Initial Groundwater Assessment: Chesterfield, Clarendon, Kershaw, Lee, Richland and Sumter Counties, South Carolina

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Executive Summary

South Carolina's Groundwater Use and Reporting Act[1] declares that *the general welfare and public interest require that the groundwater resources of the State be put to beneficial use to the fullest extent to which they are capable, subject to reasonable regulation, in order to*:

- *Conserve and protect these resources,*
- *Prevent waste, and to*
- *Provide and maintain conditions which are conducive to the development and use of water resources*.

The Act further states *where excessive groundwater withdrawal presents potential adverse effects to the natural resources or poses a threat to public health, safety, or economic welfare or where conditions pose a significant threat to the long-term integrity of a groundwater source, including salt water intrusion, the board, after notice and public hearing, in accordance with the Administrative Procedures Act, shall designate a capacity use area.*[2] At this time, there are five designated Capacity Use Areas that include 22 of the 28 counties in the Atlantic Coastal Plain (ACP) region of the State—known as the South Carolina Coastal Plain (SCCP).

- Waccamaw: Georgetown and Horry Counties
- Low Country: Beaufort, Colleton, Hampton, and Jasper Counties
- Trident: Berkeley, Charleston, and Dorchester Counties
- Pee Dee: Darlington, Dillon, Florence, Marion, Marlboro, and Williamsburg Counties
- Western: Aiken, Allendale, Bamberg, Barnwell, Calhoun, Lexington, and Orangeburg Counties

Groundwater withdrawers[1] in Capacity Use Areas (CUAs) are required to apply for a groundwater withdrawal permit and report their monthly water use to the Water Quantity Permitting Section (the Department) of the South Carolina Department of Health and Environmental Control (SCDHEC) by January 30th of the following year. Groundwater withdrawers within the SCCP but outside of a Capacity Use Area are required to submit a Notice of Intent to the Department 30 days prior to the construction of any new well and to register their wells and report water use.

Chesterfield, Clarendon, Kershaw, Lee, Richland, and Sumter are the six counties remaining in the SCCP that are not part of one of the five existing Capacity Use Areas are (Figure 1). This report provides an initial assessment of the groundwater conditions in these six remaining SCCP counties as the first step toward designating these counties as the Santee-Lynches Capacity Use Area (proposed Santee-Lynches Area or simply Santee-Lynches Area).

[1] A groundwater withdrawer is defined as a person or entity who withdraws in excess of three million gallons in any one month from a single well or multiple wells under common ownership within a one-mile radius from any existing or proposed well(s). Groundwater Use and Reporting Act, S.C. Code Ann. § 49-5-12.

Introduction

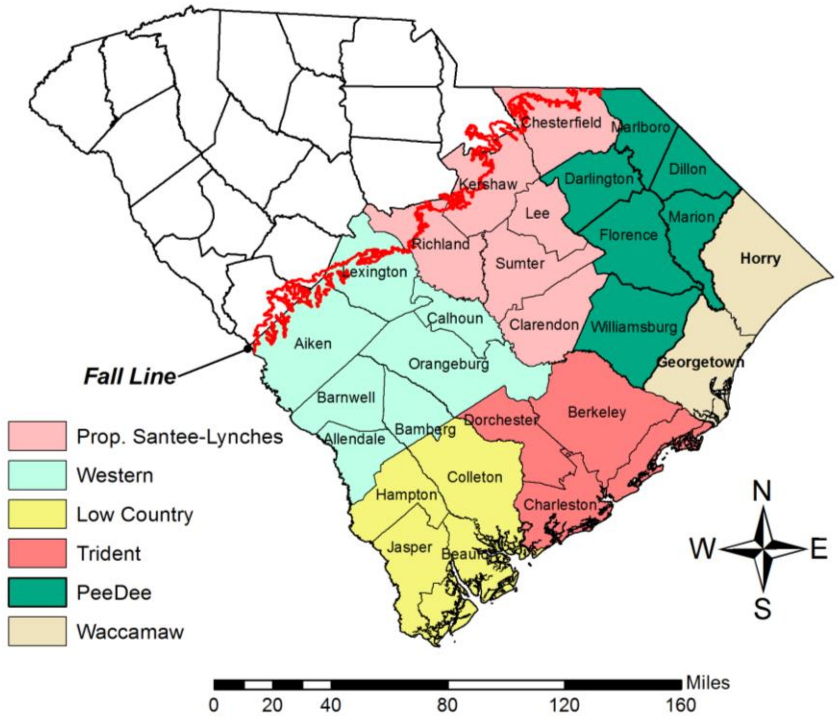


Figure 1: Map of the existing and proposed Capacity Use Areas.

Location, Topography, and Land Use/Cover

The counties in the proposed Santee-Lynches Area are in the northeastern part of the state with Chesterfield County bordering North Carolina and Clarendon County bordering Berkeley County to the south (Figure 1). The topography varies across these counties from the low-relief outer coastal plain through the gently rolling hills of the sandhills region (part of the upper coastal plain at the Fall Line; see the Physiography and Hydrology Section). The total elevation ranges from 25 feet to 720 feet above mean sea level (AMSL).

Chesterfield and Kershaw Counties are largely covered by mixed, deciduous, and evergreen forests (Figure 2). Richland County has the highest concentration of urban/developed land cover reflecting the state capitol of Columbia and the development along SC Highway 1 running to the northeast through Elgin, Lugoff, and Camden in Kershaw County. Cultivated cropland covers a significant portion of Lee, Sumter, and Clarendon Counties.

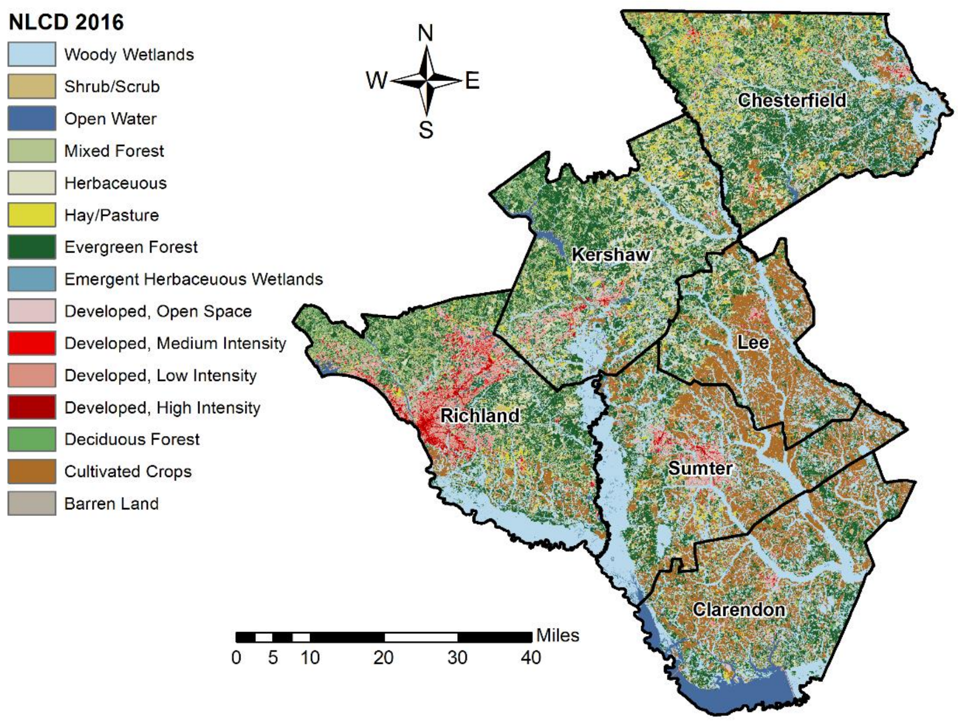


Figure 2: Land Cover from the National Land Cover Database from 2016. Multi-Resolution Land Characteristics Consortium; https://mrlc.gov; accessed February 28, 2020.

Population and Geo-Political Structure

The July 2018 population estimates for the Santee-Lynches Area counties totaled 683,276 (Figure 3). Richland County is the most populous at 61% of this total, and Lee County the least populous at 2%.

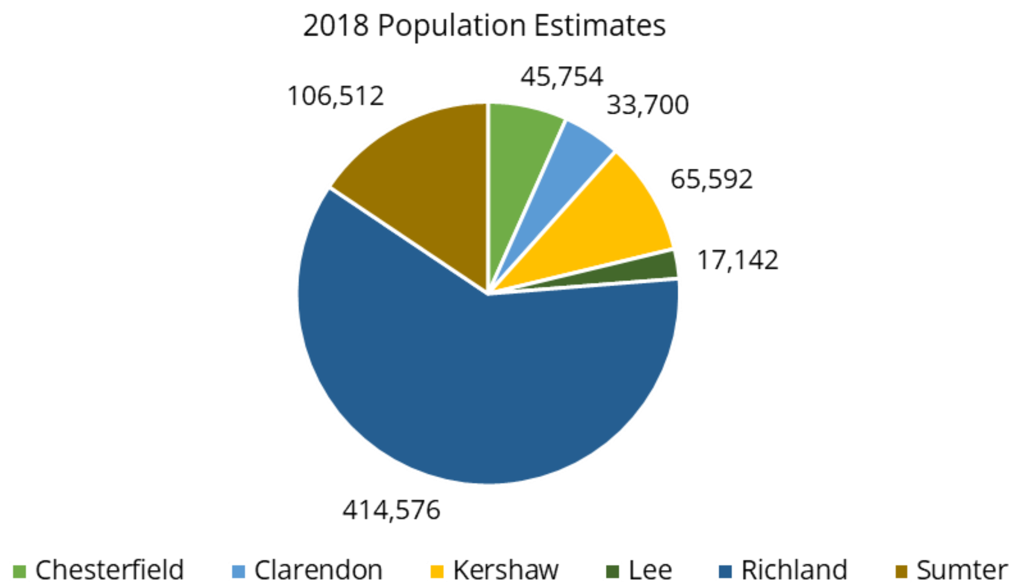


Figure 3: July 2018 population estimates for the proposed Santee-Lynches Area counties. www.census.gov; accessed February 21, 2020.

South Carolina is divided into ten official planning districts known as Councils of Governments (COG). The Mission of the COGs is to "…work collectively to benefit all of South Carolina. We do this by functioning as a valuable extension of county and local governments, serving as a resource for technical assistance, securing state and federal dollars to address critical issues for our communities, and by advocating at a state and national level for economic and quality of life improvements for our state.
Three COGs operate within the proposed Santee-Lynches Area: Chesterfield County is in the Pee Dee Council of Governments (PDCOG), Clarendon, Kershaw, Lee, and Sumter Counties are in the Santee-Lynches Council of Governments (SLCOG), Richland County is in the Central Midlands Council of Governments (CMCOG).

- PDCOG is currently governed by a 27-member Board of Directors from six participating counties and serves 33 incorporated municipalities (8 in Chesterfield County)[3].
- SLCOG is currently governed by a 29-member Board of Directors from four participating counties and serves 12 incorporated municipalities[2].
- CMCOG is currently governed by a 51-member Board of Directors from four participating counties and serves 30 incorporated municipalities including the state capital of Columbia, South Carolina[4].

Chesterfield, Clarendon, Lee and Sumter counties are governed by a Council/Administrator form of government. Kershaw and Richland counties are governed by a Council form of government. Cities, towns, and municipalities in the proposed Santee-Lynches CUA implement various forms of government, including Mayor/Council, Council/Manager, or Council only.

Climate

South Carolina has a humid, sub-tropical climate with summer high temperatures that can exceed 100 degrees and mild winters[5]. Annual averages of temperature and precipitation from long-term meteorological station records across South Carolina are presented in Appendix A, Figures A1 – A3. The record length at each of these stations varies from a few years to more than 100 years[4].

Hydrogeologic Framework

Physiography and Hydrology

The six Santee-Lynches Area counties are diverse in physiography and hydrology resulting from their areal extent within the state. From the northernmost county of Chesterfield to the southernmost county of Clarendon, the Santee-Lynches Area spans three of the four physiographic provinces (Figure 4A). Chesterfield, Kershaw, and Richland Counties cross the Fall Line with portions in the Piedmont and Upper Coastal Plain. Lee and Sumter Counties are divided between the Upper and Lower Coastal Plains, and Clarendon County is entirely within the Lower Coastal Plain.

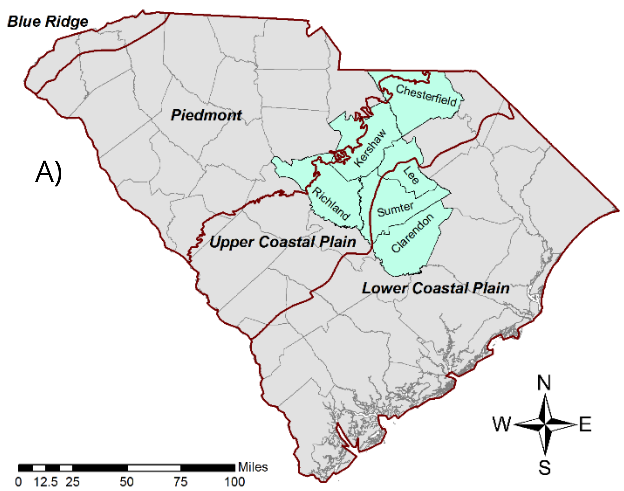


Figure 4: Maps of the proposed Santee-Lynches Area counties in relation to South Carolina's A) Physiographic Provinces and B) Major River Basins. River Basins are simplified from the Hydrologic Unit Code accounting units for the region.

Surface Water

The Santee-Lynches Area is drained by five of the eight major river basins in the northeastern half of the state—the Broad, Catawba, Pee Dee, Saluda and Santee Basins (Figure 4B). Major rivers that pass through or define county boundaries are the Saluda, Broad, Congaree, Wateree, Santee, Lynches, Black, and Pee Dee Rivers. Major lakes in South Carolina are formed by damned river systems, and lakes in this area include Lake Wateree, Lake Murray, Lake Robinson, and Lake Marion (Figure 5). Surface water bodies incise and interact heavily with aquifer systems within the region, especially closest to the Fall Line (Figure 6). In some cases, the incised valleys isolate water-bearing units from the greater regional aquifer(s). The interconnectivity of surface and groundwater in the Santee-Lynches Area is a defining regional characteristic, particulary within the Upper Coastal Plain.

