POTENTIOMETRIC SURFACE OF THE BLACK CREEK AQUIFER IN SOUTH CAROLINA

NOVEMBER 2009

STATE OF SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES

LAND, WATER AND CONSERVATION DIVISION

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POTENTIOMETRIC SURFACE OF THE BLACK CREEK AQUIFER IN SOUTH CAROLINA

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ABSTRACT

The potentiometric surface of the Black Creek aquifer for November 2009 shows that the generally southeastward ground-water flow is affected by several potentiometric lows. These cones of depression have developed because of ground-water pumping in the Andrews-Georgetown area and around Marion, Johnsonville, and west of Hemingway.

Comparing the November 2009 data with historical data shows that water levels near the outcrop areas of this aquifer have not changed significantly. In areas influenced by pumping, water levels have declined as much as 183 feet during various periods of record.

INTRODUCTION

The Black Creek aquifer is the source of water for many public, industrial, and agricultural supplies in much of the Coastal Plain of South Carolina. This important water resource is monitored by regularly measuring the nonpumping water levels in wells. The potentiometric surface of an aquifer is defined by the elevations at which water stands in tightly cased wells completed in the aquifer. This potentiometric-surface map was prepared by the Land, Water and Conservation Division of the South Carolina Department of Natural Resources (DNR), using data collected during late 2009. Trends in ground-water levels for selected wells are shown by hydrographs.

METHOD OF INVESTIGATION

The boundaries of the Black Creek aquifer used in this investigation are those defined by Aucott, Davis, and Speiran (1987), who delineated the aquifer on the basis of geologic data (primarily geophysical well logs), water-level data, water-chemistry data, and previous investigations. They acknowledged that the complex deposition of sediments in the Coastal Plain makes aquifer delineation problematic. This aquifer has been studied extensively by Cooke (1936), Siple (1957), Colquhoun and others (1983), Renken (1984), Aucott and Speiran (1985a, and 1985b), Aucott (1988 and 1996), Aadland and others (1995), Stringfield and Campbell (1993), and Hockensmith (1997, 2003, and 2008).

The potentiometric map presented here was constructed by using water levels measured in 141 wells in November and December 2009 (see table). Water-level measurements made during that period are likely to be representative of median aquifer conditions, whereas in other periods, such as late winter or midsummer, measurements represent maximum and minimum levels, respectively. Data were collected by DNR, U.S. Department of Energy, South Carolina Department of Health and Environmental Control, and U.S. Geological Survey, Office of Ground Water, Ground-Water Resources (USGS) personnel. Wells measured by previous investigators were used, where possible, to compare 2009 data with historical potentiometric maps.

The hydrographs were constructed from measurements by DNR and USGS. Where continuous records were available, daily mean water levels were plotted.

GEOHYDROLOGIC FRAMEWORK

The Coastal Plain formations compose a wedge of sediments that thickens from 0 at the Fall Line to more than 4,000 ft (feet) at the coastline. The sediment consists of sand, clay, and limestone of late Cretaceous and younger ages that have been deposited on a pre-Cretaceous basement of metamorphic, igneous, and consolidated sedimentary rock.

The Black Creek aquifer is the youngest of the Cretaceous aquifers in the region. It is composed mostly of per-

Table showing water-level elevations during November 2009 in wells completed in the Black Creek aquifer in South Carolina

