U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with the
Louisiana Department of Natural Resources

Scientific Investigations Map 3311

Introduction

The Carrizo-Wilcox aquifer is the primary source of fresh groundwater for public supply as well as industrial, agricultural, and domestic uses in several parishes in northwestern Louisiana, including Bienville, Bossier, Caddo, De Soto, Natchitoches, Red River, Sabine, and Webster (fig. 1). In 2010, about 19 million gallons per day (Mgal/d) (table 1) were withdrawn from the Carrizo-Wilcox aquifer in Louisiana (Sargent, 2011). This is an increase of over 6 Mgal/d (table 1) from 1990 withdrawal amounts. The largest increase in withdrawals occurred in Caddo (3.79 Mgal/d) and De Soto Parishes (2.32 Mgal/d), whereas the largest decrease in withdrawals occurred in Natchitoches Parish (1.17 Mgal/d). Groundwater withdrawals from the Carrizo-Wilcox aquifer have caused water-level declines throughout much of the aquifer in the study area (fig. 1). Additional knowledge about the effects of withdrawals on water levels and flow directions in the Carrizo-Wilcox aquifer are needed to assess current conditions in the aquifer. In 2012, the U.S. Geological Survey (USGS) in cooperation with the Louisiana Department of Natural Resources began a study to document current water levels and water-level changes in selected aquifers.

This report presents data and maps that illustrate the potentiometric surface of the Carrizo-Wilcox aquifer during March–May 2013 and water-level differences from 1991 to 2013. The potentiometric surface map (fig. 1) can be used for determining the direction of groundwater flow, hydraulic gradients, and effects of withdrawals on the groundwater resource. The rate of groundwater movement also can be estimated from the gradient when the hydraulic conductivity is applied. Water-level data collected for this study are stored in the USGS National Water Information System (NWIS) (http://waterdata.usgs.gov/nwis) and are on file at the USGS office in Baton Rouge, La.

Table 1. Groundwater withdrawals from the Carrizo-Wilcox aquifer, in the study area, 1990 and 2010.

Parish	Withdrawals by parish (million gallons per day)	
	1990	2010
Bienville	0.54	0.99
Bossier	2.07	2.39
Caddo	2.99	6.78
De Soto	1.79	4.11
Natchitoches	2.20	1.03
Red River	0.76	1.19
Sabine	1.57	1.81
Webster	1.38	1.03
Total	13.30	19.33

