POTENTIOMETRIC SURFACE OF THE BLACK CREEK AQUIFER IN SOUTH CAROLINA

NOVEMBER 2004

STATE OF SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES

LAND, WATER AND
CONSERVATION DIVISION

SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES

DNR

WATER RESOURCES
REPORT 47
2008

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STATE OF SOUTH CAROLINA
The Honorable Mark H. Sanford, Governor

South Carolina Department of Natural Resources

Board Members

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ABSTRACT

The potentiometric surface of the Black Creek aquifer for October and November 2004 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 Florence, Marion, and Sumter.

Comparing the November 2004 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 200 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 2004. 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 and 2003).

The potentiometric map presented here was constructed by using water levels measured in 137 wells in October and November 2004 (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 2004 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 permeable 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 slopes irregularly toward the coast, thus the direction of ground-water flow is generally southeastward. In areas where

Table showing water-level elevations during November 2004 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 above or below (-) mean sea level, in feet *	Change in water level from 2001 to 2004, in feet
AIK-497	38U-f1	333301	813926	333.1	
AIK-634	39X-l4	331744	814104	175.2	0
AIK-691	39X-d6	331959	814359	191.9	-1
AIK-824	40V-s5	332616	814515	235.8	-1
AIK-825	40V-s6	332616	814614	235.3	-3
AIK-846	36U-o3	333232	812908	270.7	0
AIK-847	36U-o4	333232	812908	270.2	0
AIK-848	36U-o5	333232	812908	264.8	0
AIK-859	38W-n2	332238	813827	218.5	-1
AIK-860	39X-n37	331712	814319	167.7	0
AIK-861	39W-w1	332016	814231	204.7	0
AIK-862	39X-k35	331729	814028	175.3	0
AIK-863	40Y-k6	331252	814532	149.0	2
AIK-870	38W-n4	332238	813827	216.3	-1
AIK-879	39X-k27	331730	814028	175.4	0
AIK-880	39X-k28	331730	814028	175.6	0
AIK-887	39X-n63	331712	814319	169.7	0
AIK-888	39X-n64	331712	814319	169.9	0
AIK-893	39W-w4	332016	814231	203.3	0
AIK-894	39W-w5	332016	814231	205.3	0
AIK-898	39X-k36	331730	814028	175.5	0
AIK-904	39X-i6	331831	814138	176.3	7
AIK-929	38X-c1	331911	813706	187.2	0
AIK-1499	39W-x33	332020	814329	200.7	-1
AIK-1523	39W-x57	332005	814352	193.7	-1
AIK-1536	39W-y35	332051	814414	208.3	-2
AIK-1544	39W-y43	332052	814401	207.9	-1
AIK-1549	39W-y48	332048	814425	204.8	-1
AIK-1567	39W-y66	332036	814444	196.5	-1
AIK-1606	39W-y14	332016	814445	192.2	-1
AIK-1655	39X-d24	331944	814354	189.6	-1
AIK-1659	39X-d28	331937	814316	190.8	0
AIK-1672	39X-d41	331914	814346	185.4	1
AIK-1765	39X-e18	331944	814429	188.0	-1
AIK-2379	40W-q3	332112	814833	165.0	0
AIK-2564	34T-n6	333741	811820	301.5	
ALL-367	37Z-t8	330648	813022	154.9	0
ALL-369	37Z-x10	330647	813021	155.1	0
ALL-376	35AA-q9	330129	812306	144.3	3

