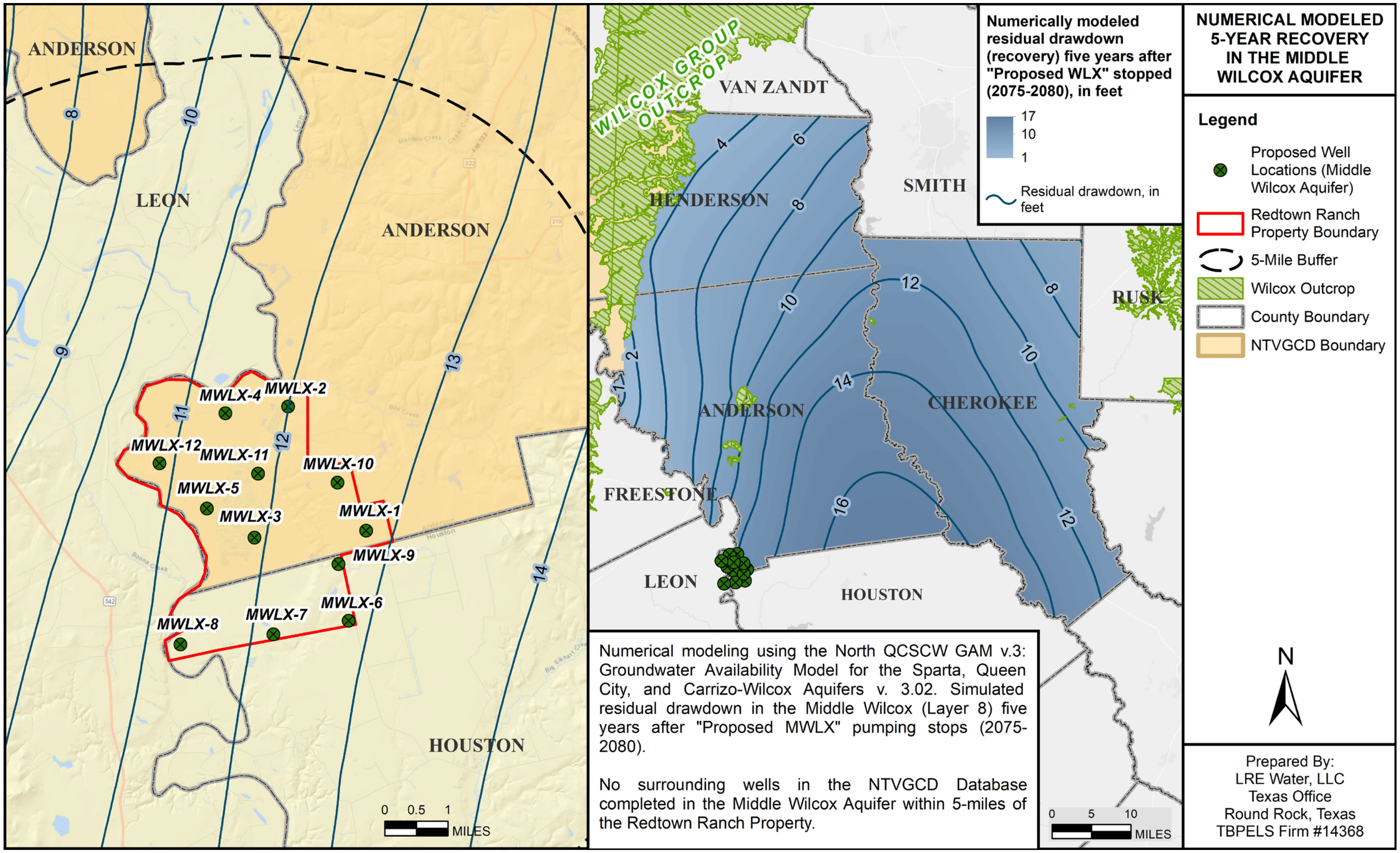

Figure 4. Numerically modeled recovery (residual drawdown) in the Middle Wilcox Aquifer (Layer 8) from "Proposed MWLX" after 5 years (2075-2080)

Table 8. Numerically model-predicted average drawdown in Anderson County

Aquifer	Model Layer	Average Drawdown in Anderson County, in Feet					
		5-Year Drawdown (2025-3030)			50-Year Drawdown (2025-2075)		
		"Base Run" (TM 21-01)	"Base Run" + "Proposed MWLX"	"Proposed MWLX" Only	"Base Run" (TM 21-01)	"Base Run" + "Proposed MWLX"	"Proposed MWLX" Only
Carrizo Sand	6	108.49	126.88	**18.38**	118.28	139.95	**21.67**
Upper Wilcox	7	117.58	136.88	**19.30**	127.87	150.38	**22.50**
Middle Wilcox	8	141.14	248.92	**107.78**	153.22	267.01	**113.79**
Lower Wilcox	9	175.95	277.61	**101.66**	189.17	299.40	**110.23**
Avg CZ-WLX	6-9	130.40	183.22	**52.83**	141.45	199.09	**57.64**

Note: "Base Run" indicates the Groundwater Availability Model (GAM) Scenario 33, TM 21-01 (Hutchinson, 2021b), "Proposed MWLX" indicates proposed production of production of the auto-reduced flowrates in Table 7 in the Middle Wilcox Aquifer (North QCSCW GAM; Layer 8), "Avg CZ-WLX" indicates average of drawdown in the Carrizo-Wilcox Aquifer (Layers 6-9).

Table 9. Numerically model-predicted average 5-year residual drawdown (recovery) from 2075-2080 in Anderson County

Aquifer	Model Layer	Average Residual Drawdown in Anderson County, in Feet			
		"Base Run" (TM 21-01)	"Base Run" + "Proposed MWLX"	"Proposed MWLX" Only	Recovered Head from "Proposed MWLX" Only
Carrizo Sand	6	108.49	124.45	**15.96**	**5.71**
Upper Wilcox	7	117.58	134.39	**16.81**	**5.69**
Middle Wilcox	8	141.14	162.87	**21.73**	**92.06**
Lower Wilcox	9	175.95	201.51	**25.56**	**84.66**
Avg CZ-WLX	6-9	130.40	149.59	**19.19**	**38.45**

Note: "Base Run" indicates the simulated average drawdown from 2025-2075 in the Groundwater Availability Model (GAM) Scenario 33, TM 21-01 (Hutchinson, 2021b), Proposed MWLX" indicates proposed production of auto-reduced flowrates in Table 7 in the Middle Wilcox Aquifer (North QCSCW GAM; Layer 8), Recovered Head" is the difference between drawdown after 50 years from the "Proposed MWLX" pumping only and recovery after five years from the "Proposed MWLX" pumping only, "Avg CZ-WLX" indicates average of drawdown in the Carrizo-Wilcox Aquifer (Layers 6-9).

Groundwater Availability Models (GAMs) are regional-scale numerical tools designed to simulate the effects of groundwater pumping on aquifers and estimate current and future groundwater availability for groundwater resource management and water planning purposes. The TWDB emphasizes that the GAM grid cell sizes are generally too large to accurately depict localized impacts from pumping. Therefore, for site-specific evaluations, the TWDB recommends that analytical models be used where site specific aquifer properties are available. When evaluating the impacts of the proposed production on the aquifer based on the results presented above, it is crucial to understand the assumptions and limitations associated with both analytical models (Cooper-Jacob, 1946) and numerical models (GAMs, MODFLOW).

In this analysis, the analytical modeling does not capture the boundary conditions imposed on the aquifer, such as recharge and faulting, or the variability in aquifer properties, such as hydraulic conductivity. Numerical modeling can account for both of these factors but at a lower resolution (due to grid size), which may not accurately represent site specific parameters (without further modification). In addition, where local aquifer properties differ from the GAM hydraulic properties, numerical models may overestimate or underestimate the actual impacts of pumping to the aquifer. In this analysis, higher pumping rates in the same cells resulted in the cells going "dry," which initiated the auto-flow reduction feature. While this adjustment produces a model that runs to completion for the requested pumping periods, this feature also reduces the accuracy of the model simulation. Therefore, these limitations and assumptions in the analytical and numerical modeling should be carefully considered when evaluating the impacts of pumping to the aquifer.

As requested, the TWDB GAM modeling files used to develop the numerical modeling results will be provided with this Addendum.

LRE appreciates the opportunity to provide you with this Addendum to the Hydrogeologic Report on behalf of Redtown Ranch Holdings, LLC. If you have any questions, please do not hesitate to contact us.

Sincerely,

LRE Water

STATE OF TEXAS
THERESA BUDD
GEOLOGY
15233
LICENSED
PROFESSIONAL GEOSCIENTIST
11/19/2024
TBPG Firm #50516

Theresa Budd, PG
Senior Project Hydrogeologist

STATE OF TEXAS
GRETCHEN R. MILLER
113115
LICENSED
PROFESSIONAL ENGINEER
TBPE Firm #14368
11/19/2024

Gretchen Miller, PhD, PE, PG
Senior Project Manager

LRE WATER

References

Cooper, H.H. and C.E. Jacob, 1946, A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys. Union Trans., vol. 27, pp.526-534.

Hutchison, W.R., 2021a, GMA 11 Technical Memorandum 21-01, Adjusted Pumping Simulations for Joint Planning with Updated Groundwater Availability Model for the Sparta, Queen City, and Carrizo-Wilcox Aquifers, 31 p.

Hutchison, W.R., 2021b, Base Scenario Pumping Factors using Updated Groundwater Availability Model for the Sparta, Queen City, and Carrizo-Wilcox Aquifers.

Hutchinson, W.R., 2021c, Desired Future Conditions Explanatory Report (Final) Carrizo Wilcox/Queen City/Sparta Aquifers for Groundwater Management Area 11.

Kruseman, G.P., and N.A. de Ridder, 1994, Analysis and Evaluation of Pumping Test Data (2nd ed.), Publication 47, Intern. Inst. for Land Reclamation and Improvement, Wageningen, The Netherlands, 370 p.