Well number	Grid number	Latitude, in degrees, minutes, and seconds	Longitude, in degrees, minutes, and seconds	Water level elevation, in feet above or below (-) mean sea level	Change in water level from 2004 to 2009, rounded to nearest foot
AIK-497	38U-f1	33 33 01	81 39 26	329	-4
AIK-634	39X-l4	33 17 44	81 41 04	174	-1
AIK-824	40V-s5	33 26 16	81 45 15	234	-2
AIK-825	40V-s6	33 26 16	81 46 14	234	-1
AIK-846	36U-o3	33 32 32	81 29 08	268	-3
AIK-847	36U-o4	33 32 32	81 29 08	268	-2
AIK-848	36U-o5	33 32 32	81 29 08	264	-1
AIK-859	38W-n2	33 22 38	81 38 27	217	-1
AIK-860	39X-n37	33 17 12	81 43 19	166	-1
AIK-861	39W-w1	33 20 16	81 42 31	202	-2
AIK-863	40Y-k6	33 12 52	81 45 32	149	0
AIK-870	38W-n4	33 22 38	81 38 27	215	-2
AIK-874	40Y-k9	33 12 51	81 45 32	> 154	
AIK-887	39X-n63	33 17 12	81 43 19	169	-1
AIK-888	39X-n64	33 17 12	81 43 19	169	-1
AIK-893	39W-w4	33 20 16	81 42 31	200	-3
AIK-894	39W-w5	33 20 16	81 42 31	203	-2
AIK-2378	40W-q2	33 21 09	81 48 36	222	
AIK-2379	40W-q3	33 21 12	81 48 33	164	-1
AIK-2450	39U-r6	33 31 29	81 42 32	306	-4
AIK-2564	34T-n6	33 37 41	81 18 20	298	-4
ALL-367	37Z-t8	33 06 48	81 30 22	152	-3
ALL-368	37Z-t9	33 06 49	81 30 20	153	
ALL-369	37Z-x10	33 06 47	81 30 21	153	-2
ALL-376	35AA-q9	33 01 29	81 23 06	141	-3
BAM-7	31X-m3	33 17 42	81 02 15	149	
BAM-27	31X-m6	33 17 13	81 02 28	152	-9
BRK-89	15X-l1	33 17 09	79 41 40	-21	-3
BRN-324	38X-i3	33 18 39	81 36 23	188	0
BRN-325	38X-i4	33 18 38	81 36 22	188	0
BRN-326	38X-i5	33 18 38	81 36 22	188	0
BRN-328	37Y-o5	33 12 09	81 34 41	171	-1
BRN-329	37Y-o6	33 12 09	81 34 41	171	-1
BRN-331	33Y-m4	33 12 51	81 37 26	173	0
BRN-332	38Y-m5	33 12 45	81 37 23	171	3
BRN-353	34Y-x5	33 10 43	81 18 54	163	-4
BRN-355	34Y-x7	33 10 44	81 18 55	163	-3

Table showing water-level elevations during November 2009 in wells completed in the Black Creek aquifer in South Carolina (continued)

Well number	Grid number	Latitude, in degrees, minutes, and seconds	Longitude, in degrees, minutes, and seconds	Water level elevation, in feet above or below (-) mean sea level	Change in water level from 2004 to 2009, rounded to nearest foot
BRN-365	35X-e5	33 19 15	81 24 28	202	-3
BRN-368	35X-e8	33 19 14	81 24 28	202	-3
BRN-371	39X-u5	33 15 11	81 40 21	172	0
BRN-372	38Y-b10	33 14 46	81 36 59	178	0
BRN-373	37Y-t2	33 11 28	81 30 48	170	-1
BRN-374	37W-u2	33 20 41	81 30 01	212	-1
BRN-375	37X-p5	33 16 30	81 34 25	188	0
BRN-376	38Z-i4	33 08 49	81 36 27	161	-1
BRN-377	39Y-u2	33 10 57	81 40 43	161	-1
BRN-378	37Y-f6	33 13 47	81 34 31	178	-1
BRN-380	38X-n57	33 17 10	81 38 06	180	-1
BRN-389	37W-u8	33 20 41	81 30 01	212	-2
BRN-392	38Y-b4	33 14 46	81 36 58	178	0
BRN-393	38Y-b5	33 14 45	81 36 58	178	0
BRN-394	38Y-b6	33 14 46	81 36 59	185	-1
BRN-402	36Z-i8	33 08 48	81 362 6	161	-1
BRN-406	37Y-t4	33 11 28	81 30 48	170	-1
BRN-412	39-u4	33 10 57	81 40 44	164	-1
BRN-413	39Y-u5	33 10 57	81 40 44	161	-1
BRN-418	37Y-f9	33 13 46	81 34 31	178	0
BRN-424	38Y-o11	33 12 39	81 39 27	168	0
BRN-431	38X-n59	33 17 09	81 38 06	180	-1
BRN-432	38X-n60	33 17 09	81 38 06	180	-1
BRN-437	39X-u8	33 15 11	81 40 21	172	-3
BRN-464	38Y-o13	33 12 39	81 39 27	168	0
BRW-1862*	2Q-j3	33 53 34	78 35 01	2	
BRW-1863*	2Q-j4	33 53 33	78 35 22	0	-6
BRW-1864*	2Q-j5	33 53 33	78 35 22	-31	
CAL-2	27U-q2	33 33 23	80 43 04	115	-6
CAL-49	28T-t2	33 36 46	80 45 07	104	-2
CHN-16	17DD-v1	32 45 31	79 51 22	4	-1
CHN-182	12Y-l1	33 12 03	79 26 08	-36	-9
CLA-16	21S-r3	33 41 38	80 12 46	81	
CLA-27	21S-s1	33 41 18	80 11 38	80	
CLA-30	19Q-i3	33 53 50	80 01 44	55	
CLA-32	22T-b1	33 39 06	80 16 49	100	-5
CLA-33	22T-b2	33 39 04	80 16 49	98	9