Table showing water-level elevations during November 2004 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 above or below (-) mean sea level, in feet *	Change in water level from 2001 to 2004, in feet
BAM-27	31X-m6	331713	810228	160.8	4
BRK-89	15X-l1	331709	794140	-18.7	-5
BRN-324	38X-i3	331839	813623	188.5	0
BRN-325	38X-i4	331838	813622	188.7	0
BRN-326	38X-i5	331838	813622	188.3	0
BRN-328	37Y-o5	331209	813441	172.3	0
BRN-329	37Y-o6	331209	813441	172.2	1
BRN-331	33Y-m4	331251	813726	172.4	0
BRN-332	38Y-m5	331245	813723	167.8	0
BRN-353	34Y-x5	331043	811854	166.2	2
BRN-355	34Y-x7	331044	811855	166.3	2
BRN-365	35X-e5	331915	812428	204.7	1
BRN-368	35X-e8	331914	812428	205.0	1
BRN-371	39X-u5	331511	814021	172.1	0
BRN-372	38Y-b10	331446	813659	178.0	0
BRN-373	37Y-t2	331128	813048	171.5	0
BRN-374	37W-u2	332041	813001	213.2	0
BRN-375	37X-p5	331630	813425	187.8	0
BRN-376	38Z-i4	330849	813627	162.3	0
BRN-377	39Y-u2	331057	814043	161.7	0
BRN-378	37Y-f6	331347	813431	178.6	0
BRN-380	38X-n57	331710	813806	180.4	1
BRN-389	37W-u8	332041	813001	213.5	0
BRN-392	38Y-b4	331446	813658	178.4	0
BRN-393	38Y-b5	331445	813658	178.3	0
BRN-394	38Y-b6	331446	813659	185.9	1
BRN-402	36Z-i8	330848	813626	162.5	0
BRN-406	37Y-t4	331128	813048	171.1	0
BRN-412	39Y-u4	331057	814044	165.1	0
BRN-413	39Y-u5	331057	814044	161.5	0
BRN-418	37Y-f9	331346	813431	178.1	0
BRN-424	38Y-o11	331239	813927	167.5	-1
BRN-425	38Y-o5	331239	813927	163.8	-4
BRN-431	38X-n59	331709	813806	180.4	1
BRN-432	38X-n60	331709	813806	180.4	1
BRN-437	39X-u8	331511	814021	175.0	3
BRN-464	38Y-o13	331239	813927	167.5	0
BRN-694	38Y-m35	331225	813712	168.8	0
BRW-1863	2Q-j4	335333	783522	6.1	3

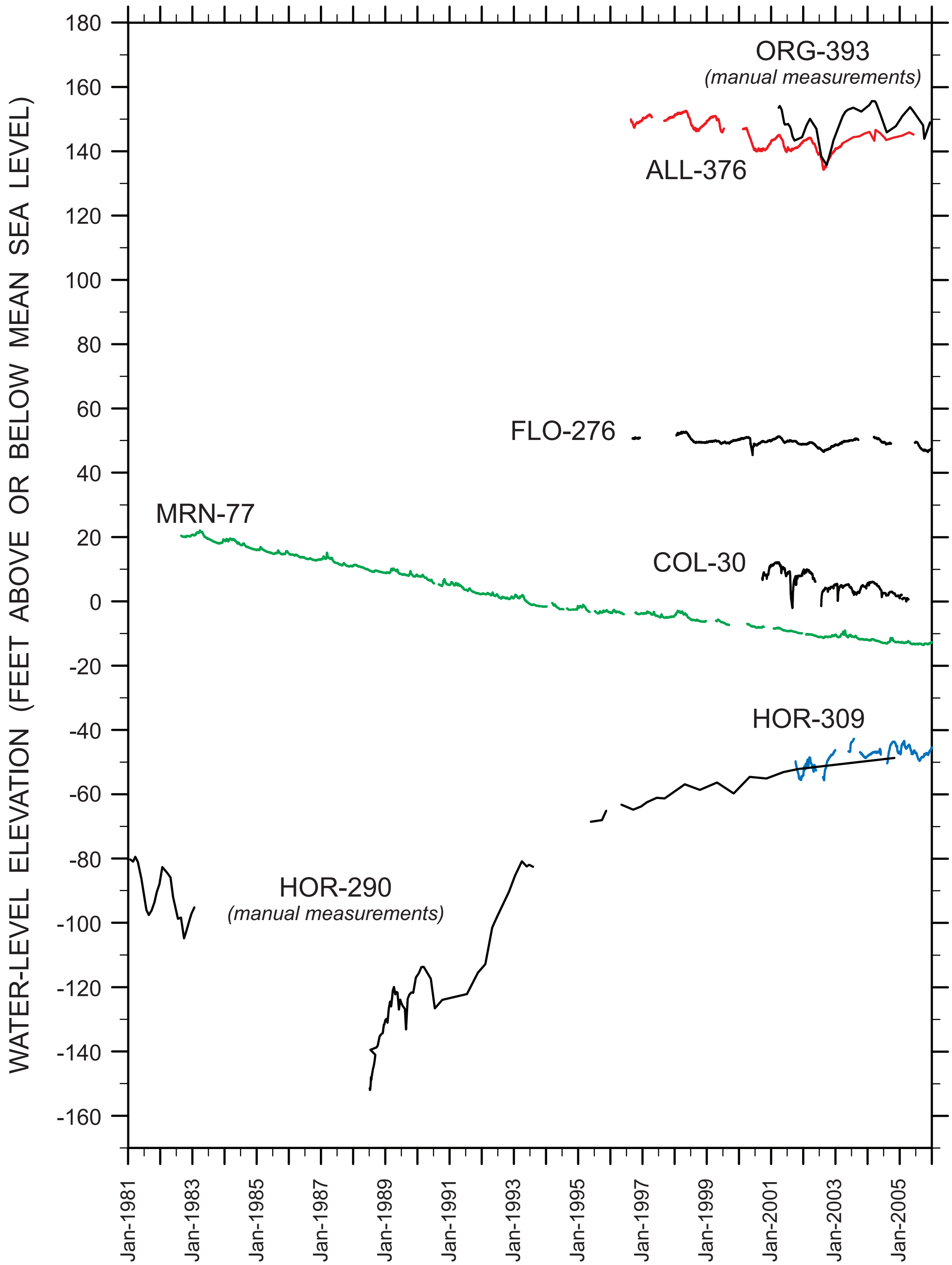
Table showing water-level elevations during November 2004 in wells completed in the Black Creek aquifer in South Carolina (continued)

