Preliminary Engineering Report

City of Abernathy

Water Supply Evaluation

Abernathy, Texas

January 2015

PSC Project # 01002611

PARKHILL SMITH & COOPER

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Water Supply Evaluation

Abernathy, Texas

STATE OF TEXAS
LEONARD W. NAIL
92642
LICENSED
PROFESSIONAL ENGINEER

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PARKHILLSMITH&COOPER

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EXECUTIVE SUMMARY

City of Abernathy ("City") is presented an evaluation of the City's water supply life expectancy at current demands and an analysis of the effect on well life expectancy with an additional 131,400,000 gallons per year of use by Golden Spread Electric Cooperation ("Golden Spread"). This evaluation includes a preliminary examination of the volume of water supply available and determination of ability to produce and supply the water needs for the citizens of Abernathy within regulatory requirements. The current system consists of five (5) wells and approximately 12 total miles of collection and transmission pipelines

The scope of this report is limited to the above description of the water system and the information provided by the City of Abernathy. It makes use of readily available data furnished by the City and includes historic data.

DESCRIPTION OF EXISTING FACILITIES

The City receives water from Wells No. 1, 4, 5, 6 and 7 located on property owned by the City. These wells sit along the water supply transmission line and supply 100% of the water needs of the citizens of Abernathy. All City-owned wells are completed in the Ogallala Aquifer, which is the region's major water supply source. A map showing the City's existing infrastructure can be seen in Figure 1.

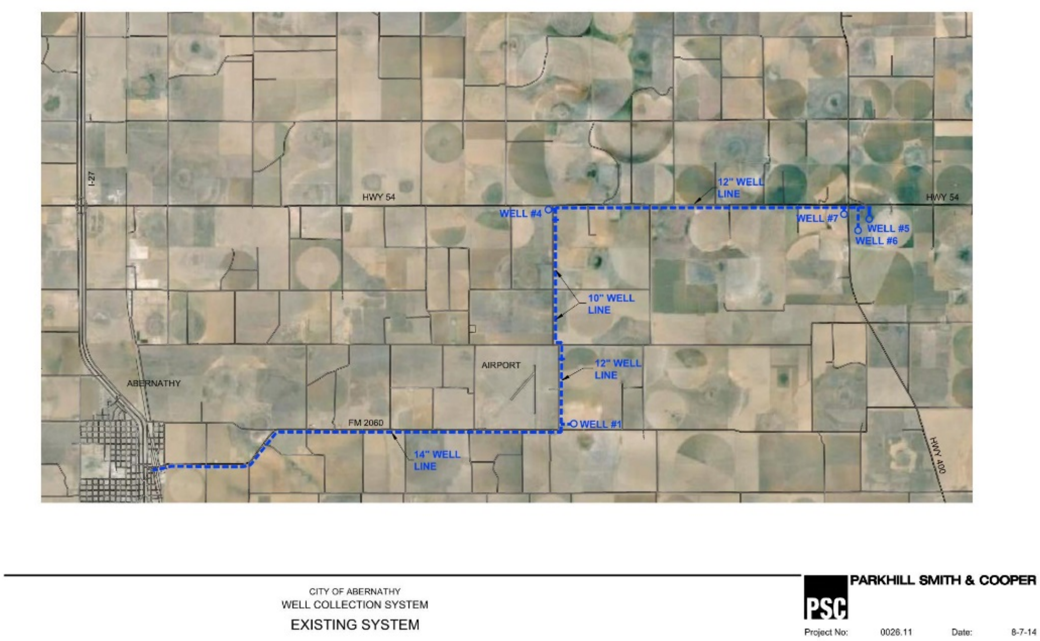


Figure 1. City of Abernathy Water Supply System

A project is currently underway to expand the water transmission system to allow for more efficient operation of the existing wells. The project includes replacing the 10- and 12-inch line between Well #4 and Well #1 with a 14-inch higher pressure transmission line. This 14-inch line will match the existing transmission line which is currently installed from Well #1 to the City. The increase in line diameter and pressure class will allow the wells to operate under less head pressure, increasing the ultimate capacity of the City's water supply system.