Table showing water-level elevations during November 2009 in wells completed in the Black Creek aquifer in South Carolina (continued)

Well number	Grid number	Latitude, in degrees, minutes, and seconds	Longitude, in degrees, minutes, and seconds	Water level elevation, in feet above or below (-) mean sea level	Change in water level from 2004 to 2009, rounded to nearest foot
CLA-36	23U-d1	33 34 52	80 23 40	87	
CLA-60	17Q-o1	33 52 24	79 54 15	38	
CLA-63	19Q-f1	33 53 31	80 04 44	66	
CLA-146	22T-i1	33 38 07	80 16 01	81	
COL-30	27CC-j1	32 53 45	80 40 40	43	-6
CTF-222	22J-v2	34 25 44	80 16 58	261	
DAR-118	15L-o3	34 17 17	79 44 49	104	-2
DAR-230	19M-y3	34 10 23	80 04 14	150	
DIL-28	10L-a1	34 19 46	79 15 53	51	-6
DIL-70	11J-f1	34 28 23	79 24 05	72	
DIL-132	10J-g2	34 28 57	79 18 54	88	1
FLO-85	18I-i1	34 08 06	79 56 31	100	-8
FLO-114	18P-s1	33 56 06	79 56 01	56	-7
FLO-147	13P-d1	33 59 34	79 33 28	-69	-79
FLO-148	12R-b3	33 49 52	79 26 40	-34	
FLO-207	16O-m2	34 02 10	79 47 20	35	-3
FLO-276	16Q-s2	33 51 22	79 46 00	0	-2
FLO-298	16M-w6	34 10 20	79 47 20	61	107
FLO-317	14P-b1	33 59 40	79 36 05	27	27
GEO-77	10W-c1	33 24 15	79 17 35	-133	-8
GEO-78	12V-v1	33 25 26	79 26 57	-121	
GEO-86	10X-d2	33 19 47	79 18 42	-126	-7
GEO-153	9W-q2	33 21 48	79 13 42	-99	-4
GEO-154	9W-v2	33 20 59	79 11 41	-105	
GEO-185	11W-r1	33 21 25	79 22 55	-230	
GEO-187	12V-w1	33 25 29	79 27 01	-124	
GEO-193	13V-o2	33 27 29	79 34 51	-121	18
GEO-233	11Y-e3	33 14 59	79 23 32	-81	-9
GEO-249	9T-e1	33 39 46	79 14 47	-69	-26
GEO-296	9Y-h2	33 13 39	79 12 18	-50	
HOR-225	9P-c2	33 59 55	79 12 08	2	-3
HOR-246	4R-y1	33 45 18	78 49 22	-51	-8
HOR-290	6S-v2	33 40 14	78 56 23	-55	-6
HOR-304	5S-q2	33 41 40	78 53 53	-56	-1
HOR-307	7Q-x2	33 50 58	79 03 27	-31	-8
HOR-309	6R-q3	33 46 07	78 58 03	-66	-21
HOR-319	7S-l1	33 42 39	79 01 23	-52	-12

Table showing water-level elevations during November 2009 in wells completed in the Black Creek aquifer in South Carolina (continued)