Well number	Grid number	Latitude, in degrees, minutes, and seconds *	Longitude, in degrees, minutes, and seconds *	Water level elevation above or below (-) mean sea level, in feet *	Change in water level from 2001 to 2004, in feet
CAL-2	27U-q2	333323	804304	120.7	4
CAL-49	28T-t2	333646	804507	105.5	3
CHN-16	17DD-v1	324531	795122	5.3	
CHN-182	12Y-l1	331203	792608	-26.6	-4
CLA-32	22T-b1	333906	801649	105.4	3
CLA-33	22T-b2	333904	801649	89.2	
CLA-36	23U-d1	333451	802341	96.1	
COL-30	27CC-j1	325345	804040	49.0	0
DAR-98	19M-y2	341010	800402	158.6	3
DAR-118	15L-o3	341717	794449	106.4	5
DIL-28	10L-a1	341946	791553	57.0	19
FLO-35	16M-u2	341008	794535	-14.1	
FLO-85	18I-i1	340806	795631	107.9	
FLO-114	18P-s1	335606	795601	63.7	-2
FLO-147	13P-d1	335934	793328	10.1	
FLO-207	16O-m2	340210	794720	38.0	-1
FLO-276	16Q-s2	335122	794600	2.5	-5
FLO-298	16M-w6	341020	794720	-45.5	
GEO-77	10W-c1	332415	791735	-124.9	-4
GEO-80	7U-q2	333158	790322	-58.2	7
GEO-85	10V-i2	332830	791643	7.4	1
GEO-86	10X-d2	331947	791842	-118.9	34
GEO-87	8V-j1	332846	790557	-82.5	20
GEO-131	7U-i3	333346	790143	-61.8	-3
GEO-153	9W-q2	332148	791342	-95.0	2
GEO-188	12W-r1	332143	792742	-145.3	-14
GEO-193	13V-o2	332729	793451	-139.7	14
GEO-233	11Y-e3	331459	792332	-71.6	-5
GEO-249	9T-e1	333946	791447	-43.1	-2
HOR-225	9P-c2	335955	791208	4.3	-2
HOR-246	4R-y1	334518	784922	-43.3	0
HOR-269	3R-n4	334747	784357	-40.1	11
HOR-290	6S-v2	334014	785623	-48.7	3
HOR-303	7Q-w1	335009	790232	-12.8	2
HOR-304	5S-q2	334140	785353	-55.5	5
HOR-307	7Q-x2	335058	790327	-22.7	1
HOR-309	6R-q3	334607	785803	-44.8	10
HOR-311	2Q-p5	335123	783927	0.3	11
HOR-315	2Q-m3	335230	783710	2.7	11