Theis, C.V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage, Am. Geophysics. Union Trans., vol 16, pp. 519-524.

Appendix A –

Response Letters provided by AGS (Dated October 28, 2024)
and Mr. John Stover (Dated October 23, 2024)

Email correspondence between LRE and AGS
(Dated November 1, 2024 and November 6, 2024)

SSBWW | Skelton Slusher Barnhill Watkins Wells
ATTORNEYS AT LAW PLLC

John D. Stover
Direct Dial: 936.633.3130
Direct Fax: 936.632.6545
jstover@ssbww.law

October 21, 2024

Quinn McColly, PhD, Managing Director, Water Resources
Conservation Equity Management
Parkland Hall at Old Parkland
3889 Maple Avenue, 6th Floor
Dallas, Texas 75219
Via Email: qm@cem-tx.com

RE: Neches and Trinity Valleys Groundwater Conservation District Well Applications

Dear Mr. McColly:

This is to clarify our discussions concerning the hydrology report for your applications to the Neches and Trinity Valleys Groundwater Conservation District. You indicated that your engineering team could put together reports that look forward for 50 years. I agreed that it would be a sufficient period of time. I did not specify the contents of that report, not being a hydrologist. Reports are not needed on the individual wells, but for the two well fields.

While the decisions about the completeness of the report will be up to our groundwater hydrologist, there are several things that I would like to see included, such as illustrations or maps showing the cone of depression depicting the contours for impacts for all of the wells listed in Appendix B in the LRE Water Report of September 5, 2024 for the well fields. The hydrologist has indicated that I will receive a response from him on this, this week.

I do not recall suggesting or agreeing to a report limited to a five year period. I have reviewed my notes and did not find anything in them that addresses the length of time that the report should cover. You must have misunderstood me. A five year period is not adequate for legal and scientific use.

As to the other items listed in the deficiencies that we previously submitted to you, all have been satisfied except for the hydrology report.

Please let me know if you have other questions.

Yours very truly,

John D. Stover
JDS/jsa
Clio: 1347225

cc: Penny Hanson

SSBWW Skelton Slusher Barnhill Watkins Wells
ATTORNEYS AT LAW PLLC

John D. Stover
Direct Dial: 936.633.3130
Direct Fax: 936.632.6545
jstover@ssbww.law

October 29, 2024

Quinn McColly, PhD, Managing Director, Water Resources
Conservation Equity Management
Parkland Hall at Old Parkland
3889 Maple Avenue, 6th Floor
Dallas, Texas 75219
Via Email: qm@cem-tx.com

RE: Neches and Trinity Valleys Groundwater Conservation District-
Applications from Pine Bliss, LLC and Redtown Ranch Holdings, LLC

Dear Mr. McColly:

Attached is a letter from the District's consulting hydrologist, James Beach, containing the results of his review of the hydrology report you submitted with the above referenced applications. Please have your hydrologist address these matters and supplement their reports.

Please let me know if there are any questions.

Yours very truly,

John D. Stover
JDS/jsa
Clio: 1350311

Attachment

cc: Penny Hanson

cc: Holli Pryor-Blaze

cc: Scott Skelton

AGS
Advanced Groundwater Solutions, LLC
www.advancedgw.com

October 28, 2024

John D. Stover
Skelton Slusher Barnhill Watkin Wells
1616 South Chestnut
Lufkin, Texas 75901

Dear Mr. Stover,

As requested by Neches Trinity Valley Groundwater Conservation District (NTVGCD, the District), Advanced Groundwater Solutions, LLC (AGS) has reviewed the hydrogeologic reports provided for the proposed Pine Bliss LLC wellfield (also known as Bluebonnet) in Henderson County and Redtown Ranch wellfield in Anderson County and Houston County. As per your direction, AGS has not completed a quantitative assessment of the groundwater modeling completed by LRE to confirm the modeling results contained in the September 5, 2024 hydrogeological report addendum. However, we do have the following general comments.

District rule 5.4(k) provides the following requirements for hydrogeological reports – "a hydrogeological report addressing the area of influence, draw down, recovery time, and other pertinent information required by the district." The hydrogeologic reports developed by LRE discuss the geologic and hydrogeologic setting, results of pumping tests, hydraulic properties estimated in the wellfields from available data, and the estimated impacts of pumping as required by rule 5.4(k).

LRE used two methods to evaluate water level decline from the proposed wells, (1) an analytical method known as the Cooper-Jacob solution, and (2) the Texas Water Development Board Groundwater Availability Model (the TWDB GAM). The two approaches provide significantly different results regarding drawdown.

The Cooper-Jacob solution is an approximation of the Theis (1935) solution. The critical value of u required to achieve reasonable accuracy with the Cooper and Jacob approximation is alternately given as $u \leq 0.05$ (Driscoll 1986) and $u \leq 0.01$ (Kruseman and de Ridder 1994). A smaller value for the critical value of u leads to a more accurate approximation of the Theis well function. Therefore, the drawdowns shown in the hydrogeological reports at some combinations of variables (r, T, S) may not meet the criteria. We request that LRE show the value of the Cooper and Jacob "u" value for the calculations. In addition, it is unclear how the Cooper and Jacob solution was applied to estimate drawdowns when the transmissivity varies from well to well. We assume the principle of superposition was employed, but it was not described in the report. We ask that LRE explain the approach and speak to the validity of the approximation.

For the numerical modeling using the TWDB GAM, the recovery time was not documented in the hydrogeologic reports. We ask that LRE document the recovery time using the TWDB GAM.

LRE compares the water level decline after 5 years from the project to the DFC drawdown noted in the tables as "Simulated "Base Run" Scenario 33 (TM 21-01)". The DFC drawdown noted in the comparisons is the simulated water level decline in 2080. We request that LRE provide a comparison with the simulated water level decline from the project in 2080.

We also ask that LRE provide the TWDB GAM modeling files used to develop the results in the hydrogeologic reports.

Please let me know if you have any questions.

Best regards,

Advanced Groundwater Solutions, LLC

James Beach

James Beach, PG

References:

Cooper, H.H. and C.E. Jacob, 1946. A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys. Union Trans., vol. 27, pp. 526-534.

Driscoll, F.G., 1986. Groundwater and Wells (2nd ed.), Johnson Filtration Systems, Inc., St. Paul, Minnesota, 1089p.

Kruseman, G.P. and N.A. de Ridder, 1994. Analysis and Evaluation of Pumping Test Data (2nd ed.), Publication 47, Intern. Inst. for Land Reclamation and Improvement, Wageningen, The Netherlands, 370p. [pdf]

Theis, C.V., 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage, Am. Geophys. Union Trans., vol. 16, pp. 519-524.

Outlook

Re: Neches Trinity Valley GCD - Comments

From James Beach <james.beach@advancedgw.com>
Date Wed 11/13/2024 10:09 AM
To Gretchen Miller <gretchen.miller@lrewater.com>
Cc Jordan Furnans <jordan.furnans@lrewater.com>; John Stover <jstover@ssbww.law>; Theresa Budd <theresa.budd@lrewater.com>

Gretchen,

Sorry for the confusion on item 2.
Please model 5 years of recovery with the existing model out to 2080.

thanks.

James Beach
(512) 796-8636

On Tue, Nov 12, 2024 at 2:53 PM Gretchen Miller <gretchen.miller@lrewater.com> wrote:

Hi James,

Just to clarify item 2 on your email below, for the recovery calculations, we planned to present a plot and table of drawdown at the 5-year mark after pumping ceases (e.g., recovery obtained by 2080). Based on my notes from our conversation, that was sufficient, but I'm seeing some ambiguity in your email below. Just want to make sure that we fully understood what was needed.

Thanks,
Gretchen

Gretchen Miller, Ph.D., P.E., P.G.
Senior Project Manager
LRE Water | A Spheros Environmental Company
Office: 512-300-0435 | Direct: 979-676-1273
gretchen.miller@lrewater.com

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A SPHEROS ENVIRONMENTAL COMPANY

LREWATER.COM
600 Round Rock West Dr. #601, Round Rock, TX 78681

From: James Beach <james.beach@advancedgw.com>
Sent: Wednesday, November 6, 2024 7:53 AM
To: Gretchen Miller <gretchen.miller@lrewater.com>
Cc: Jordan Furnans <jordan.furnans@lrewater.com>; John Stover <jstover@ssbww.law>; Theresa Budd <theresa.budd@lrewater.com>
Subject: Re: Neches Trinity Valley GCD - Comments

Gretchen,

1. Yes, the 2025-2075 is fine for the 50-year run.
2. Yes, repeating the 2080 stress period is fine. Please show recovery results after 5 years (2080) also.
3. If the auto-flow reduction is required for convergence, that is fine. I obviously cannot speak to how the District will receive changes to the model or other approaches for estimating impacts, but I am open to considering your technical approaches to addressing model limitations.

James Beach
(512) 796-8636

On Fri, Nov 1, 2024 at 1:28 PM Gretchen Miller <gretchen.miller@lrewater.com> wrote:

James,

We are working on generating these model runs and need to clarify the following details with you:

1) For the previous analyses, we used predictive Scenario 33 generated by Bill Hutchison as part of the GMA-11 planning process (i.e., GR21-016 MAG). This scenario models years 2013 to 2080. Can you confirm that you are requesting that we model the intended pumping in that version of the GAM for 50 years, presumably from 2025 to 2075?

2) Given the above, we can only model recovery for an additional 5 years after 2075, given the model's current structure. If we were to continue for an additional 25 years (to 2105), what would you consider an acceptable model modification? Should we repeat the last (2080) stress period for those additional years?

3) The current parameters in the GAM do not allow for pumping at the rates requested in the permit(s), as we based those on site-specific field data. Thus, the pumping simulated in the

GAM must be reduced in order for the model, as originally constructed and approved, to converge. Do you concur with our use of the auto-flow reduction routines in MODFLOW to adapt for that? Or do you have another preferred method for handling this limitation?