INTEGRATED WATER RESOURCE EVALUATION

Two analyses of the City's current water sources were performed. The first analysis projects well life at the City's average current usage of 169,400,000 gal/year. The second analysis took into consideration an increase of 131,400,000 gal/year of additional water use by Golden Spread.

WELL FIELD LIFE AT CURRENT USAGE

The Ogallala Aquifer in the South Plains Region of Texas has experienced high volume regional pumping for agriculture and municipal supply which has contributed to the aquifers regionally declining levels. The City's wells are no exception to the declining levels of the aquifer. Data provided by the City, summarized in Table 1, shows how water levels in the wells have historically responded.

Table 1
Summary of City Well Water Levels

Well	Total Depth (ft)	Initial Water Level (ft)	Current Water Level (ft)	Total Decline (ft)	Avg. Yearly Decline (ft/yr)	Avg. Yearly Decline Since 2008 (ft/yr)
1	285	-167.0	-239.7	-72.7	-1.5	-0.7
4	397	-198.0	-252.3	-54.3	-1.4	-0.9
5	351	-186.0	-280.8	-94.8	-2.8	-5.3
6	358	-186.0	-279.5	-93.5	-2.8	-9.9
7	330	-247.1	-274.4	-27.3	-5.5	-5.5

The saturated thickness of all the wells has steadily declined over the period of record. Average yearly decline is as little as -1.4 feet per year (ft/yr) and as much as -5.5 ft/yr. Historical information for each well can be seen in Appendix A. The declining water levels match the regional trend. High Plains Water District (HPWD) has a system of observation wells to monitor the aquifer levels in the region. HPWD monitors 122 wells in Hale County and 144 wells in Lubbock County. Table 2 shows the water level trend for those two counties.

Table 2
Lubbock and Hale County Water Level History

County	Average Change 2004 to 2014 (ft)	Average Change 2009 to 2014 (ft)	Average Change 2013 to 2014 (ft)
Hale	-15.84	-10.02	-1.65
Lubbock	-4.54	-4.71	-0.96

The average yearly decline in Hale County from 2004 to present is -1.58 ft/yr, while the average of 2009 to present is a steeper decline of -2 ft/yr. Sharper water level declines of the past five years match the trend seen in Wells 5, 6 and 7. This is most likely attributed to the recent drought and higher water usage that corresponds to drought conditions. The aerial imagery in Figure 2 shows there are high concentrations of center pivot irrigation close to Wells 5, 6 and 7.

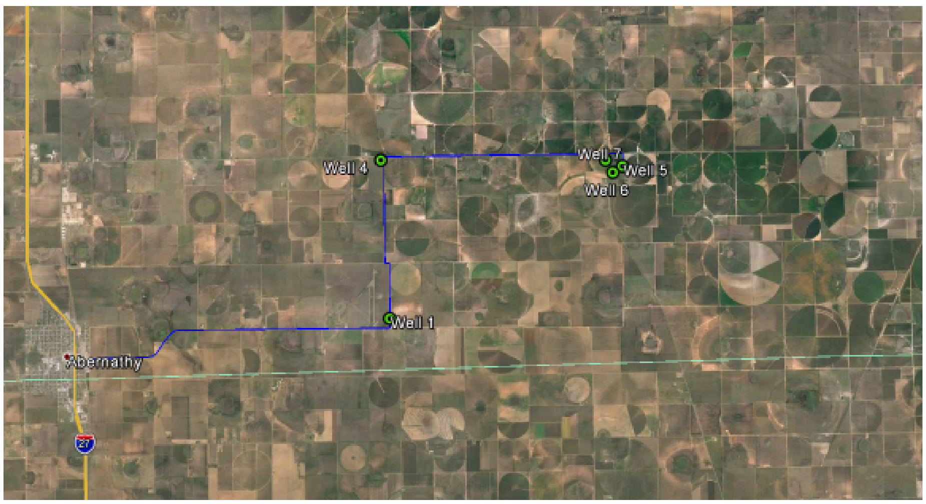


Figure 2. Irrigation Near the Well Field

The concentration of irrigation is dense in the area of Wells 5, 6 and 7 making these wells susceptible to drought. To the north and east of Wells 5, 6 and 7 the saturated thickness of the aquifer becomes too thin for large scale pumping that is needed for irrigation and municipal supply. Irrigation occurs around Wells 1 and 4, but center pivots are less dense.