Table showing water-level elevations during November 2004 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 above or below (-) mean sea level, in feet *	Change in water level from 2001 to 2004, in feet
HOR-319	7S-l1	334239	790123	-40.8	1
HOR-335	3R-b2	334900	784154	-23.6	-2
HOR-339	4R-l1	334705	784605	-29.8	1
HOR-346	3Q-r1	335102	784218	-14.5	8
HOR-485	5O-g2	340327	785329	19.4	0
HOR-673	7T-h2	333823	790221	-48.0	1
HOR-739	5S-i8	334303	785136	-63.9	-8
HOR-752	3R-o7	334752	784525	-43.8	-7
HOR-977	7N-j2	340824	790048	23.1	-26
MRN-9	11M-p2	340957	792430	-22.6	2
MRN-77	10Q-p1	335142	791950	-12.7	-2
ORG-385	31W-l6	332208	810151	153.4	9
ORG-388	31W-s3	332149	810203	149.4	16
ORG-393	29U-v1	333030	805154	147.8	
SUM-133	23Q-r6	335152	802247	103.2	-3
SUM-288	21P-c3	335909	801248	-5.0	-5
SUM-322	24O-v7	340055	802606	190.0	
WIL-11	16S-y1	333956	794945	0.8	-14
WIL-20	16S-f1	334030	794935	-9.8	-7
WIL-64	18U-e4	333431	795926	60.5	-3

* Latitude and longitude locations for wells are generally estimated from topographic maps, unless surveyed or located by global positioning system.



Hydrographs of selected wells

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 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 Marion, Sumter, southern Georgetown, and northern Florence Counties. The lowest point on the potentiometric map, -145 ft msl, is west 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). 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. Historical water-level trends in seven Black Creek aquifer wells are shown on the hydrographs.

The worst multiyear drought on record, from June 1998 through August 2002, caused significant effects on hydrologic conditions in South Carolina. Historical low flows were recorded in 2001 for numerous regulated and unregulated streams (Kiuchi, 2004). Many of the large lakes, originally built for hydroelectric power or flood control, were at their lowest levels near the end of the drought: some were substantially below desired operating levels (Gellici and Badr, 2004). Water levels in selected Coastal Plain wells averaged declines of 8.7 ft (Gellici and Harwell, 2004) as a direct result of this meteorological event or, indirectly, because of increased ground-water pumping in response to the rainfall and surface-water deficit.

The lowest point on the potentiometric surface is -145 ft msl (GEO-188), is 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 200 ft. On the southern flank of the cone, water levels declined 4 to 14 ft between 2001 and 2004 (BRK-89, CHN-182, GEO-188, and GEO-233). In the west, near Andrews, water levels recovered 14 ft (GEO-193). Along the coast, water levels recovered 2 to 34 ft in this period. Public water supplies for the city of Georgetown and the Waccamaw Neck area of Georgetown County are obtained from the Pee Dee and Waccamaw Rivers, and wells serve as backup sources. Ground-water pumpage for Georgetown County declined from 3.48 to 2.85 mgd (million gallons per day) from 2001 to 2004, according to Bristol (2003) and Childress and Bristol (2005).

The greatest change in water levels in Horry County occurred near Green Sea, where a decline of 26 ft was found in HOR-977 from 2001 to 2004. Most coastal wells showed recoveries ranging from 1 to 11 ft. Exceptions to this are HOR-335, HOR-739, and HOR-752, with declines ranging from 2 to 8 ft. The hydrograph for HOR-309 shows that water levels varied as much as 13 ft during this period. Since 1988, when most of the 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 was nearly the same in 2004 as in 2001 (Bristol, 2003; and Childress and Bristol, 2005).