As you can see, there are multiple technical complications associated with the GAM that make your requests less than straightforward to accomplish. Before we set about trying to meet them, I want to make sure we agree as to the approach.

Also, if you have any other suggestions or preferred methods you'd like for us to use for this analysis, please let us know now before we commence.

Thank you,
Gretchen

Gretchen Miller, Ph.D., P.E., P.G.
Senior Project Manager
LRE Water | A Spheros Environmental Company
Office: 512-300-0435 | Direct: 979-676-1273
gretchen.miller@lrewater.com

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A SPHEROS ENVIRONMENTAL COMPANY

LREWATER.COM
600 Round Rock West Dr. #601, Round Rock, TX 78681

From: James Beach <james.beach@advancedgw.com>
Sent: Friday, November 1, 2024 9:40 AM
To: Jordan Furnans <jordan.furnans@lrewater.com>
Cc: John Stover <jstover@ssbww.law>
Subject: Re: Neches Trinity Valley GCD - Comments

Jordan,

Thanks for your email. Good to see you at TWCA as well.
I'm copying John Stover on this email to keep him in the loop.

Regarding documentation of recovery with the GAM, it seems reasonable to document water level decline for the 50-year period simulated for each "project" as indicated in your hydrogeologic reports. Please illustrate contours of water level decline 1, 2, 5, 10, and 30 years after pumping stops.

Please make the TWDB GAM files available on a shared site, and we can download them to confirm the results in the hydro report. We would like to get all the files needed to complete the runs (i.e., not just the WEL file) for each project (Pine Bliss and Redtown).

Let me know if you have any questions.

thank you,

James Beach
(512) 796-8636

On Tue, Oct 29, 2024 at 12:53 PM Jordan Furnans <jordan.furnans@lrewater.com> wrote:

> Hey James -
>
> Good to see you last week at TWCA.
>
> I just got your 2-pg letter to Mr. Stover regarding our hydrogeological reports for Pine Bliss and Redtown Ranch.
>
> Question:
> How would you like recovery modeled and documented using the GAM? We did recovery modeling using Theis, and provided those results. It is frustrating that the district does not have explicit rules/requirements for hydrogeological reporting, such that we could just do what is needed once, rather than have to keep responding to requests.
>
> That being said, we'll do what you ask in your letter. Do you believe the GAM is accurate enough in this region to provide the district with useful information regarding the proposed projects?
>
> Thanks,
>
> Jordan
>
> **Jordan Furnans, PhD, PE, PG**
> **Vice President - Texas Operations**
> LRE Water | A Spheros Environmental Company
> Office: 512-300-0435 Direct: 512-736-6485
> Jordan.Furnans@LREwater.com
> LREWATER.COM
> 600 Round Rock West Dr. #601, Round Rock, TX 78681

Appendix B –

Hydrogeologic Report Prepared for the NTVGCD for the Proposed Middle Wilcox Wellfield on the Redtown Ranch Property (Dated September 11, 2024)

CONNECTING WATER TO LIFE

September 12, 2024

Penny Hanson, General Manager
Neches and Trinity Valleys GCD
501 Devereaux Street
Jacksonville, TX 75766

RE: Hydrogeological Report for the Neches and Trinity Valleys GCD
Middle Wilcox Wellfield – Redtown Ranch Property, Anderson County, TX

Dear Ms. Hanson,

LRE Water ("LRE") is pleased to submit this Hydrogeological Report to the Neches and Trinity Valleys Groundwater Conservation District ("NTVGCD" or District) on behalf of Redtown Ranch Holdings, LLC. The purpose of this Hydrogeological Report is to assess the potential impacts associated with a proposed wellfield on an approximately 7,465-acre property (herein referred to as the "Redtown Ranch Property") in Anderson and Houston County, Texas. According to District Rule 5.4(k), an applicant requesting to drill and operate a proposed new well or well system with a daily maximum capacity of more than 2 million gallons or requesting to modify to increase production or production capacity of a non-exempt well with an outside casing diameter greater than 10 inches is required to submit a Hydrogeological Report with the permit application. This Hydrogeologic Report addresses the area of influence, estimated drawdown, recovery time, relation of proposed pumping to the modeled available groundwater (MAG) and the desired future conditions (DFCs), and water usage for the proposed production as it relates to the current Regional Water Plan. The information provided herein is intended to supplement the Groundwater Availability Study prepared by LRE for Redtown Ranch Holdings, LLC, dated May 31, 2024, and to address deficiencies in the permit application, as noted in the District's letter to Redtown Ranch Holdings, LLC, dated August 8, 2024.

The proposed wellfield in Anderson County will consist of eight (8) wells on the Redtown Ranch Property producing a total combined production capacity of 7,050 gallons per minute (gpm), or 11,401 acre-feet per year (ac-ft/yr) from the Middle Wilcox Aquifer of the Carrizo-Wilcox Aquifer System. The intended use for which production is requested includes all beneficial purposes as those terms are defined in Section 36.001(9), Texas Water Code (2011), and NTVGCD Rule 1(c). The produced water from this wellfield is planned to be used within Regional Water Planning Areas C, G, H, K, and/or L.

Background

For this work, LRE compiled and reviewed publicly available information pertaining to the geologic structure, lithology, and hydraulic properties of the Middle Wilcox Aquifer beneath the Redtown Ranch Property. This included a review of geologic and hydrogeologic data from published groundwater studies, geologic maps, state well reports, well drilling reports, and other applicable information from published literature. Data sources included the Texas Commission on Environmental Quality (TCEQ), the Texas Water Development Board (TWDB) Groundwater Database, the Submitted Drillers Report (SDR) Database, the Brackish Resources Aquifer Characterization System (BRACS) Database, and LRE files. LRE's literature review included the TWDB Report No. 150 ("R-150") "Ground-Water Conditions in Anderson, Cherokee, Freestone, and Henderson Counties, Texas by Guyton & Associates (1972) and TWDB Report No. 18 ("R-18") "Ground Water Resources of Houston County, Texas" by G.E. Tarver (1966). Hydraulic properties for the Middle Wilcox Aquifer were obtained from the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifer Groundwater Availability Model ("North QCSCW GAM") Conceptual Report by Schorr and others (2020).

Appendix A provides the latitude and longitude coordinates and pumping rates for the proposed wells on the Redtown Ranch Property. The proposed wellfield in Anderson County (within the jurisdiction of the NTVGCD) includes eight (8) wells completed in the Middle Wilcox Aquifer producing a total combined production capacity of 7,050 gpm (11,401 ac-ft/yr). The proposed wellfield in Houston County (outside the jurisdiction of the NTVGCD) consists of four (4) wells completed in the Middle Wilcox Aquifer producing a total combined production capacity of 3,700 gpm (5,984 ac-ft/yr). Each proposed well will be completed with an outer casing diameter greater than 10 inches and will be equipped with a pump capable of producing the proposed pumping rates provided in Appendix A. On August 15, 2024, the District provided LRE (via email) a list of all exempt and non-exempt wells registered with the NTVGCD in Anderson County. LRE compiled all publicly available well data from the NTVGCD, the TWDB, and the SDR Databases to identify wells in Anderson County within a 5-mile radius of the Redtown Ranch Property, as shown in Figure 1 and in the table provided in Appendix B. All proposed well locations within the District boundaries are at least a ¼-mile radial distance from the nearest property boundary and other surrounding wells (Figure 1). The proposed well locations in Anderson County meet the minimum well spacing requirements outlined in District Rule 7(a) and adhere to the TCEQ's well setback requirements from potential sources of contamination or flood-prone areas, as specified in Title 30 of the Texas Administrative Code (30 TAC) §290.41(c)(1).