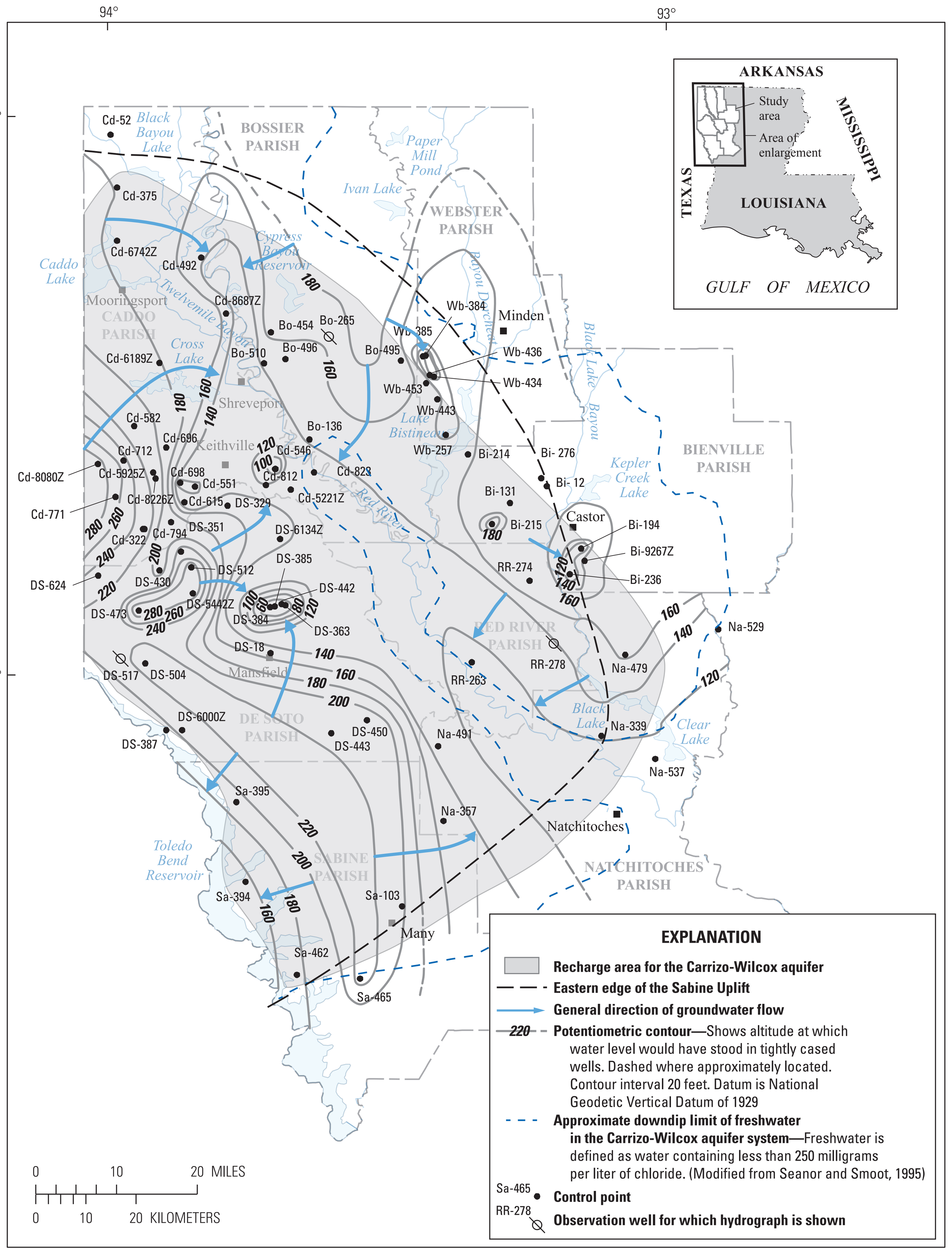

Figure 1. Potentiometric surface of the Carrizo-Wilcox aquifer in north-west Louisiana, March–May 2013.

Hydrogeology

The Carrizo Sand of Eocene age (fig. 2), the oldest formation of the Claiborne Group, is a discontinuous, massive sand that lies unconformably over the eroded surface of the Wilcox Group (Page and May, 1964). In northwestern Louisiana, the Wilcox Group is composed of an undifferentiated series of interbedded sands and clays mixed with sandy lignite layers. Because the Carrizo Sand and Wilcox Group are hydraulically connected, the units act as a single aquifer (Ryals, 1982) which is referred to as the "Carrizo-Wilcox aquifer."

The Carrizo-Wilcox aquifer ranges in total thickness from zero feet (ft) in Caddo Parish to about 3,700 ft in southeastern Natchitoches Parish. In the study area, the thickness of the Carrizo Sand ranges from a few feet in Caddo Parish to about 130 ft in Natchitoches and Sabine Parishes. Individual sands in the Wilcox Group range in thickness from a few feet to 115 ft. The Carrizo Sand contains medium to coarse sand, whereas the Wilcox Group contains very fine to medium sand (Ryals, 1982). The average hydraulic conductivity is about 27 feet per day (ft/d) for the Carrizo Sand and about 12 ft/d for the Wilcox Group (Page and May, 1964). The lower hydraulic conductivities in the Wilcox Group are due to the limited areal extent of individual sands and variations in sand thickness, depth, grain size, and sorting.

The Carrizo-Wilcox aquifer crops out within most of the study area (fig. 3). Water in the Carrizo-Wilcox aquifer is under confined conditions except in the outcrop areas where water-table conditions occur. The aquifer is mostly horizontal within the recharge area but dips near the edge of the Sabine Uplift (fig. 1), a broad structural dome located in northwest Louisiana. Formations affected by the Sabine Uplift dip radially from the top of the dome in all directions (Page and May, 1964). Secondary structural features affecting the hydrogeologic system in the study area include a complex and extensive system of faults, probably the result of stresses induced by the Sabine Uplift (Rapp, 1996). Recharge occurs from infiltration of precipitation in areas where the aquifer crops out and from overlying aquifers including the Red River alluvial aquifer, Upland terrace aquifer, and the Sparta aquifer (fig. 2). Discharge from the Carrizo-Wilcox aquifer primarily is to pumping wells and to deposits of Quaternary age (Page and May, 1964).

