

# Water-level Trends in Aquifers of South Carolina

S.V. Harder<sup>1</sup>, J.A. Gellici<sup>1</sup>, A. Wachob<sup>1</sup>

---

AUTHORS: <sup>1</sup>South Carolina Department of Natural Resources, Columbia, SC, 29201, USA

REFERENCE: Proceedings of the 2012 South Carolina Water Resources Conference, held October 10-11, 2012 at the Columbia Metropolitan Convention Center

---

**ABSTRACT.** Ground-water levels are examined to document and evaluate short- and long-term trends observed in each of the major aquifers in the State. Data are compiled from ground-water monitoring networks maintained by the South Carolina Department of Natural Resources (SCDNR), the South Carolina Department of Health and Environmental Control (DHEC), and the United States Geological Survey (USGS). The data are used in the support of ground water management and allocation, assessment of droughts, ground-water flow modeling, and resource assessment. Hydrographs from approximately 170 wells are reviewed with periods of record ranging from 1 to 56 years.

Water levels across most of the State were affected by droughts occurring from 1998-2002 and from 2007-2008. In the Piedmont, water-level declines varied substantially from 1 to 2 ft to over 10 ft during these drought periods. Though water levels typically returned to baseline levels in many wells, several sites experienced little to no recovery with overall downward trends of 10 to 12 ft over the past twelve years.

Middendorf aquifer levels in eastern Berkeley County have declined by approximately 55 ft since the early 1990s. In southern Florence County and southern Lexington County, water levels have declined by approximately 10 ft in the Middendorf aquifer with little to no recovery after the 1998-2002 and 2007-2008 droughts. Similar declines are noted in the Middendorf aquifer in Aiken, Allendale, and Barnwell Counties, where water levels have dropped 3 to 10 ft since the mid-1990s.

In the Black Creek aquifer, water levels in southern Marion County and southern Florence County have declined by 40 ft and 16 ft over their respective periods of record. In Aiken, Allendale, and Barnwell Counties, water levels have dropped 4 to 12 ft in the Black Creek aquifer since the mid-1990s, similar to declines observed in the Middendorf aquifer in these counties.

Water levels in the Tertiary Sand aquifer have declined 6 to 15 ft in Allendale and Barnwell Counties since the mid-1990s, similar to patterns observed in the Middendorf and Black Creek aquifers in these counties. This pattern suggests that aquifers have not fully

recovered to levels observed before the 1998-2002 drought.

Floridan aquifer water levels have experienced a leveling off or a slight recovery during the past ten years after steady declines throughout the 1970s and 1980s at several wells sites in Beaufort County. Observations in southern Colleton County and southern Charleston County indicate water-level declines in the Floridan aquifer of about 8 and 12 ft, respectively, since 2000. Observations in central Charleston County indicate a decline of about 20 ft since the early 1980s, while observations in northern Colleton County indicate a decline of about 20 ft since the late 1970s.

## INTRODUCTION

The South Carolina Department of Natural Resources (DNR) routinely collects ground-water level data for water-resource assessments and for management and planning purposes. These data are used to identify short- and long-term changes in ground-water levels and storage due to changes in withdrawals, recharge rates, and climatic conditions; to calibrate ground-water flow models; and to determine regional hydraulic gradients and ground-water flow rates and directions of the major aquifers. DNR's base ground-water monitoring network currently includes approximately 110 wells (Figure 1). Water levels of 64 wells are measured hourly with automated data recorders (ADRs); the remaining wells are measured periodically typically on a bimonthly basis, using an electric measuring tape. Most monitoring wells have been measured since the mid-to-late 1990s, although a number of wells existed before then, one dating back to 1955.

Recent multi-year droughts from 1998-2002 and 2007-2008 have highlighted the importance of long-term ground-water level data in the assessment of ground water resources. The potential for significant increases in ground water use for agricultural and golf course irrigation, industry, energy production, and public water supply over the next several decades further stresses the need for long-term ground-water level monitoring.

The DNR well network is part of a collaborative monitoring effort with the Department of Health and Environmental Control (DHEC) and the United States Geologic Survey (USGS). The goal of this cooperative effort is to develop and maintain a statewide ground-water monitoring network that provides scientifically defensible information for use in planning, managing, and developing South Carolina's ground-water resources in a responsible and sustainable manner for all current and future users. DHEC currently maintains 40 continuous ground water level monitoring sites, while the USGS maintains 21 sites.