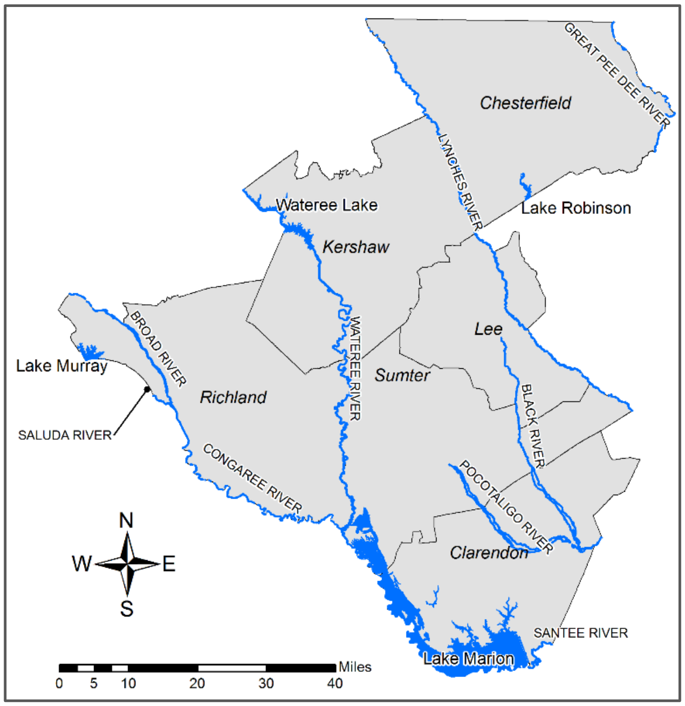


Figure 5: Major Rivers and Lakes of the proposed Santee-Lynches Capacity Use Area.

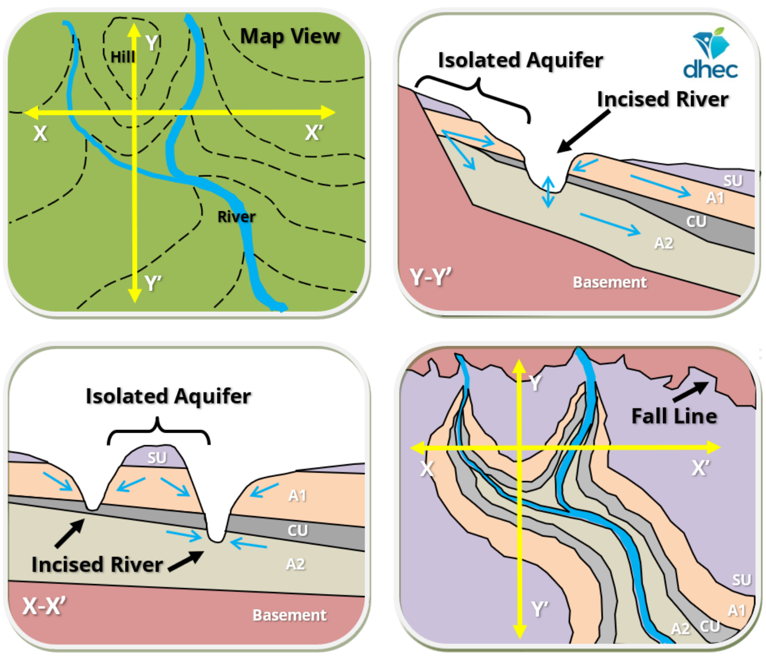
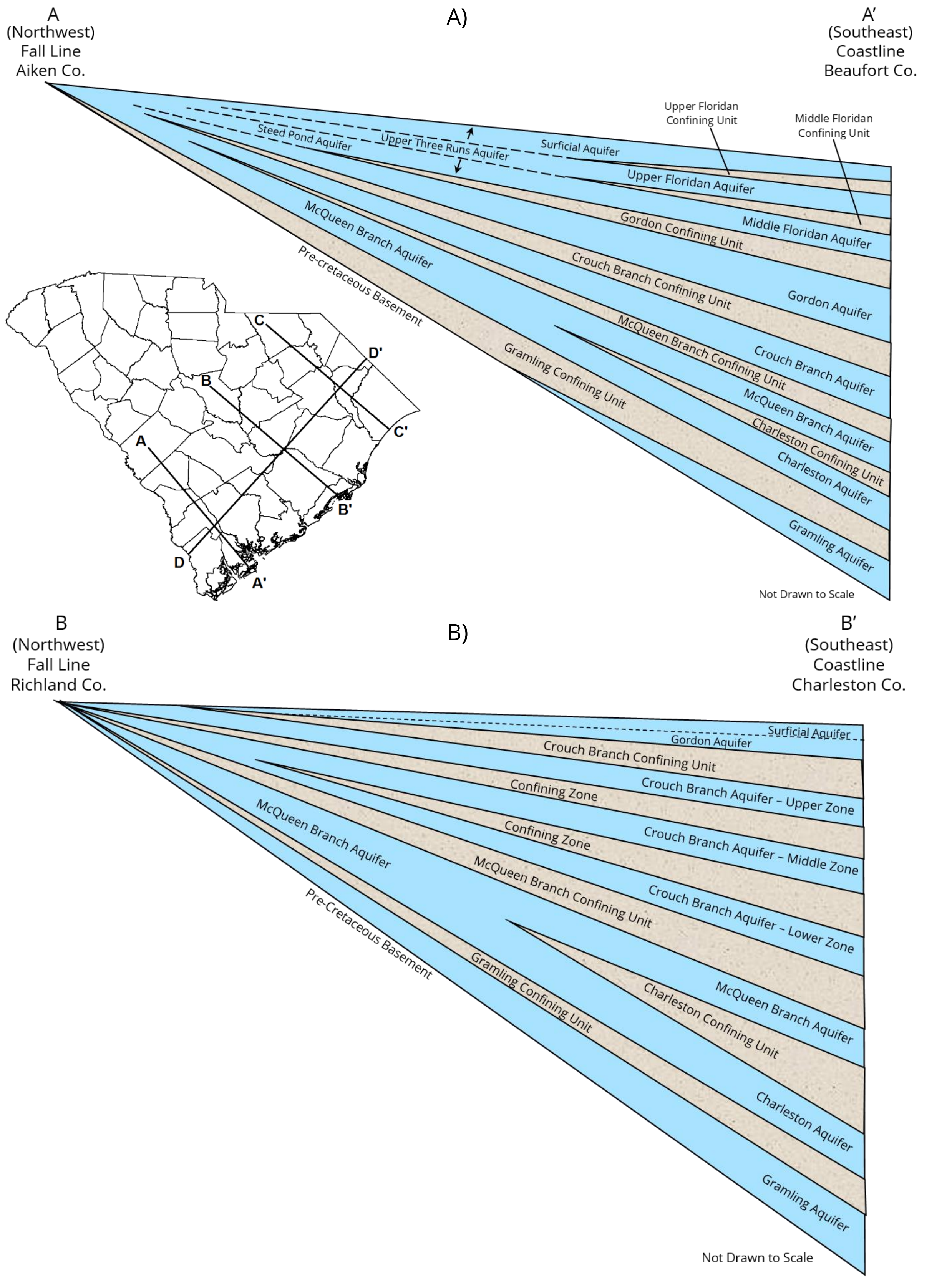


Figure 6: Illustration of the relationship between surface water and groundwater via incised river valleys in the Santee-Lynches Area close to the Fall Line.

Aquifer Characteristics

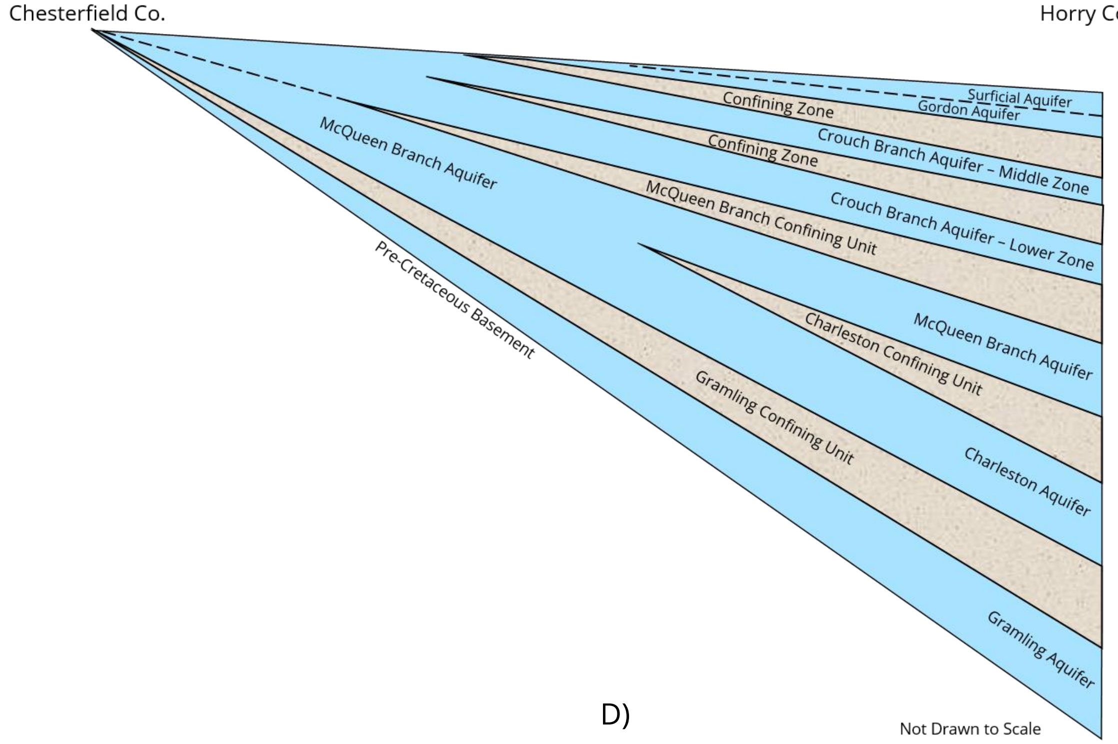
The South Carolina Coastal Plain (SCCP) is part of the larger Atlantic Coastal Plain (ACP) hydrogeologic system containing water-bearing, permeable sand or carbonate rock aquifers alternating with low-permeability confining units, usually consisting of clay or silt. The Fall Line (Figure 1) marks the location where the ACP sediments thin and pinch-out over the crystalline rock of the Piedmont physiographic province. Above the Fall Line, water-bearing zones are within the cracks of the crystalline rock and in thicker sections of weathered rock (regolith) at the surface[5].

The ACP aquifers present beneath the proposed Santee-Lynches area are composed of sediments deposited during the late Cretaceous to Tertiary periods. From oldest to youngest, the Cretaceous units are the Gramling, Charleston, McQueen Branch, and Crouch Branch aquifers. The Tertiary unit is the Gordon aquifer, and the Surficial Aquifer is Quaternary in age (Figure 7). In the proposed Santee-Lynches area, the confining units gradually thin and taper out to the northwest (geologically speaking, "up-dip"). Below Chesterfield County, the McQueen Branch and Crouch Branch aquifers coalesce to form the Dublin-Midville Aquifer System, and below Richland and Kershaw Counties, the Crouch Branch aquifer and surficial aquifer combine and ultimately pinch out at the Fall Line (Figures 7B and 7C). As a result, the aquifers closest to the Fall Line are shallower, more interconnected, and show a greater degree of surface water interaction than those in the southern extent of the proposed Santee-Lynches Area where aquifers are more discrete and separated by confining units[6].



Figures 7A and B: General structure of aquifers and confining units in the South Carolina Coastal Plain. Modified from Campbell, B.G., and A.L. Coes, eds. (2010)[8]. Inset map shows locations of the cross-sections.

C)



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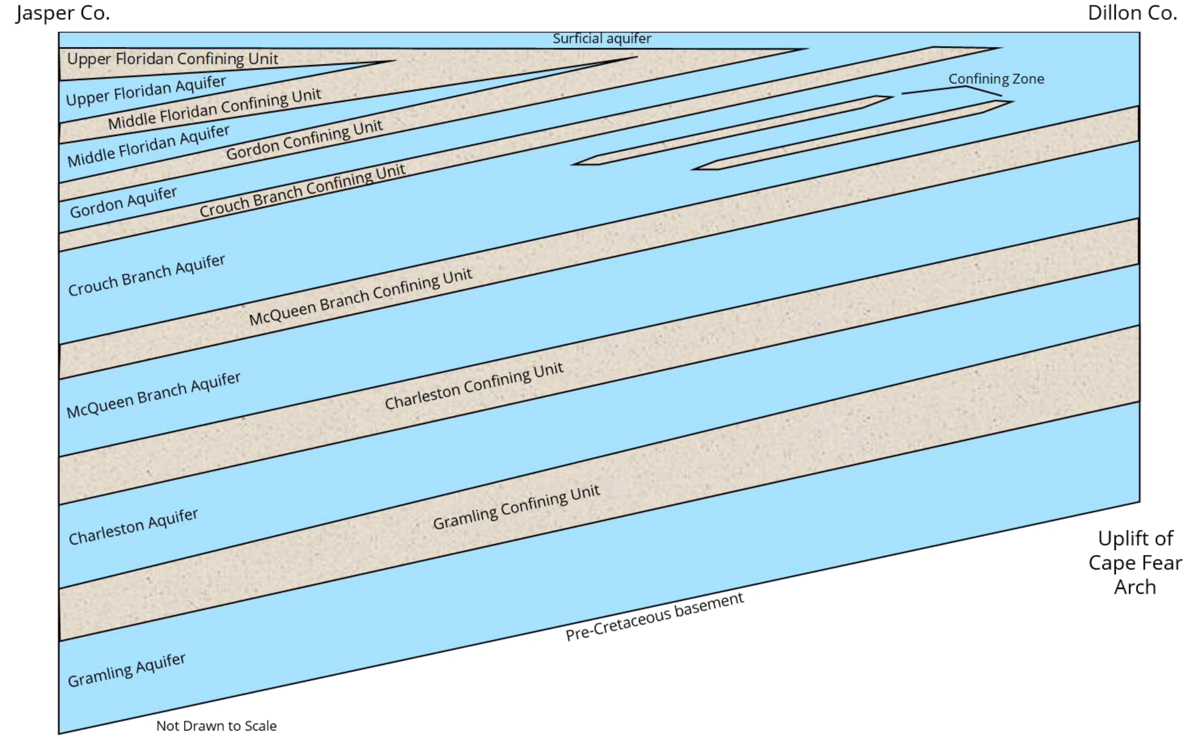


Figures 7C and D: General structure of aquifers and confining units in the South Carolina Coastal Plain. Modified from Campbell, B.G., and A.L. Coes, eds. (2010)[8].

The Piedmont province (Figure 4A) is composed of pre-Cretaceous age rocks with complex depositional, metamorphic, and intrusion histories that are beyond the scope of this report. Weathering of these metamorphic and igneous rocks has produced a layer of unconsolidated sediment of varying thicknesses at the surface (regolith). In contrast to the SCCP aquifers, groundwater in the Piedmont province is found within the cracks and fractures of the rocks as well as in the thicker packages of unconsolidated sediment at the surface[7].