System	Series	Stratigraphic unit		Hydrogeologic unit (Aquifer or confining unit)
Quaternary	Holocene and Pleistocene	Red River alluvial deposits		Red River alluvial aquifer or surficial confining unit
		Northern Louisiana terrace deposits		Upland terrace aquifer or surficial confining unit
		Unnamed Pleistocene deposits		
Tertiary	Pliocene	Pliocene and Miocene aquifers are absent in this area		
	Miocene			
	Oligocene	Vicksburg Group, undifferentiated		Vicksburg-Jackson confining unit
	Eocene	Jackson Group, undifferentiated		
		Claiborne Group	Cockfield Formation	Cockfield aquifer or surficial confining unit
			Cook Mountain Formation	Cook Mountain aquifer or confining unit
			Sparta Sand	Sparta aquifer or surficial confining unit
			Cane River Formation	Cane River aquifer or confining unit
			Carrizo Sand	Carrizo-Wilcox aquifer or surficial confining unit
			?	
	Paleocene	Wilcox Group, undifferentiated		
		Midway Group, undifferentiated		Midway confining unit

(modified from Lovelace and others, 1995)

Figure 2. Hydrogeologic column of aquifers in north Louisiana.

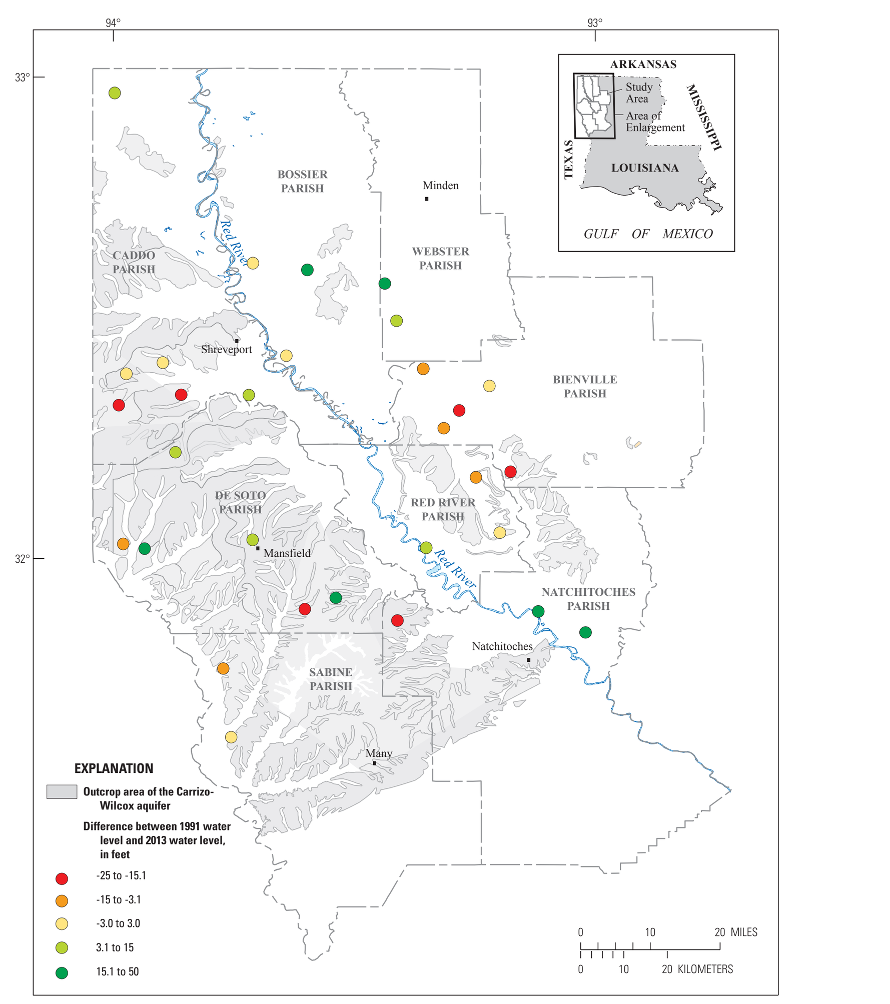

Figure 3. Water-level differences, 1991–2013, in the Carrizo-Wilcox aquifer in northwest Louisiana.

Potentiometric Surface

The potentiometric surface of the Carrizo-Wilcox aquifer (fig. 1) was constructed by using the altitude of water levels from 77 wells measured March–May 2013 (table 2). Water levels were measured by using a steel or electric tape marked with 0.01-ft graduations and were reported to one-hundredths of a foot, following procedure in Cunningham and Schalk (2011). Water levels were measured in wells that were not being pumped at the time of measurement. The altitude of water levels ranged from 43.35 ft above the National Geodetic Vertical Datum of 1929 (NGVD 29) in De Soto Parish to 296.22 ft above NGVD 29 in Caddo Parish.