Well number	Grid number	Latitude, in degrees, minutes, and seconds	Longitude, in degrees, minutes, and seconds	Water level elevation, in feet above or below (-) mean sea level	Change in water level from 2004 to 2009, rounded to nearest foot
HOR-485	5O-g2	34 03 27	78 53 29	18	-1
HOR-673	7T-h2	33 38 23	79 02 21	-59	-11
HOR-730	5S-i8	33 43 03	78 51 36	-7	57
LEX-191	31S-n1	33 42 08	81 03 32	245	
MRN-77	10Q-p1	33 51 42	79 19 50	-16	-3
ORG-256	31T-t2	33 36 33	81 00 25	277	
ORG-385	31W-l6	33 22 08	81 01 51	138	-15
ORG-388	31W-s3	33 21 49	81 02 03	133	-17
ORG-393	29U-v1	33 30 30	80 51 54	142	-6
SUM-288	21P-c3	33 59 09	80 12 48	118	123
SUM-296	25S-l1	33 42 38	80 31 56	81	-1
SUM-297	25S-l2	33 42 38	80 31 56	74	
SUM-322	24O-v7	34 00 55	80 26 06	189	-1
SUM-497	24Q-l2	33 52 28	80 26 16	158	158
WIL-354	14U-d2	33 3415	79 38 40	-36	
WIL-11	16S-y1	33 40 03	79 49 32	13	12
WIL-12	16S-y2	33 40 17	79 49 40	6	6
WIL-16	13S-h1	33 43 36	79 32 58	-26	-26
WIL-32	13S-i1	33 43 51	79 31 02	-25	-25
WIL-34	17S-t1	33 41 01	79 50 18	-7	-7
WIL-51	16R-n2	33 47 15	79 48 15	17	17
WIL-64	18U-e4	33 34 31	79 59 26	13	-48
WIL-123	16V-a1	33 29 52	79 45 51	43	
WIL-177	17U-q1	33 31 32	79 53 34	34	
WIL-189	18U-e3	33 34 59	79 59 16	49	
WIL-193	13S-j2	33 43 18	79 30 36	-19	
WIL-196	16U-v1	33 30 03	79 46 10	43	
WIL-201	18U-d1	33 34 44	79 58 50	46	
WIL-211	13S-x1	33 40 54	79 33 26	-18	
Other Wells:					
Middendorf/Black Creek aquifers					
MRN-9	11M-p2	34 09 57	79 24 30	0	23

* Wells BRW-1862, BRW-1863, and BRW-1864 are located in Brunswick County, North Carolina.

meable sediments of the Black Creek Formation (hence its name), but locally it may include sediments from underlying or overlying formations. The aquifer comprises thin- to thick-bedded sand and clay deposited in marginal marine or delta plain environments. The coarsest sand and least clay content are found in the western part of the Coastal Plain.

The aquifer crops out in the eastern Coastal Plain along a narrow band extending from Lexington County to Sumter County and along a wider area from Sumter County to Dillon County. It dips southeastward toward the coast. The top of the aquifer is at elevation 300, -250, and -1,000 ft msl (feet, referenced to mean sea level) at Aiken, Little River, and Charleston, respectively. Thickness ranges from about 100 ft near Aiken to more than 400 ft at the coast.

GROUND-WATER FLOW

The potentiometric surface of the Black Creek aquifer generally slopes toward the coast, and the direction of ground-water flow is southeastward. In areas where the aquifer crops out it is recharged directly by rainfall. In the upper Coastal Plain, stream valleys are incised into the aquifer; where contours are deflected upstream near the Santee, North Edisto, South Edisto, and Savannah Rivers, the aquifer discharges to those rivers. In the lower Coastal Plain the aquifer discharges only into overlying aquifers and through pumping wells.

Dimpling this surface are cones of depression caused by pumping. The potentiometric surface has been most affected by pumping in Johnsonville, Marion, and southern Georgetown County. The lowest point on the potentiometric map, -133 ft msl, is north of the City of Georgetown.

