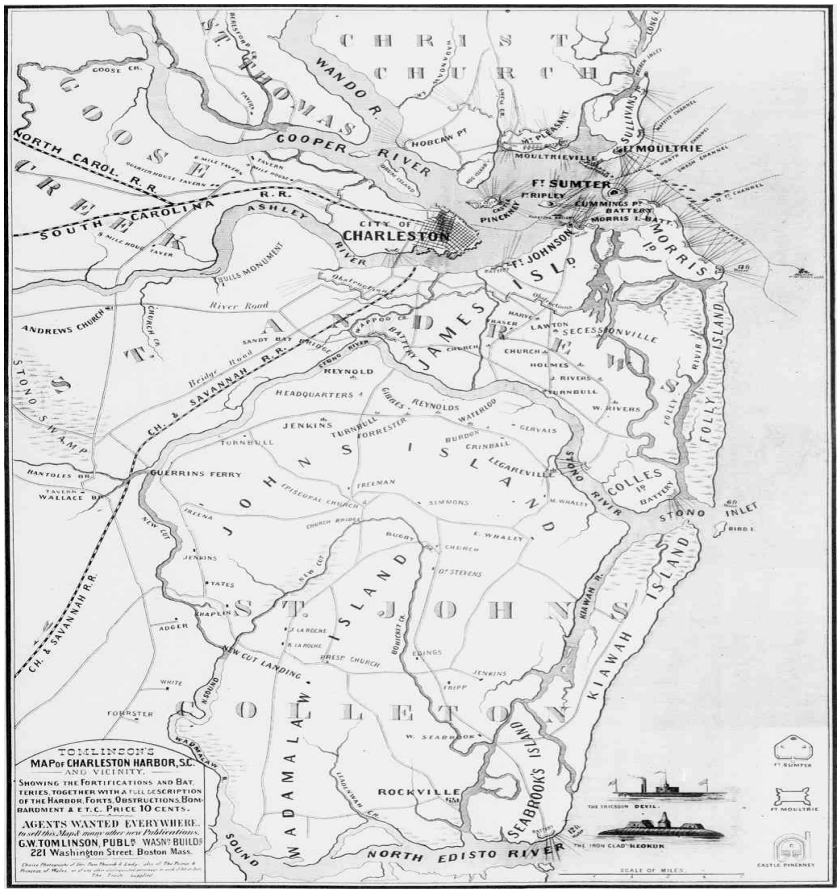
BUREAU OF WATER

South Carolina Department of Health and Environmental Control

A PRELIMINARY ASSESSMENT OF THE GROUNDWATER CONDITIONS IN CHARLSTON, BERKELEY AND DORCHESTER COUNTIES, SOUTH CAROLINA



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INTRODUCTION

The South Carolina Department of Health and Environmental Control (Department) has been requested to designate the Trident Area, consisting of Berkeley, Charleston and Dorchester Counties, as a Capacity Use Area. The request was made by the Commissioners of Public Works for the Town of Mount Pleasant, commonly known as Mount Pleasant Waterworks (MPWW). The location of the proposed Capacity Use Area, along with the existing Waccamaw and Lowcountry Capacity Use Areas, is shown in Figure 1. In a designated Capacity Use Area, any person withdrawing groundwater in excess of three million gallons during any one month from a single well or from multiple wells under common ownership within a one-mile radius from any one existing or proposed well must obtain a permit from the Department.

Section 49-5-60 of the Groundwater Use and Reporting Act states, in part, that... "In the State 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. The department, local government authorities, other government agencies, or groundwater withdrawers may initiate the capacity use area designation process. The notice and public hearing must be conducted such that local government authorities, groundwater withdrawers, or the general public may provide comments concerning the capacity use area designation process. A capacity use area must be designated by the board based on scientific studies and evaluation of groundwater resources and may or may not conform to political boundaries. After notice and public hearing, the department shall coordinate the affected governing bodies and groundwater withdrawers to develop a groundwater management plan to achieve goals and objectives stated in Section 49-5-20. In those areas where the affected governing bodies and withdrawers are unable to develop a plan, the department shall take action to develop the plan. The plan must be approved by the board before the department may issue groundwater withdrawal permits for the area."

Comprehensive groundwater investigations in the Trident area have documented progressive water-level declines, salt-water intrusion, and an increasing demand on groundwater resources as a result of rapid industrial and commercial growth, particularly along Highways 52 and 17-A, between Charleston and Moncks Corner. This report investigates the conditions in the Trident area that warrant designation as a Capacity Use Area.

GEOHYDROLOGIC FRAMEWORK

Rock units underlying the Trident area represent a wide range of lithologies, depositional environments, and ages. The oldest units (Cape Fear, Middendorf, Black Creek, and Peedee Formations) are Late Cretaceous in age. Depositional environments range from continental to innershelf marine and their lithologies consist mainly of sand, silt, and clay. Units overlying the Late Cretaceous formations include the Tertiary age Black Mingo, Santee Limestone, and Cooper

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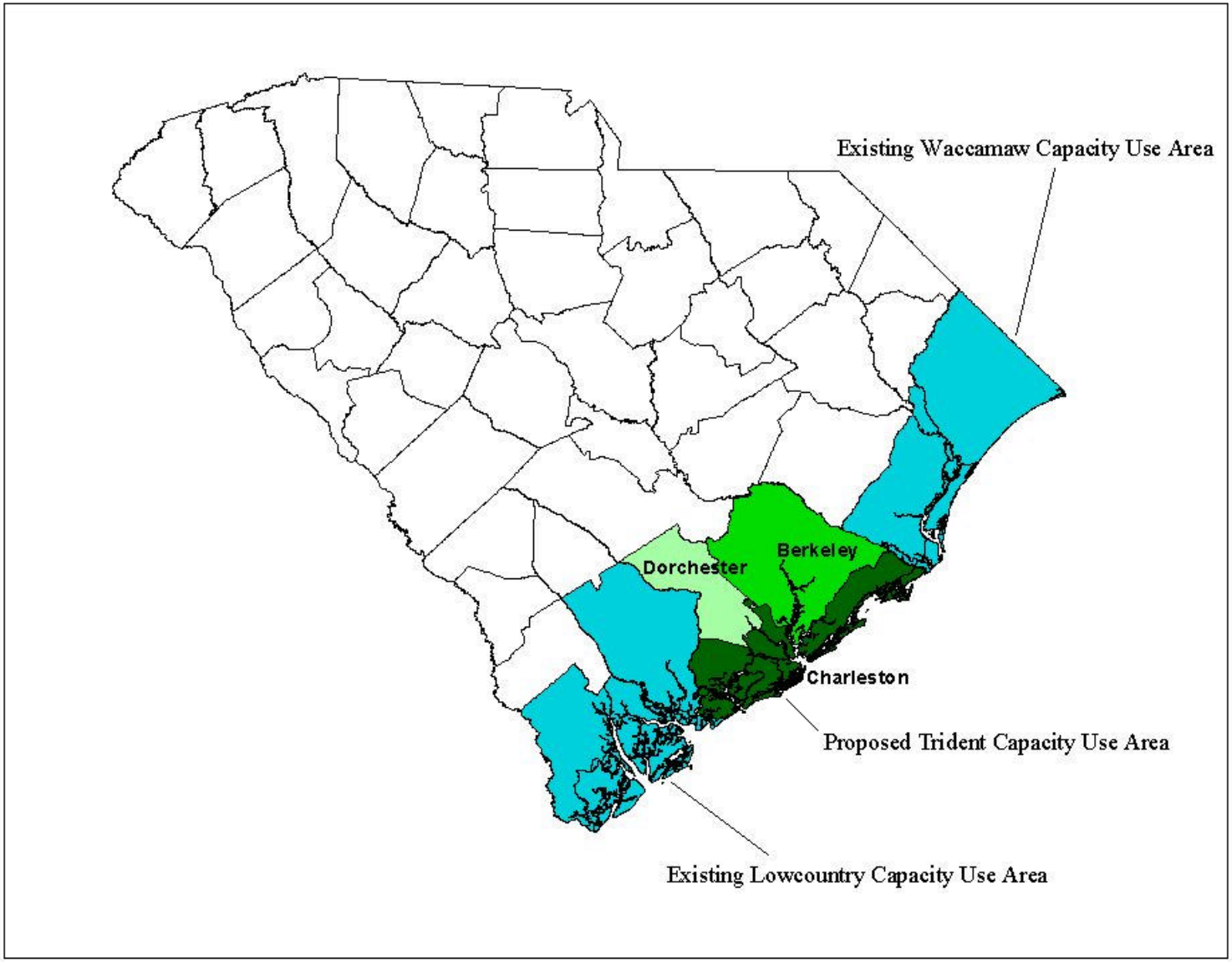

Figure 1. Location of existing Capacity Use areas and the proposed Trident Capacity Use area.

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Formations. These units were deposited in marine environments and range from marginal marine to outer shelf deposits. The lithology of the lower part of this assemblage is predominately sand, silt and clay, with the upper part being mainly pure to impure limestone. The Tertiary units are overlain by a sequence of sand, silt, clay, and shells of Pleistocene age, generally no more than 50 feet thick.

These stratigraphic units are part of a wedge of overlapping sediments that thicken towards the coast; from a feather edge at the Fall Line to more than 3,000 feet in Charleston County. Their general occurrence is shown on the geohydrologic section in Figure 2.

Because of their abundance of clay, and therefore lower transmissivities, the Peedee and Cooper Formations are not productive aquifers and act more as confining units. The Black Creek aquifer is not as productive as the underlying Middendorf aquifer and contains objectional amounts of flouride. Therefore, most of the water in the proposed capacity use area is obtained from the Middendorf aquifer, the Santee/Black Mingo aquifer, and the shallow aquifer system.