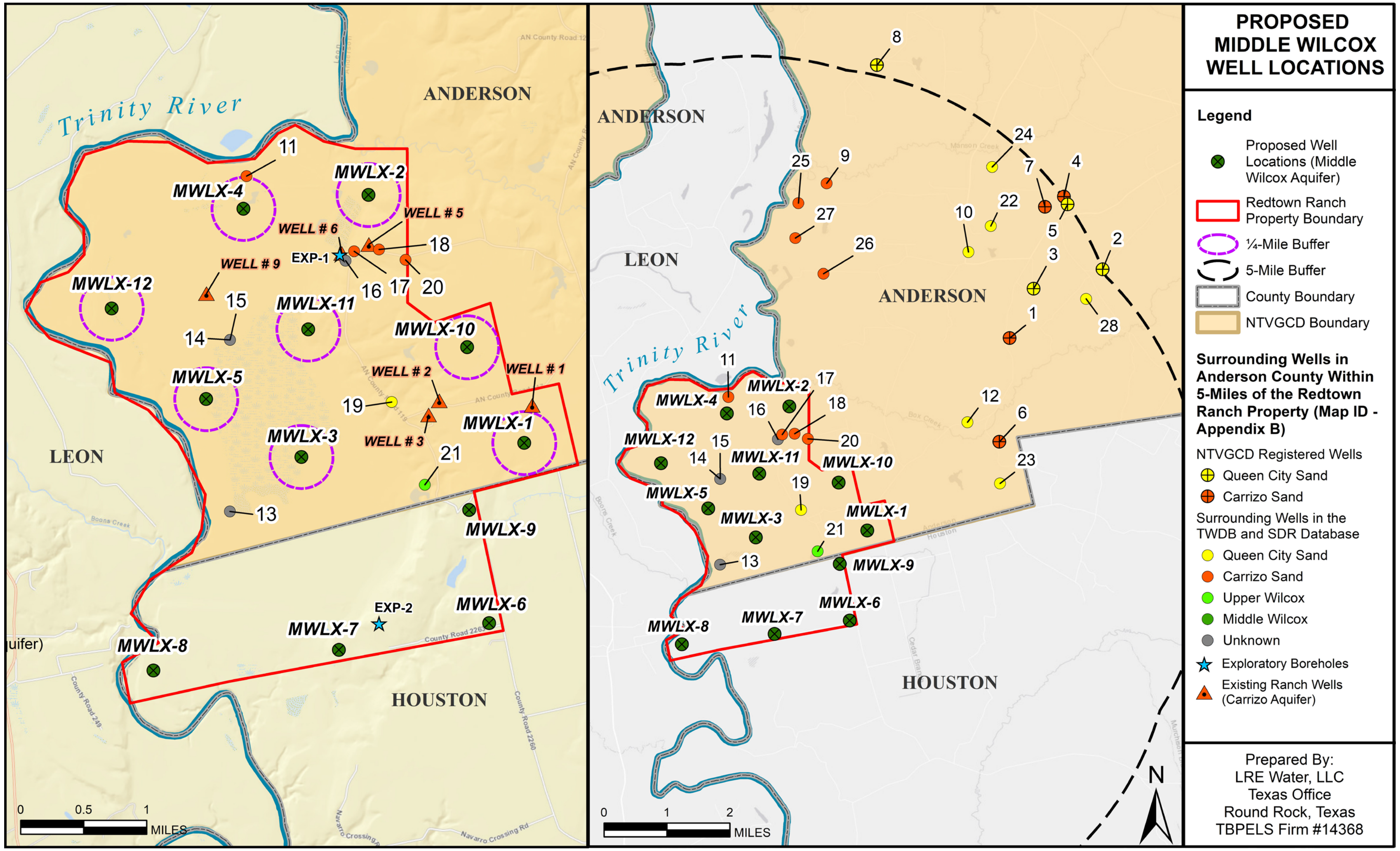

Figure 1. Proposed Well Locations on the Redtown Ranch Property

Hydraulic Aquifer Properties

Andrews & Foster Drilling Company (A&F) drilled two 7.875-inch exploratory boreholes ("EXP-1" and "EXP-2") to determine formation depths and sand thickness of the aquifers beneath the Redtown Ranch Property. Exploratory borehole EXP-1 was drilled in Anderson County at Latitude 31.540694, Longitude -95.716917 to approximately 1,197 feet below land surface (ft bls), and exploratory borehole EXP-2 was drilled in Houston County at Latitude 31.498361, Longitude -95.710417 to approximately 1,307 ft bls, as shown in Figure 1. LRE used the geophysical logs from the exploratory boreholes and geophysical logs in the BRACS database to correlate formation depths and calculate net sand thickness of the formations beneath the Redtown Ranch Property. Based on the depths of the exploratory boreholes and interpreted depths for the Wilcox Group beneath the Redtown Ranch Property, the exploratory boreholes EXP-1 and EXP-2 did not likely penetrate the Middle Wilcox Aquifer.

Due to the absence of site-specific aquifer test data for the Middle Wilcox Aquifer on the Redtown Ranch Property, LRE utilized reported pumping test data from nearby wells. Within 15 miles of the Redtown Ranch Property, transmissivity estimates for two wells (State Well Numbers 3811901 and 3811801), as reported in TWDB R-150, are 17,200 gallons per day per foot (gpd/ft) and 24,000 gpd/ft (Guyton & Associates, 1972), respectively. Estimated transmissivity values for the Middle Wilcox Aquifer were calculated using reported specific capacity data and the Driscoll (1986) estimation method. Transmissivity estimates from eight (8) surrounding wells completed in the Middle Wilcox Aquifer range from approximately 1,000 gpd/ft to 12,400 gpd/ft using the Driscoll (1986) estimation method.

Hydraulic conductivity values for the two wells completed in the Middle Wilcox Aquifer, as reported in TWDB R-150, are 78 gallons per day per foot squared (gpd/ft^2) and 81 gpd/ft^2 (Guyton & Associates, 1972), respectively. Estimates of hydraulic conductivity for nearby wells, using transmissivity derived from the Driscoll (1986) method, range between 10.6 gpd/ft^2 and 84.7 gpd/ft^2. According to the North QCSCW GAM Conceptual Report (Schorr and others, 2020), the hydraulic conductivity of the Middle Wilcox Aquifer (Layer 8) beneath the Redtown Ranch Property is 65.63 gpd/ft^2. The hydraulic conductivity of 65.63 gpd/ft^2 is within the range of hydraulic conductivities for the Middle Wilcox Aquifer from surrounding data. Therefore, transmissivity for the Middle Wilcox Aquifer beneath the Redtown Ranch Property was calculated by multiplying the hydraulic conductivity of 65.63 gpd/ft^2 from the North QCSCW GAM Conceptual Report (Schorr and others, 2020) by the Middle Wilcox net sand thickness estimated from surrounding geophysical logs, which resulted in estimates of transmissivity ranging from 14,110 gpd/ft to 16,735 gpd/ft.

Table 1 summarizes the estimated hydraulic properties for the Middle Wilcox Aquifer from surrounding well data, interpretation of geophysical logs, and data obtained from the Conceptual North QCSCW GAM Report (Schorr and others, 2020).

Table 1. Estimated Hydraulic Properties for the Middle Wilcox Aquifer

Proposed Well	Top of Screen (ft bls)	Bottom of Screen (ft bls)	Aquifer Thickness (ft)	Net Sand Thickness (ft)	Pump Setting (ft bls)	Static Water Level* (ft bls)	S*	K* (gpd/ft^2)	T (gpd/ft)
MWLX-1	1,215	1,800	585	220	755	145	0.001	65.63	14,440
MWLX-2	1,180	1,790	610	235	660	95	0.001	65.63	15,425
MWLX-3	1,130	1,720	590	235	680	55	0.001	65.63	15,425
MWLX-4	1,135	1,735	600	230	665	55	0.001	65.63	15,095
MWLX-5	1,130	1,725	595	235	690	55	0.001	65.63	15,425
MWLX-10	1,210	1,810	600	230	740	140	0.001	65.63	14,110
MWLX-11	1,175	1,770	595	230	725	100	0.001	65.63	15,095
MWLX-12	1,125	1,720	595	230	655	50	0.001	65.63	16,735
MWLX-6	1,215	1,780	565	215	745	130	0.001	65.63	14,440
MWLX-7	1,160	1,740	580	230	685	80	0.001	65.63	15,095
MWLX-8	1,135	1,730	595	255	645	55	0.001	65.63	15,095
MWLX-9	1,210	1,790	580	220	760	135	0.001	65.63	15,095

"ft bls" indicates feet below land surface; land surface elevation from NED (USGS, 2004), "ft" indicates feet, "gpd/ft^2" indicates gallons per day per foot squared, "gpd/ft" indicates gallons per day per foot, "*" indicates property obtained from the North QCSCW GAM Conceptual Report (Schorr and others, 2020), static water levels assumed to be 20 feet lower than the 2015 water level elevations (Layer 8), S = Storativity (confined aquifer), K = hydraulic conductivity, T = Transmissivity, cells highlighted in gray indicate wells located in Houston County (outside NTVGCD boundary).

Analytical Groundwater Modeling

LRE conducted analytical groundwater modeling to assess local drawdown impacts, recovery time, and well interference between proposed wells on the Redtown Ranch property. The input parameters used in the analytical modeling are presented in Table 1. Proposed well locations and pumping rates were selected based on considerations of the hydrogeologic conditions, including aquifer depths, net sand thickness, aquifer productivity, hydraulic characteristics, and well spacing requirements. The results of the analytical modeling simulating the proposed production of 11,401 ac-ft/yr from the Middle Wilcox Aquifer in Anderson County and 5,984 ac-ft/yr from the Middle Wilcox Aquifer in Houston County after five years are summarized in Table 2.

The cumulative drawdown, calculated using the Cooper-Jacob (1946) equation, includes drawdown in the wellbore from both the pumping well and additional drawdown imposed from surrounding proposed wells producing from the Middle Wilcox Aquifer on the Redtown Ranch Property (Table 2). This modeling includes production from proposed wells located on the Redtown Ranch Property in Houston County (which are located outside of the NTVGCD boundaries) to more accurately depict the well interference and cumulative drawdown in the wellfield.

Table 2. Five-Year Analytical Modeling Results

Proposed Well	County	Proposed Pumping Rate (gpm)	Proposed Production (ac-ft/yr)	Drawdown from Pumping Well (ft)	Drawdown Imposed from Surrounding Wells (ft)	Cumulative Drawdown (ft)	Recovery Time (Days)
MWLX-1	Anderson	900	1,456	247	323	570	1,875
MWLX-2	Anderson	900	1,456	232	306	538	2,023
MWLX-3	Anderson	800	1,294	206	356	562	1,915
MWLX-4	Anderson	900	1,456	237	309	546	1,977
MWLX-5	Anderson	900	1,456	232	338	570	1,876
MWLX-10	Anderson	900	1,456	232	331	563	1,905
MWLX-11	Anderson	800	1,294	210	354	564	1,890
MWLX-12	Anderson	950	1,536	250	295	545	1,982
MWLX-6	Houston	900	1,456	253	300	553	1,948
MWLX-7	Houston	900	1,456	236	307	543	1,992
MWLX-8	Houston	1,100	1,779	262	267	529	2,060
MWLX-9	Houston	800	1,294	219	342	561	1,902

“gpm” indicates gallons per minute, “ft” indicates feet, “ac-ft/yr” indicates acre-feet per year, “*” indicates average, cells highlighted in gray indicate wells located in Houston County (outside of NTVGCD boundary).