The background and methods described in this study are for the DNR monitoring network. Ground water level trends are discussed mainly for those wells in the DNR network; however, several USGS sites are referenced as well. The periods of record for wells in the DHEC network only range from 1 to 4 years, and hence, are too short to adequately evaluate trends. Wells sites for all three agencies are illustrated in Figure 1.

## RELATED WORK

DNR has published a series of reports documenting ground-water level data collected from the DNR monitoring network. Harwell and others (2004) documents water-level data collected from 56 wells during the period from 2000 through 2001. Agerton and others (2007) contains water-level data collected from 69 wells during the period from 2000 through 2005. Other ground-water level compilations include intermittent and periodic water-level measurements of 16 Piedmont province wells and 266 Coastal Plain province wells by Waters (2003). That report represents 282 hydrographs and is the most extensive compilation of historical South Carolina ground-water level data to date. Hydrograph records range from 6 to 50 years, and about one-third of the record sets span periods greater than 20 years. Gellici and others (2004) published selected ground-water data illustrating the effects of the 1998–2002 drought. More recently, Harder and others (2012) published ground-water level data for 109 wells for the period from 2006 through 2010 and also reviewed ground-water level trends for the all the major aquifers in the state.

## METHODS

### *Well Numbering Systems and Hydrogeologic Framework*

Wells are identified by a county well number. The county well number consists of a county-name abbreviation and a sequential number that is assigned by the DNR in coordination with the USGS. For example, HAM-0050 represents the fiftieth well inventoried by the DNR in Hampton County.

The hydrogeologic framework used in this report is that of Aucott and others (1987). Aucott divided the Coastal Plain sedimentary sequence into six aquifers, which in ascending order are: Cape Fear, Middendorf, Black Creek, Tertiary sand, Floridan, and shallow aquifer system. In 1995, Aadland and others presented a detailed hydrogeologic characterization of the Coastal Plain sequence at the Savannah River Site (SRS) and surrounding area that resulted in a revised hydrogeologic framework and a new hydrostratigraphic nomenclature for west-central South Carolina (Aadland and others, 1995). Aquifers and confining units were named after local geographic features near type-well localities and the previous aquifer names, which were based on geologic formations, were abandoned at SRS. This revised framework and new nomenclature were extended across the rest of the Coastal Plain in the report *Groundwater Availability in the Atlantic Coastal Plain of North and South Carolina* (Campbell and Coes, 2010) in a chapter entitled *Hydrogeologic Framework of the Atlantic Coastal Plain, North and South Carolina* (Gellici and Lautier, 2010). For this report, the names and framework of Aucott and others (1987) continue to be used, but wells are also assigned to aquifers using the new framework and nomenclature described by Gellici and Lautier.

Aquifers in the Piedmont and Blue Ridge provinces of the state are classified as crystalline rock or shallow aquifer system. The shallow aquifer system is further differentiated as saprolite or alluvium.

### *Data Collection*

Ground-water level data are presented in feet above or below land surface and measurements and sensor settings are made relative to a specified measurement point. Most of the land-surface and measuring-point elevations were surveyed from USGS or South Carolina Geodetic Survey benchmarks and are reported to the nearest tenth or hundredth of a foot using the National Geodetic Vertical Datum of 1929 (NGVD29). Elevations at the remaining sites were taken from USGS topographic maps and estimated to the nearest foot, and are considered accurate to one-half the map contour interval. Well locations were determined with the Global Positioning System (GPS) using the North American Datum of 1983 (NAD83).

Manual measurements typically are made with electric tapes, which are capable of an accuracy of 0.01 ft (feet). However, visibility, thermal expansion and contraction, and tape sinuosity diminish measurement accuracy in field conditions, and accuracies, therefore, are assumed to be no better than 0.05 ft in practice. Flowing artesian wells are manually measured with 0–30, 0–60, or 0–100 psi (pounds per square inch) range



Bourdon-type test gages. The gages are calibrated annually by a commercial testing laboratory and are rated to 0.25 percent of their respective measurement ranges.

Water-level sensors used for automated monitoring stations include shaft encoders and pressure transducers whose readings are calibrated to manual measurements. Shaft encoders measure depth to water and have a rated accuracy and resolution of 0.01 ft. The sensor reading is set in reference to a manual tape measurement; however, well plumb, casing joints, and cable disturbances can affect subsequent readings. Measurements within 0.10 ft of a concurrent manual measurement are accepted, along with the corresponding records. Pressure transducers measure the height of water above the sensor. The sums of the transducer measurement (depth above probe) and corresponding taped measurement (depth to water) recorded at each site visit have been compared to determine transducer performance. Where the sum of measurements was found to differ by 0.2 ft from previous measurements, a potential instrument fault may have existed, but no record correction was applied. Where the specifications were exceeded repeatedly, either instruments were recalibrated or instrument failure was confirmed. If failure was confirmed, the transducer was replaced and the associated records were excluded from the hydrograph.