HISTORICAL PROBLEMS

SHALLOW AQUIFER SYSTEM

The most widely used source of groundwater (primarily for individual residential needs) is the sands and shell beds of the shallow aquifer system. These aquifers are used everywhere in the Trident area, but are most productive in Charleston County where they obtain a thickness of 40 to 60 feet. Although the shallow system probably receives some recharge from the Santee Limestone aquifer, most is provided by local precipitation. In areas near the coast and south of Mt. Pleasant, the shallow aquifers are the only economical means of obtaining potable water for domestic users (Park, 1985). Although they are fairly productive, they are prone to salt-water intrusion. The shallow well field for the Town of Folly Beach became brackish when overpumping resulted in the intrusion of salt water from nearby surface water bodies. Similar problems have occurred on other barrier islands and elsewhere along the coast.

SANTEE/BLACK MINGO AQUIFER

During the summer of 1984, the former South Carolina Water Resources Commission (SCWRC) began receiving reports of groundwater problems occurring south of the Town of Moncks Corner. Many residents reported that water levels had declined below their pump intakes. As a direct result of these complaints, SCWRC initiated a groundwater investigation in the area, with a resultant report on the groundwater conditions in the Santee Limestone and Black Mingo aquifers near Moncks Corner (Meadows, 1987).

At the time of the investigation, the Town of Moncks Corner was utilizing a combination of the Santee Limestone and Black Mingo aquifers for its potable water supply. The Town has since (1995) gone to surface water for the majoity of its potable supply, only 2% of this being supplied by groundwater. The majority of the population in Berkeley County is still dependent on

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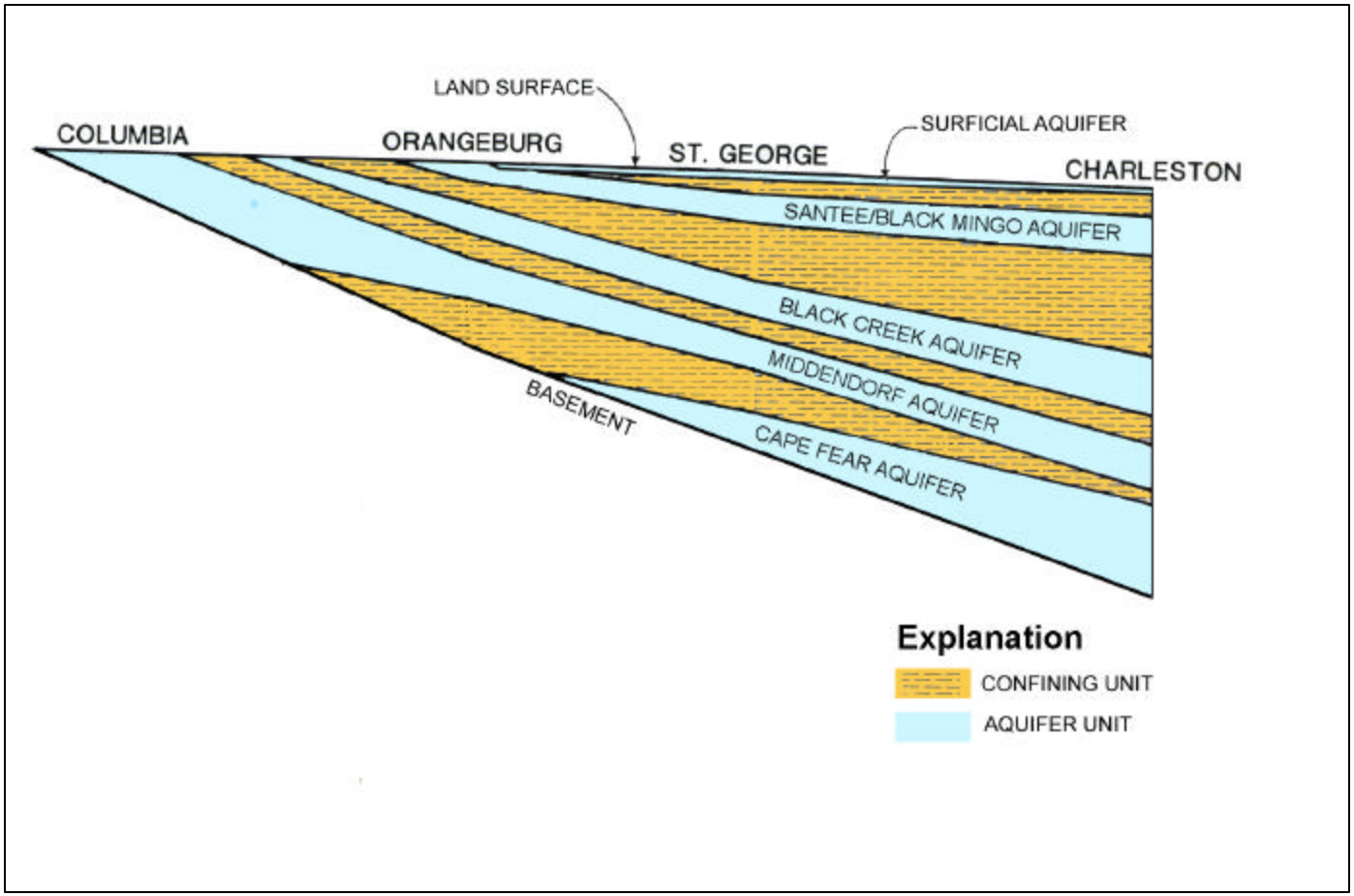

Figure 2. Generalized geohydrologic section (modified from Aucott and Speiran, 1985).

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individual residential wells. Well casing is usually seated in the Cooper Formation, with the borehole open to both the Santee and Black Mingo aquifers. With an increase in population comes a natural increase in water use. According to State figures, Berkeley County's population increased by about 13 percent between 1990 and 2000 (State of SC, ORSS, 2000). According to figures from 1985 (Meadows, 1987), 90 percent of the total 7.822 million gallons per day (MGD) of groundwater used came from privately owned wells. Most of the groundwater users in this area, whether public or private, rely solely on the Santee/Black Mingo aquifer system for a potable water supply. Therefore, declining water levels would affect numerous individual domestic wells.

Well BRK-0091, located near Summerville (Figure 3), is completed in the Santee/Black Mingo aquifer. Figure 4 represents a water-level record for this well from 1978 through 1986. Although there are other outside influences depicted on the hydrograph (nearby pumping, etc.), the overall water-level trend has been one of substantial decline, more than 50 feet over an eight year period. The potentiometric map in Figure 5 shows the elevation of water levels for the Santee/Black Mingo aquifer in 1982. Note the "trough" of lower water levels running between Charleston and Moncks Corner. These lowered water levels appear to be caused by a rapid increase in regional pumping. This coincides with the "development corridor" along Highways 52 and 17-A. Meadows estimated the average rate of decline to be about 3 feet per year in this area. Well BRK-0091 was destroyed in June 1992; therefore, water-level data is no longer available for this well.

No other wells in the immediate area are presently being continuously monitored for water levels; however, SCDNR conducted a water-level survey of the Santee/Black Mingo aquifer in the Trident area in November/December 1998. Water-level data from this survey were used to construct a potentiometric map for the Floridan aquifer and Tertiary Sand aquifer (Hockensmith, 2001). (Note: The Floridan aquifer system is comprised, in part, of the Santee/Black Mingo aquifers.) The map depicts a slight rebound in water levels in northern Berkeley County from the 1982 map; however, the "trough" of lower water levels along the development corridor between Charleston and Moncks Corner still persists (Figure 6). Even though the Town of Moncks Corner discontinued use of the Santee/Black Mingo aquifer more than seven years ago, the water levels in the area remain depressed. The aquifer remains heavily relied upon for domestic, irrigation, and industrial supplies.

Jamestown, in Berkeley County, has also experienced declining water levels. In 1978, a limestone quarry, located 2 miles east of town, was withdrawing 36 MGD from the Santee Limestone during quarry dewatering operations. Prior to the quarry reducing its groundwater withdrawals, water levels frequently fell below sea level resulting in creeks drying up, nearby landowners experiencing water supply problems, and sinkholes developing, some as large as 25 feet in diameter. Sinkhole collapses occured on road rights of way, adjacent to houses and in fields near the quarry (Park, 1985). In 1998, the South Carolina Department of Natural Resources (DNR) published "South Carolina Water Plan." The plan contained recommendations regarding "Trigger Levels" for various aquifers. A Trigger Level is defined as the minimum water level allowed in an aquifer