HISTORICAL TRENDS

The potentiometric levels of the Black Creek aquifer have been recorded since 1917 or earlier (Cooke, 1936). Potentiometric maps of the Black Creek aquifer have been published by Aucott and Speiran (1985a and 1985b), Stringfield and Campbell (1993), and Hockensmith (1997, 2003, and 2008). Aucott and Speiran (1985b) compared estimates of the predevelopment surface with November 1982 water levels and determined that Black Creek aquifer water levels had declined in Horry and Georgetown Counties. Stringfield and Campbell (1993) published November 1989 water levels and observed that levels in Georgetown, Horry, northern Marion, and northeastern Williamsburg Counties had declined since 1982. November 1995 (Hockensmith, 1997) and November 2001 (Hockensmith, 2003) data showed additional declines and a generally southeastward ground-water flow influenced by large cones of depression near Marion, Andrews, Georgetown, and Pawleys Island. November 2004 data (Hockensmith, 2008) showed cones of depression in the Andrews-Georgetown area and around Florence, Marion, and Sumter.

The lowest point on the potentiometric surface is -133 ft msl (GEO-77), within a cone of depression about Andrews and Georgetown, and represents a total decline from estimated predevelopment levels (above 50 ft msl, according to Aucott and Speiran, 1985a) of about 183 ft. Within the cone, water levels declined 4 to 26 ft between 2004 and 2009 (CHN-182, GEO-77, GEO-86, GEO-153, GEO-233, and GEO-249). In Andrews, water levels recovered 18 ft to -121 ft from 2004 to 2009 (GEO-193). Annual ground-water pumpage for Georgetown County increased from 1,039 to 1,247 Mgal (million gallons) from 2004 to 2009, according to Childress and Bristol (2005) and Butler (2010).

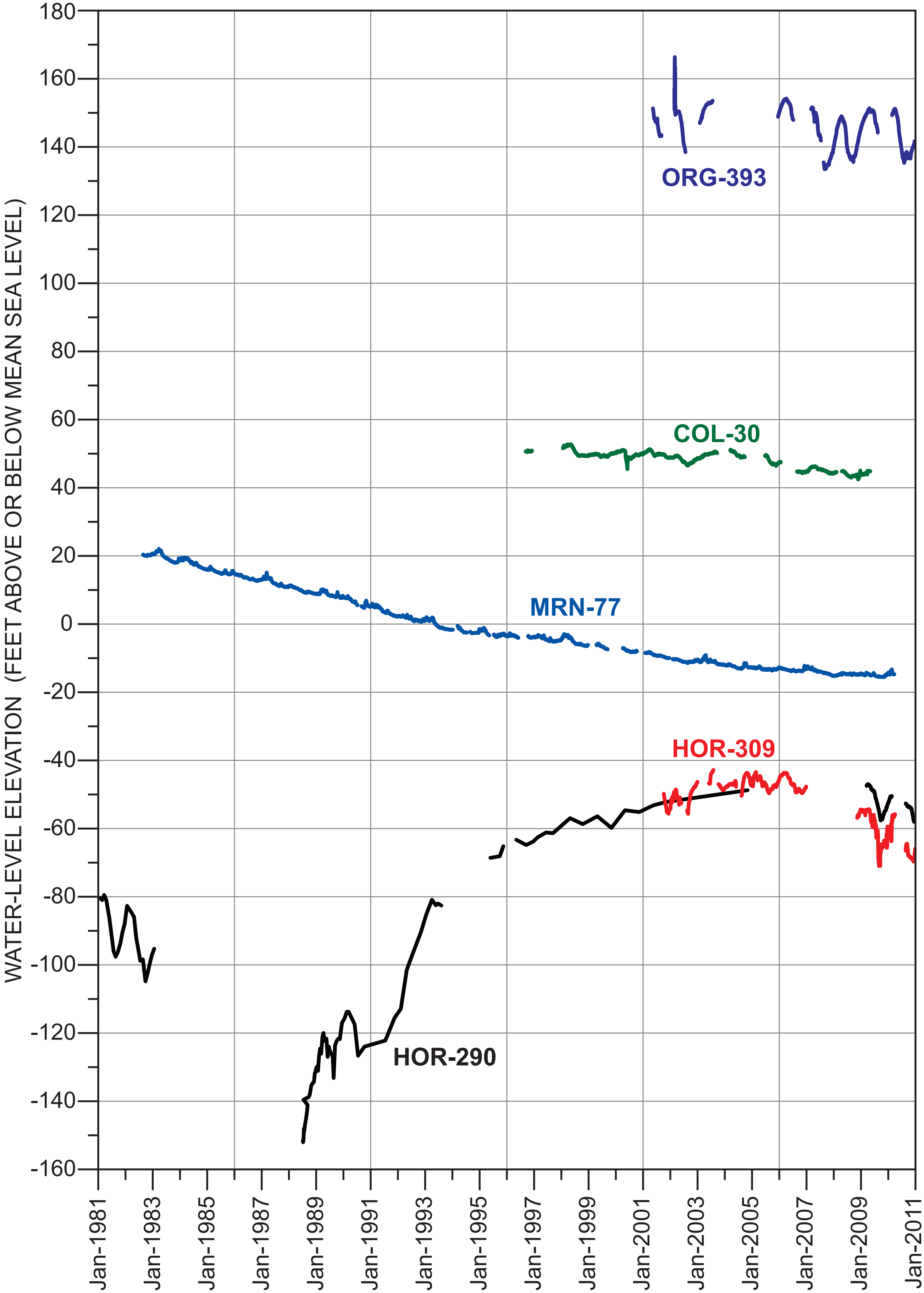
Water levels in Horry County declined from 1 to 21 ft from 2004 to 2009. The hydrographs for HOR-290 and HOR-309 show similar water-level trends in 2009 with lows of -58 and -70 ft msl, respectively, occurring in early September. Since 1988, when most public water suppliers in Horry County began a conversion to surface water, potentiometric levels in HOR-290 recovered 103 ft to -49 ft msl. Total ground-water use reported for the county increased from 1,947 to 2,534 Mgal in 2004 and 2009, respectively (Childress and Bristol, 2005; and Butler, 2010).