Aquifer Recharge

South Carolina receives an average of 45 inches or more of precipitation each year (Appendix A, Figure A3). However, most water never infiltrates below the root zone into the deeper subsurface to function as groundwater storage. A significant portion of water is taken up by plants within the root zone or discharged into surface water systems before infiltrating deep enough to enter the groundwater system. Therefore, the amount of water that enters as groundwater storage is a small fraction of precipitation received. Inflow into the groundwater system is also heavily dependent on when and where precipitation occurs. The portions of the state where water infiltrates into the SCCP aquifers are known as recharge areas (Figure 8).

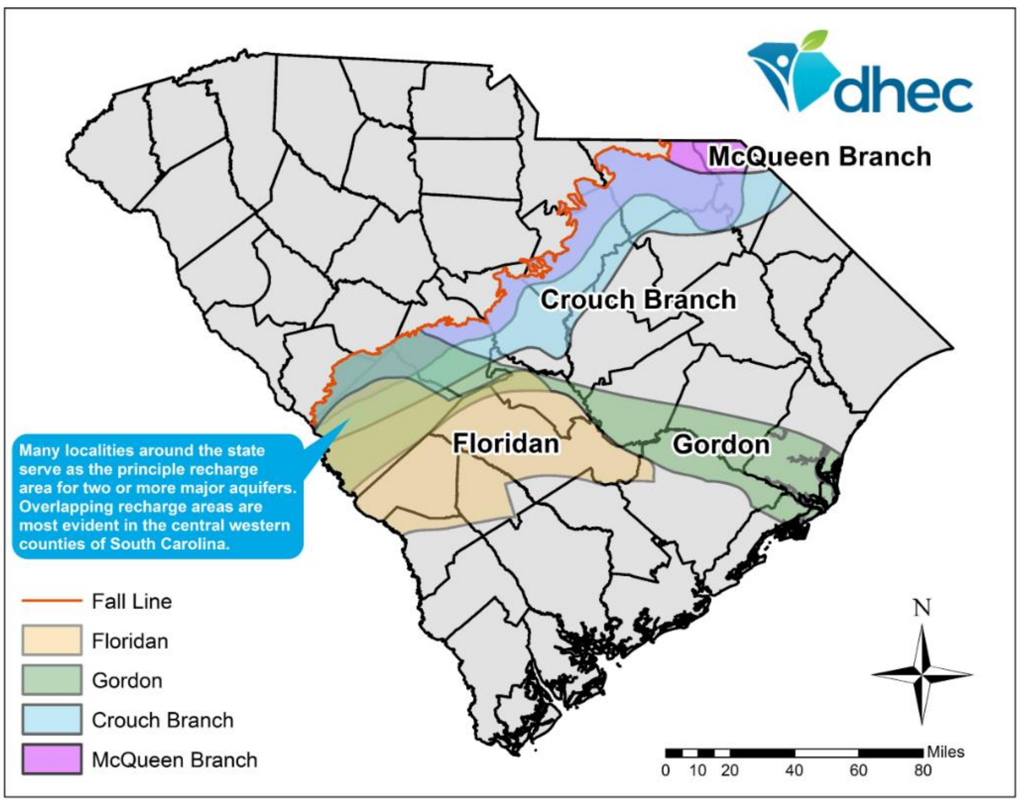


Figure 8: General recharge areas for the major SCCP aquifers. Data provided by SCDNR.

The recharge areas for the state's major aquifers are generally within the Upper Coastal Plain. The exceptions being surficial aquifers, parts of the deeper SCCP aquifers near the Fall Line, and the Gordon Aquifer which has a recharge area that extends to the coast (Figures 7 and 8). As mentioned previously, the SCCP aquifers near the Fall Line are closer to the surface, more interconnected, and have a greater connection to surface water allowing more local recharge. Aquifers extending all the way to the coast (Figure 7) are dependent on precipitation infiltrating in the recharge areas (Figure 8) further "up-dip", then moving slowly "down-dip" (southeast) to continuously replenish groundwater supply to the deeper parts of the aquifers. Consequently, the rate at which groundwater is replenished in the aquifers is controlled by the rate at which groundwater travels from the recharge areas to the coast. Typical groundwater flow rates for silts to well-sorted sands range from 0.003 to 300 feet per day[8]. This means that once water becomes part of the groundwater system, it may take from a few years to tens of thousands of years to reach the deeper aquifers located along the coast.

Drought in South Carolina

Over the past twenty years (January 2000 – January 2020), three major periods of drought occurred in South Carolina—1998 to 2003, 2007 to 2008, and 2011 to 2013 (Appendix A, Figure A4). However, drought conditions varied in severity and extent among the Santee-Lynches Area counties (Figure A5) with no apparent spatial trend. In order to better understand how drought and the consequential increases in groundwater use have impacted the groundwater sources in the proposed Santee-Lynches Area, trends in groundwater levels were examined.

Groundwater Trends

Groundwater in South Carolina is monitored using a network of wells maintained by SCDNR as well as the United States Geological Survey (USGS). A map of the complete SCDNR well network is located in Appendix A (Figure A6). SCDNR maintains 19 wells in the Santee-Lynches Area, and the USGS maintains 7. The Department selected a subset of these 26 wells to present here based on how well the water level records represented the aquifer and county. That is, did the well record reflect the typical hydrograph seen in the remaining wells for a specific area and aquifer. Additionally, wells with the longest monitoring record were chosen in order to understanding groundwater trends for a given county/aquifer combination.

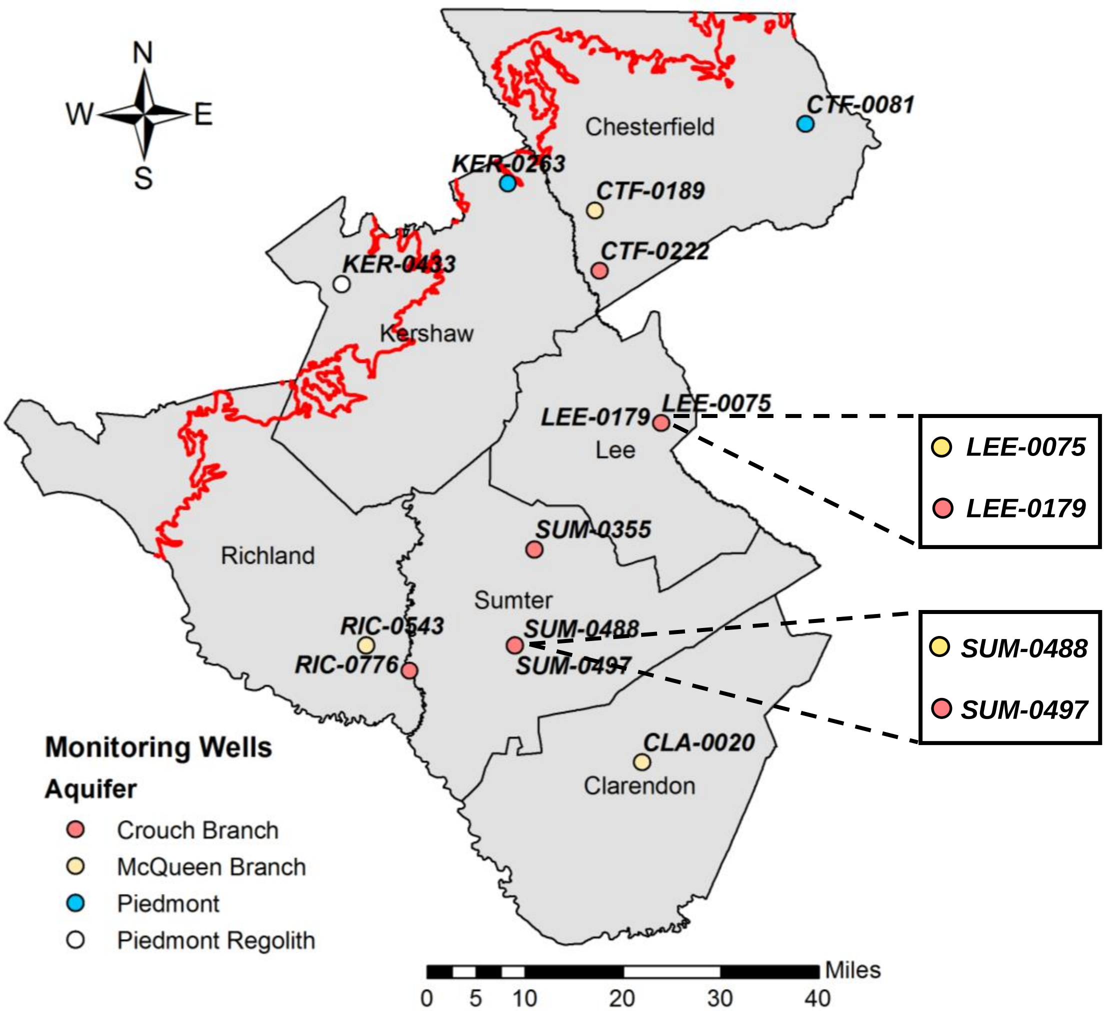
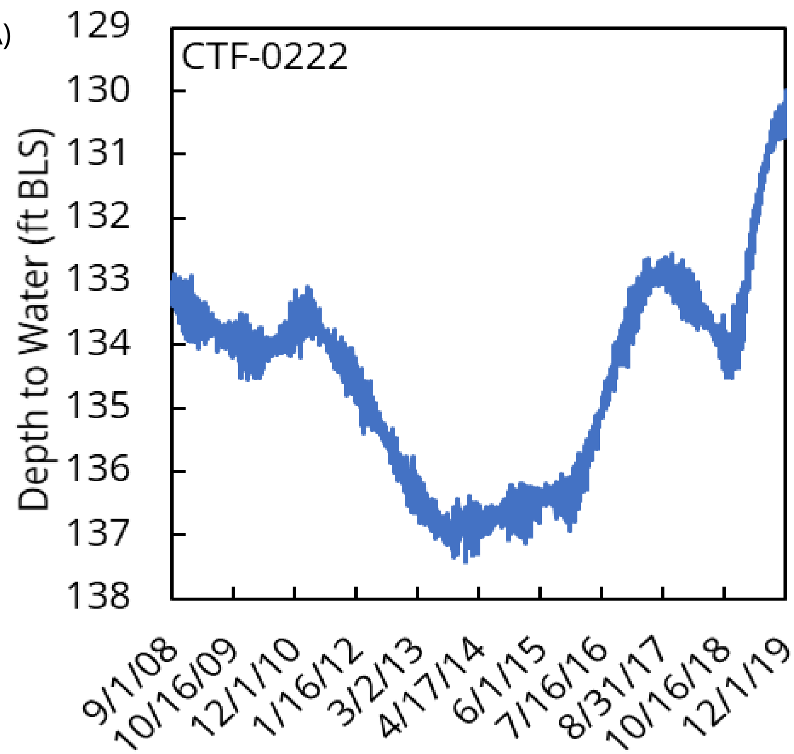


Figure 9: Map showing the locations of the wells used to evaluate groundwater trends. The colors represent the aquifer into which each well is screened. The pop-out boxes provide individual well information for well clusters in Lee and Sumter Counties.

Crouch Branch Aquifer

A)



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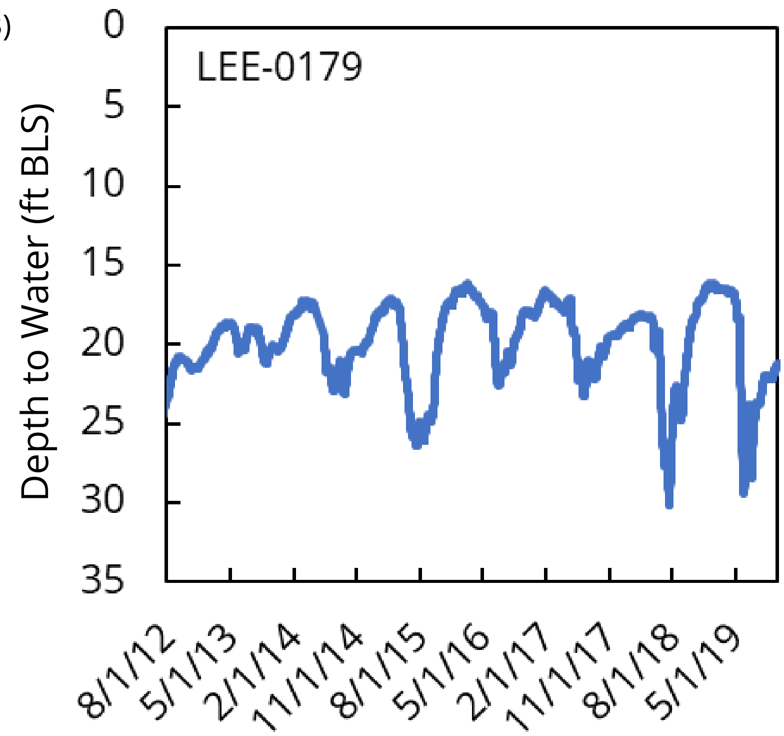
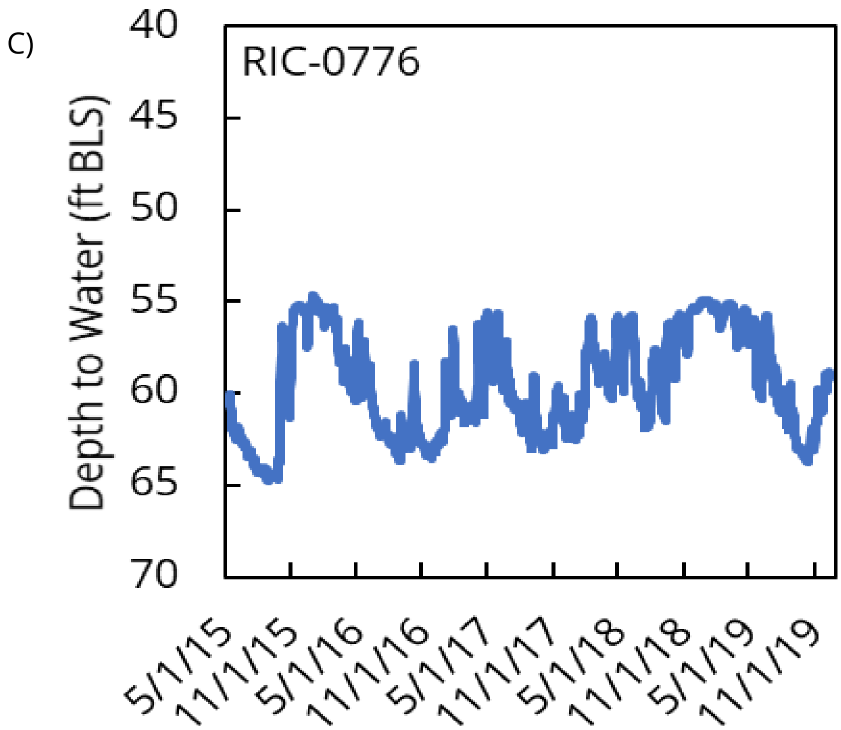
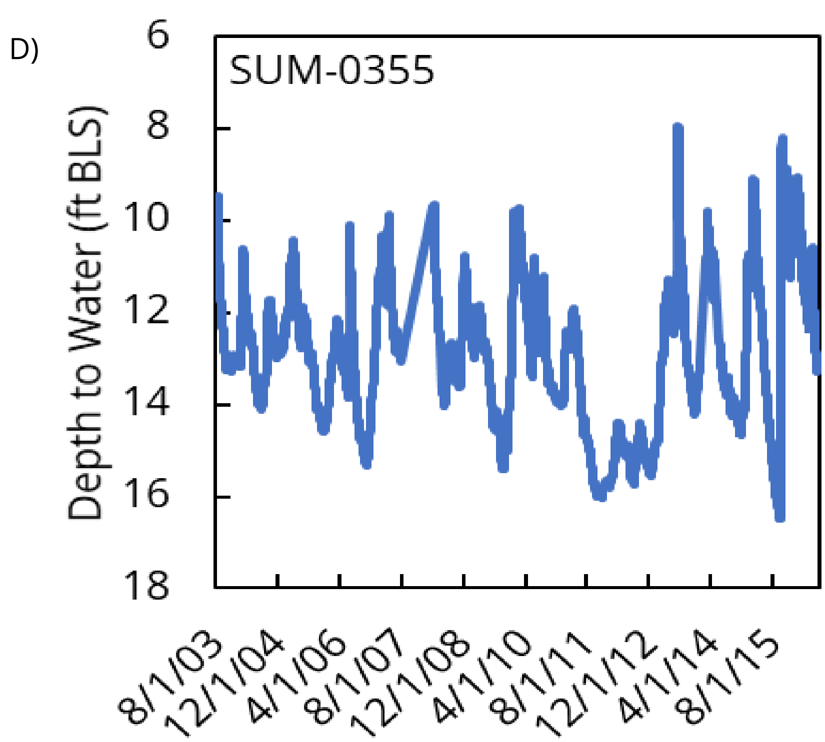