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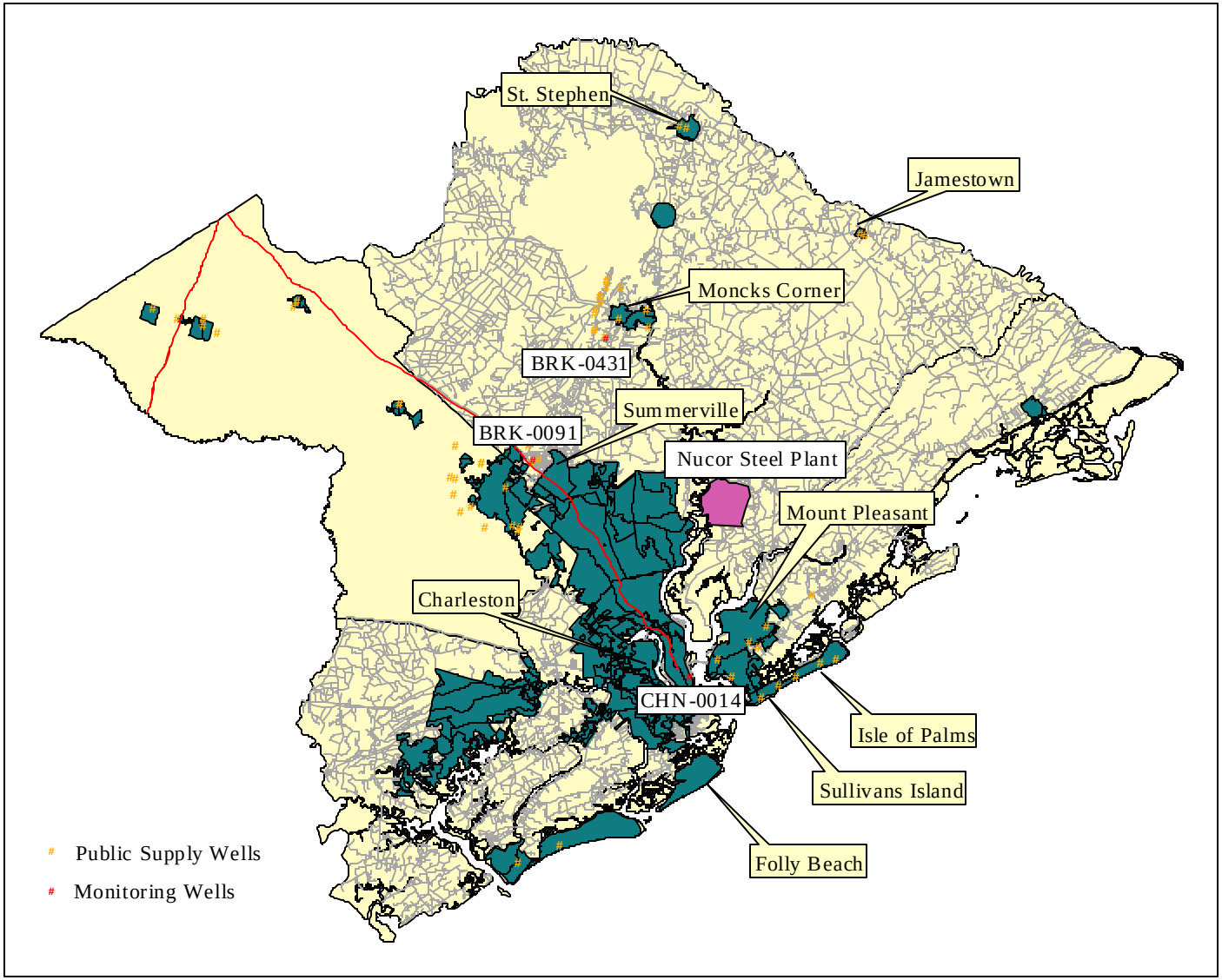

Figure 3. Location of major referenced features.

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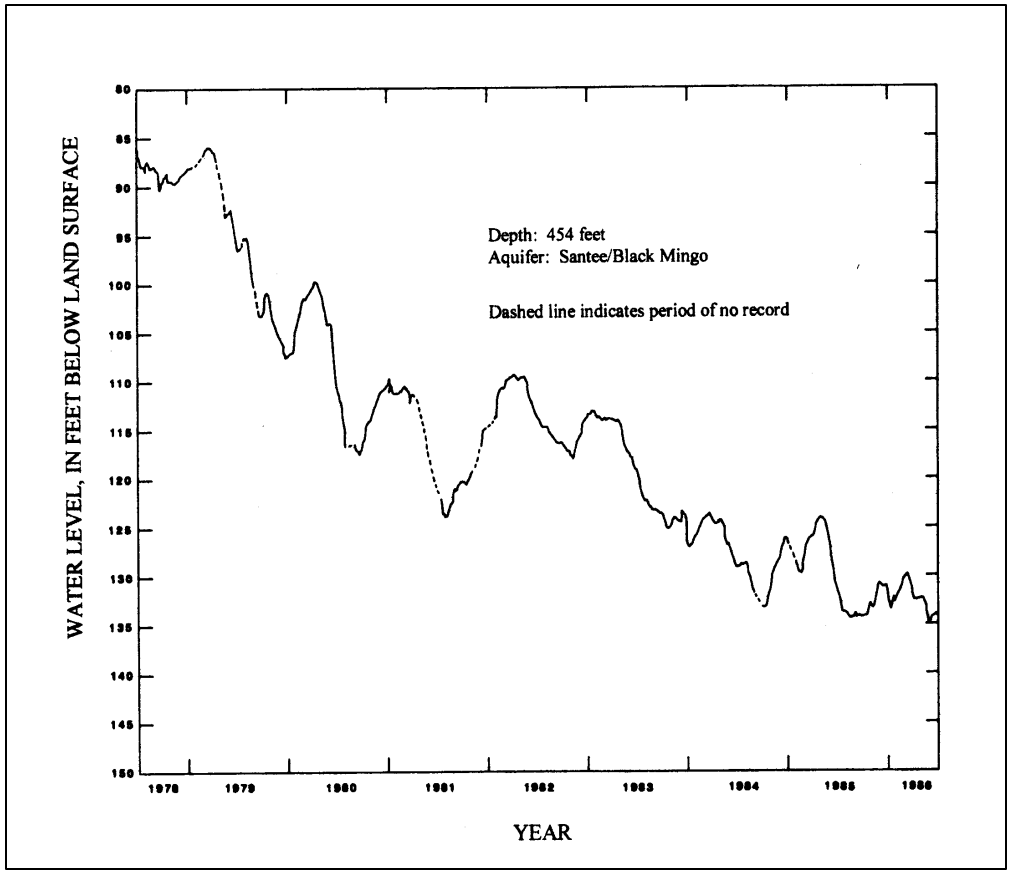

Figure 4. Hydrograph of well BRK-0091, near Summerville, 1978-1986.

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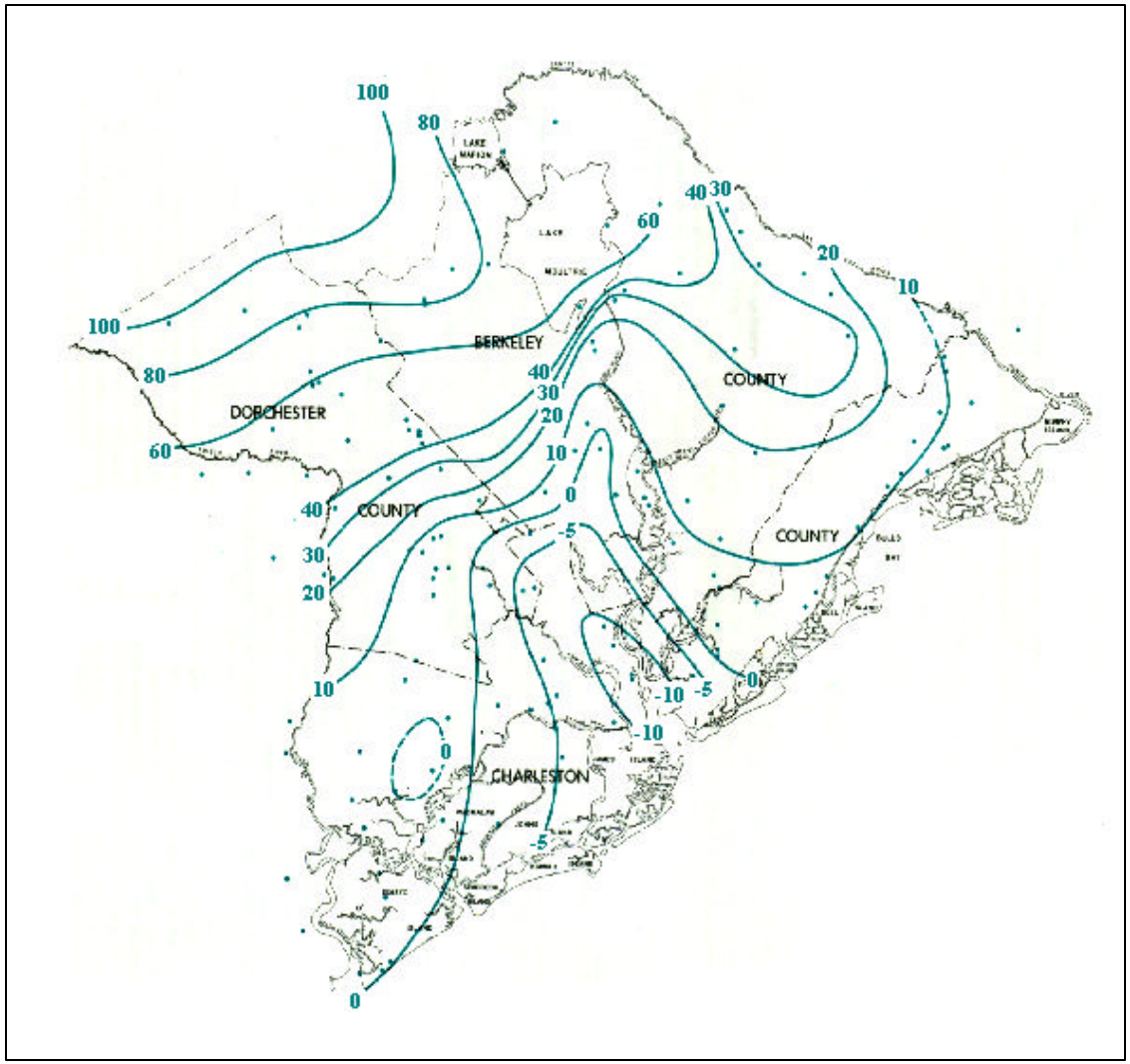

Figure 5. Potentiometric surface of the Santee/Black Mingo aquifers (after Park, 1985).