Groundwater movement in the Carrizo-Wilcox aquifer generally is toward the Red River Valley and areas of heavy withdrawals (fig. 1). Localized cones of depressions in the potentiometric surface caused by heavy withdrawals (more than 0.5 Mgal/d; Sargent, 2011) are located near or at the towns of Mansfield (De Soto Parish), Keithville (southern Caddo Parish), and Castor (Bienville Parish) and have altered the regional flow patterns in these areas.

Water-Level Differences

Differences in water levels in the Carrizo-Wilcox aquifer measured at 30 wells in 1991 and 2013 are listed in table 2 and shown on figure 3. Water-level differences were calculated by subtracting the 2013 water-level measurement from the 1991 water-level measurement. These differences do not necessarily indicate a trend but show whether water levels have increased or decreased from 1991 to 2013.

Of these 30 wells, 15 showed an increase in water level, and the other 15 showed a decrease in water level. In general, wells with decreasing water levels are located in Bienville and Red River Parishes and the southwestern part of Caddo Parish, and wells with increasing water levels are located in Bossier, Natchitoches, and Webster Parishes (fig. 3).

Hydrographs for most wells screened in the Carrizo-Wilcox aquifer show seasonal fluctuations with little net change in water levels (figs. 4A, B, and C). The hydrograph for well Bo-265 (fig. 4A), located in Bossier Parish, shows an upward trend of about 1.5 ft per year since 2002, and hydrographs for wells DS-517 (fig. 4B) and RR-278 (fig. 4C) show slight downward trends (less than 1 ft per year) in water levels since the mid-1990s. These slight downward trends are probably the result of increased withdrawals in the parishes rather than changes in precipitation. Figure 4D shows annual precipitation data for the period 1981–2013 for the Red River Research Station (Station ID: COOP 167738), located in Shreveport, La. (National Climactic Data Center, 2014).