Due to the relatively small areas of water rights owned by the City and the high concentration of irrigation in the area it is best to look at well life on a regional basis. HPWD has an observation well (23-03-802) adjacent to Wells 5, 6 and 7. From 1971 to 1988 water levels declined an average of -2.3 ft/yr. From 2004 to 2014 water levels declined an average of -3.56 ft/yr. From 1971 to 2014 water levels declined an average of -3.08 ft/yr. Detailed water level data and a map of the observation well can be found in Appendix B. The water level declines of this observation well are consistent with the declines recorded in the City well field. Declines in aquifer's saturated thickness are a regional issue and are not limited to the City's well field.

To project the remaining life of the City well field the current saturated thickness was found by subtracting the static water level from the total well depth. An operational saturated thickens was determined by looking at average drawdowns of each individual well and minimum pump submergence for proper operation. The operational saturated thickness is the thickness remaining that the well can operate without the pump losing suction due to drawdown. Table 3 shows the expected life remaining when taking this into account.

Table 3
Expected Remaining Individual Well Life

Well	Total Depth (ft)	Initial Saturated Thickness (ft)	Current Saturated Thickness (ft)	Current Operational Saturated Thickness (ft)	Total Decline (ft)	Avg. Yearly Decline (ft/yr)	Well Life Remaining (yr)
1	285	118.0	45.3	18.3	-72.7	-1.5	12.1
4	397	199.0	144.7	124.7	-54.3	-1.4	89.5
5	351	165.0	70.2	41.2	-94.8	-2.8	14.8
6	358	172.0	78.5	51.5	-93.5	-2.8	18.7
7	330	82.9	55.6	34.6	-27.3	-5.5	6.3

The data for Well 7 is from 2009 to present. All other wells have historical data from the 1970's to present. Well 4 has an expected life that is inconsistent with the other four wells, which is likely attributed to less irrigation in the immediate area and the well having a higher saturated thickness than the other four wells. It is likely that with decreasing saturated thickness in the other wells, Well 4 will be operated more and the actual life will be less than the 89.5 years projected in Table 3.

The data in Table 3 for Wells 1, 4, 5 and 6 takes into account water levels from the 1970's to the present. It is possible that water use today is different than the average over a long period. Drought in the region will have a direct effect on water use. Table 4 shows data collected in the previous 6 years.

Table 4
Water Levels 2008 – 2014

Well	Total Depth (ft)	Current Saturated Thickness (ft)	Current Operational Saturated Thickness (ft)	Avg. Yearly Decline Since 2008 (ft/yr)	Projecting 2008 - Present Trend (yr)
1	285	45.3	18.3	-0.7	25.0
4	397	144.7	124.7	-0.9	141.1
5	351	70.2	41.2	-5.3	7.8
6	358	78.5	51.5	-9.9	5.2
7	330	55.6	34.6	-5.5	6.3

Wells 5, 6 and 7 have experienced higher than average decreases in water levels since 2008. Drought conditions have been prevalent through most of the recent years forcing an increase in irrigation water to make up for lack of rainfall. If drought conditions persist, water levels will continue the steep decline.

Wells 1 and 4 have experienced less decline since 2008 compared to historical declines. The declines in Wells 1 and 4 are less than the regional average for Hale County. The lower than average declines are most likely due to less irrigation in the area and higher aquifer saturated thickness surrounding Well 4.

Remaining life of the City's well field is a function of all wells operated together for optimal production, quality, cost and life. Table 5 takes the average of each of the current operational saturated thickness and divides by the average declines over the period of record to develop an estimated remaining well field life.