Figures 10A through E: Water levels recorded at monitoring wells screened in the Crouch Branch aquifer. Vertical axes are depth to water in the well below land surface (BLS). Note the differences in the dates for each hydrograph along the horizontal axis. All wells are SCDNR wells except where noted on the individual graphs. A) and B) Monitoring Wells screened in the Crouch Branch Aquifer. See Figure 9 for well locations.





Figures 10C and D: Monitoring wells screened in the Crouch Branch Aquifer. See Figure 9 for well locations.

E)

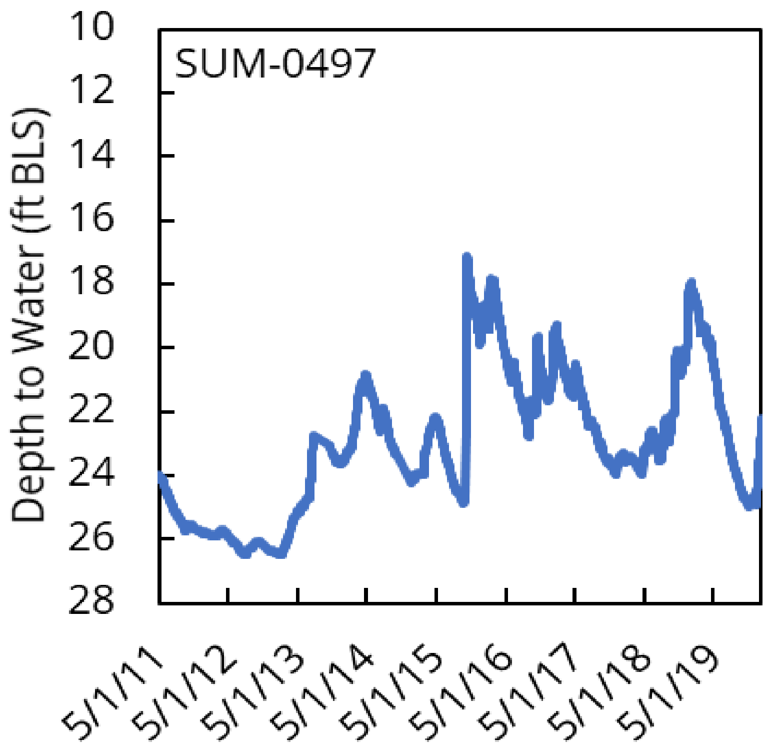
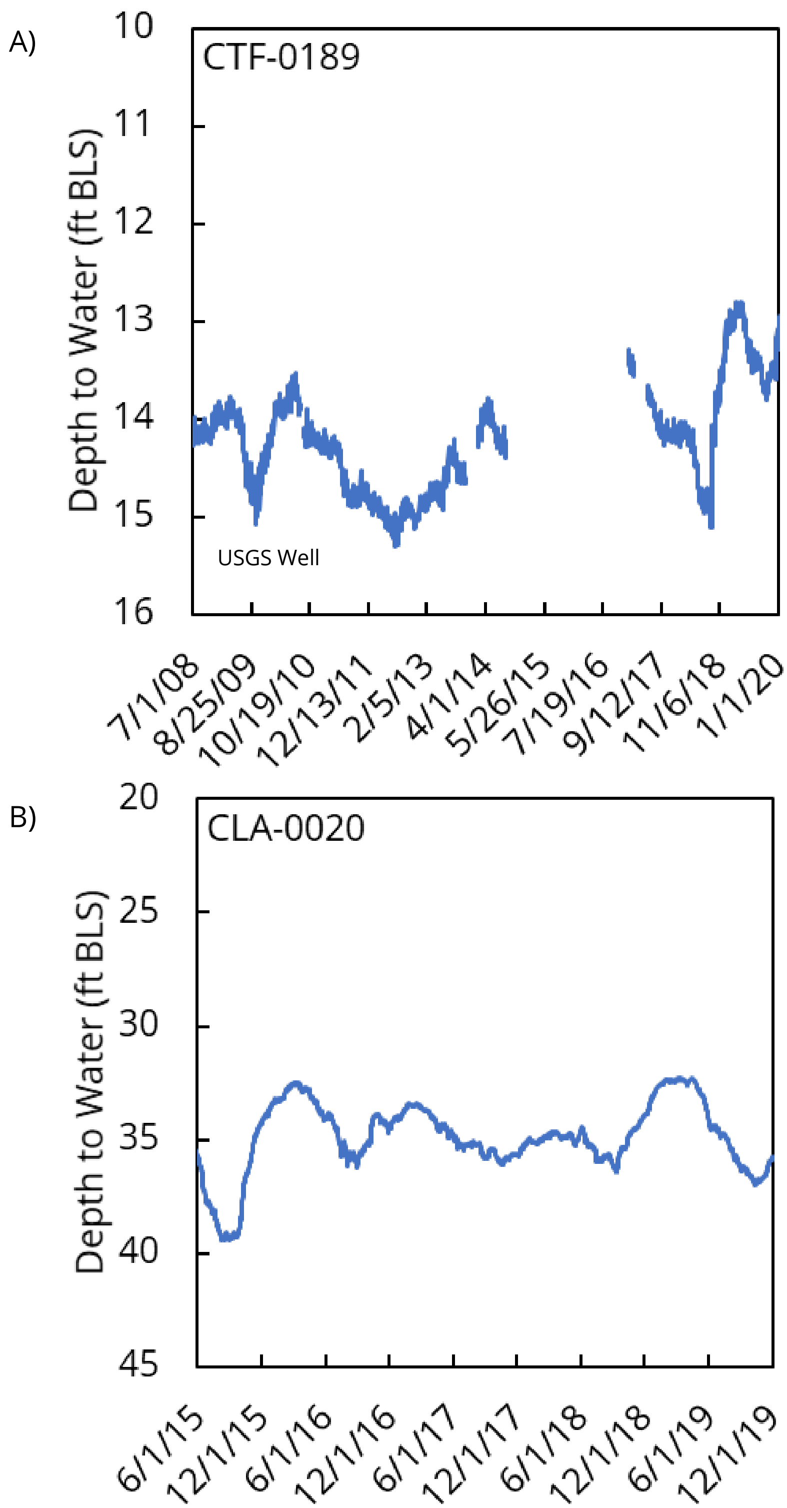


Figure 10E: Monitoring well screened in the Crouch Branch Aquifer. See Figure 8 for well location.

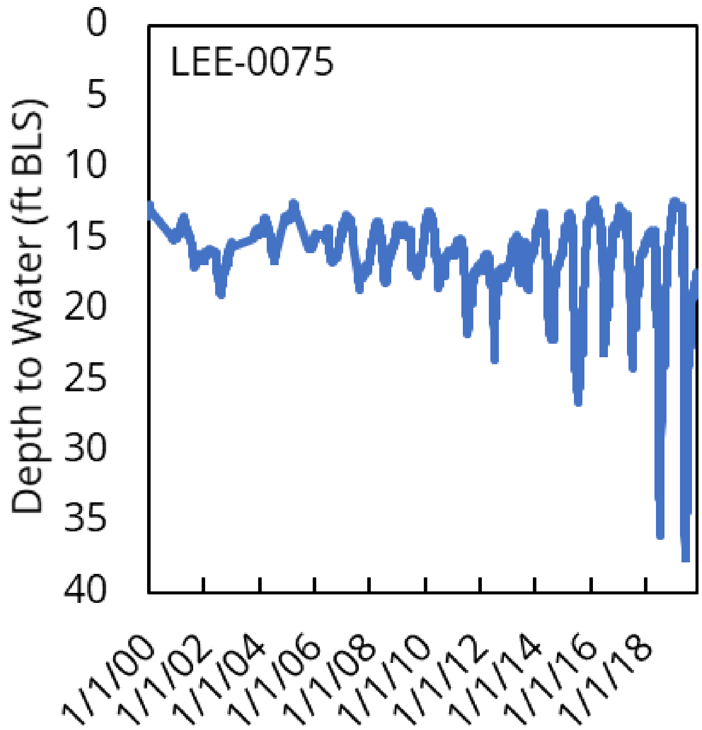
There is no apparent groundwater level trend among the hydrographs for the Crouch Branch aquifer (Figures 10A to E). There is, however, some evidence of the impact of drought. In particular, lowered groundwater levels can be seen in CTF-0222, SUM-0355, and SUM-0497 that coincide with the drought from 2011 to 2013. Note that these monitoring well records do not include the severe state-wide period of drought beginning in 1998 and may not represent total drawdown from levels prior to 1998. As stated previously, the "up-dip" portions of the SCCP aquifers are recharged locally and are affected more rapidly by changes in precipitation and the close connections with surface water. Summer drawdown of groundwater from evapotranspiration (ET) and irrigation can also be seen in the wells in Lee and Sumter Counties (LEE-0179 and SUM-0355). Following each summer or drought-induced drawdown, the groundwater levels have generally rebounded.

McQueen Branch Aquifer



Figures 11A through E: Water levels recorded at monitoring wells screened in the McQueen Branch aquifer. Vertical axes are depth to water in the well below land surface (BLS). Note the differences in the dates for each hydrograph along the horizontal axis. All wells are SCDNR wells except where noted on the individual graphs. A) and B) Monitoring Wells screened in the McQueen Branch Aquifer. See Figure 9 for well locations.

C)



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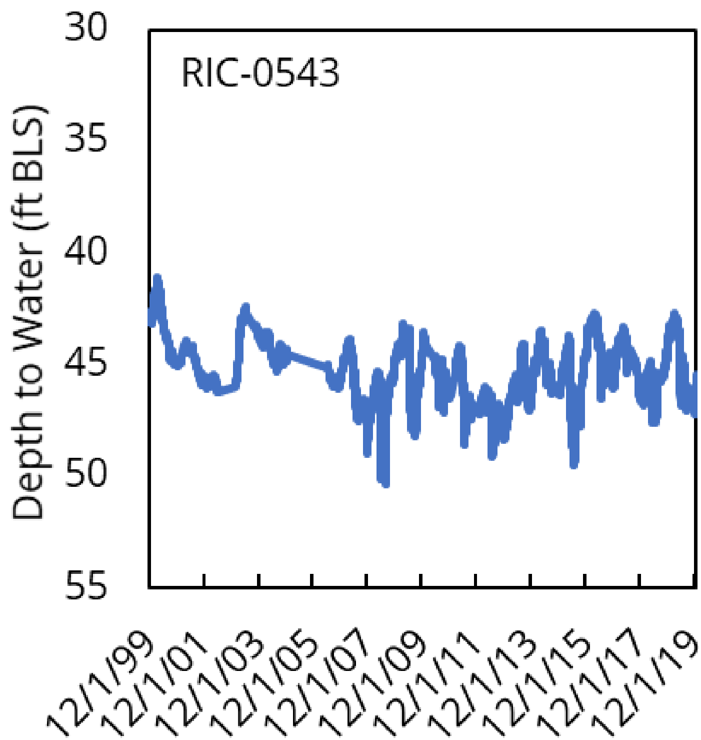


Figures 11C and D: Monitoring wells screened in the McQueen Branch Aquifer. See Figure 9 for well locations.

E)

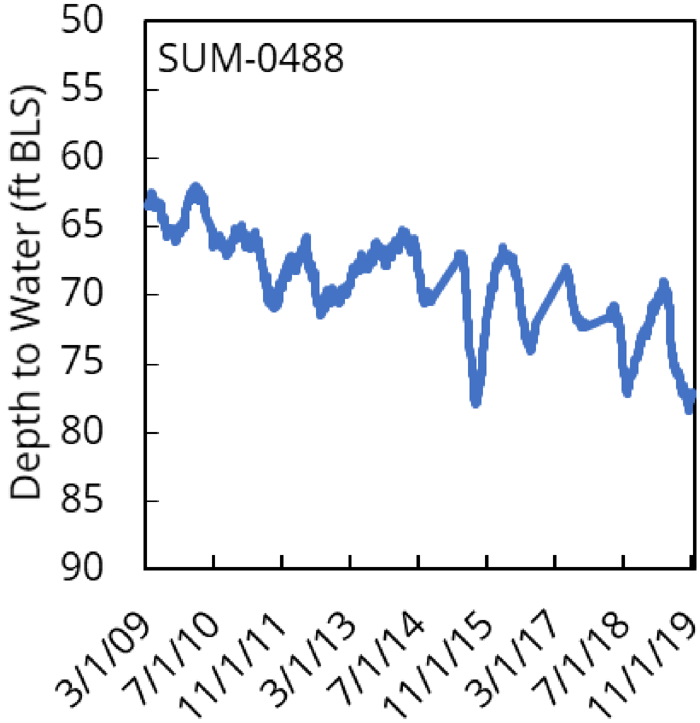


Figure 11E: Monitoring well screened in the McQueen Branch Aquifer. See Figure 9 for well location.