Based on the proposed pumping rates and estimated hydraulic properties in Table 1, cumulative drawdown in the proposed wells in Anderson County ranges from 538 feet to 570 feet after five years (Table 2). Recovery time was calculated as the time required for water levels to recover 90% of the drawdown after pumping for five years using the Theis (1935) equation. The time for water levels to recover in the Middle Wilcox Aquifer in Anderson County ranges from 1,875 days to 2,023 days (Table 2). Appendix C provides hydrographs of the simulated pumping and recovery water levels in the proposed wells due to the combined production of 11,401 ac-ft/yr in Anderson County and 5,984 ac-ft/yr in Houston County. The area of influence can typically be defined as the distance where the impacts from pumping result in 1-foot of drawdown in the aquifer. Figure 2 illustrates the area of influence and cumulative drawdown in the Middle Wilcox Aquifer within the District boundaries after five years of pumping, based on the analytical modeling using the Cooper-Jacob (1946) equation and input parameters in Table 1.

It is important to note the analytical modeling assumes the aquifer is infinite and homogeneous, and does not take into account the existence of any boundary conditions, such as faults, transformation flow, or recharge from the land surface. Therefore, actual aquifer conditions and impacts to the Middle Wilcox Aquifer may differ from the results presented herein.

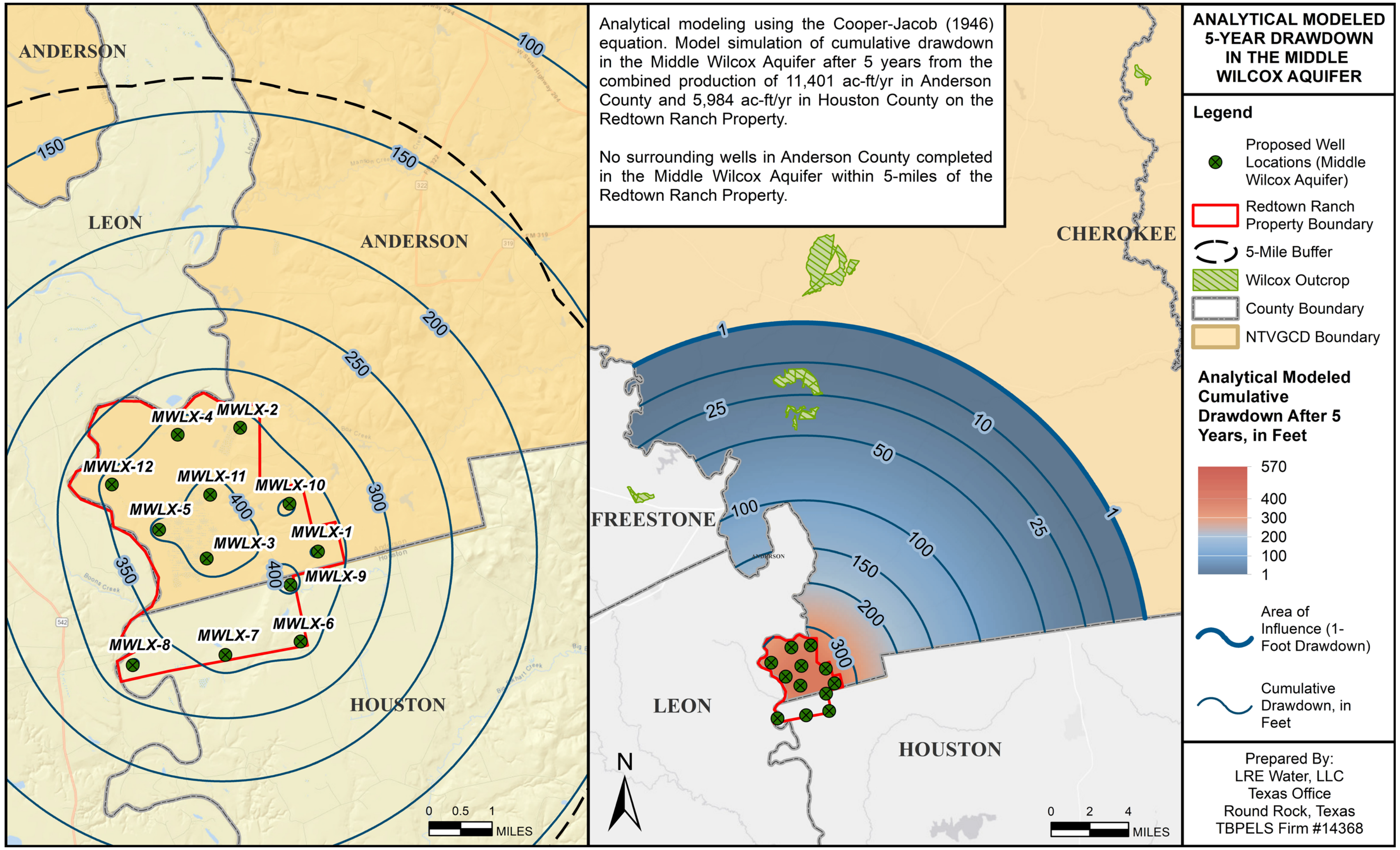

Figure 2. Analytical Modeled Cumulative 5-Year Drawdown in the Middle Wilcox Aquifer

Numerical Groundwater Modeling

LRE conducted numerical modeling to evaluate the regional impacts of the proposed production on the adopted DFCs after five years of pumping. LRE added the proposed well locations in the North QCSCW GAM model cells in MODFLOW and simulated the proposed combined annual production of 11,401 ac-ft from the Middle Wilcox Aquifer in Anderson County and 5,984 ac-ft from the Middle Wilcox Aquifer in Houston County (North QCSCW GAM; Layer 8) for five years. This modeling included production from proposed wells located in Houston County on the Redtown Ranch Property (outside of the NTVGCD boundaries) to accurately depict the impacts from the proposed wellfield. The numerical modeled cumulative drawdown in the Middle Wilcox Aquifer resulting from the proposed production at the Redtown Ranch Property is illustrated in Figure 3.

The results of the numerical modeling suggest that the proposed combined production amount of 17,835 ac-ft/yr from the Middle Wilcox Aquifer at the Redtown Ranch Property could not be sustained for five years under current model constraints. Based on LRE's evaluation, hydraulic properties for the Middle Wilcox Aquifer in the North QCSCE GAM Conceptual Report (Schorr and others, 2020; Layer 8), specifically estimates of transmissivity and storativity, are higher than those in the North QCSCW GAM Numerical Report (Panday and others, 2020; Layer 8), which are used in the numerical modeling. Therefore, the proposed production of 17,835 ac-ft/yr that could be sustained from the analytical modeling were not attainable in the numerical modeling. To mitigate this numerical modeling constraint, MODFLOW algorithms automatically reduced the simulated pumping rates to prevent the model cells from being depleted (a process called "auto-flow" reduction in MODFLOW). The production amount of 17,835 ac-ft/yr was automatically reduced in MODFLOW to 17,246 ac-ft (Year 1), 16,117 ac-ft (Year 2), 15,831 ac-ft (Year 3), 15,723 ac-ft (Year 4), and 15,656 ac-ft (Year 5), a production decrease of approximately 0.8-9.9% (Table 3).

Table 3. Auto-Flow Reductions in the Middle Wilcox Aquifer (Layer 8) in the Numerical Modeling

Model Time (Years)	Pumping Rate (gpm)	Production Amount (ac-ft)	Percent Reduction (%)
0	10,750	17,385	0
1	10,664	17,246	0.8
2	9,966	16,117	7.3
3	9,789	15,831	8.9
4	9,722	15,723	9.6
5	9,681	15,656	9.9

"gpm" indicates gallons per minute, "ac-ft/yr" indicates acre-feet per year.