Table 5
Expected Remaining Well Field Life

Well	Total Depth (ft)	Current Operational Saturated Thickness (ft)	Total Decline (ft)	Avg. Yearly Decline (ft/yr)	Well Life Remaining (Yr)
1	285	18.3	-72.7	-1.5	6.6
4	397	124.7	-54.3	-1.4	44.8
5	351	41.2	-94.8	-2.8	14.8
6	358	51.5	-93.5	-2.8	18.5
7	330	34.6	-27.3	-5.5	12.4
Well Field Average		54.1	-68.5	-2.8	19.4

Based on the average decline across the well field and current saturated thickness of each well, the City can expect its well field to last about 19 years based on historical conditions and usage.

WELL FIELD LIFE WITH ADDITIONAL GOLDEN SPREAD USAGE

Golden Spread Electric Cooperative has proposed to increase the City's water use by as much as 131,400,000 gallons per year or 77.5% of current average use. The goal of this analysis is to determine how the proposed increased usage would affect the life of the well field.

The proposed usage of Golden Spread is shown in Table 6 compared to the City's current usage and operation.

Table 6
Proposed Golden Spread Usage and City Historical Data

Estimated Increase in Water Needs	Minimum	Peak
Gallon/Minute	450	500
Gallon/Hour	27,000	30,000
Gallon/Day (12 Hour per day operation)	324,000	360,000
Gallon/Year	118,260,000	131,400,000
City Current Water Use	Year (Gallon)	Day (Gallon)
2009	163,600,000	448,219
2010	152,100,000	416,712
2011	201,100,000	550,959
2012	163,600,000	448,219
2013	167,800,000	459,726
Average	169,640,000	464,767
Anticipated Increase in Volume (Gallon/Year)		Percent Increase
Minimum	287,900,000	69.7%
Peak	301,040,000	77.5%

The projected increased Golden Spread usage is a significant increase when compared to the current City water use. Irrigation is the biggest water user in the region. Over 90% of Ogallala withdrawals in the Texas High Plains are for irrigation; however, the Ogallala is essentially a closed basin and withdrawals have greatly exceeded recharge, resulting in a severe decline of groundwater levels since irrigation development began. In some areas, more than 50% of the predevelopment saturated thickness has been pumped, and groundwater levels have dropped over 50 m (McGuire, 2003).

HPWD rules allow for a production rate of 1.5 ac-ft per contiguous acre per year. This rule allows irrigation for one section of land to be up to 18" of application per year. If area farmers use the full allotted amount the usage would be 960 ac-ft per section. Converting 960 ac-ft/yr to an average gallon per minute (gpm) would equate to each section farmed producing a yearly average of 595 gallons per minute per section over the course of a year. With the additional use proposed by Golden Spread the City expects to deliver up to a total volume of 301,040,000 gallons per year, or 924 ac-ft/year. With irrigation of the region being the largest water user, it becomes apparent that irrigation will control the water levels in the aquifer and therefore the remaining life of the City wells.

The current annual usage for the City is 169,640,000 gallons which is the equivalent to 520 ac-ft/year or 0.54 sections (345.6 acres) of irrigation. With the expected increased volume from Golden Spread the City could deliver up to 301,040,000 gallons, equivalent to 924 ac-ft/yr or 0.96 sections (614.4 acres) of irrigation.

TRANSMISSION SYSTEM ANALYSIS

The current transmission system is able to deliver up to 1,252,800 gal/day, or 870 gpm to the City distribution system. The peak daily demand occurred in July 2011 and was 1,107,000 gal, or 769 gpm. The pipeline project that is currently underway will increase the system capacity up to an expected 1,480 gpm ultimate capacity with an installed well capacity of 1,295 gpm. In the scenario that the City repeats its peak day and Golden Spread takes its estimated peak volume of 360,000 gallons per day, the City would need the capacity to deliver 1,467,000 gal or 1,019 gpm. The capacity to meet peak day demands and peak Golden Spread volumes are only possible after the completion of the current pipeline project. Table 7 summarizes the transmission system capacity volumes required.