Black Creek water levels in northern Marion County have declined from predevelopment levels of between 50 and 75 ft msl (Aucott and Speiran, 1985a). The water level in MRN-9, a well screened in both the Black Creek and Middendorf aquifers, was 0 ft msl and had recovered 23 ft since 2004. Water-supply pumpage for the county decreased from 1,357 Mgal in 2004 to 1,171 Mgal in 2009 (Childress and Bristol, 2005; and Butler, 2010) and was withdrawn from both the Black Creek and Middendorf aquifers. Contours for the Black Creek are drawn to reflect the estimated effects of pumping; however, the pumping effects are thought to be greater in the Black Creek aquifer than in the Middendorf.

Water levels in southern Marion County (MRN-77) declined 3 ft to -16 ft msl between 2004 and 2009 and have declined steadily since 1982. Predevelopment levels near the well were estimated to be higher than 45 ft msl (Aucott and Speiran, 1984) implying a total decline of more than 61 ft.

In Florence County, indications of a cone of depression about Florence are absent. Water level in FLO-298 recovered 107 ft to 61 ft msl from 2004 to 2009 (the well had not been pumped in a year). Water levels in other wells in the county declined by 2 to 8 ft (FLO-85, FLO-114, FLO-207, and FLO-276). The center of the cone of depression about Johnsonville is -34 ft msl (FLO-148).

Ground-water pumpage in Florence County declined from 4,915 in 2004 to 4,851 Mgal in 2009. Water-supply



Hydrographs of selected wells.

pumpage, as the greatest use of ground water, increased by 545 Mgal to 4,418 Mgal from 2004 to 2009 (Childress and Bristol, 2005; and Butler, 2010). This increase in water-supply withdrawals, though not all from the Black Creek aquifer, is likely the cause for the water-level declines.

Water-level declines in Sumter County are a result of pumping in and around the City of Sumter. Water levels in SUM-322 declined 1 ft to 189 ft msl from 2004 to 2009. Predevelopment levels were estimated at 160 ft msl (Cooke, 1936) in this area. Two new wells, SUM-488 (Middendorf aquifer) and SUM-497 (Black Creek aquifer), drilled for DNR for use as observation wells had water levels of 117 and 158 ft msl, respectively. These two new wells, plus the installation of a water-level recorder in SUM-288, should help with future analyses of water-level trends in Sumter County.