Logged measurements are stored in both raw-data and processed-data tables. The raw-data table contains uncorrected hourly measurements and reflects the readings and the performance of various sensors as they were originally stored in data loggers. Raw data are stored mainly “as is” and are archived at DNR for insight into hardware conditions and for quality assurance. Processed-data tables are corrected for barometric pressure, where appropriate, and are winnowed of measurement anomalies and hardware failures. Average daily water level is calculated for each day having 17 or more hourly measurements. Ground water data presented in this report are daily averaged values. Ground-water data and statistics are available on the DNR website at <http://www.dnr.sc.gov/water/hydro/groundwater/index.html>. Additional information on the ground water monitoring network can be found in Harder and others (2012).

## RESULTS

### *Crystalline Rock Aquifer*

Hydrographs for most wells in the Crystalline Rock aquifer show noticeable seasonal fluctuations, which can range from 1 ft in AND-0326 (Figure 2) to 16 ft in SAL-0069. Significant declines in water levels due to the multi-year droughts of 1998-2002 and 2007-2008

are observed in some wells such as CRK-0074, GRV-3342, and LRN-1706, but declines are less severe in other wells such as GRV-2543, GRV-3335, and AND-0326. Most sites in the DNR network have recovered from the effects of these droughts and little to no long-term declines are observed; however, MCK-0052 and SPA-1585, both maintained by the USGS, have experienced long-term declines of over 10 ft and 15 ft, respectively, over their 18-year periods of record.

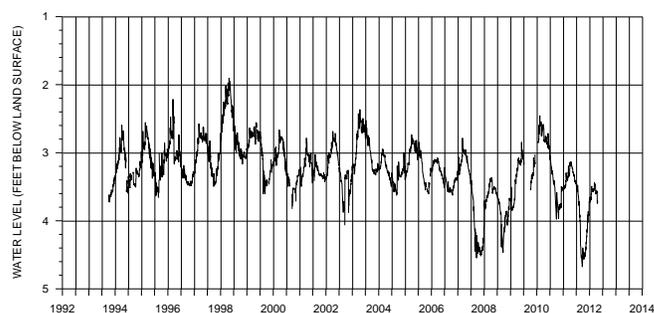


Figure 2. Daily average water levels for AND-0326 (Crystalline Rock aquifer).

### *Middendorf*

In southern Florence County, the water level in the Middendorf aquifer has steadily dropped about 10 ft over the past ten years at well FLO-0274 (Figure 3) in Lake City. In southern Lexington County, the water level in the Middendorf declined about 10 ft during the 1998–2002 drought, leveled off after the drought, and has yet to fully recover to pre-drought levels. Similar declines are noted in the Middendorf aquifer in Aiken, Allendale, and Barnwell Counties, where water levels have dropped 3 to 10 ft since the mid-1990s (AIK-0845, ALL-0347 and BRN-0349, for example).

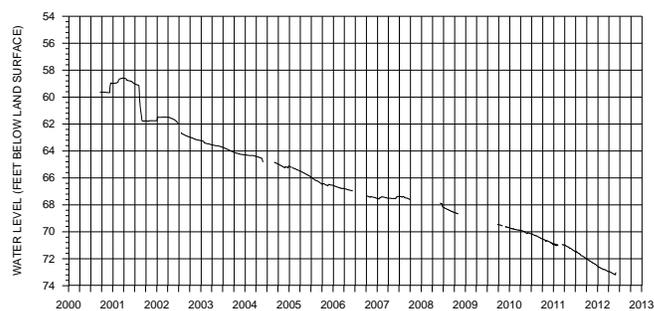


Figure 3. Daily average water levels for FLO-0274 (Middendorf aquifer).

Well BFT-2055, at Hilton Head Island, is screened in both the Cape Fear and Middendorf aquifers; measurements therefore reflect composite water levels. They are presumed to more closely reflect Middendorf

water levels, owing to that system's greater thickness and hydraulic conductivity. Consequently, BFT-2055 measurements are presented with Middendorf aquifer data. Water levels in wells BFT-2055 and JAS-0426 have been declining over the past 10 years, by 28 ft in BFT-2055 and by about 12 ft in JAS-0426. BRK-0431, a well maintained by the USGS, has experienced a decline of approximately 55 ft since 1990.