Table 7
Operational Scenario for Well Field

Scenario	Gal / Day	GPM
City Peak Day	1,107,000	769
City and Golden Spread Peak Day	1,467,000	1,019
Transmission System - Current	1,252,800	870
Transmission System - Future	1,864,800	1,295
Transmission System - Ultimate	2,131,200	1,480

Transmission System - Current represents the volume of water currently deliverable to the City including wells and transmission pipeline. Transmission System - Future represents the volume of water that can be delivered after the pipeline project is complete with currently installed wells operating at full capacity. Transmission System - Ultimate represents the volume of water that is expected to be available if additional wells are added to the system after the pipeline project is complete. This analysis does not consider the City’s ability to meet peak conditions during periods of well downtime or maintenance.

CONCLUSION

The water supply future of the City depends on irrigation in the region. Even with the additional use of Golden Spread the City's total yearly water use would equal roughly one section of yearly irrigation. Declining aquifer levels show the majority of the wells have experienced large declines in water levels. If the trend from the 1970's to present continues the City should expect their water resources to last about 19 years. If the region stays in drought conditions the majority of the City's wells could be below pumping levels in 10 years. These projections do not take into account any change in rules or allowable pumping limits. Wells 5, 6 and 7 are the most susceptible to the declining water levels and appear to be the first wells that will go dry. Declining levels in the City's water rights areas will, at some point, contribute to declining yields in each well.

APPENDIX A

HISTORICAL WELL LEVELS

Well #1						
Date	Static Level	Pumping Level	Draw Down	GPM	Saturated Thickness	Pumping Saturated Thickens
11/25/2014	239.7	246.2	6.5	100	45.3	18.3
5/12/2014	243.0	266.0	23.0	230	42.0	15.0
3/10/2009	239.3	251.9	12.6	300	45.7	18.7
5/24/2011	238.0	247.6	9.6	100	47.0	20.0
8/27/2001	230.8	248.6	17.8	300	54.3	27.3
12/22/1998	224.8	231.0	6.2	350	60.2	33.2
7/2/1998	227.3	244.0	16.8	350	57.8	30.8
1/2/1998	225.6	243.7	18.1	350	59.4	32.4
8/13/1997	235.4	243.0	7.6	350	49.6	22.6
11/6/1996	221.0	225.0	4.0	320	64.0	37.0
8/14/1996	221.0	230.0	9.0	300	64.0	37.0
5/8/1996	240.0	265.0	25.0	360	45.0	18.0
12/15/1995	225.0	232.4	7.4	350	60.0	33.0
12/15/1994	223.0	231.0	8.0	405	62.0	35.0
7/9/1993	211.0	225.0	14.0	402	74.0	47.0
7/23/1992	212.0	225.0	13.0	320	73.0	46.0
12/11/1992	213.0	226.0	13.0	330	72.0	45.0
12/12/1991	208.0	222.0	14.0	310	77.0	50.0
7/16/1991	220.0	230.0	10.0	210	65.0	38.0
7/30/1990	217.0	229.0	12.0	210	68.0	41.0
7/12/1990	219.0	223.0	4.0		66.0	39.0
8/1/1989	218.0	222.0	4.0		67.0	40.0
7/20/1989	223.0	248.0	25.0		62.0	35.0
12/9/1987	204.0	220.0	16.0		81.0	54.0
7/1/1978	214.0	218.0	4.0		71.0	44.0
7/1/1977	215.0	225.0	10.0		70.0	43.0
7/1/1976	211.0	229.0	18.0		74.0	47.0
6/1/1975	209.0	240.0	31.0		76.0	49.0
7/1/1974	228.0	263.0	35.0		57.0	30.0
6/1/1974	214.0				71.0	44.0
5/1/1974	200.0	225.0	25.0		85.0	58.0
8/1/1973	187.0	219.0	32.0		98.0	71.0
2/1/1973	185.0	212.0	27.0		100.0	73.0
5/1/1972	180.0	208.0	28.0		105.0	78.0
6/1/1972	182.0	209.0	27.0		103.0	76.0
4/1/1972	178.0	206.0	28.0		107.0	80.0
5/1/1971	176.0	211.0	35.0		109.0	82.0
5/30/1971	179.0	203.0	24.0		106.0	79.0
5/1/1970	178.0	202.0	24.0		107.0	80.0
4/1/1968	167.0	190.0	23.0		118.0	91.0
4/1/1967	169.0	191.0	22.0		116.0	89.0
4/1/1966	167.0	190.0	23.0		118.0	91.0
		Average	20.0 ft		72.7	Total Decline
					1.5	ft/yr