Because the McQueen Branch aquifer is deeper within the stack of SCCP sediments, the effect of drought on groundwater levels is reduced but still visible in the water level records (Figure 11). The seasonal reduction in groundwater levels due to summer water use is clearly seen in the Lee and Sumter County wells (LEE-0075 and SUM-0488). In the Lee County well (LEE-0075), the seasonal drawdown of the water level has deepened significantly over time from less than 5 feet to more than 20 feet during the summer. Also, during the 2011-2013 drought, the fall/winter rebound did not return to previous levels until the fall/winter of 2014 (Fig 11C). Overlying the seasonal trend seen in the Sumter County Well (SUM-0488), there has been an overall decline of approximately 10 feet in the groundwater level since 2009.

Changes to Potentiometric Surfaces

The major aquifers below the proposed Santee-Lynches Area counties are the Crouch Branch and McQueen Branch. The Gordon and Charleston Aquifers only extend to portions of Clarendon County. The McQueen Branch and Charleston aquifers together are known as the Midville Aquifer System (please refer to the Hydrostratigraphic Section of this report) and formerly classified as the Middendorf aquifer under historical nomenclature.

Groundwater flows within an aquifer from areas of high pressure to low pressure. Pressure within an aquifer is a combination of the overburden pressure of the aquifer material (rock, sand, soil, etc.) and water above the point at which the pressure is measured. The pressure of water within an aquifer can be determined by measuring the level of water within a well that has been drilled to and screened within the aquifer. These water level measurements can be combined to generate a contour map of the water levels known as a potentiometric map. Groundwater flows in paths that are perpendicular to (at right angles to) the potentiometric contour lines.

SCDNR has been making water level measurements and publishing potentiometric maps for the aquifers and aquifer systems of South Carolina since 1987—providing a vital, long-term record of the condition of South Carolina's aquifers. SCDHEC uses this record as one tool to determine whether groundwater withdrawals in SCCP aquifers present "potential adverse effects to the natural resources" or "pose a significant threat to the long-term integrity of a groundwater source". Potentiometric maps of groundwater below the proposed Santee-Lynches Area are available for the Crouch Branch and Middendorf (McQueen Branch) aquifers.

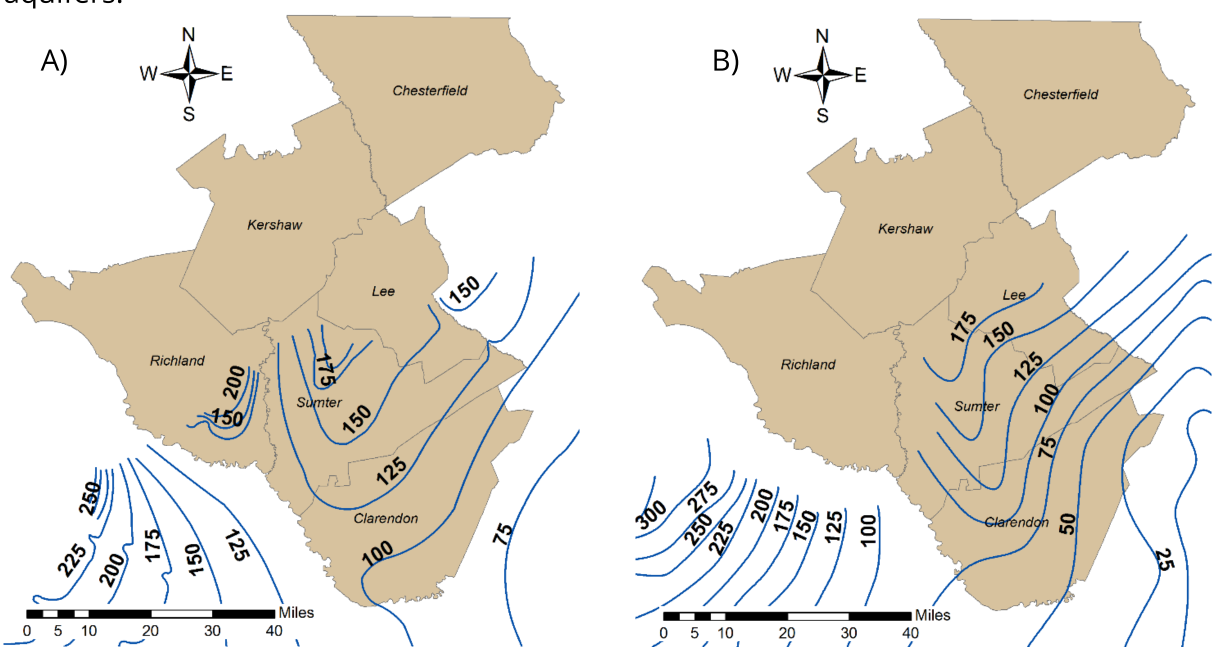


Figure 12: Potentiometric Surface Maps of the Crouch Branch Aquifer. A) Pre-Development (1900) and B) 2016. The dashed lines indicate an approximation of the contour location due to insufficient water level measurements in that area. Contour lines connect points of equal water elevation measurements.

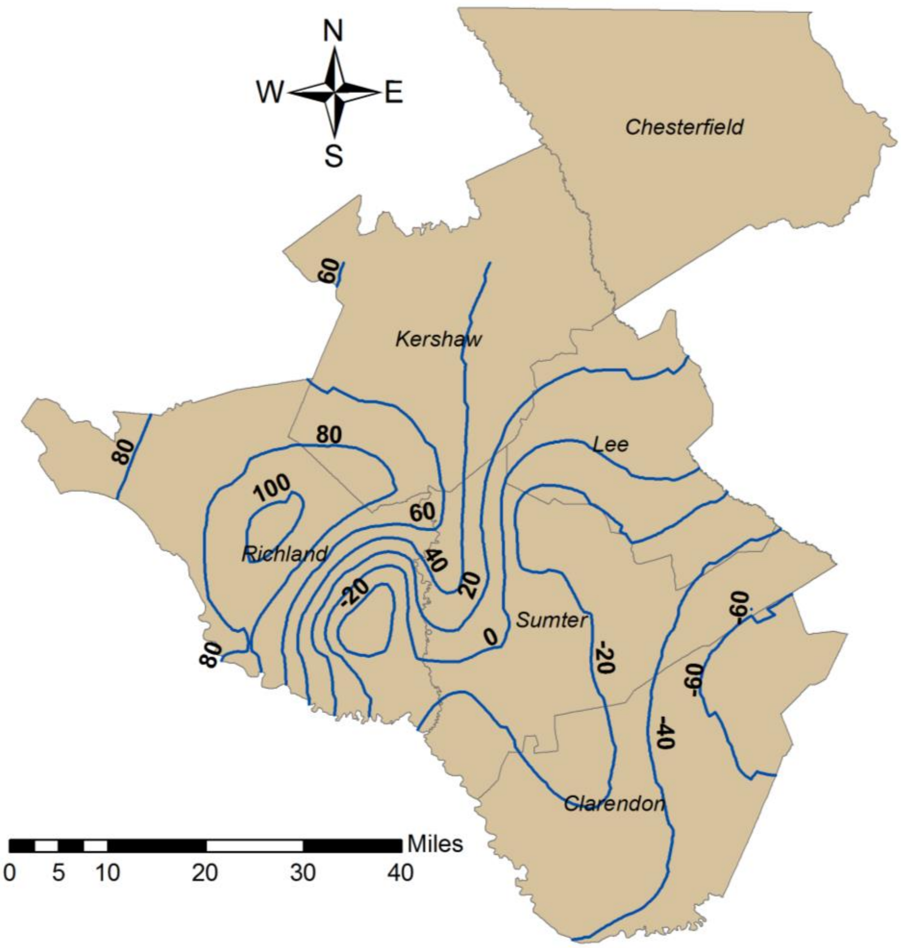


Figure 13: Change in Crouch Branch Aquifer Potentiometric Surface, Pre-Development to 2016. Contour lines represent points of equal change to the potentiometric surface.

A comparison of the pre-development [9] (Figure 12A) and 2016 (Figure 12B) potentiometric surfaces of the Crouch Branch aquifer indicate that the direction of groundwater flow below the Santee-Lynches Area counties is largely unchanged. However, the potentiometric surface has dropped by as much as 60 feet in the south and east portions of Sumter and Clarendon Counties (Figure 13). This is the result of the deepening of the aquifer and thickening of the confining units in the southeast direction from the Fall Line as discussed in the Hydrogeologic Framework section. The counties close to the Fall Line are subject to more rapid, local recharge, whereas the counties to the southeast depend on the natural rate of groundwater flow "down dip" to supply aquifer recharge. The lowering of the potentiometric surface in these areas is an indication that recharge does not keep pace with groundwater demand.

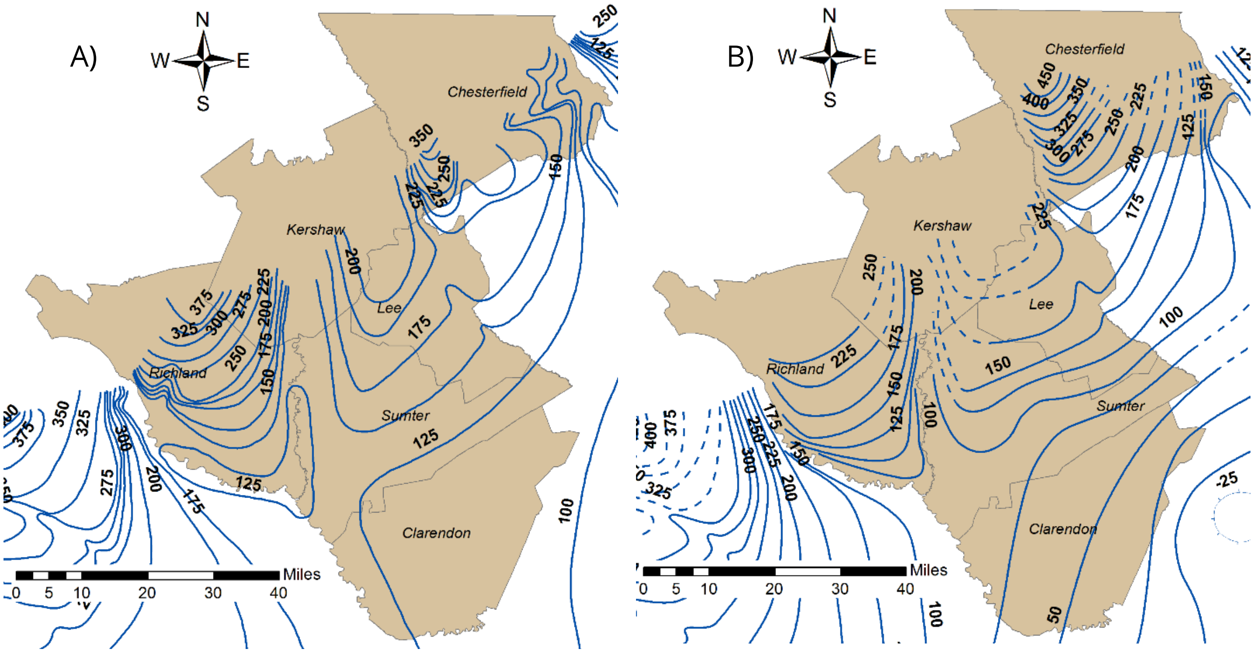


Figure 14: Potentiometric Surface Maps of the Middendorf Aquifer (McQueen Branch Aquifer). A) Pre-Development (1900) and B) 2016. The dashed lines indicate an approximation of the contour location due to insufficient water level measurements in that area. Contour lines connect points of equal water elevation measurements.

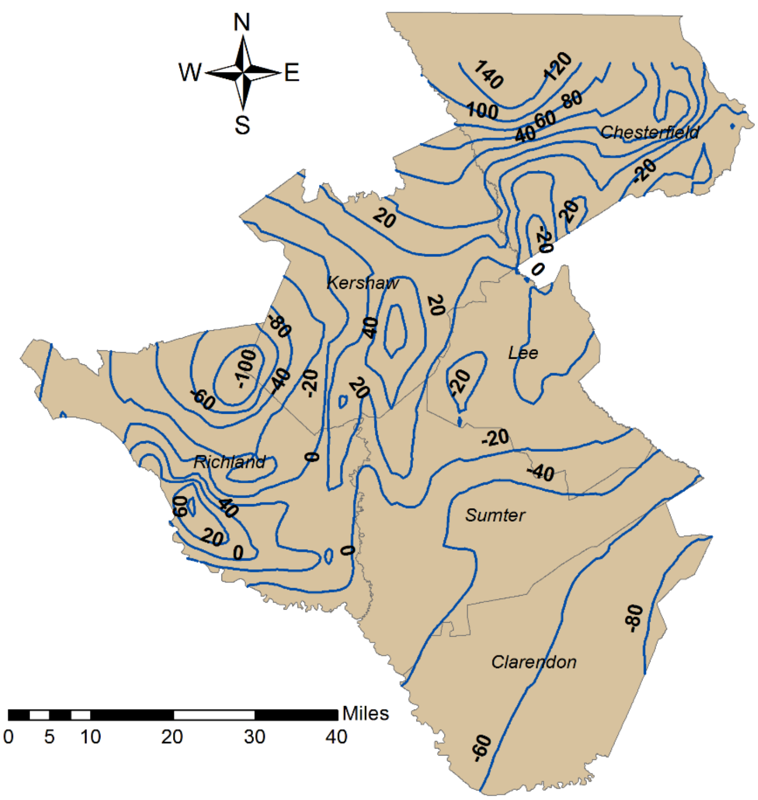


Figure 15: Change in Middendorf Aquifer (McQueen Branch) Potentiometric Surface, Pre-development to 2016. Contour lines represent points of equal change to the potentiometric surface.