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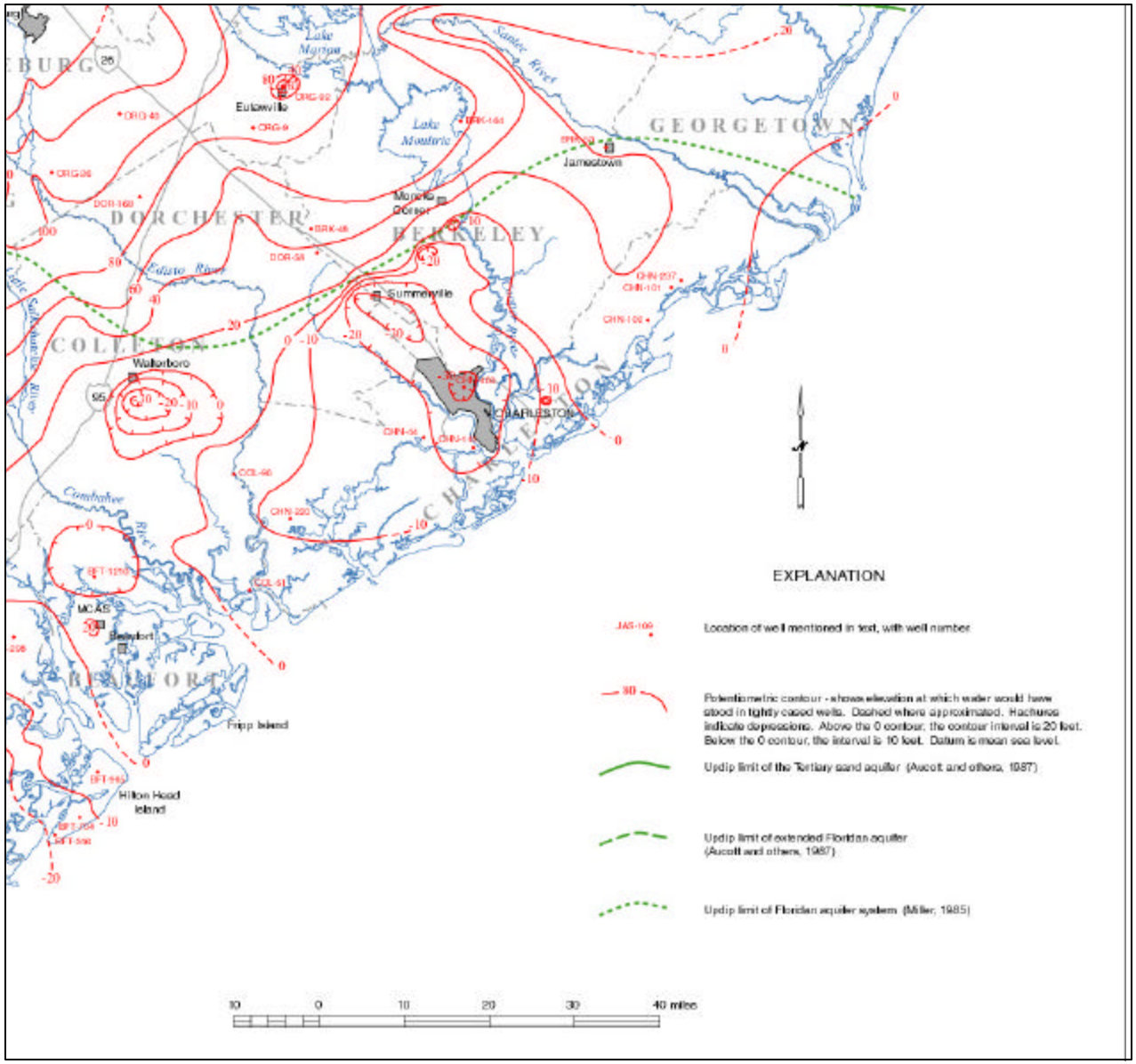

Figure 6. Potentiometric surface of the Floridan Aquifer and Tertiary Sand Aquifer in South Carolina - 1998.

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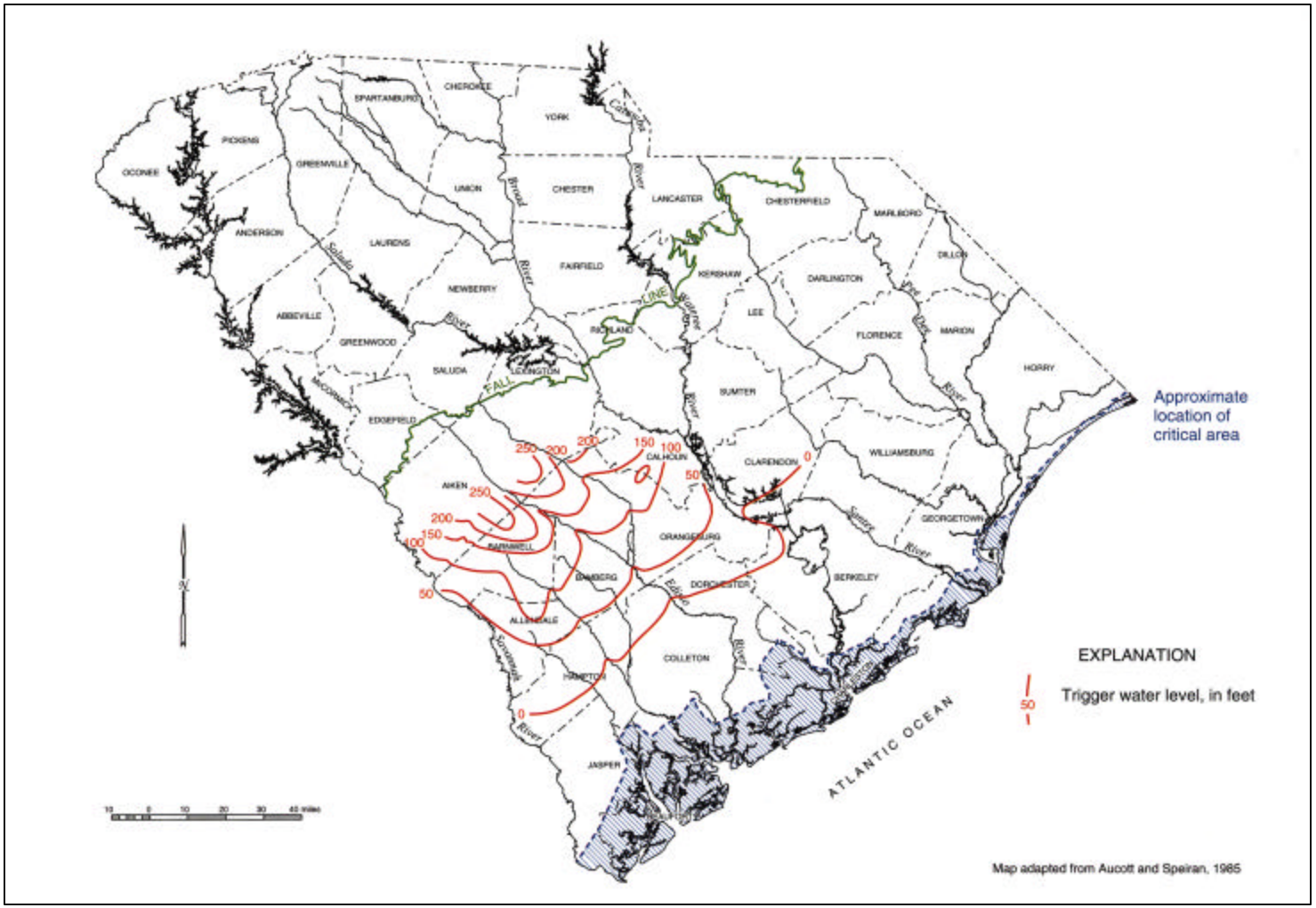

Figure 7. Trigger levels for the Floridan aquifer system.

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before the processes to declare a Capacity Use Area is automatically initiated. DNR has determined that the Trigger Level is a water level decline equal to 150 feet below the predevelopment level of an aquifer, except for the Floridan aquifer system, in which the Trigger Level is a decline of 75 feet below the predevelopment level or to mean sea-level, whichever is the least decline. Figure 7 shows the Trigger Levels for the Floridan aquifer system. As shown, the Trigger Level for almost all of Berkeley, Charleston, and Dorchester Counties is when the water level declined to sea-level. The potentiometric map for 1998 (Figure 6) indicates that water levels in much of the area are already below sea level.

MIDDENDORF AQUIFER

Water levels in the Middendorf aquifer have declined substantially from predevelopment (1879) levels in the Trident area as a result of concentrated public supply and industrial usage. Prior to development, water levels in the Middendorf aquifer in Charleston were 126 feet ***above*** mean sea level (msl). In 1989, they were 10 feet ***below*** msl (Campbell, 1996), a total decline of 136 feet. When measured in March 2000, the water level in Charleston was about 56 feet below msl, a total decline of over 180 feet.

Mt. Pleasant, and, until recently (1994), Summerville, were the major users of water from the Middendorf aquifer in the Trident area. Summerville now receives surface water from the Santee-Cooper Regional Water Authority. In Charleston, the first Middendorf aquifer well (CHN-0014) was drilled in 1879. The well freely flowed under artesian conditions until late in 1989 when continued pumping in the area had lowered water levels to a point below land surface. When completed, the well initially flowed at 465 gallons per minute (gpm). Charleston completed four more wells in the Middendorf aquifer, but these wells produced progressively less water and eventually the city was forced to a surface water source to meet the potable demand. Other users of the Middendorf aquifer in the Trident area include Isle of Palms, St. Stephens, and Jamestown.