Well #4						
Date	Static Level	Pumping Level	Draw Down	GPM	Saturated Thickness	Pumping Saturated Thickens
12/1/2014	252.3	252.3	0.0	300	144.7	124.7
5/12/2014	256.0	257.0	1.0	400	141.0	121.0
5/25/2011	252.0	252.0	0.0	300	145.0	125.0
3/11/2009	251.6	251.6	0.0	450	145.4	125.4
8/27/2001	248.0	250.0	2.0	500	149.0	129.0
12/23/1998	228.2	233.7	5.5	450	168.8	148.8
7/2/1998	245.8	247.8	2.0	550	151.3	131.3
1/2/1998	225.1	234.6	9.5	600	171.9	151.9
8/13/1997	243.3	243.7	0.4	600	153.8	133.8
11/8/1996	232.0	241.0	9.0	650	165.0	145.0
8/14/1996	244.0	244.0	0.0	600	153.0	133.0
5/5/1996	228.0	249.0	21.0	600	169.0	149.0
12/15/1995	226.4	237.7	11.2	650	170.6	150.6
12/14/1994	224.0	233.0	9.0	700	173.0	153.0
7/9/1993	229.0	242.0	13.0	700	168.0	148.0
7/23/1992	224.0	230.0	6.0	325	173.0	153.0
12/11/1992	217.0	226.0	9.0	700	180.0	160.0
12/12/1991	223.0	231.0	8.0	575	174.0	154.0
7/16/1991	213.0	225.0	12.0	500	184.0	164.0
7/31/1990	233.0	258.0	25.0	550	164.0	144.0
7/13/1990	240.0	249.0	9.0		157.0	137.0
7/20/1989	228.0	247.0	19.0		169.0	149.0
12/1/1987	218.0	225.0	7.0		179.0	159.0
2/1/1986	185.0	205.0	20.0		212.0	192.0
10/1/1983	205.0	209.0	4.0		192.0	172.0
9/1/1983	205.0	212.0	7.0		192.0	172.0
8/1/1982	212.0	225.0	13.0		185.0	165.0
1/1/1982	200.0	218.0	18.0		197.0	177.0
8/1/1980	208.0	226.0	18.0		189.0	169.0
7/1/1978	213.0	228.0	15.0		184.0	164.0
7/20/1977	216.0	226.0	10.0		181.0	161.0
7/1/1976	185.0	214.0	29.0		212.0	192.0
6/30/1975	198.0	218.0	20.0		199.0	179.0
6/25/1975	198.0	216.0	18.0		199.0	179.0
		Average	12.2 ft		54.3	Total Decline
					1.4	ft/yr