As seen in the Crouch Branch Aquifer, the groundwater flow directions in the McQueen Branch Aquifer have not changed significantly from pre-developent conditions (Figure 14A) to 2016 (Figure 14B). Mapping the change in the McQueen Branch potentiometric surface (Figure 15) indicates that it has dropped from between 20 and 80 feet below Sumter and Clarendon Counties. The reason for this observed decline is identical to that found for the Crouch Branch Aquifer (groundwater withdrawal rate exceeds the recharge rate through "down dip" groundwater flow). In addition, the McQueen Branch aquifer is deeper within the stack of aquifers and confining units of the SCCP, which means that the travel time of groundwater within the aquifer is longer than in the shallower Crouch Branch aquifer to the same vertical location below each county.

Current Demand

Under the Groundwater Use and Reporting Act[10], a groundwater withdrawer is defined as a person or entity who withdraws in excess of three million gallons in any one month from a single well or multiple wells under common ownership within a one-mile radius from any existing or proposed well(s). In the proposed Santee-Lynches Area, groundwater withdrawers are required to register their wells with the Department. For 2018, 502 registered wells reported water use in the proposed Santee-Lynches Area (Figure 16; Table 1).

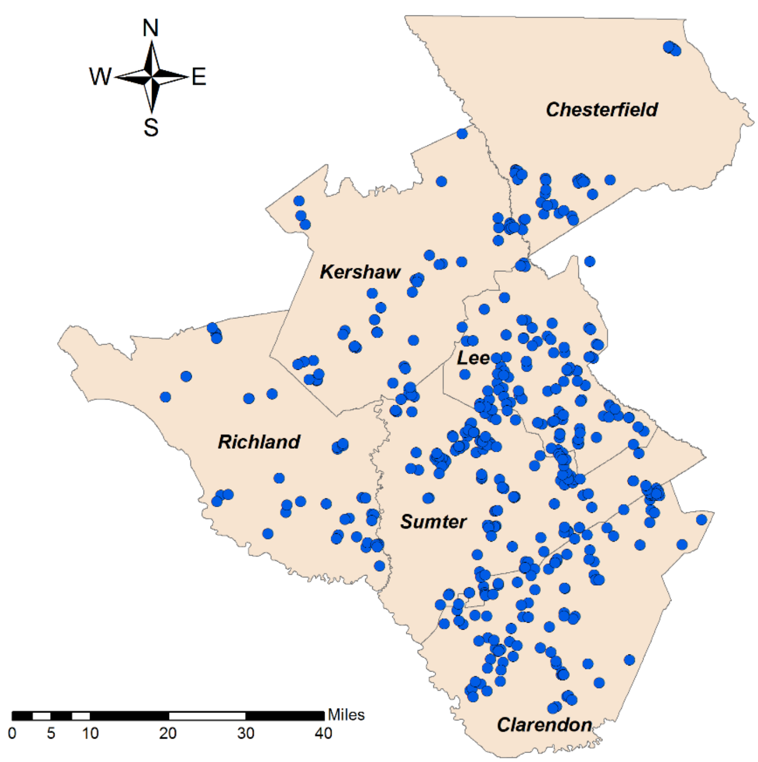


Figure 16: Map of the Registered Well Locations in the proposed Santee-Lynches Area Counties Reporting 2018 Water Use.

Table 1: Number of Wells Reporting Water Use in 2018: Santee-Lynches Area

Use Category	**Chesterfield**	**Clarendon**	**Kershaw**	**Lee**	**Richland**	**Sumter**	***Total (Percent)***
Aquaculture (AQ)	0	1	0	0	1	0	***2 (0.4%)***
Golf Course (GC)	0	3	1	0	18	3	***25 (5.0%)***
Industry (IN)	1	0	41	0	3	17	***62 (12.4%)***
Irrigation (IR)	17	76	4	73	12	87	***269 (53.6%)***
Mining (MI)	0	0	0	0	1	0	***1 (0.2%)***
Other (OT)	0	0	0	0	0	0	***0 (0.0%)***
Hydro Power (PH)	0	0	0	0	0	0	***0 (0.0%)***
Nuclear Power (PN)	0	0	0	0	0	0	***0 (0.0%)***
Thermal Power (PT)	0	0	0	0	0	0	***0 (0.0%)***
Water Supply (WS)	18	30	33	7	10	45	***143 (28.5%)***
Total (Percent)	***36 (7.2%)***	***110 (21.9%)***	***79 (15.7%)***	***80 (15.9%)***	***45 (9.0%)***	***152 (30.3%)***	***502 (100.0%)***

Sumter and Clarendon Counties had the greatest number of registered wells, and Chesterfield and Richland Counties had the fewest. Irrigation and water supply use wells made up the majority in most counties except for Kershaw (industry and water supply) and Richland (golf course, irrigation, and water supply). More than half of the wells reporting water use for 2018 were irrigation wells (269 out of 502: 54%).

In a similar pattern to the number of registered wells, Sumter County reported the highest groundwater use for 2018 at 8,743 million gallons (MG) (Table 2). Clarendon County reported the next highest use (2,706 MG) followed by Lee (2,126 MG), Chesterfield (1,626 MG), Kershaw (1,451), and Richland Counties (1,367). For Chesterfield, Clarendon, Lee, and Sumter Counties, the majority of 2018 reported water use fell into the irrigation and water supply use categories. Kershaw and Richland Counties were the exceptions to this trend in that the highest reported water use categories were water supply and industry.

Table 2: 2018 Reported Water Use by County and Use Category (millions of gallons: MG)[a]

Use Category	**Chesterfield**	**Clarendon**	**Kershaw**	**Lee**	**Richland**	**Sumter**	***Total (Percent)***
Aquaculture (AQ)	0	0	0	0	17	0	***17 (0.1%)***
Golf Course (GC)	0	26	22	0	43	29	***120 (0.7%)***
Industry (IN)	0	0	671	0	697	174	***1,542 (8.6%)***
Irrigation (IR)	451	1,930	7	1,636	200	3,095	***7,319 (40.6%)***
Mining (MI)	0	0	0	0	117	0	***117 (0.6%)***
Other (OT)	0	0	0	0	0	0	***0 (0.0%)***
Hydro Power (PH)	0	0	0	0	0	0	***0 (0.0%)***
Nuclear Power (PN)	0	0	0	0	0	0	***0 (0.0%)***
Thermal Power (PT)	0	0	0	0	0	0	***0 (0.0%)***
Water Supply (WS)	1,174	750	751	490	292	5,444	***8,902 (49.4%)***
Total (Percent)	***1,626 (9.0%)***	***2,706 (15.0%)***	***1,451 (8.1%)***	***2,126 (11.8%)***	***1,367 (7.6%)***	***8,743 (48.5%)***	***18,018 (100.0%)***

[a]Water use is reported in millions of gallons. For example, 451 is 451 million gallons (MG) or 451,000,000 gallons. 1,636 MG is 1,636,000,000 gallons.

Historic Groundwater Use

The department reviews historic water use in order to better understand significant changes over time among counties and among use categories. Reported groundwater use across all of the Santee-Lynches Area counties increased from 11,856 MG in 2001 to 18,018 MG in 2018 (Figure 17). It should be noted that from 2001 through 2013, reported use remained relatively constant (averaging 12,500 MG). A sharp increase in water use occurred from 2013 to 2015 to just over 16,000 MG followed by a slight increase to the high volume reported in 2018 (the last complete water use reporting year). Sumter County consistently reported the highest water use of all the Santee-Lynches Area counties with an average from 3 to 6 times greater than the remaining five counties.

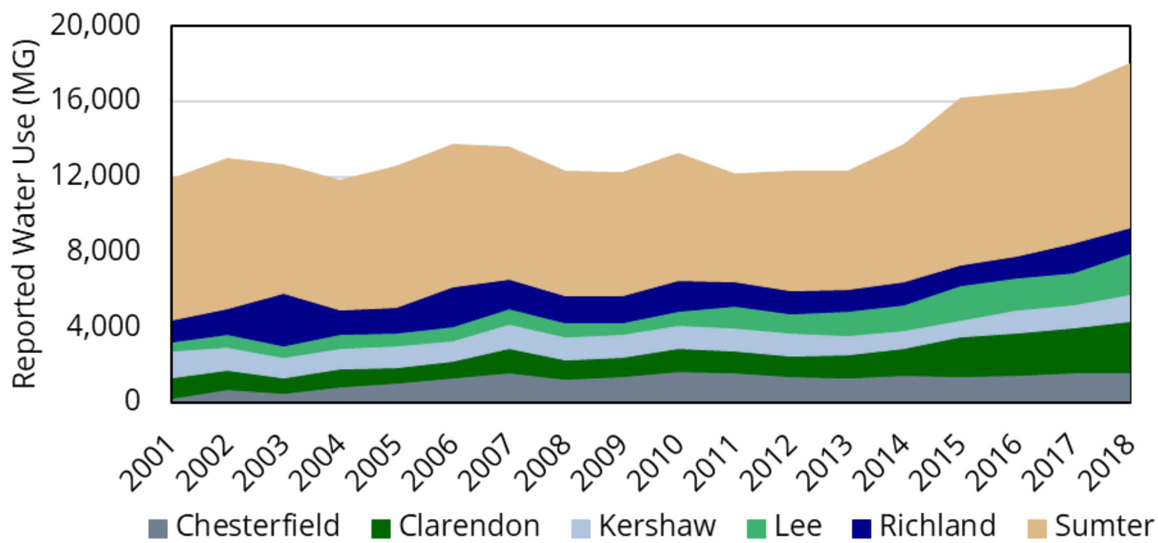


Figure 17: Reported Groundwater Use for the Santee-Lynches Area Counties from 2001 through 2018. Each county's reported water use is stacked on the other such that the top line of the upper area forms a line which is the total water use across all counties. For example, the total water use for the 6 counties for 2001 is approximately 12,000 MG.

From 2001 to 2013, the water supply use category comprised the majority of reported water use for the Santee-Lynches Area counties (Figure 18). Beginning in 2013, reported water use for the irrigation category increased through 2018, at which time the volumes came close to that reported for water supply (IR: 7,319 MG; WS: 8,902 MG). This increase in irrigation water use resulted in the increased total water use for the Santee-Lynches Area from 2013 to 2018. It should be noted that the sharp increase in groundwater use (2013 to 2015) immediately followed a period of significant drought (see Appendix A, Figure A4).

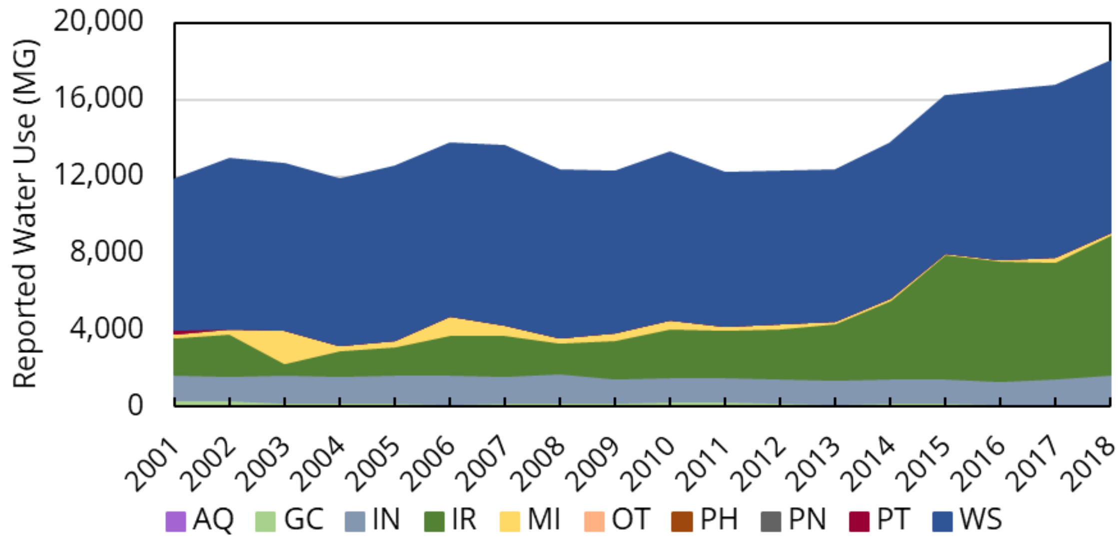


Figure 18: Reported Water Use for the proposed Santee-Lynches Area by Use Category - 2001 through 2018.

Changes in population may be one factor driving the variations seen in reported groundwater use. For the Santee-Lynches Area, the overall population has increased from 581,732 in 2001 to 682,276 in 2018 (Figure 19). An increase in the population in Richland County is the primary reason for the overall population increase in the area, but Richland County does not report the greatest groundwater use for the Santee-Lynches Area. Comparing historic reported water use (Figure 17) with historic population (Figure 19), it is clear that the population trends do not account for changes in reported groundwater use. Because the majority of the increase in reported water use fell within the irrigation category, trends in agricultural irrigation were reviewed.

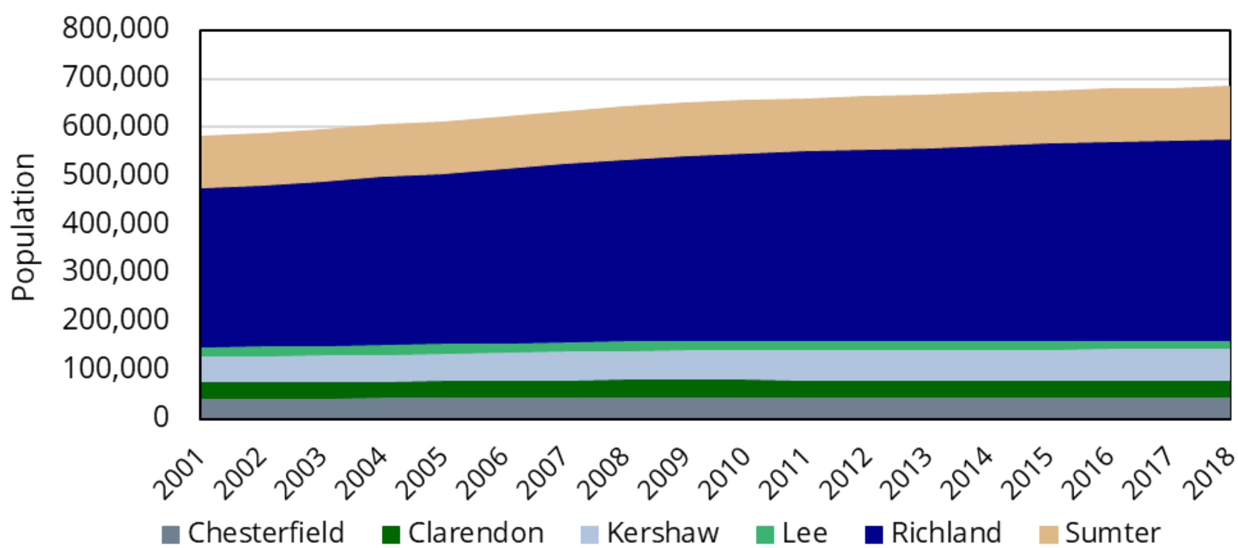
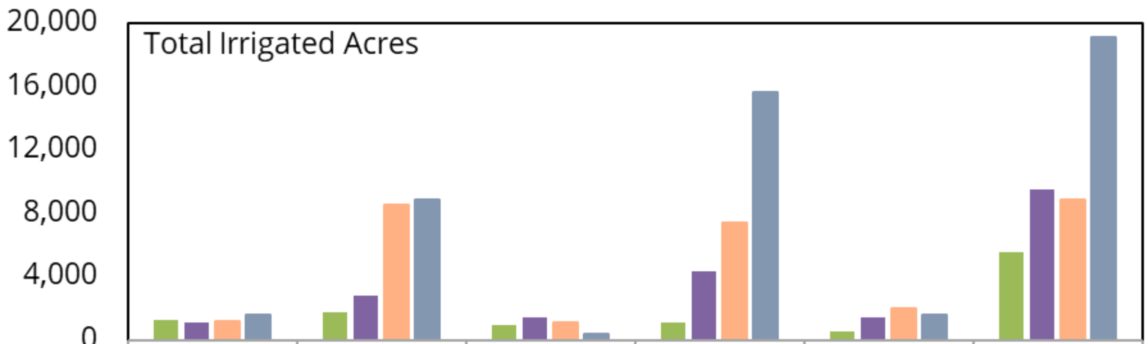


Figure 19: Population by County for the proposed Santee-Lynches Area from 2001 to 2018. Numbers presented are either census data (2010) or population estimates (www.census.gov; accessed February 3, 2020.)