Black Creek water levels in northern Marion County have declined from predevelopment levels 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 -22 ft msl and had recovered 3 ft since 2001. The Marco Rural Water Company and the city of Marion pump water from both aquifers, and combined pumpage by the utilities averaged 3.5 and 2.9 mgd in 2000 and 2005, respectively (Newcome, 2000; and Newcome, 2005). 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 2 ft to -13 ft msl between 2001 and 2004 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 57 ft.

In Florence County the center of a cone of depression about Florence is defined by FLO-35, with a water level of -14 ft msl. In the southern part of the county, water levels declined between 1 and 5 ft (FLO-114, FLO-207, and FLO-276).

Water-level declines in Sumter County are a result of pumping in and around the city of Sumter. Water levels in SUM-133 and SUM-288 have declined 3 and 5 ft since November 2001. At -5 ft msl, the water level at SUM-288 is 165 ft below predevelopment levels (Cooke, 1936). Average ground-water withdrawal from the Black Creek and Middendorf aquifers in 2005 exceeded 15 million gallons per day at Sumter (the State's largest municipal ground-water user) and the nearby High Hills Water District (Newcome, 2005). 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 exists about the city, although it is not delineated by the data distribution.

In Kingstree, water levels in wells declined 7 to 14 ft between 2001 and 2004. Water levels in WIL-64, in southwestern Williamsburg County, declined 3 ft in the same period. Ground-water pumpage in the county increased by about 0.3 mgd from 2001 to 2004 (Bristol, 2003; and Childress and Bristol, 2005). A cone of depression about Johnsonville, evident in 1995, is not discernible in 2004 data because of the loss of observation points near Johnsonville.

Water-level changes in Aiken and Barnwell Counties between 2001 and 2004 were inconsistent, because water levels in this region are sensitive to rainfall and pumping. Changes ranged from –3 to 7 ft with an average of –0.2 ft in Aiken County and from –4 to 3 ft with an average of 0.3 ft in Barnwell County. Ground-water users in Aiken and Barnwell Counties pumped 18.83 and 2.78 mgd, respectively (Childress and Bristol, 2005) from Cretaceous aquifers in 2004. The extent to which pumping affects water levels is not discernible from the 2004 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.

ALL-376 shows the minimum water level for the period of record of 135 ft msl during early September 2002 with a recovery of 9 ft by late 2004 (Agerton and others, 2007). Water levels in two wells (ALL-367 and ALL-369) in northwestern Allendale County are at nearly the same levels as in late 2001.

Water levels in two wells, ORG-385 and ORG-388, in southwestern Orangeburg County, show recoveries of 9 to 16 ft. Ground-water pumpage in this area is used for power-generation cooling purposes when surface-water sources are inadequate. Recoveries in water level may reflect diminished pumpage resulting from improved surface-water conditions following the end of the drought period in 2002. The hydrograph for ORG-393 shows the lowest water level for the period of record (136 ft msl) in September 2002, with a recovery of about 12 ft by late 2004.

Water level in the Black Creek aquifer at Walterboro remained unchanged, according to data for COL-30. The water level in this well in November 2001, at 49 ft msl, had declined 2 ft from November 1995.

There is a need for additional observation wells in several areas of the Coastal Plain. In constructing this map, several cones of depression are each defined by only one well (Florence and Sumter) or inferred from historical data and water-use data (Marion). Some counties either had no observation wells (Beaufort, Dorchester, Hampton, and Jasper) or only one (Bamberg, Berkeley, Charleston, and Colleton). The northern and western boundaries of the cone of depression in southern Georgetown County are poorly known because of a paucity of observation wells. Lastly, the extent to which North Carolina or Georgia ground-water pumping 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 137 wells measured during late 2004, shows that the generally southeastward ground-water flow is affected by potentiometric lows around Andrews and Georgetown, Florence, Marion, and Sumter.