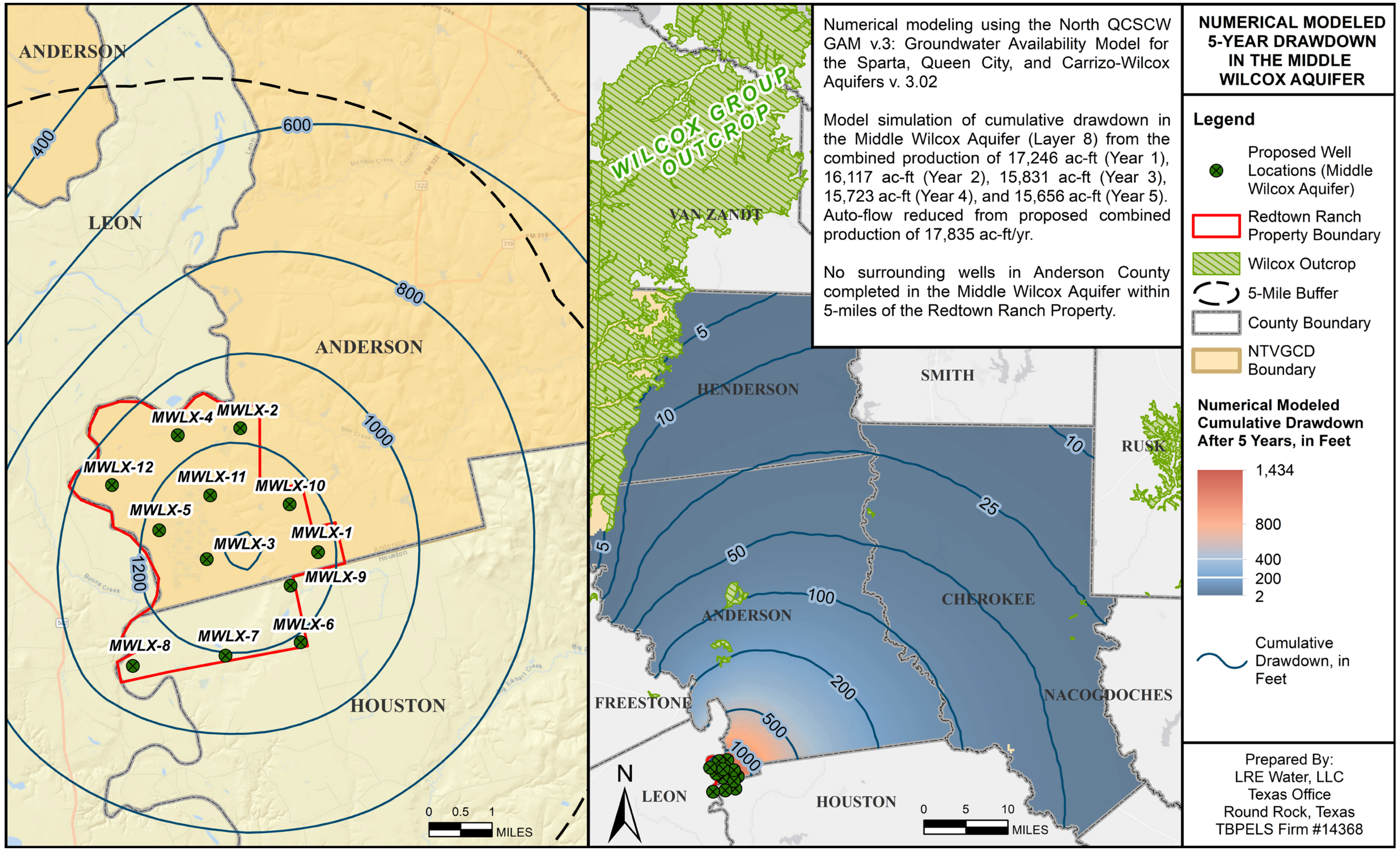

Figure 3. Numerical Modeled Cumulative 5-Year Drawdown in the Middle Wilcox Aquifer (North QCSCW GAM; Layer 8)

Due to model assumptions and limitations, projected impacts from the proposed production of 17,385 ac-ft/yr in the Middle Wilcox Aquifer could not be accurately depicted. Figure 3 presents the numerical modeled cumulative drawdown in the Middle Wilcox Aquifer as result of the proposed pumping at the rates in Table 3. It is important to note that the hydraulic properties for the Middle Wilcox Aquifer in the North QCSCW GAM Conceptual Report (Schorr and others, 2020) are higher than those in the North QCSCW GAM Numerical Report (Panday and others, 2020). Therefore, the drawdown and projected impacts from the proposed production in the numerical modeling are greater than the drawdown and impacts from the analytical modeling. To more accurately reflect current aquifer conditions and regional impacts from the proposed combined production, updates to the hydraulic properties of the Middle Wilcox Aquifer (Layer 8) in the North QCSCW GAM will be necessary.

Modeled Available Groundwater

Modeled available groundwater (MAG), as defined in Chapter 36 of the Texas Water Code (2011), is the estimated average amount of water that may be produced annually to achieve a DFC. The MAG, as set forth in Section H of the District's Groundwater Management Plan (Amended August 15, 2019), is based on the model run GAM Run 17-024 MAG from June 19, 2017 (Wade, 2017). The MAG for the Carrizo-Wilcox Aquifer is 29,088 ac-ft in Anderson County from 2010 to 2070 based on the GAM Run 17-024 MAG (Wade, 2017). The TWDB issued the most recent GAM Run-21-016 MAG Report for the Carrizo-Wilcox, Queen City, and Sparta Aquifers in GMA-11 on February 17, 2022 (Wade, 2022). This report used the North QCSCW GAM and documented development of the estimated modeled available groundwater associated with the DFCs adopted by GMA-11 on August 11, 2021. According to the 2021 Joint Planning Cycle GAM Run 21-016 MAG, the MAG for the Carrizo-Wilcox Aquifer is 27,024 ac-ft in Anderson County from 2020 to 2080 (Wade, 2022).

The most recent DFCs were approved by GMA-11 on August 11, 2021, based on Scenario 33, as documented in Technical Memorandum 21-01 (Hutchinson, 2021a). As described in the GMA-11 Desired Future Conditions Explanatory Report (Hutchinson, 2021c), average drawdown across the county represents the regional average drawdown occurring from pumping during the period of interest. The most recently adopted DFCs for the Carrizo-Wilcox Aquifer are 155 feet in Anderson County from 2013 to 2080 (Hutchinson, 2021a).

Cumulative drawdown from the numerical modeling was computed and compared to the drawdown from the "Base Run" used to calculate the 2021 DFC's for the Carrizo-Wilcox

Aquifer (Hutchison, 2021b). Table 4 presents the MODFLOW modeling results comparing the simulated "Base Run" average drawdown in Anderson County after five years, based on Scenario 33 documented in Technical Memorandum 21-01 (Hutchinson, 2021b), and the simulated model-predicted average drawdown in Anderson County after five years of pumping from only the Middle Wilcox Aquifer at the rates presented in Table 3.

The average drawdown in Anderson County from the "Base Run" scenario is 122.18 feet in the Middle Wilcox Aquifer (Layer 8) after five years (Hutchinson, 2021b) (Table 4). The additional drawdown in the Middle Wilcox Aquifer in Anderson County as a result of only production from the Redtown Ranch Property at the rates presented in Table 3 is approximately 174.18 feet after five years (Table 4).

Table 4. Five-Year Model Predicted Average Drawdown in Anderson County

Aquifer	Model Layer	Simulated "Base Run" Scenario 33 (TM 21-01)	Simulated "Base Run" & "Proposed MWLX"	Simulated "Proposed MWLX" Only
Average Drawdown in Anderson County, in Feet				
Queen City	4	32.05	65.31	33.26
Carrizo Sand	6	93.77	201.15	107.38
Upper Wilcox	7	102.10	218.80	116.70
Middle Wilcox	8	122.18	296.36	174.18
Lower Wilcox	9	154.60	375.40	220.80
Avg CZ-WLX	6-9	116.24	264.03	147.79

"Base Run" indicates the Groundwater Availability Model (GAM) Scenario 33, TM 21-01 (Hutchinson, 2021b), "Proposed MWLX" indicates proposed production of 17,835 ac-ft in the Middle Wilcox Aquifer (Layer 8).

LRE calculated the average drawdown in Anderson County in all layers of the Carrizo-Wilcox Aquifer (Layers 6-9) as a result of the proposed production in Table 3 from the Middle Wilcox Aquifer at the Redtown Ranch Property. The average drawdown in the Carrizo-Wilcox Aquifer in Anderson County from the "Base Run" scenario is 116.24 feet after five years (Hutchinson, 2021b), and the additional drawdown in the Carrizo-Wilcox Aquifer in Anderson County as a result of the combined annual production in Table 3 is approximately 147.79 feet after five years (Table 4).

It is important to note that the average drawdown in Anderson County presented in Table 4 is a result of the production rates in Table 3, as the combined annual production of 17,385 ac-ft from the Middle Wilcox Aquifer could not be accurately depicted due to current model limitations and assumptions.

Regional Water Plan

The place of use for the proposed water will be in areas that are currently experiencing significant water challenges, specifically in counties that are part of Regional Water Planning Areas C, G, H, K, and/or L. Detailed and board-approved water plans are accessible at the following links: https://www.twdb.texas.gov/waterplanning/rwp/regions/ and https://texasstatewaterplan.org/statewide. Based on the 2021 Interactive State Water Plan Viewer, the following deficits are projected:

- Region C: A shortfall of 250,000 acre-feet by 2030, increasing to a 1.24 million acre-feet deficit by 2070.
- Region G: A shortfall of 100,000 acre-feet by 2040, increasing up to a 300,000 acre-feet deficit by 2070.
- Region H: A shortfall of 210,000 acre-feet by 2030, increasing to 700,000 acre-feet deficit by 2070.
- Region K: A shortfall of 40,000 acre-feet by 2040, increasing to a 100,000 acre-feet deficit by 2070.
- Region L: A shortfall of 50,000 acre-feet by 2030, increasing to a 210,000 acre-feet deficit by 2070.

Based on the planning data for 2026, which is currently under development, greater deficits are expected in these Regional Planning Areas. However, according to the 2021 Interactive State Water Plan Viewer, Anderson County is projected to have no water deficit from now until 2070. The water to be produced from the Middle Wilcox Aquifer is crucial for serving populations in regions of Texas that are expected to face significant water shortages.

LRE appreciates the opportunity to provide you with this Hydrogeologic Report on behalf of Redtown Ranch Holdings, LLC. If you have any questions, please do not hesitate to contact us.

Sincerely,

LRE Water

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References

Cooper, H.H. and C.E. Jacob, 1946, A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys. Union Trans., vol. 27, p. 526-534.

Driscoll, F.G., 1986, Groundwater and Wells. 2nd Edition, Johnson Division, St. Paul.

Guyton, W.F., and Associates, 1972, Ground-Water Conditions in Anderson, Cherokee, Freestone and Henderson Counties, Texas: Texas Water Development Board Rept. 150, 250 p.

Hutchison, W.R., 2021a, GMA 11 Technical Memorandum 21-01, Adjusted Pumping Simulations for Joint Planning with Updated Groundwater Availability Model for the Sparta, Queen City, and Carrizo-Wilcox Aquifers, 31 p.

Hutchison, W.R., 2021b, Base Scenario Pumping Factors using Updated Groundwater Availability Model for the Sparta, Queen City, and Carrizo-Wilcox Aquifers.

Hutchinson, W.R., 2021c, Desired Future Conditions Explanatory Report (Final) Carrizo-Wilcox/Queen City/Sparta Aquifers for Groundwater Management Area 11.

Neches and Trinity Valleys Groundwater Conservation District Groundwater Management Plan, Adopted June 11, 2003. Amended August 15, 2019.

Neches and Trinity Valleys Groundwater Conservation District Rules, Effective as of June 11, 2003. Amended September 17, 2020.

Schorr, S., Zivic, M., Hutchinson, W.R., Panday, S., Rumbaugh, J., 2020. Conceptual Model Report: Groundwater Availability Model for Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers. Final Report prepared for Texas Water Development Board, Contract Number 1648302063.

Tarver, G.E., 1966, Ground-water Resources of Houston County, Texas: Texas Water Development Board Rept. 18, 68 p.