	Chesterfield	Clarendon	Kershaw	Lee	Richland	Sumter
2002	1,269	1,704	903	1,072	516	5,537
2007	1,083	2,761	1,438	4,322	1,425	9,486
2012	1,169	8,533	1,134	7,414	1,951	8,863
2017	1,584	8,871	386	15,602	1,611	19,133

Figure 20: Total Irrigated Acres from the USDA NASS Agriculture Census 2007 and 2017. Irrigated acres in this report include both crop and pasture land.

The water use category of Irrigation, for the purposes of permitting, includes every form of irrigation with the exception of golf courses—which has its own water use category. Irrigators in South Carolina are primarily agricultural, although there are some ornamental landscape irrigation wells, too. Trends in irrigated acres can be found in the United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) publication--Census of Agriculture[11]. This report is published every five years, and data available from this report include the number of irrigated acres by county (Figure 20). Since 2002, the number of irrigated acres has increased significantly in Clarendon, Lee, and Sumter Counties and has remained comparatively stable for Chesterfield and Richland Counties. The number of irrigated acres in Kershaw county decreased significantly from 2012 to 2017.

Both surface and groundwater are used for irrigation in South Carolina. A comparison was made between reported surface water and groundwater irrigation use. For the Santee-Lynches Area, groundwater use for irrigation has consistently been greater than surface water (Figure 21) with the exception of reported use in 2003—a "wet" year in terms of precipitation ending the drought of 2000 through the end of 2002.

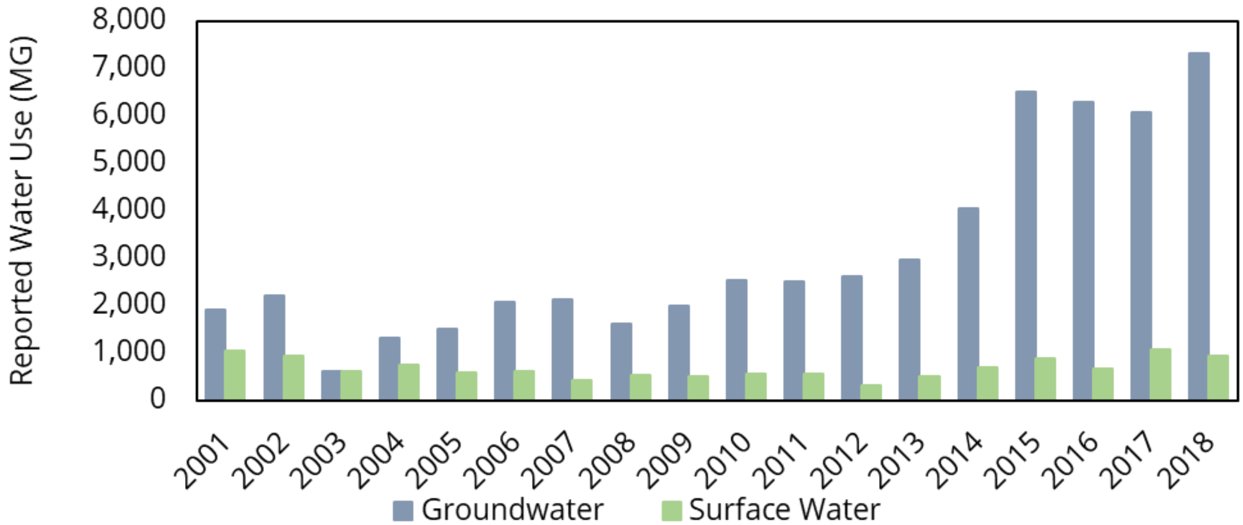


Figure 21: Reported Groundwater and Surface Water Use for the proposed Santee-Lynches Area from 2001 through 2018. Note: there was no water use reported for irrigation in 2000.

Although the number of registered irrigation wells has increased from fewer than 10 (2001) to 269 (2018), the average reported water use per well has remained roughly the same since 2004 (average of 27 MG/Well) (Figure 22). The maximum value of water use per well occurred in 2001, which was the height of that particular drought period. It should be noted that this is a rough calculation as a large number of smaller capacity wells could result in an under-estimation. However, this result is likely due to improvements in agricultural irrigation efficiency in recent years. Even though the use per well for irrigation has remained stable, the significant increase in active irrigation wells accounts for the overal increase in reported water use for the Santee-Lynches Area.

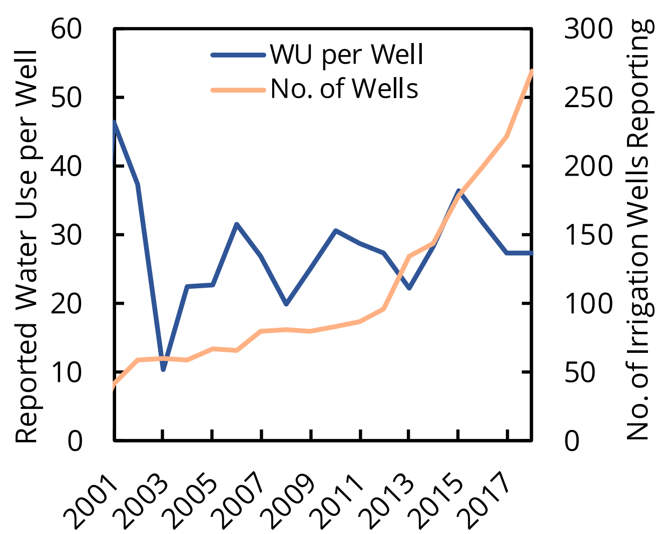


Figure 22: Reported Water Use (MG) per Reporting Well and the Number of Registered Wells from 2000 through 2018.

Aquifer Demand

The Department typically analyzes the demand trends for each SCCP aquifer in a Capacity Use Area to better understand how groundwater withdrawal is impacting that resource. For the Santee-Lynches Area counties, details of well depth and screened interval were not sufficiently available because it is not required information for a well registration. Of the 502 registered wells (2018 reporting year) in the Santee-Lynches Area, the Department has drill depth information for 288 wells and screened interval information for only 101 wells. Therefore, groundwater demand cannot be assigned to specific aquifers. It is anticipated that this dataset would improve if the Santee Lynches Area is designated a Capacity Use Area

Groundwater Evaluation and Recommendations

Both water level measurements in the monitoring network and the change to the potentiometric surfaces in the Santee-Lynches Area indicate that groundwater levels have fallen up to 60 feet in the Crouch Branch aquifer and 80 feet in the McQueen Branch aquifer below both Sumter and Clarendon Counties. These declines in water level suggest that groundwater withdrawal from these aquifers exceeds the rate at which they recharge. Groundwater use for the Santee-Lynches Area reported to the Department has also increased by 50% from 2013 through 2018, with the greatest increases reported in the irrigation use category. This corresponds to an increase in irrigated acres reported by the USDA and an increase in the number of registered irrigation wells.

An additional concern are the increases in groundwater use corresponding to periods of drought in South Carolina. Prior drought research and models have suggested that drought frequency in the southeastern United States may increase in the coming decades due to increasing evapotranspiration over precipitation resulting from climate change[12,13,14]. The prior increases in groundwater demand in response to drought combined with predictions of increased drought frequency suggests that the State's groundwater resources will be further stressed in the coming decades.

Finally, as the counties in the proposed Santee-Lyches Area are only required to register their large-capacity wells, the Department lacks sufficient well data to determine which aquifer is most utilized for groundwater demand. Therefore, no determination can be made as to the overuse of any particular groundwater source for the area.

The results of this initial assessment indicate groundwater resources in Chesterfield, Clarendon, Kershaw, Lee, and Richland Counties have been developed to the extent that reasonable regulation and a permitting program will provide the benefit of protecting, preserving, and developing the area's groundwater resources. It is the Department's recommendation that these counties be designated as the Santee-Lynches Capacity Use Area. This report is the first step to facilitate public comment and coordination among counties, COGs, and interested stakeholders.

Appendix A

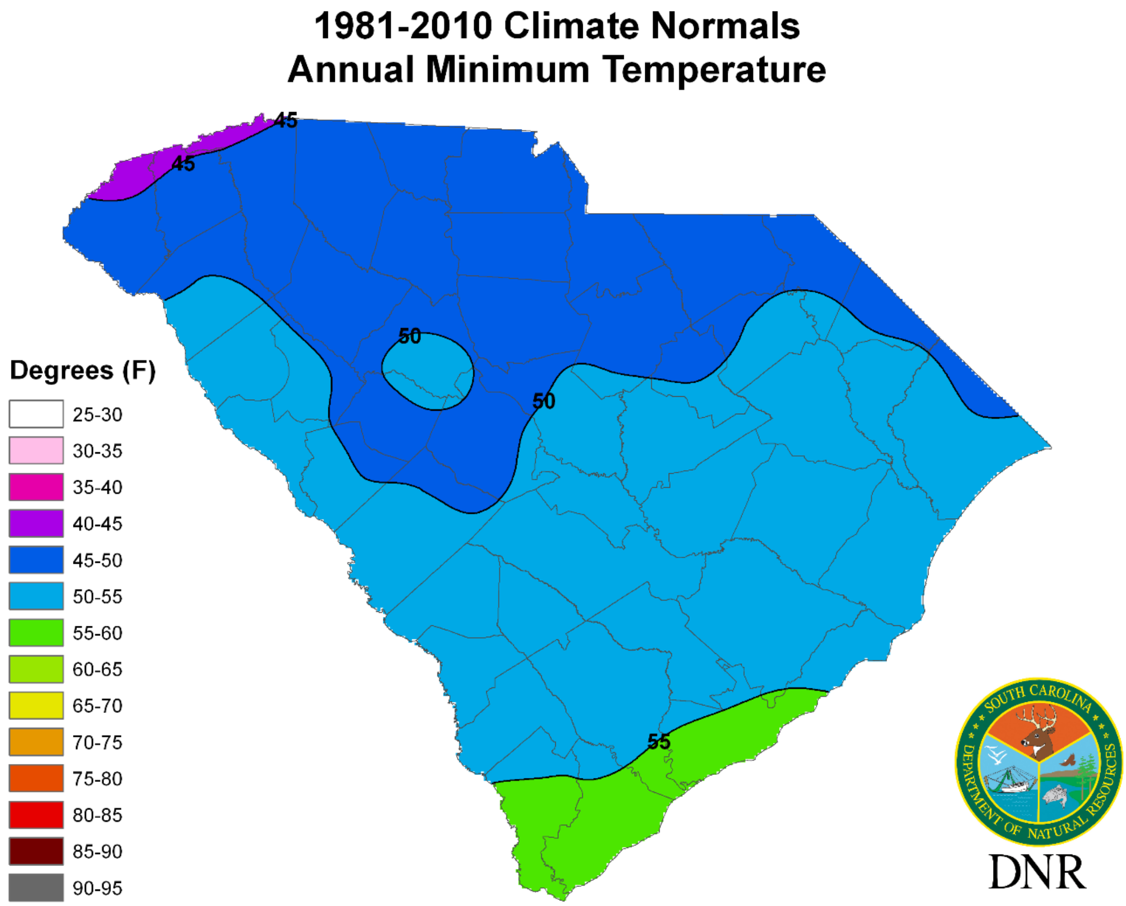


Figure A1: Average of the daily minimum temperatures from 1981 to 2010. South Carolina State Climatology Office, www.portal.dnr.sc.gov/climate.

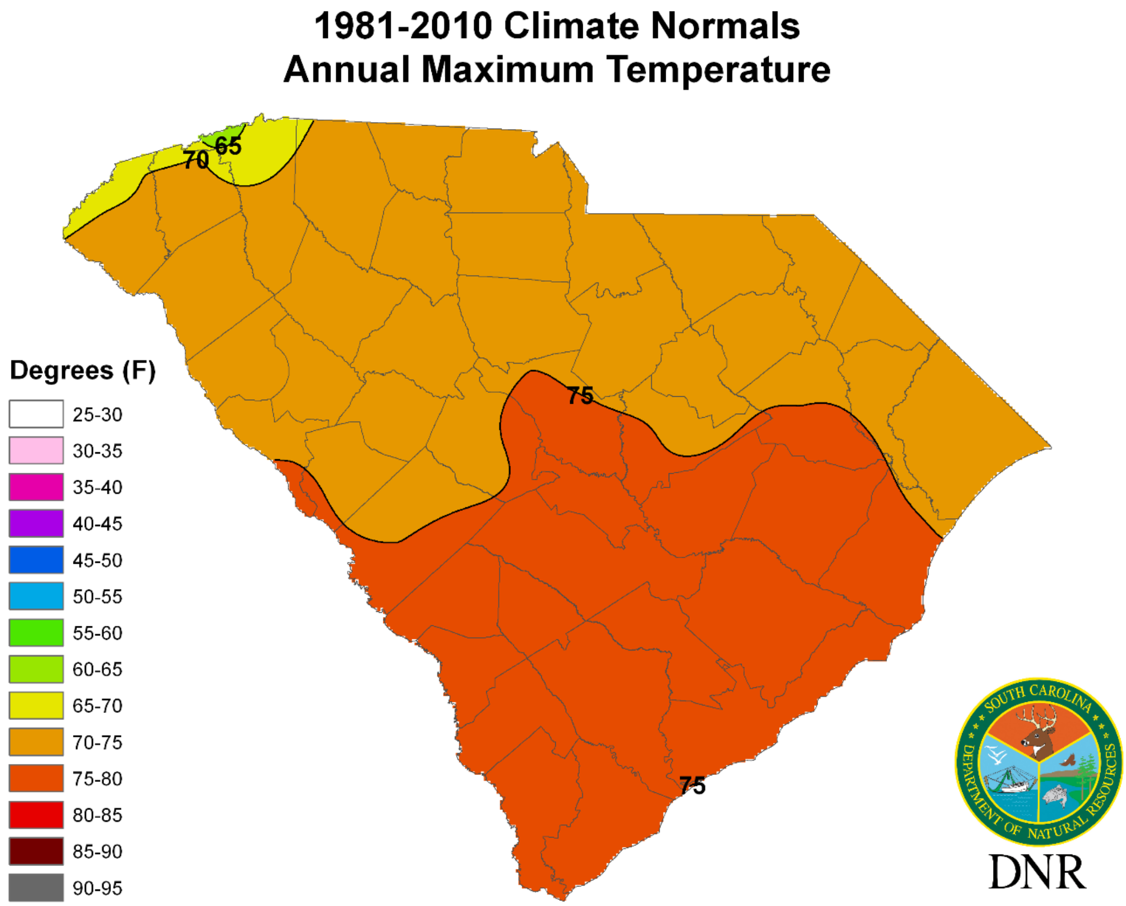


Figure A2: Average of the daily maximum temperatures from 1981 to 2010. South Carolina State Climatology Office, www.portal.dnr.sc.gov/climate.