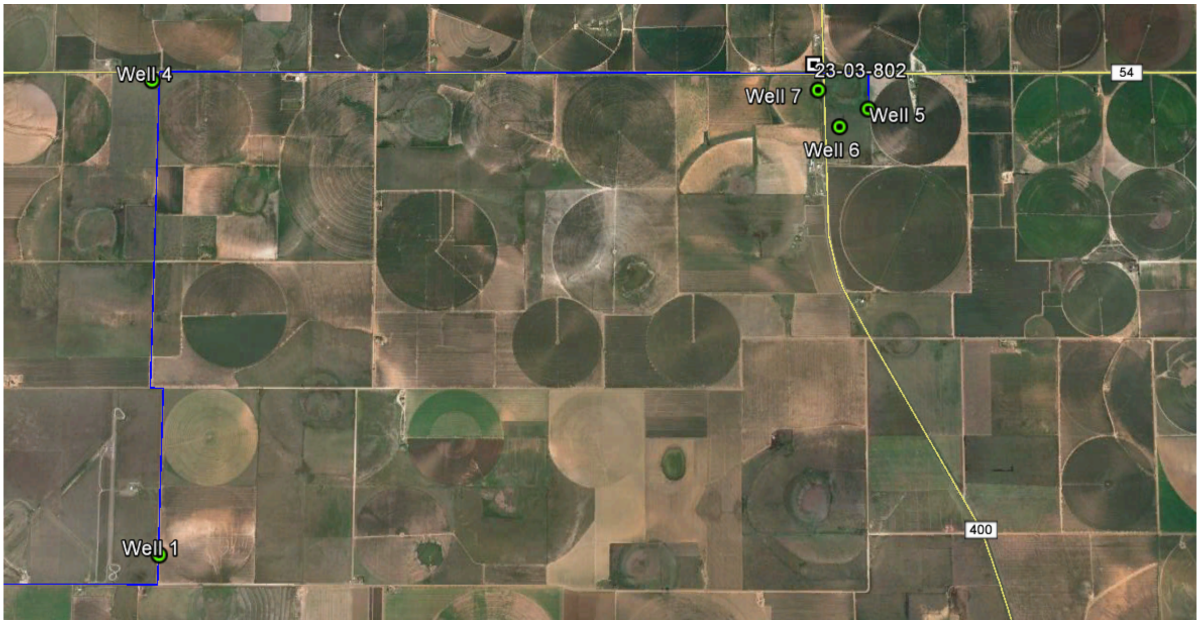
Well #5						
Date	Static Level	Pumping Level	Draw Down	GPM	Saturated Thickness	Pumping Saturated Thickens
11/25/2014	280.8	302.9	22.1	500	70.2	41.2
5/12/2014	278.0	302.0	24.0	500	73.0	44.0
5/25/2011	261.0	279.0	18.0	400	90.0	61.0
3/10/2009	254.3	272.8	18.4	600	96.7	67.7
8/27/2001	267.8	285.6	17.8	600	83.3	54.3
12/22/1998	220.0	238.0	18.0	550	131.0	102.0
7/1/1998	241.6	256.8	15.3	600	109.4	80.4
1/5/1998	219.0	236.3	17.3	600	132.0	103.0
8/13/1997	232.0	251.5	19.5	650	119.0	90.0
11/6/1996	221.0	237.8	16.8	600	130.0	101.0
8/14/1996	238.0	254.0	16.0	550	113.0	84.0
5/13/1996	232.0	248.0	16.0	500	119.0	90.0
12/19/1995	214.0	229.0	15.0	550	137.0	108.0
12/14/1994	213.0	230.0	17.0	500	138.0	109.0
7/9/1993	210.0	229.0	19.0	600	141.0	112.0
7/23/1992	208.0	229.0	21.0	600	143.0	114.0
12/11/1992	205.0	227.0	22.0	600	146.0	117.0
12/12/1991	198.0	217.0	19.0	500	153.0	124.0
7/16/1991	203.0	225.0	22.0	600	148.0	119.0
12/28/1990	197.0	211.0	14.0		154.0	125.0
7/13/1990	210.0	230.0	20.0		141.0	112.0
7/20/1989	198.0	215.0	17.0		153.0	124.0
12/1/1987	167.0	200.0	33.0		184.0	155.0
2/24/1986	187.0	210.0	23.0		164.0	135.0
9/8/1983	186.0	208.0	22.0		165.0	136.0
8/10/1982	186.0	208.0	22.0		165.0	136.0
1/1/1982	178.0	197.0	19.0		173.0	144.0
8/8/1980	186.0	200.0	14.0		165.0	136.0
		Average	19.2 ft		94.8	Total Decline
					2.8	ft/yr