Texas Water Code, 2011, http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf.

Theis, C.V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage, Am. Geophysics. Union Trans., vol 16, 519-524 p.

U.S. Geological Survey, 2004, National Elevation Dataset 30-Meter Resolution Digital Elevation Model.

Wade, Shirley, 2022, GAM Run 21-016 MAG: Modeled Available Groundwater for the Carrizo-Wilcox, Queen City, and Sparta Aquifers in Groundwater Management Area 11. Texas Water Development Board.

Wade, Shirley, 2017, GAM Run 17-024 MAG: Modeled Available Groundwater for the Carrizo-Wilcox, Queen City, and Sparta Aquifers in Groundwater Management Area 11. Texas Water Development Board.

Appendix A

Location of Proposed Middle Wilcox Wells on the Redtown Ranch Property

Appendix A – Location of Proposed Middle Wilcox Wells on the Redtown Ranch Property

Proposed Well	Latitude (NAD83) Decimal Degrees	Longitude (NAD83) Decimal Degrees	Latitude (NAD83) Degrees Minutes Seconds	Longitude (NAD83) Degrees Minutes Seconds	Proposed Pumping Rate (gpm)	Proposed Production (ac-ft/yr)
MWLX-1	31.5195	-95.6915	31° 31' 10.325" N	95° 41' 29.366" W	900	1,455
MWLX-2	31.5476	-95.7132	31° 32' 51.460" N	95° 42' 47.676" W	900	1,456
MWLX-3	31.5173	-95.7214	31° 31' 2.255" N	95° 43' 17.019" W	800	1,294
MWLX-4	31.5457	-95.7300	31° 32' 44.426" N	95° 43' 48.072" W	900	1,456
MWLX-5	31.5237	-95.7344	31° 31' 25.248" N	95° 44' 3.815" W	900	1,456
MWLX-10	31.5304	-95.6995	31° 31' 49.429" N	95° 41' 58.141" W	900	1,456
MWLX-11	31.5320	-95.7209	31° 31' 55.164" N	95° 43' 15.226" W	800	1,294
MWLX-12	31.5338	-95.7474	31° 32' 1.763" N	95° 44' 50.611" W	950	1,536
Total Production in Anderson County					7,050	11,401
MWLX-6	31.4987	-95.6956	31° 29' 55.367" N	95° 41' 44.164" W	900	1,455
MWLX-7	31.4952	-95.7157	31° 29' 42.709" N	95° 42' 56.574" W	900	1,455
MWLX-8	31.4923	-95.7406	31° 29' 32.269" N	95° 44' 26.023" W	1,100	1,779
MWLX-9	31.5117	-95.6987	31° 30' 42.034" N	95° 41' 55.190" W	800	1,294
Total Production in Houston County					3,700	5,984

"NAD83" indicates North American Datum of 1983, "gpm" indicates gallons per minute, "ac-ft/yr" indicates acre-feet per year, cells highlighted in gray indicate proposed wells located in Houston County (outside NTVGCD boundary).

Appendix B

Surrounding Wells in Anderson County Within 5-Miles of the Redtown Ranch Property

Appendix B – Surrounding Wells in Anderson County Within 5-Miles of the Redtown Ranch Property

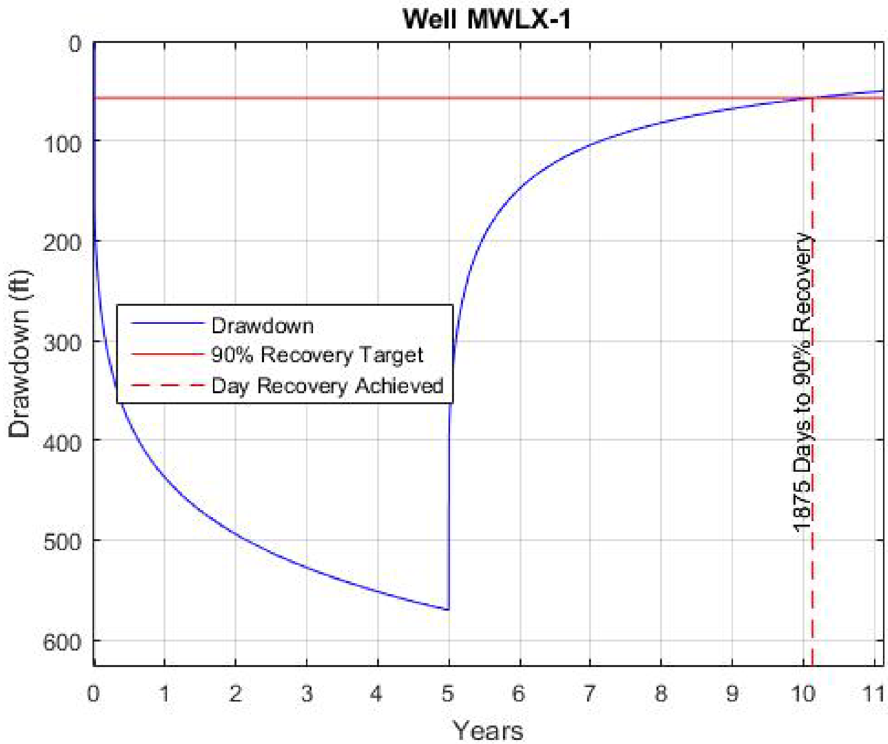
Map ID	Well ID (Well Report Tracking Number, or State Well Number)	Source ID (NTVGCD, SDR, TWDB Database)	Latitude (NAD83)	Longitude (NAD83)	Well Name/Owner	Well Depth/ Borehole Depth (ft)	Well Use	LRE-Designated Aquifer
1	402572	NTVGCD	31.56461	-95.65446	LINH HOANG LE'S HOPE FARM LLC 1	600	Domestic	Carrizo
2	661718	NTVGCD	31.58095	-95.62991	KERRY JAMES LOCKE	200	Domestic	Queen City
3	561846	NTVGCD	31.576111	-95.648334	JESSE JAMES	178	Domestic	Queen City
4	-	NTVGCD	31.59744	-95.64077	REYNALDO VERA	640	Domestic	Carrizo
5	441813	NTVGCD	31.59569	-95.63975	MIKE TROCKO	255	Domestic	Queen City
6	-	NTVGCD	31.54069	-95.65656	LEON BARTON, JR	460	Domestic	Carrizo
7	403727	NTVGCD	31.595	-95.645833	MIKE FRANKS	695	Domestic	Carrizo
8	-	NTVGCD	31.626667	-95.691944	JERALD UNDERWOOD	110	Domestic	Queen City
9	3827201	TWDB	31.599167	-95.704723	Emmett Coleman	565	Irrigation	Carrizo
10	3827304	TWDB	31.584167	-95.666112	Emmett Coleman	330	Stock	Queen City
11	3827401	TWDB	31.549445	-95.729722	Moore & Wardlaw	417	Irrigation	Carrizo
12	3827602	TWDB	31.545	-95.665278	Mary Johnson	36	Domestic	Queen City
13	3827702	TWDB	31.510834	-95.730833	Moore & Wardlaw	-	Irrigation	Unknown
14	3827703	TWDB	31.530555	-95.731389	Moore & Wardlaw	-	Irrigation	Unknown
15	3827704	TWDB	31.530555	-95.731389	Moore & Wardlaw	-	Irrigation	Unknown
16	3827705	TWDB	31.54	-95.716111	Vernon Calhoun	-	Irrigation	Unknown
17	3827706	TWDB	31.541111	-95.715001	Moore & Wardlaw	425	Irrigation	Carrizo
18	3827707	TWDB	31.541389	-95.711667	Vernon Calhoun	350	Domestic	Carrizo
19	3827708	TWDB	31.523889	-95.709445	Vernon Calhoun	50	Unused	Queen City
20	3827804	TWDB	31.540278	-95.708056	Ronald Burke	300	Domestic	Carrizo
21	3827805	TWDB	31.514445	-95.704723	Vernon Calhoun	600	Domestic	Upper Wilcox
22	43690	SDR	31.590278	-95.660278	Carl Rutledge	144	Domestic	Queen City
23	223632	SDR	31.531111	-95.656112	Cook, D.	161	Domestic	Queen City
24	337816	SDR	31.603889	-95.660278	D. Criswell	223	Domestic	Queen City
25	47021	SDR	31.594445	-95.712223	Nat Coleman	500	Irrigation	Carrizo
26	47058	SDR	31.578333	-95.705001	Gary Gunnels	455	Irrigation	Carrizo
27	262950	SDR	31.586389	-95.712778	Ronnie Steadman	485	Irrigation	Carrizo
28	410138	SDR	31.574056	-95.634167	CHARLES RYLEE	182	Irrigation	Queen City

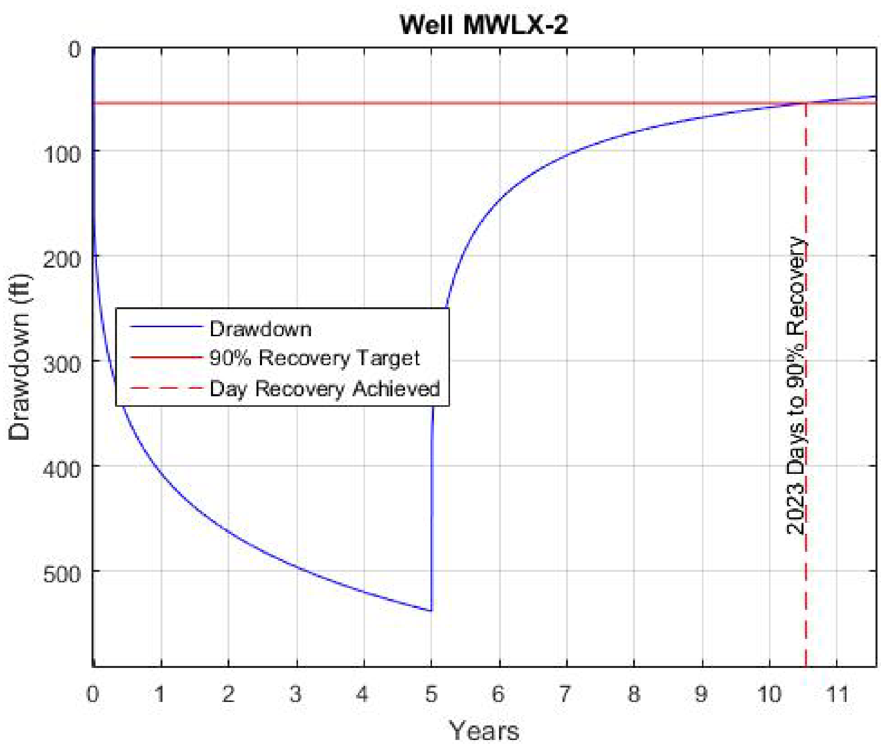
"NAD83" indicates North American Datum of 1983, "ft" indicates feet, LRE-designated aquifer classification based on well depth and/or screen intervals, "-" indicates not applicable or missing data.