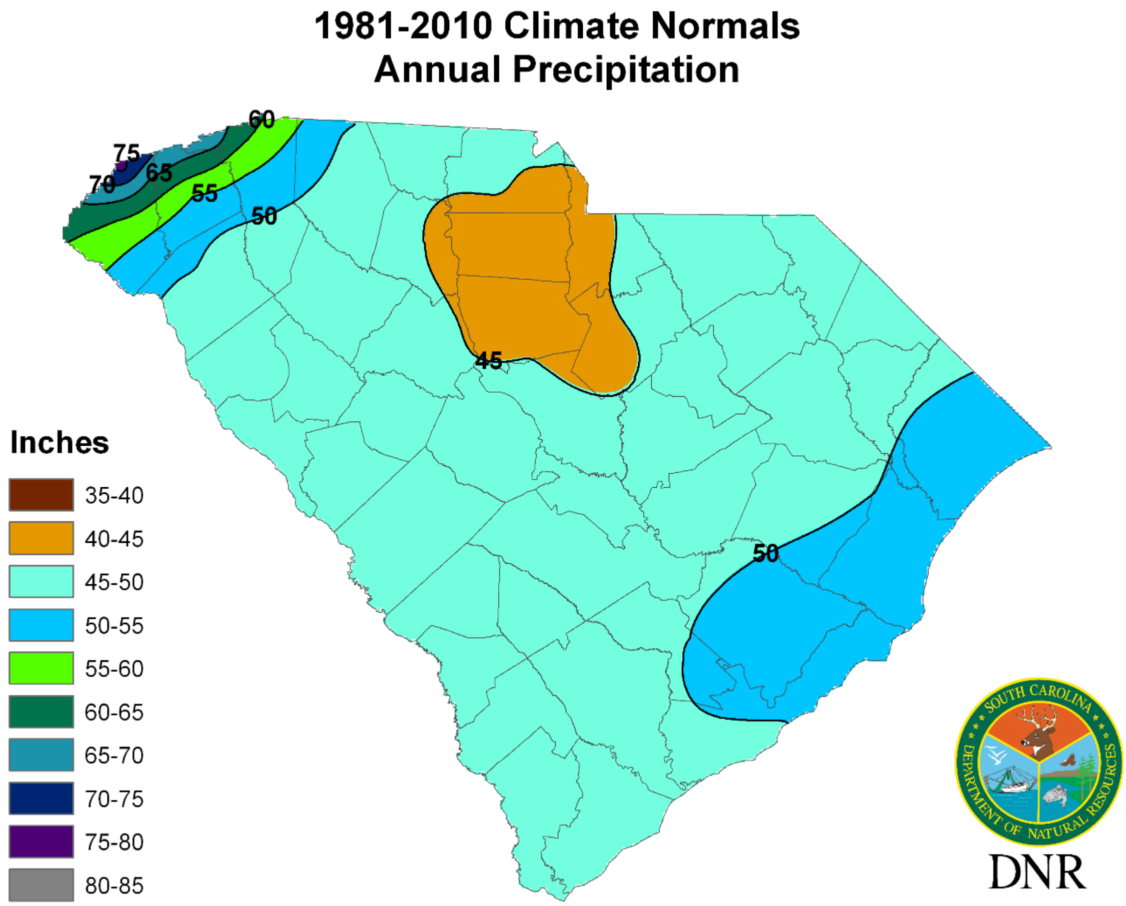
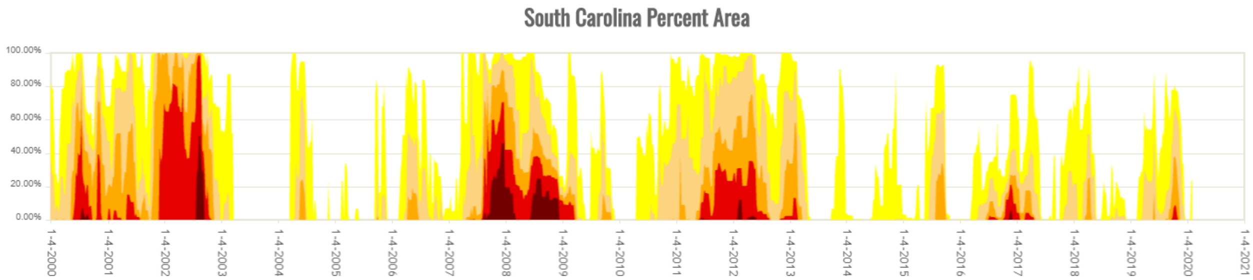


Figure A3: Average annual precipitation from 1981 to 2010. South Carolina State Climatology Office, www.portal..sc.gov/climate.



- D0: Abnormally Dry
- D1: Moderate Drought
- D2: Severe Drought
- D3: Extreme Drought
- D4: Exceptional Drought

Figures A4 (above) and A5 (next page): Drought Severity and Coverage Index (DSCI) timeseries for South Carolina as well as each county in the proposed Santee-Lynches Area. The colors represent drought severity, and the extent of areal coverage of the state (as a percent) is indicated on the vertical axis from 0 to 100%. United States Drought Monitor, https://droughtmonitor.unl.edu; accessed February 14, 2020.

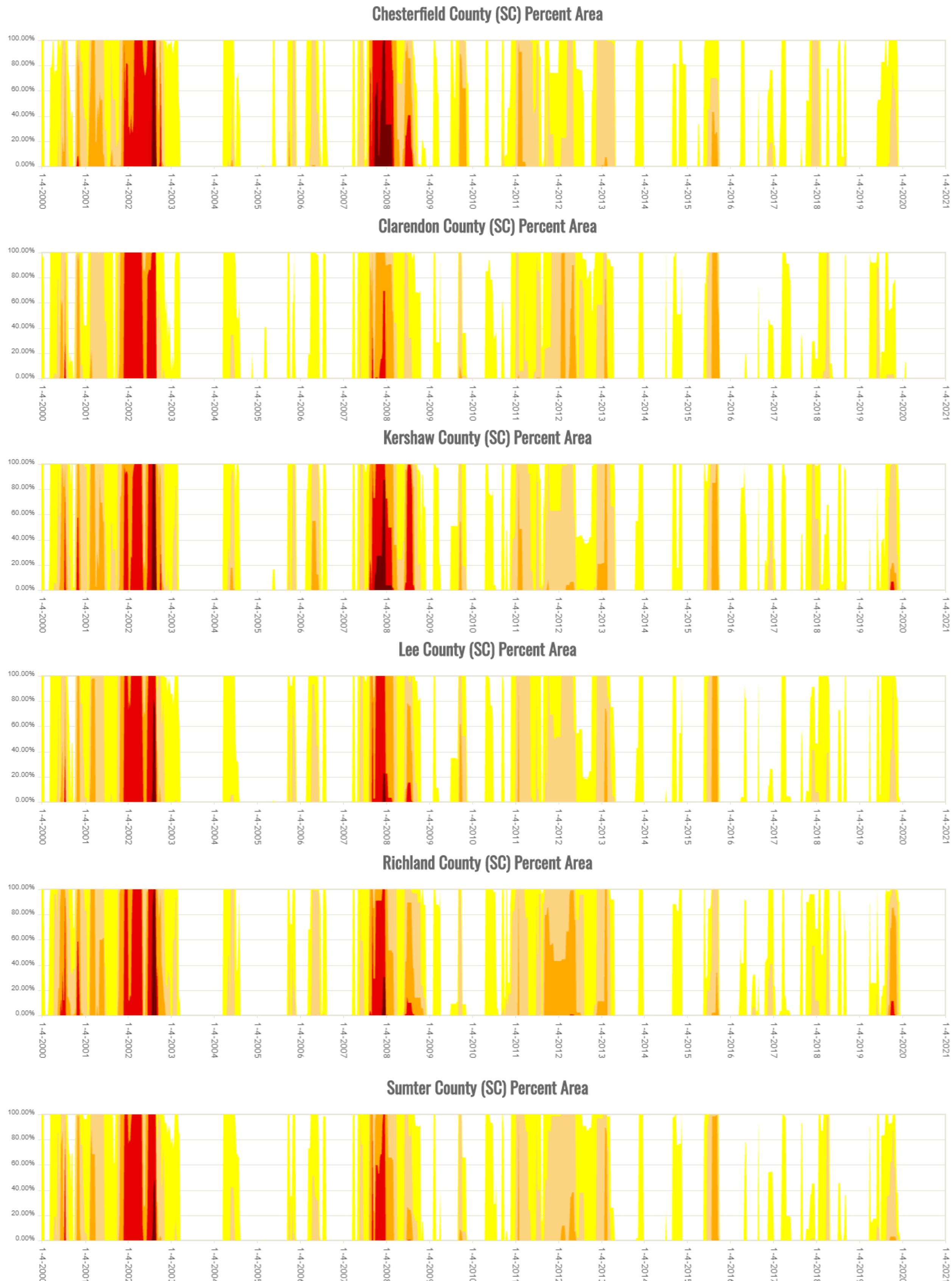

Chesterfield County (SC) Percent Area
Clarendon County (SC) Percent Area
Kershaw County (SC) Percent Area
Lee County (SC) Percent Area
Richland County (SC) Percent Area
Sumter County (SC) Percent Area
100.00%
80.00%
60.00%
40.00%
20.00%
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Figure A5

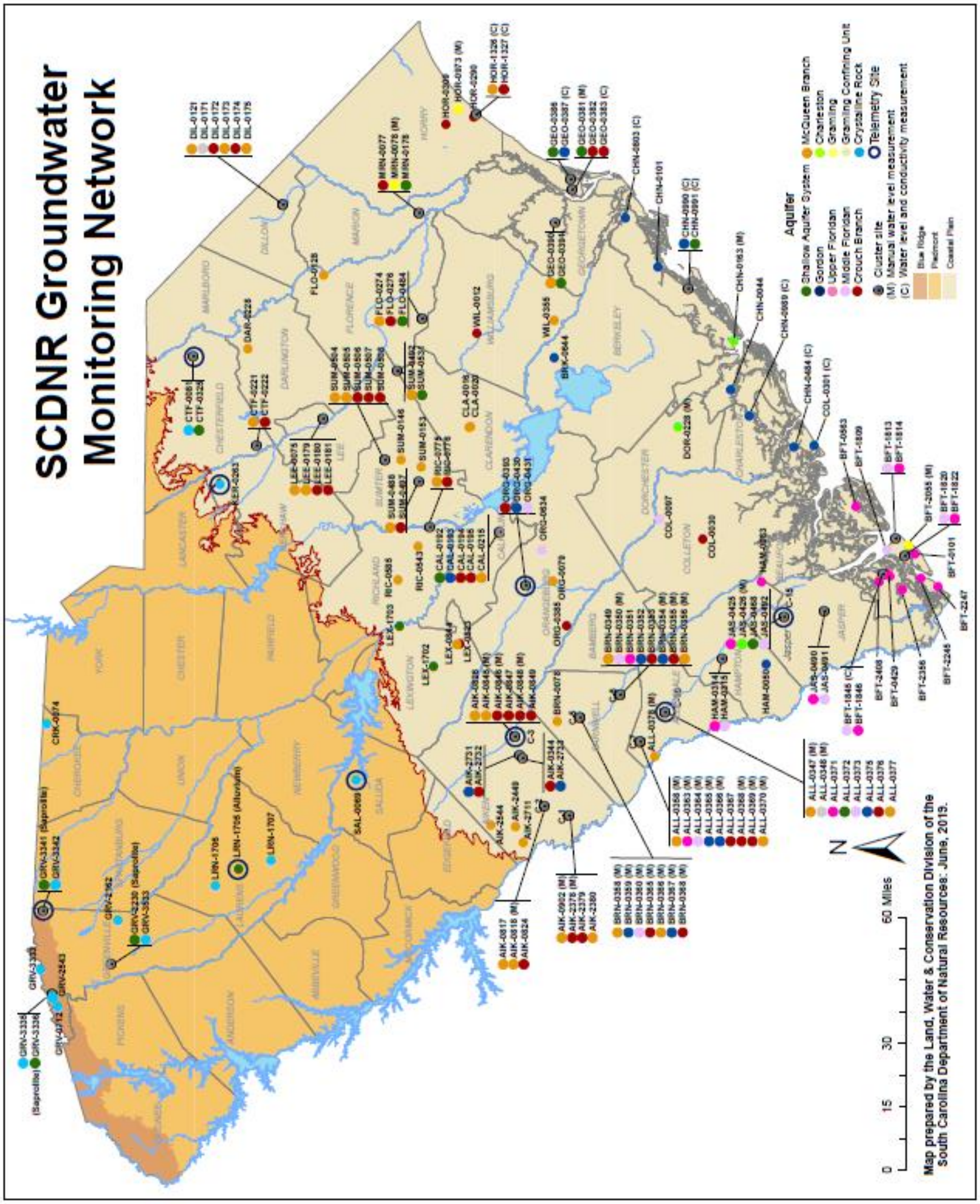

Figure A6: Map of the SCDNR Monitoring Well Network.

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