Historical data show that water levels are stable near the aquifer’s outcrop area and that fluctuations have occurred in areas influenced by pumping. Near the outcrop, wells have recovered since the cessation of a severe drought in 2002. The cone of depression in southern Georgetown County, where water levels have declined as much as 200 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 number 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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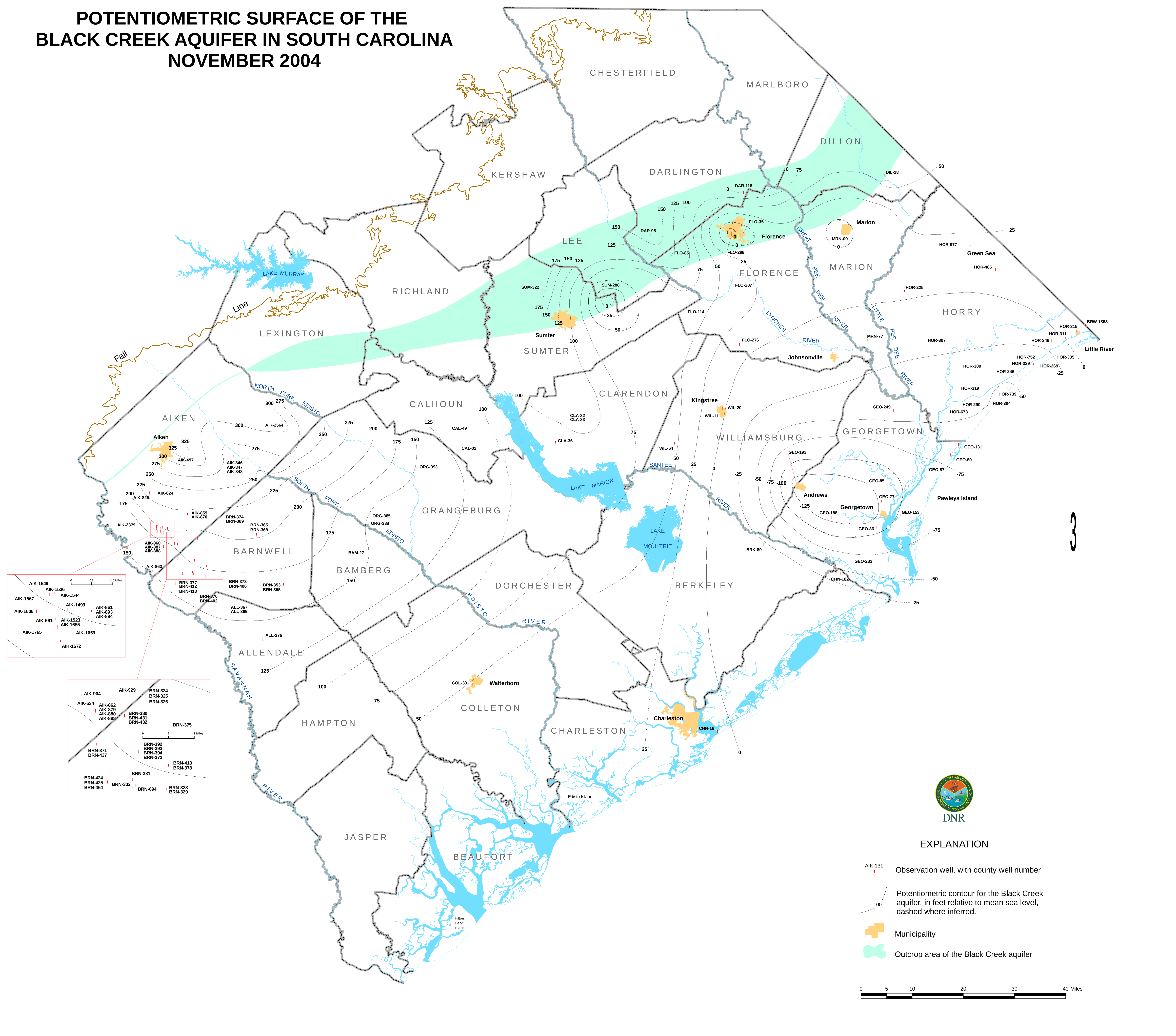
POTENTIOMETRIC SURFACE OF THE BLACK CREEK AQUIFER IN SOUTH CAROLINA NOVEMBER 2004



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