In well FLO-0128, the water level has been recovering since August 1999 when it hit an all-time low of 92.07 ft below land surface. By 2010, the water level recovered to 41.24 ft bls, as the City of Florence continues to supplement its ground-water supply with surface water from the Pee Dee River.

In Lee, Darlington and Richland Counties (RIC-0543, RIC 0585, DAR-0228, and LEE-0075) water levels have experienced little to no long-term decline over the past 10 to 15 years. Seasonal fluctuations are observed in the data from wells in these counties as well as drawdowns from the severe droughts from 1998-2002 and from 2007-2008. Water levels returned to baseline levels after each of these two droughts.

### Black Creek

The water level in well MRN-0077 (Figure 4), located at Britton's Neck, steadily declined about 40 ft from 1993 to 2010. Well FLO-0276, in Lake City, has seen its water level drop 16 ft from 2001 to 2010. In Aiken, Allendale, and Barnwell Counties, water levels have dropped 4 to 12 ft in the Black Creek aquifer since the mid-1990s (AIK-0847, ALL-0367 and BRN-0355, for example), similar to declines observed in the Middendorf aquifer in these counties.

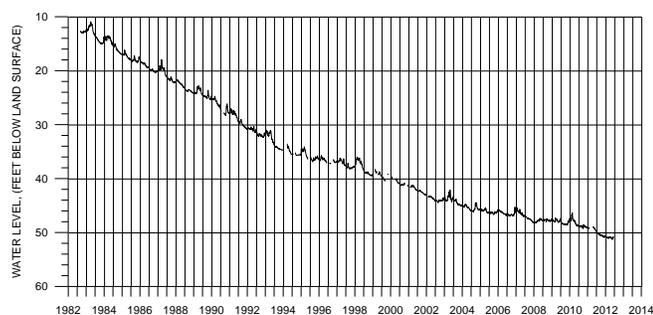


Figure 4. Daily average water levels for MRN-0077 (Black Creek aquifer).

Water levels in COL-0030 have experienced declines of approximately 4 ft from 1996 to 2010, while maintaining noticeable seasonal fluctuations. Water levels at ORG-0393 have seen long-term declines of only 1 to 2 ft since 2001, but the water levels exhibit strong seasonal fluctuations ranging from 8 to 20 ft.

### Tertiary Sand

Water levels in the Tertiary sand aquifer have declined about 6 to 15 ft in Allendale and Barnwell Counties since the mid-1990s (ALL-0375-Figure 5 and BRN-0360, for example), similar to patterns observed in the Middendorf and Black Creek aquifers in these counties. This pattern suggests that aquifers have not fully recovered to levels observed before the 1998–2002 drought. Water levels at HAM-0050 have experienced little to no long-term decline since 2001 and although noticeable declines due to the severe droughts of 1998-2002 and 2007-2008 are evident, water levels have returned to baseline levels.

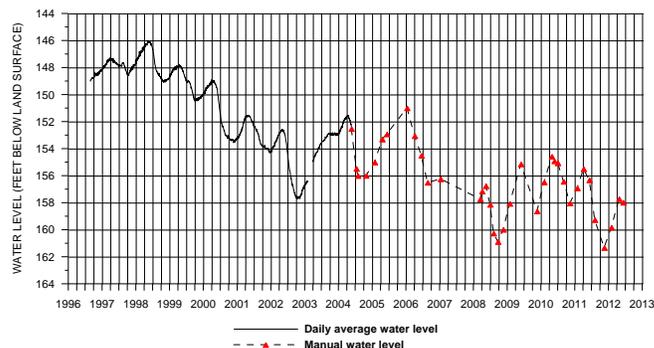


Figure 5. Daily average water levels for ALL-0375 (Tertiary Sand aquifer).

### Floridan

Water levels in BFT-0101 (Figure 6) have shown a slight recovery during the past ten years after a steady decline throughout the 1970s and 1980s; however, seasonal fluctuations have increased from 1 to 2 ft to 4 to 9 ft during the same period. Well BFT-0429 has seen overall water levels remain steady after a decline of approximately 5 ft during the 1970s and 1980s. Similar to BFT-0101, the magnitude of seasonal fluctuations in this well has increased from 1 to 2 ft to 5 to 7 ft during the past several decades.