Annual ground-water withdrawal from the Black Creek and Middendorf aquifers in Sumter County in 2009 exceeded 5991 Mgal, a decrease of 879 Mgal from 2004 (Childress and Bristol, 2005; and Butler, 2010). Because the transmissivity of the Black Creek aquifer in Sumter County ranges from 2,900 to 32,000 gpd/ft (gallons per day per foot) (Newcome, 1993), a cone of depression is not apparent from the data distribution.

In Kingstree, water levels in wells recovered as much as 12 ft between 2004 and 2009 (WIL-11) and ranged from -7 to 13 ft msl (WIL-11, WIL-12, and WIL-34). The center of the cone of depression west of Hemingway is -26 ft msl (WIL-16). At Greeleyville, WIL-189 and WIL-201, wells new to the 2009 potentiometric run, had water levels of 49 and 46 ft msl, respectively. WIL-64, a long-time observation well, showed a decline of 48 ft to 13 ft msl in 2009, which is anomalous in view of the nearby measurements.

Water-levels in Aiken, Allendale, and Barnwell Counties between 2004 and 2009 remained the same or declined up to 4 ft in all but one well (BRN-332) which showed an increase of 3 ft. Ground-water users in Aiken, Allendale, and Barnwell Counties pumped 6,692, 3,998, and 1,093 mg, respectively (Butler, 2010), from the Cretaceous and overlying aquifers in 2009. The extent to which pumping affects water levels is not discernible from the 2009 data, owing to the high transmissivity of the Black Creek aquifer, the distribution of measurements, and the effect of natural discharge to the Savannah River.

Water levels in two wells in southwestern Orangeburg County (ORG-385 and ORG-388) showed declines of 15 to 17 ft, however, these measurements may be affected by nearby pumping for power-generation cooling purposes. The hydrograph for ORG 393 shows seasonal fluctuations and a decline of 6 ft from 2004 to 2009. Annual ground-water pumpage in the county increased from 7,053 in 2004 to 7,157 in 2009 (Childress and Bristol, 2005; and Butler, 2010).

At the City of Bamberg, the water level in BAM-27 declined 9 ft to 152 ft msl from 2004 to 2009 and the well no longer flows. Nearby BAM-7 had a similar water level of 149 ft msl.

Water level in the Black Creek aquifer at Walterboro declined, according to data for COL-30 (see hydrograph). The water level in this well in November 2009, at 43 ft msl, had declined 6 ft from November 2004. This observation well has been formally abandoned (grouted) because of development.

There is a need for additional Black Creek observation wells in several areas of the Coastal Plain. In constructing this map, several cones of depression are each defined by only one well (Johnsonville) or inferred from historical data and water-use data (Marion). Some counties had no observation wells (Beaufort, Dorchester, Hampton, and Jasper), and others only one (Berkeley, Colleton, and Lexington) or two (Bamberg, Calhoun, Charleston, Darlington, and Marion). Wells that previously defined cones of depression were unavailable (FLO-35) or have been destroyed (COL-30). The northern and western boundaries of the cone of depression in southern Georgetown County are poorly known because of a paucity of observation wells. There is a large data gap in eastern Orangeburg County. Lastly, the extent to which North Carolina or Georgia ground-water pumpage influences the aquifer is not known and, in light of pressures to provide sufficient water for all users, obtaining data in these areas should have high priority. Efforts should be intensified among ground-water users and governmental bodies to maintain existing observation wells and seek additional wells.

SUMMARY AND CONCLUSIONS

The potentiometric map of the Black Creek aquifer, constructed by using water-level data from 141 wells measured during late 2009, shows that the generally southeastward ground-water flow is affected by potentiometric lows around Andrews and Georgetown, Marion, Johnsonville, and west of Hemingway.

Historical data show that water levels are stable or declined up to 4 ft near the aquifer's outcrop area. The cone of depression in southern Georgetown County, where water levels have declined as much as 183 ft from the estimated predevelopment level, remains a major feature.

Potentiometric maps are only as good as the data available to construct them. A greater availability of observation wells, timely measurements, and periodic construction of potentiometric maps will provide improved understanding of the aquifer and allow better management of this resource.

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