Mt. Pleasant has withdrawn water from the Middendorf aquifer since 1968 when the first of six wells was drilled. Average daily withdrawals have increased from 2.4 MGD in 1984 to 5.26 MGD in 1999. An increase in demand on aquifers already stressed could lower water levels even further, unless the withdrawal rates and distribution of new and existing wells are carefully planned (Campbell, 1996). Currently, the MPWW is limited to withdrawing a maximum of 6.8 MGD, the capacity of their reverse osmosis plants.

To address the concerns of users of the Middendorf aquifer (MPWW in particular), the U.S. Geological Survey (USGS), in cooperation with the S.C. Department of Natural Resources-Water Resources Division (SCDNR-WRD), initiated an investigation to compile existing water resource information and incorporate the data into a groundwater flow model (MODFLOW). Modeling can simulate water levels under various pumping scenarios. For example, a simulated scenario can distribute pumping over a large geographic area. Withdrawals from existing and new wells are distributed evenly to meet anticipated average annual demands. This scenario has been revised to include industrial withdrawals of 4.32 MGD (3,000 gallons per minute) at the Nucor steel plant located approximately 11 miles north of Mt. Pleasant in Berkeley County. Figure 8

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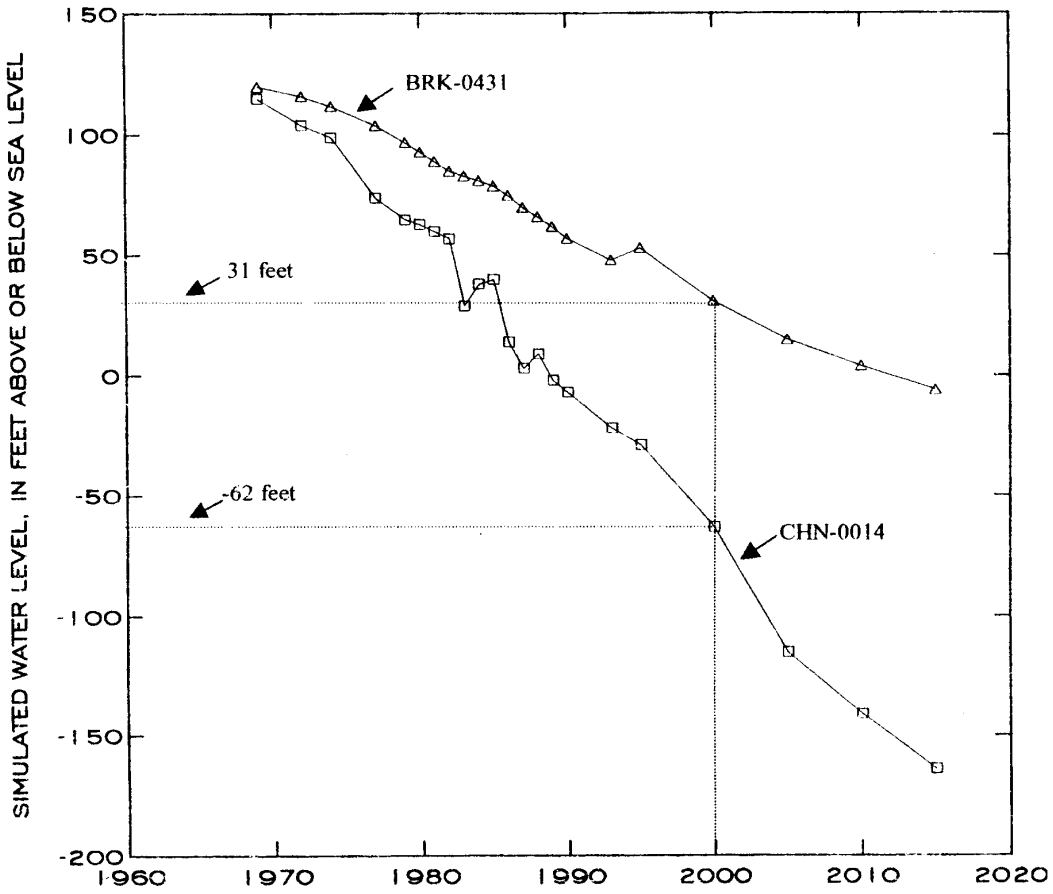

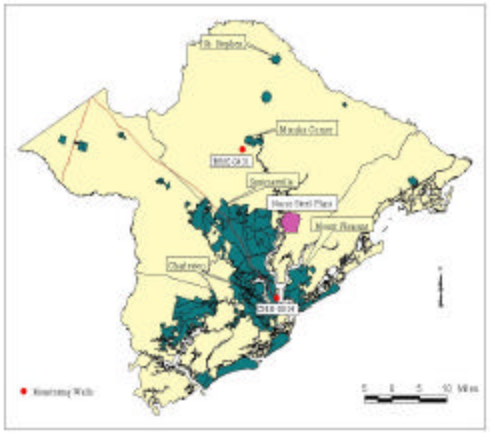

Figure 8. Simulated hydrographs for wells BRK-0431 in Moncks Corner and CHN-0014 in Charleston.

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shows hydrographs of simulated water levels from 1970 through 2015 for wells CHN-0014 (located in Charleston) and BRK-0431 (located in Moncks Corner) using this scenario. In 1993, the projected water level for the year 2000 in well BRK-0431 was approximately 31 feet above msl. When measured on March 16, 2000, the actual water level was 29.29 feet above msl - a close match. The projected water level for CHN-0014 was about 62 feet below sea level; when measured in March, the actual water level was 55.85 feet below msl. This slight descrepancy may have resulted from Sullivan's Island ceasing pumping from the Middendorf in May 1996 and the Isle of Palms purchasing 30 percent of its water from surface water sources in December1996.

Concerned about the effects of the Nucor plant's withdrawals, MPWW contracted Synesis Environmental, Inc. (SEI) to investigate groundwater usage from the Middendorf aquifer in the Trident area. SEI used the EZFlow model to simulate the impacts of future groundwater withdrawals on the potentiometric surface of the Middendorf aquifer and for optimization of Mt. Pleasant's withdrawals. Two types of simulation were performed to estimate the impact of Nucor's withdrawal. Historical and future groundwater use were used to simulate hydrographs for wells CHN-0014 and BRK-0431. In addition, simulations were made with Nucor withdrawing 0 MGD and 4 MGD, all other parameters remaining the same. This gives an estimate of the decline in water levels that would be caused solely from Nucor's pumping. Figures 9 and 10 show simulated hydrographs for wells CHN-0014 and BRK-0431, respectively, with Nucor pumping 0 MGD and 4 MGD. The effect of Nucor's simulated withdrawals is quite significant, a 22-foot decline at well CHN-0014 and 24 foot decline at well BRK-0431.

Another indication of the effect of large withdrawals is to look at actual water-level trends. Water levels in Moncks Corner (BRK-0431) were 63 feet above msl in 1983. They declined to their lowest recorded level (29.52 feet above msl) in 1995. When Summerville converted from groundwater to surface water, groundwater levels recovered to 39 feet above msl by November of 1996. Water levels have since declined again to 29.29 feet above msl.

The potentiometric surface for the Middendorf aquifer in 1989 is shown in Figure 11. Note the "0" foot water-level contours in the center of the depression near Mt. Pleasant and Summerville. Figure 12 shows the potentiometric surface for the Middendorf aquifer in 1996. Note the location of the "0" foot contour and that the center of the depression at Mt. Pleasant is now "-125" feet msl. The cone of depression centered around Summerville in 1989 is absent in 1996. Water levels at Mt. Pleasant have declined almost 260 feet since predevelopment. Water-level contours in Figure 12 do not reflect any withdrawals by Nucor Steel, which began pumping in 1997.

The Trigger Levels for the Middendorf aquifer, as defined by DNR, are shown in Figure 13. The potentiometric map in Figure 12 indicates that water levels in the Charleston area are more than 100 feet below the Trigger Level for the Middendorf aquifer.

The conversion to surface water has undoubtedly slowed the rate of groundwater declines; however, groundwater levels are expected to continue declining due to rapid growth in the area. Although most of the large municipalities in the Trident area have converted to surface water for

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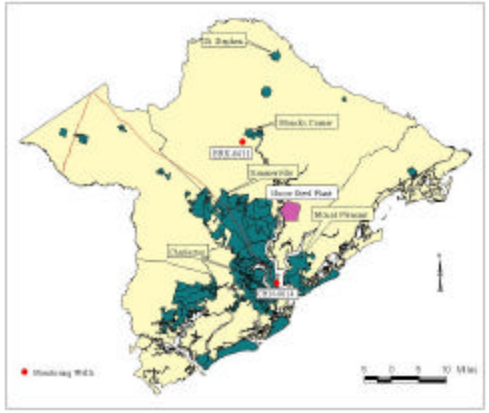