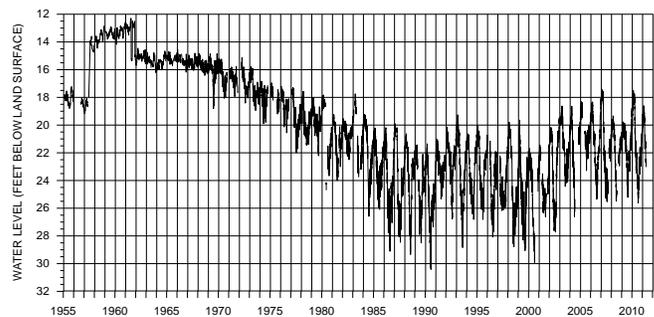


Figure 6. Daily average water levels for BFT-0101 (Floridan aquifer).

Wells COL-0301 and CHN-0484, both located near Edisto Beach, have seen water-level declines of about 8 and 12 ft, respectively, since 2000. The water level in well CHN-0044 has declined about 20 ft since the early 1980s, and well COL-0097 has seen a decline of about 20 ft since the late 1970s.

## DISCUSSION

Long term ground-water level declines have been observed in each of the major aquifers in the state. These declines are likely a result of both drought and ground water pumping. Many well sites experienced a strong response to the multi-year droughts of 1998-2002 and 2007-2008. However, while some wells experienced a recovery after these droughts, other well sites did not.

There are many challenges for the State's water managers in the interpretation of ground-water level data throughout the state. First, water-level declines can be caused by drought and/or localized pumping for water supply and irrigation as well as from the cumulative effects of pumping over broader regions. In addition, uncertainties in recharge areas and recharge rates for the State's aquifers add to the complexity of understanding ground water level behavior. Many of the wells in the network have only been monitored for 10 to 15 years and, hence, may lack a sufficient period of record from which to adequately evaluate trends. Lastly, despite having over 170 continuously monitored wells by DNR, DHEC and the USGS, large areas of the state, particularly the middle coastal plain, currently have little to no continuous monitoring.

These challenges make it difficult to evaluate the significance of these observed water-level declines; however, these trends highlight the importance of maintaining a state ground-water monitoring network and the establishment of long-term ground-water datasets. Future work should include adding wells in those aquifers and areas of the State where current monitoring is poor or nonexistent. In addition, a more detailed study on ground-water level trends should be completed that takes into account climate variability and local/regional ground-water use. Such a study is needed to differentiate the effects of drought and ground-water pumping on water level behavior.

## LITERATURE CITED

Aadland, R.K., Gellici, J.A., and Thayer, P.A., 1995, Hydrogeologic framework of west-central South Carolina: South Carolina Department of Natural Resources, Water Resources Division Report 5, 200 p.  
Agerton, K.E., Park, A.D., Gawne, C.E., and Wachob, A., 2007, Water resources data for South Carolina,

2000–2005: South Carolina Department of Natural Resources, Water Resources Report 41, 91 p.

Aucott, W.R., Davis, M.E., and Speiran, G.K., 1987, Geohydrologic framework of the Coastal Plain aquifers of South Carolina: U.S. Geological Survey Water-Resources Investigation Report 85-4271, 7 sheets.

Campbell, B.G., and Coes, A.L., eds., 2010, Groundwater availability in the Atlantic Coastal Plain of North and South Carolina: U.S. Geological Survey Professional Paper 1773, 241 p.

Gellici, J.A., Kiuchi, M., Harwell, S.L., and Badr, A.W., 2004, Hydrologic effects of the June 1998–August 2002 drought in South Carolina: South Carolina Department of Natural Resources, Water Resources Report 34, 49 p.

Gellici, J.A., and Lautier, J.C., 2010, Hydrogeologic framework of the Atlantic Coastal Plain, North and South Carolina, in Campbell, B.G., and Coes, A.L., eds., Groundwater availability in the Atlantic Coastal Plain of North and South Carolina: U.S. Geological Survey Professional Paper 1773, p. 49-162.

Harder, S.V., Gellici, J.A., Gawne, C.E., and Wachob, A., 2012, Ground-water levels in South Carolina, 2006-2010: South Carolina Department of Natural Resources, Water Resources Report 50, 154 p.

Harwell, S.L., Park, A.D., Hockensmith, B.L., and Gawne, C.E., 2004, Water resources data for South Carolina 2000–2001: South Carolina Department of Natural Resources, Water Resources Report 31, 86 p.

Waters, K.E., 2003, Water levels in South Carolina—A compilation of historical water-level data: South Carolina Department of Natural Resources, Land, Water and Conservation Division Report 26, 300 p.

**\*\*\*\*\* Note to Reviewers: Oral presentation will include many more hydrographs.**