Well #6						
Date	Static Level	Pumping Level	Draw Down	GPM	Saturated Thickness	Pumping Saturated Thickens
11/25/2014	279.5	289.8	10.3	450	78.5	51.5
5/12/2014	279.0	295.0	16.0	425	79.0	52.0
5/25/2011	219.0	230.0	11.0	450	139.0	112.0
11/10/2008	220.0	232.0	12.0	500	138.0	111.0
12/22/1998	214.0	235.0	21.0	550	144.0	117.0
7/1/1998	235.9	245.1	9.2	600	122.1	95.1
1/5/1998	214.3	237.5	23.3	600	143.8	116.8
9/13/1997	228.0	235.0	7.0	550	130.0	103.0
11/8/1996	220.0	237.5	17.5	500	138.0	111.0
8/14/1996	236.0	252.0	16.0	500	122.0	95.0
5/13/1996	226.0	240.0	14.0	400	132.0	105.0
12/15/1995	227.0	248.0	21.0	450	131.0	104.0
12/14/1994	211.0	226.0	15.0	450	147.0	120.0
7/9/1993	208.0	229.0	21.0	500	150.0	123.0
7/23/1992	200.0	220.0	20.0	500	158.0	131.0
12/11/1992	197.0	220.0	23.0	500	161.0	134.0
12/12/1991	193.0	213.0	20.0	400	165.0	138.0
7/16/1991	200.0	222.0	22.0	500	158.0	131.0
12/12/1991	193.0	210.0	17.0		165.0	138.0
12/28/1990	194.0	212.0	18.0		164.0	137.0
7/13/1990	206.0	221.0	15.0		152.0	125.0
7/20/1989	197.0	212.0	15.0		161.0	134.0
1/1/1987	180.0	213.0	33.0		178.0	151.0
2/1/1986	187.0	202.0	15.0		171.0	144.0
10/1/1983	184.0	209.0	25.0		174.0	147.0
8/1/1982	184.0	203.0	19.0		174.0	147.0
1/1/1982	180.0	197.0	17.0		178.0	151.0
8/18/1980	186.0	200.0	14.0		172.0	145.0
		Average	17.4 ft		93.5	Total Decline
					2.8	ft/yr

Well #7						
Date	Static Level	Pumping Level	Draw Down	GPM	Saturated Thickness	Pumping Saturated Thickens
11/25/2014	274.4	287.3	12.8	400	55.6	34.6
5/12/2014	268.0	283.0	15.0	500	62.0	41.0
3/7/2012	269.0	274.0	5.0	510	61.0	40.0
5/25/2011	260.3	269.5	9.3	530	69.8	48.8
3/10/2009	247.1	259.6	12.5	500	82.9	61.9
		Average	10.9 ft		27.3	Total Decline
					5.5	ft/yr

APPENDIX B

OBSERVATION WELL NO. 23-03-802



Texas Well Number 23-03-802		
Year	Depth to Water	Change in Level
1971	166.23	
1972	169.2	-2.97
1973	170.76	-1.56
1974	172.66	-1.9
1975	177.25	-4.59
1976	181.44	-4.19
1977	186.01	-4.57
1978	189.24	-3.23
1979	192.31	-3.07
1980	191.67	0.64
1981	196.25	-4.58
1982	198.86	-2.61
1983	202.09	-3.23
1984	203.13	-1.04
1985	205.22	-2.09
1986	206.88	-1.66
1987	208.8	-1.92
1988	205.45	3.35
Average (71-88)	-2.31	ft/yr
2004	263.04	
2005	266.07	-3.03
2006	263.6	2.47
2007	267.98	-4.38
2008	270.51	-2.53
2009	274.8	-4.29
2010	280.5	-5.7
2011	281.8	-1.3
2012	290	-8.2
2013	294.4	-4.4
2014	298.59	-4.19
Average (04-14)	-3.56	ft/yr
Total Decline (71-14)	-132.36 ft	-3.08 ft/yr