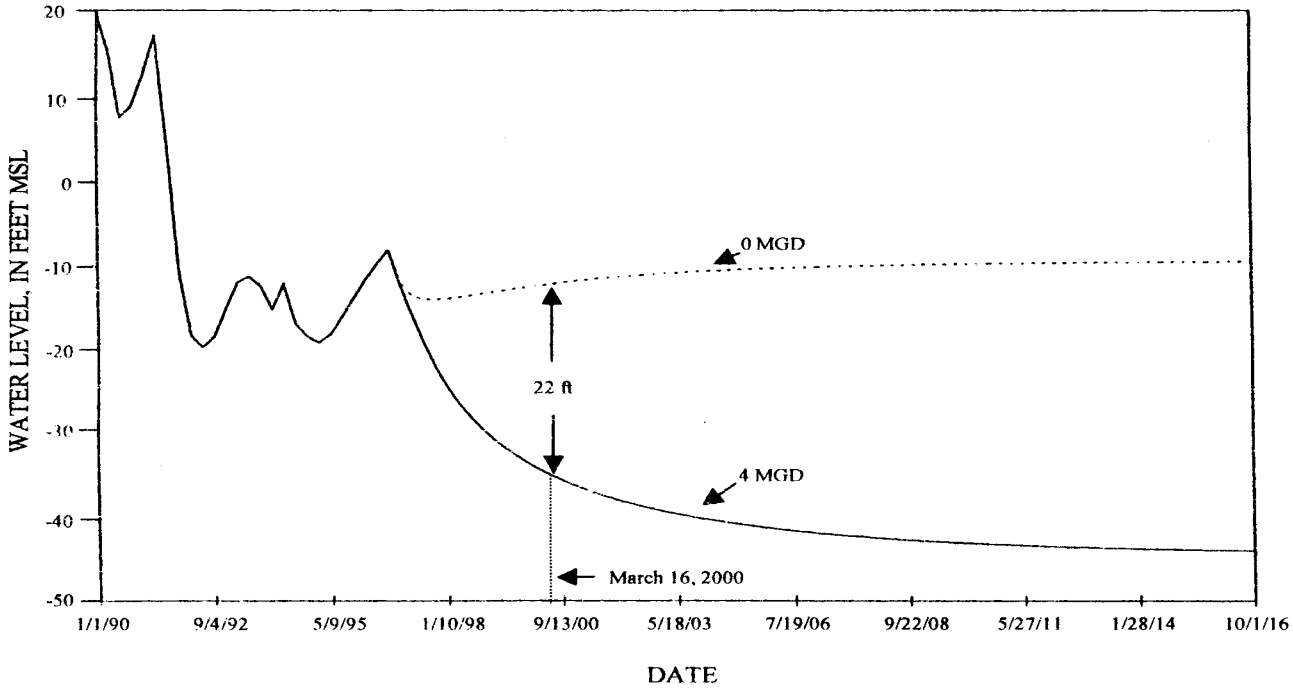

Figure 9. Predicted water-level response at Charleston (CHN-0014) with Nucor pumping.

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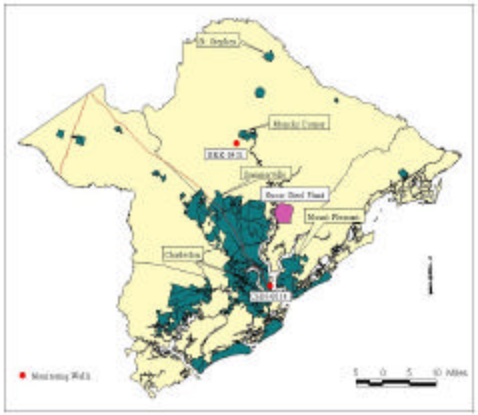

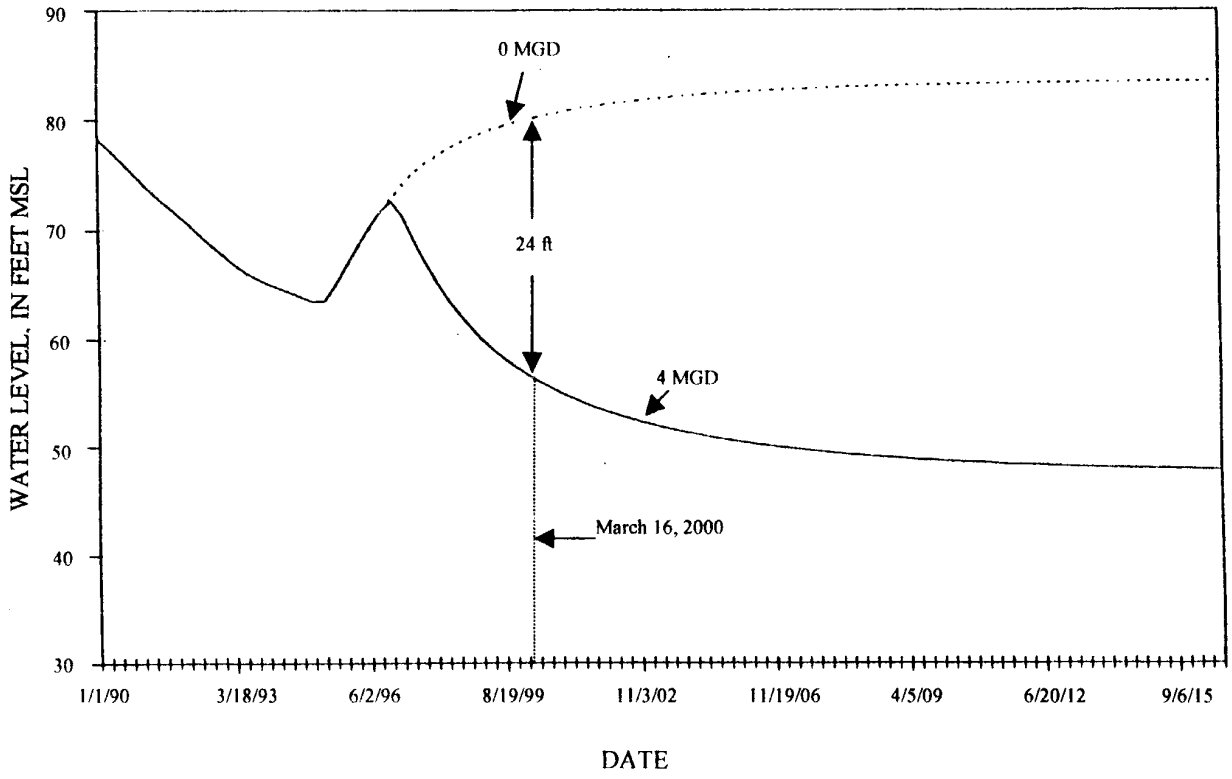

Figure 10. Predicted water-level response at Moncks Corner (BRK-0431) with Nucor pumping.

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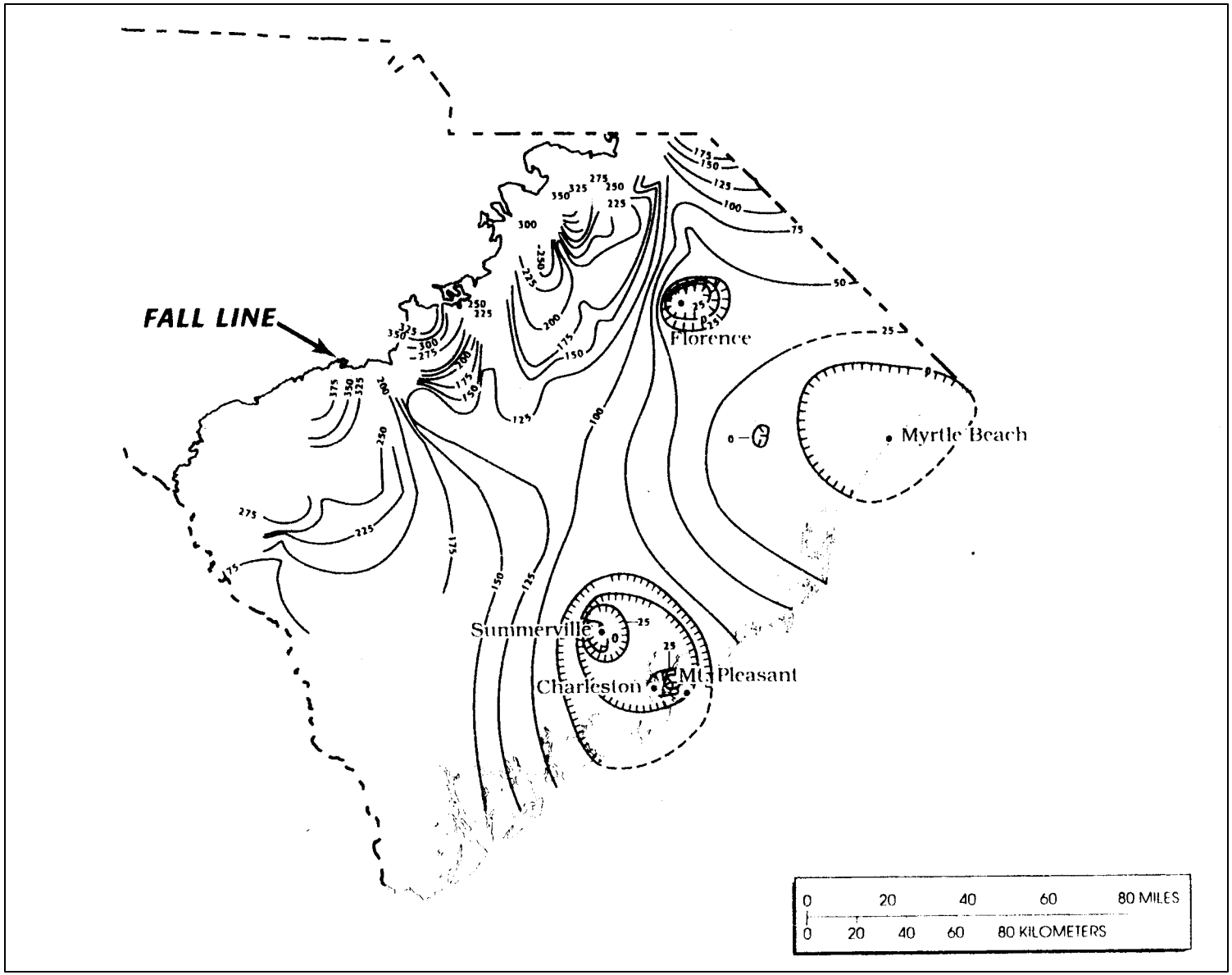

Figure 11. Potentiometric surface of the Middendorf aquifer, 1989 (after Campbell, 1996).