Appendix C

Pumping and Recovery Hydrographs from Analytical Modeling

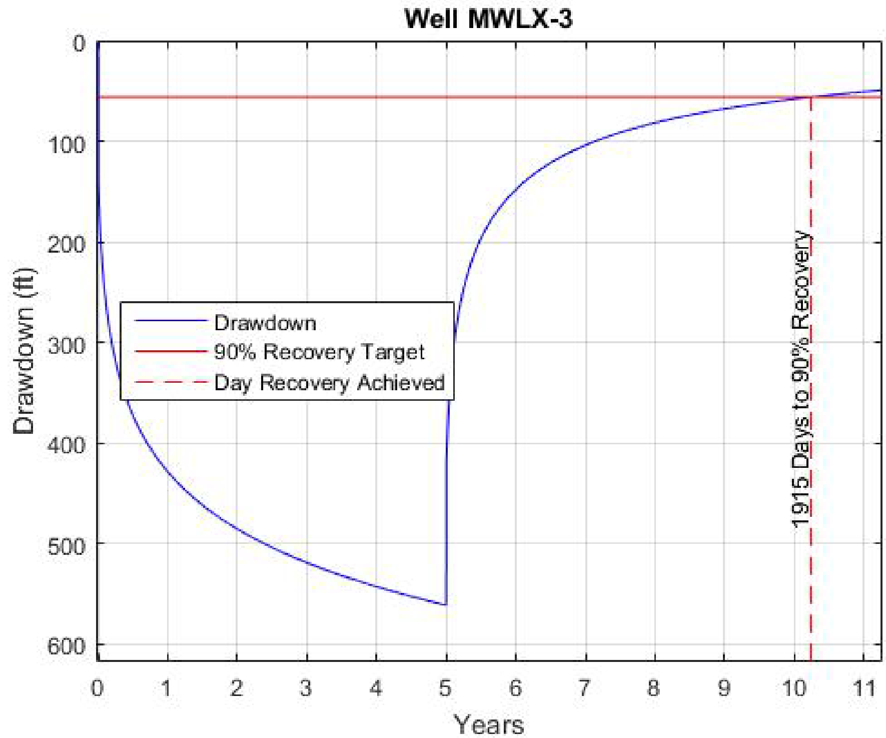
Appendix C – Pumping and Recovery Hydrographs

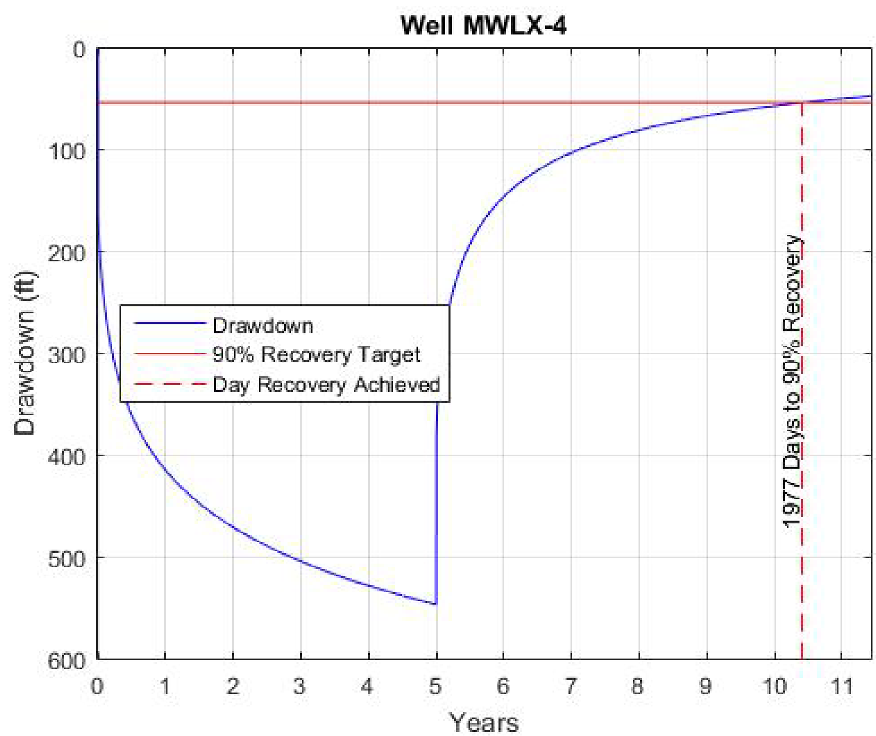




LRE WATER

Appendix C – Pumping and Recovery Hydrographs





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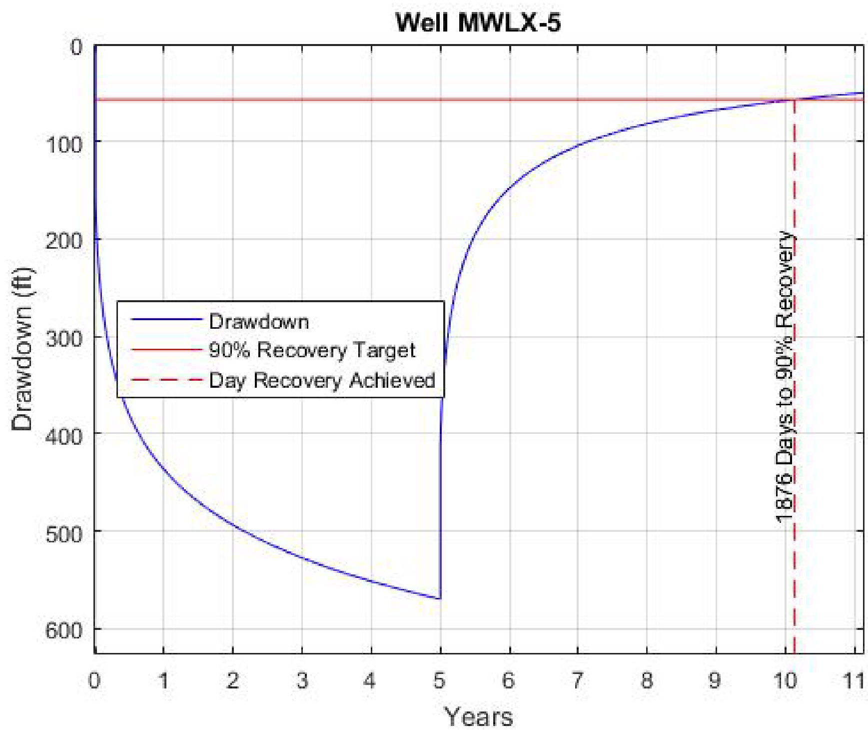

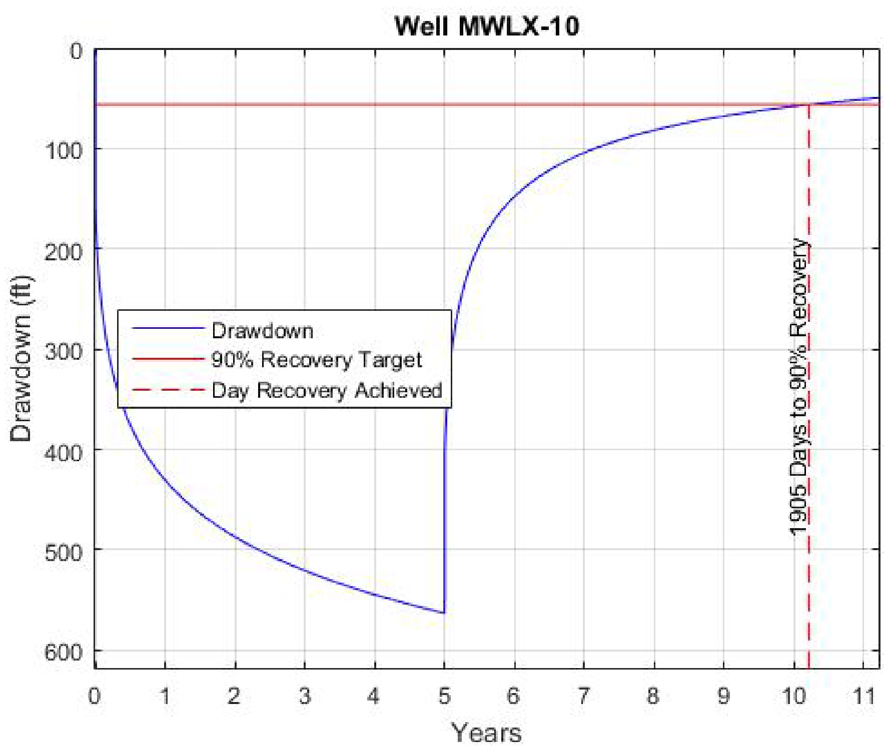

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