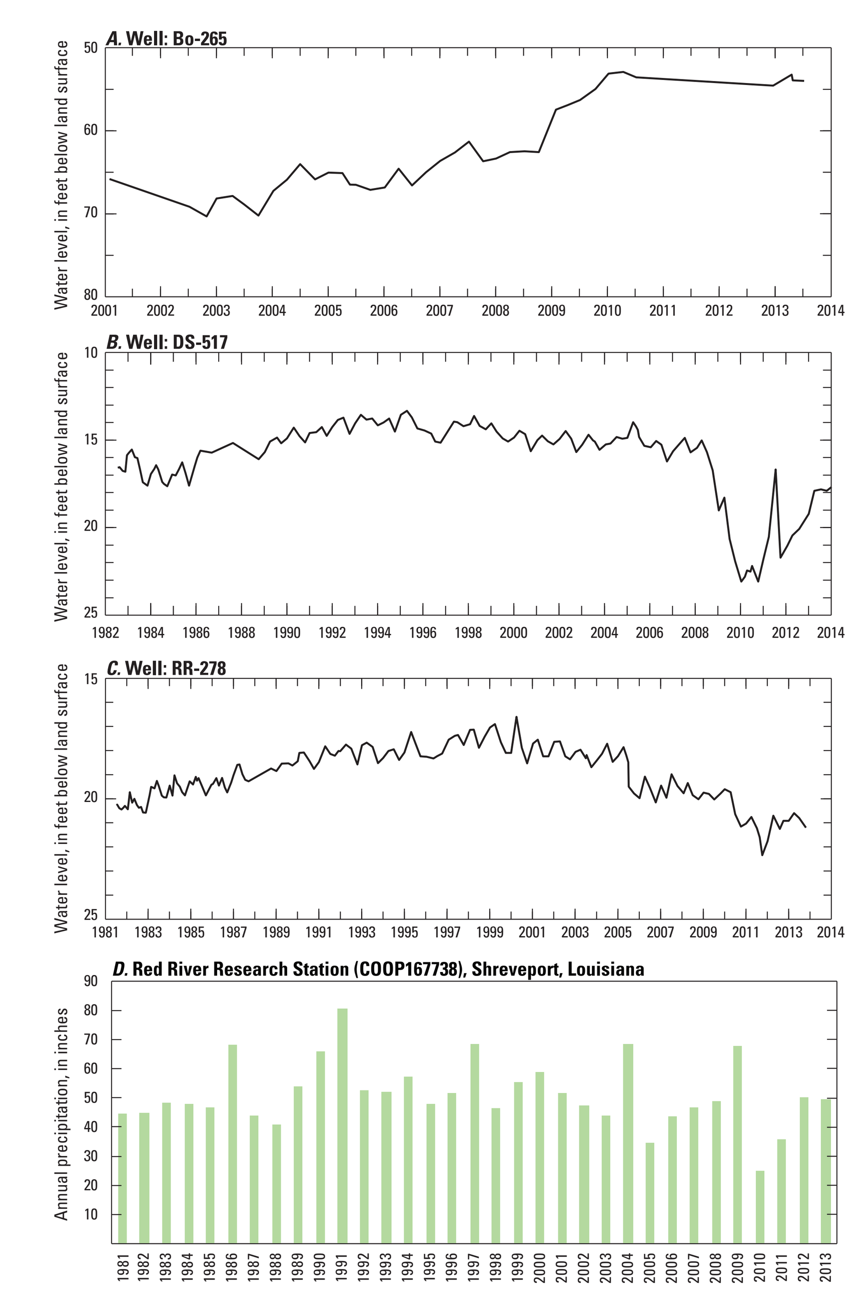

Figure 4. Hydrographs for selected wells in northwestern Louisiana.

Table 2. Water-level data used to construct maps of the potentiometric surface, March–May 2013, and water-level differences, 1991–2013, in the Carrizo-Wilcox aquifer in northwest Louisiana.

[NGVD 29, National Geodetic Vertical Datum of 1929; –, no data]