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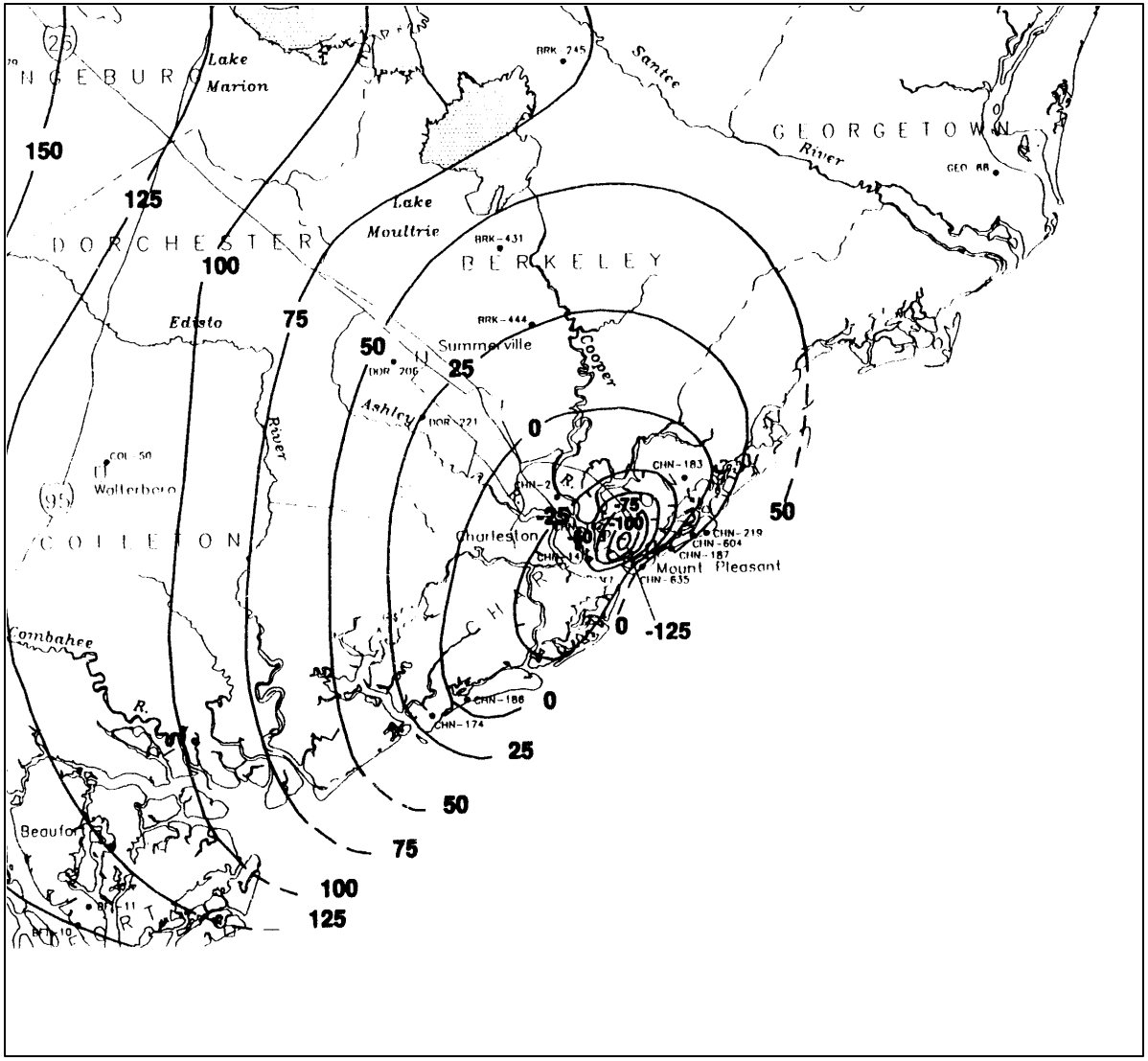

Figure 12. Potentiometric surface of the Middendorf aquifer, November 1996 (Hockensmith and Waters, 1998).

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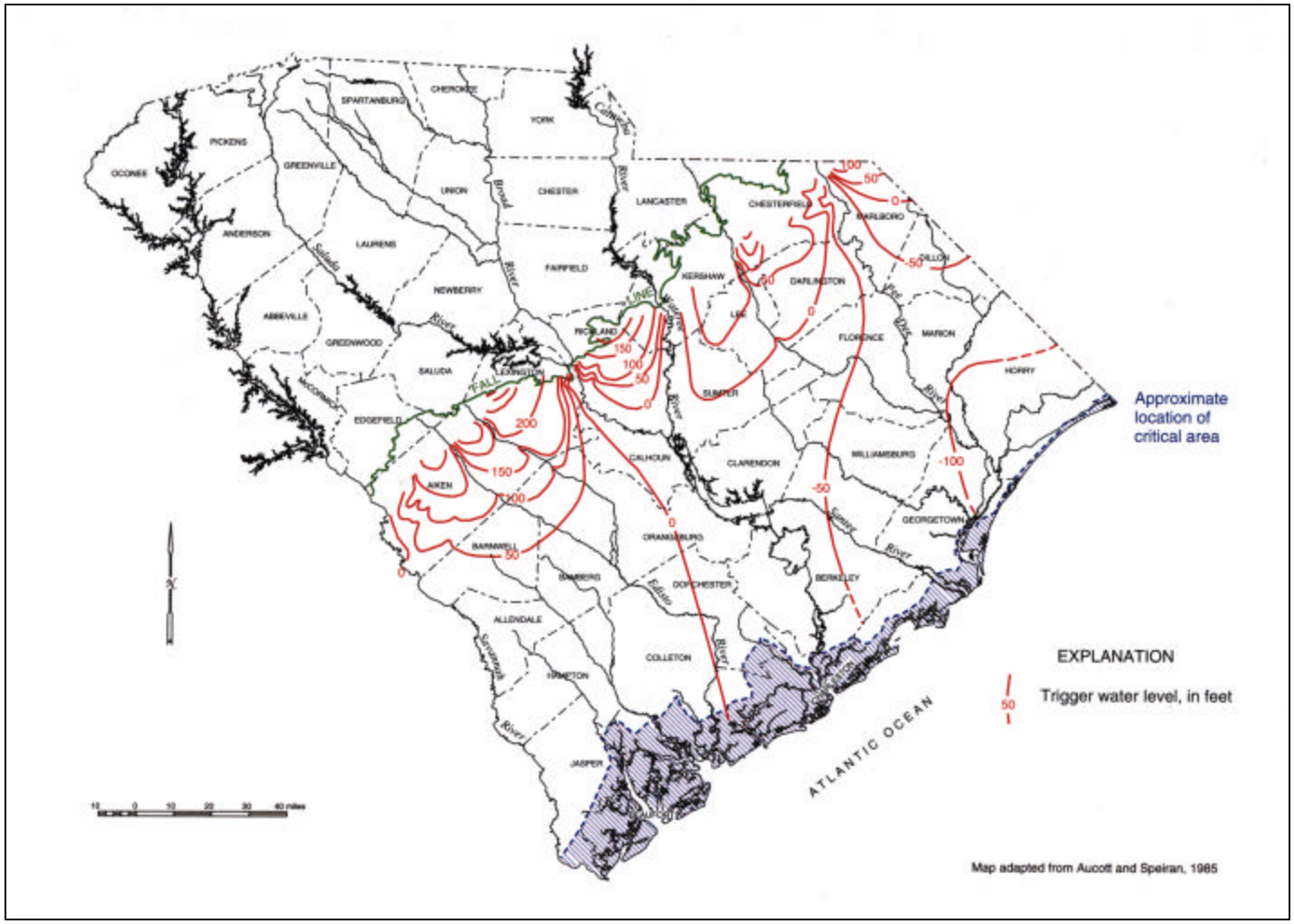

Figure 13. Trigger Levels for the Middendorf aquifer.