Well number	Altitude of land surface (feet above NGVD 29)	Well depth (in feet)	Date measured	1991 water level (in feet below land surface)	Date measured	2013 water level (in feet below land surface)[1]	2013 water level (in feet above NGVD 29)	Difference between water level (in feet)[2]
Bienville Parish								
Bi-12	230	350	–	–	04-18-13	61.28	168.72	–
Bi-131	275	311	11-21-90	86.65	03-21-13	106.78	168.22	-20.13
Bi-194	200	477	–	–	05-20-13	81.22	118.78	–
Bi-214	177	159	11-22-91	17.95	04-03-13	22.18	154.82	-4.23
Bi-215	270	215	11-22-91	47.49	03-21-13	55.67	214.33	-8.18
Bi-236	200	410	12-04-91	64.15	05-20-13	85.85	114.15	-21.70
Bi-276	270	336	12-04-91	99.40	04-29-13	98.40	171.60	1.00
Bi-9267Z	225	400	–	–	05-20-13	71.62	153.38	–
Bossier Parish								
Bo-136	155	180	11-12-91	14.45	04-09-13	11.58	143.42	2.87
Bo-265	220	258	11-12-91	74.22	04-26-13	53.93	166.07	20.29
Bo-454	170	220	11-14-91	8.99	03-19-13	8.00	162.00	0.99
Bo-495	200	250	–	–	04-05-13	33.06	166.94	–
Bo-496	165	220	–	–	04-05-13	19.52	145.48	–
Bo-510	167	200	–	–	04-08-13	19.81	147.19	–
Caddo Parish								
Cd-52	225	660	11-14-91	61.00	04-22-13	50.31	174.69	10.69
Cd-322	290	295	–	–	04-09-13	59.69	230.31	–
Cd-375	250	275	–	–	03-18-13	70.58	179.42	–
Cd-492	190	180	–	–	03-25-13	49.19	140.81	–
Cd-546	202	215	–	–	04-29-13	120.24	81.76	–
Cd-551	202	270	11-19-91	68.41	04-29-13	83.54	118.46	-15.13
Cd-582	260	212	–	–	04-03-13	45.66	214.34	–
Cd-615	240	240	–	–	04-29-13	102.53	137.47	–
Cd-696	210	170	11-19-91	14.70	04-08-13	15.27	194.73	-0.57
Cd-698	230	260	–	–	04-02-13	122.17	107.83	–
Cd-712	270	200	12-03-91	22.98	04-03-13	23.78	246.22	-0.80
Cd-771	300	211	12-03-91	0.30	04-02-13	23.13	276.87	-22.83
Cd-789	268	190	–	–	04-08-13	14.37	253.63	–
Cd-794	217	240	–	–	04-08-13	29.33	187.67	–
Cd-812	190	200	12-02-91	83.15	03-19-13	71.52	118.48	11.63
Cd-823	150	160	–	–	04-23-13	14.97	135.03	–
Cd-5221Z	160	250	–	–	04-03-13	37.80	122.20	–
Cd-5925Z	221	57	–	–	04-09-13	13.01	207.99	–
Cd-6189Z	260	180	–	–	04-04-13	78.38	181.62	–
Cd-6742Z	182	150	–	–	04-04-13	12.04	169.96	–
Cd-8080Z	340	220	–	–	04-04-13	43.78	296.22	–
Cd-8226Z	225	71	–	–	04-09-13	16.61	208.39	–
Cd-8687Z	180	140	–	–	04-04-13	23.74	156.26	–
De Soto								
DS-18	300	245	12-07-91	157.12	03-20-13	144.78	155.22	12.34
DS-329	265	258	–	–	04-04-13	114.57	150.43	–
DS-351	310	400	12-17-91	78.82	03-19-13	63.80	246.20	15.02
DS-363	160	80	–	–	04-10-13	114.88	45.12	–
DS-384	160	293	–	–	04-10-13	116.65	43.35	–
De Soto—Continued								
DS-385	180	275	–	–	04-10-13	120.55	59.45	–
DS-387	200	312	–	–	04-11-13	13.08	186.92	–
DS-430	325	427	–	–	04-11-13	126.44	198.56	–
DS-442	160	267	–	–	04-10-13	106.60	53.40	–
DS-443	280	304	11-07-91	43.56	04-04-13	65.19	214.81	-21.63
DS-450	290	262	12-03-91	127.94	04-10-13	81.66	208.34	46.28
DS-473	300	340	–	–	04-11-13	13.63	286.37	–
DS-504	280	260	12-05-91	68.52	03-19-13	47.74	232.26	20.78
DS-512	315	400	–	–	04-23-13	21.87	293.13	–
DS-517	225	131	10-03-91	14.76	04-04-13	17.90	207.10	-3.14
DS-624	270	290	–	–	04-23-13	32.40	237.60	–
DS-5442Z	345	260	–	–	04-29-13	57.45	287.55	–
DS-6000Z	265	240	–	–	04-11-13	60.24	204.76	–
DS-6134Z	181	260	–	–	04-22-13	30.54	150.46	–
Natchitoches Parish								
Na-339	130	140	12-11-91	43.08	03-21-13	-3.6	133.60	46.68
Na-357	248	469	–	–	04-08-13	98.12	149.88	–
Na-479	210	106	–	–	05-13-13	46.11	163.89	–
Na-491	250	493	11-06-91	97.50	03-21-13	117.05	132.95	-19.55
Na-529	120	540	12-12-91	flowing	04-03-13	-4.35	124.35	–
Na-537	170	115	11-06-91	79.65	05-14-13	58.02	111.98	21.63
Red River Parish								
RR-263	140	181	12-11-91	33.29	03-21-13	26.00	114.00	7.29
RR-274	235	206	12-03-91	59.10	04-03-13	63.76	171.24	-4.66
RR-278	160	348	12-03-91	18.02	04-03-13	20.60	139.40	-2.58
Sabine Parish								
Sa-103	220	170	–	–	03-18-13	18.50	201.50	–
Sa-394	265	278	11-07-91	109.23	04-08-13	112.00	153.00	-2.77
Sa-395	210	293	12-12-91	8.53	04-29-13	16.95	193.05	-8.42
Sa-462	280	178	–	–	03-18-13	103.14	176.86	–
Sa-465	265	80	–	–	04-08-13	43.33	221.67	–
Webster Parish								
Wb-257	180	116	–	–	03-25-13	48.03	131.97	–
Wb-384	226	451	–	–	03-26-13	108.93	117.07	–
Wb-385	224	398	11-14-91	144.55	03-26-13	95.58	128.42	48.97
Wb-434	215	356	–	–	03-25-13	100.03	114.97	–
Wb-436	215	250	–	–	03-19-13	112.73	102.27	–
Wb-443	190	280	11-21-91	56.02	04-19-13	49.13	140.87	6.89
Wb-453	210	138	–	–	03-20-13	56.38	153.62	–

[1]A negative depth to water level indicates water level above land surface.

[2]Negative (-) numbers indicate a decline in water level from the 1991 measurement to the 2013 measurement.

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Potentiometric Surface, 2013, and Water-Level Differences, 1991–2013, of the Carrizo-Wilcox Aquifer in Northwest Louisiana

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