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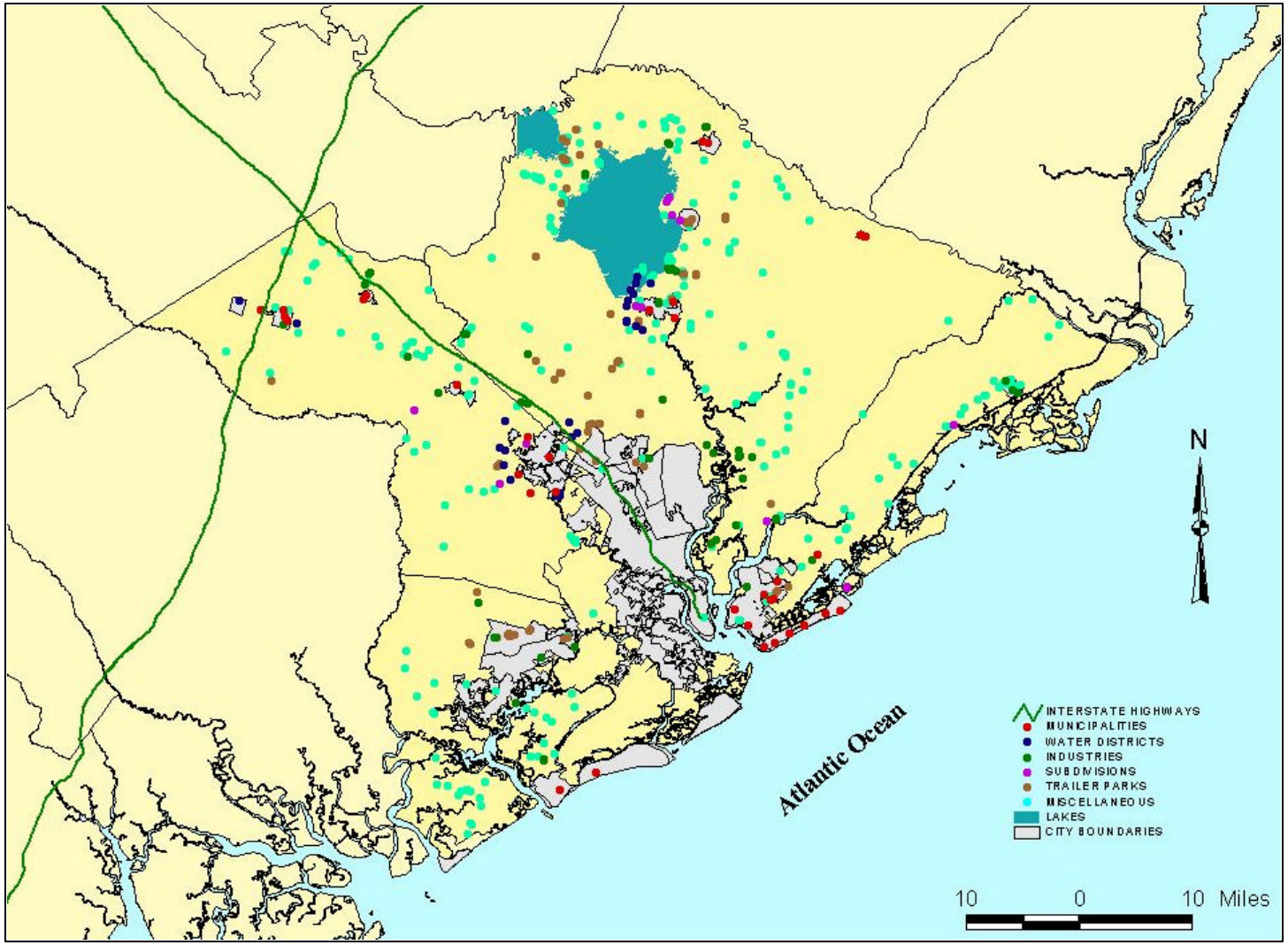

Figure 14. Location of public supply wells in the Trident area.

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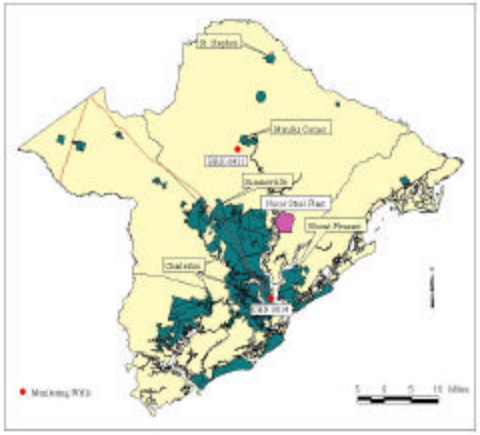

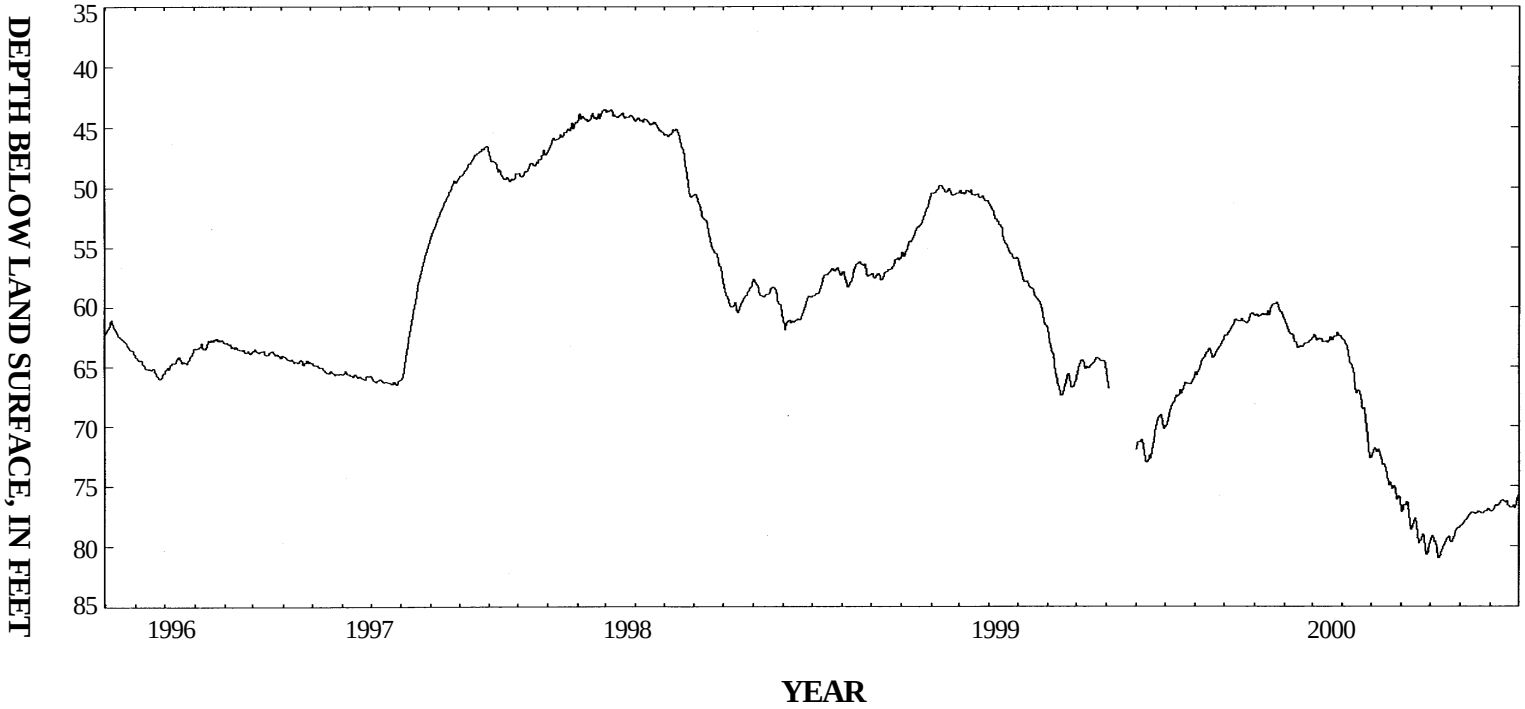

Figure 15. Hydrograph of well CHN-0014, in Charleston.

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their potable needs, there are numerous small municipalities, subdivisions, golf courses, and industries (524 total) that still rely solely on groundwater. The location of public supply wells in the Trident area, and their respective uses, is shown in Figure 14. Note the number and dispersion of industrial users. As previously noted, most of the municipalities in the tri-county area have made the conversion to surface water; however, groundwater levels continue to decline. Well CHN-0014 is located in downtown Charleston at the end of the Charleston Peninsula. Although the hydrograph for CHN-0014 depicts some cyclic fluctuations (Figure 15), the overall trend is a declining water level from approximately 62 feet below land surface in October 1996 to almost 77 feet below land surface in September 2000. This downward trend is vividly illustrated in Figure 16. The hydrograph for well BRK-0431 indicates a continuous water level decline from near land surface in early 1990 to about 29 feet below land surface late in 1994. From 1994 until mid-1996, water levels recovered approximately 4 feet (this coincides with Summerville's conversion to surface water). Water levels have since declined to about 40 feet below land surface as of October 2000.

CONCLUSIONS AND RECOMMENDATIONS

Groundwater levels in the Middendorf aquifer have declined substantially from predevelopment (1879) levels in the Trident area as a result of concentrated public supply and industrial usage. Prior to development, water levels in the Middendorf aquifer in Charleston were 126 feet above mean sea level (msl). In 2000, the water level in Charleston was approximately 56 feet below msl, a total decline of **over 180 feet**. Even with the increased use of surface water in the early 1990's, groundwater levels continue to decline. Demands for groundwater are certain to increase in the future. The population of the Trident area increased 40% from 1973 to 1994, and is expected to reach 795,879 by 2030.

Because Berkeley, Charleston, and Dorchester Counties all share the same groundwater resources, and because all of the groundwater regimes in the area are impacted, it is appropriate to include all three counties in the designation. This is consistent with the Lowcountry Capacity Use area, comprised of Beaufort, Jasper, and Colleton Counties and the Waccamaw Capacity Use area, including Georgetown, Horry and part of Marion Counties. If designated, the Trident Capacity Use area, in conjunction with the Lowcountry and Waccamaw areas, will afford a mechanism by which the aquifers underlying all of the coastal counties in South Carolina may be offered some degree of protection. This designation will also provide for measures to abate or control salt-water intrusion and measures to prevent, or at least mitigate, unreasonable adverse effects on water users within the Trident Capacity Use area.

Based on the available technical information, Department staff concludes that the Trident area has developed and utilized groundwater to the degree that coordination and regulation of groundwater supplies has become desirable and necessary. To comply with the Legislative policy provided in Section 49-5-20 and the conditions outlined in Section 49-5-60 of the Groundwater Use and Reporting Act, the staff recommends approving the Mount Pleasant Water Works' request for designation of the Trident area as a capacity use area.

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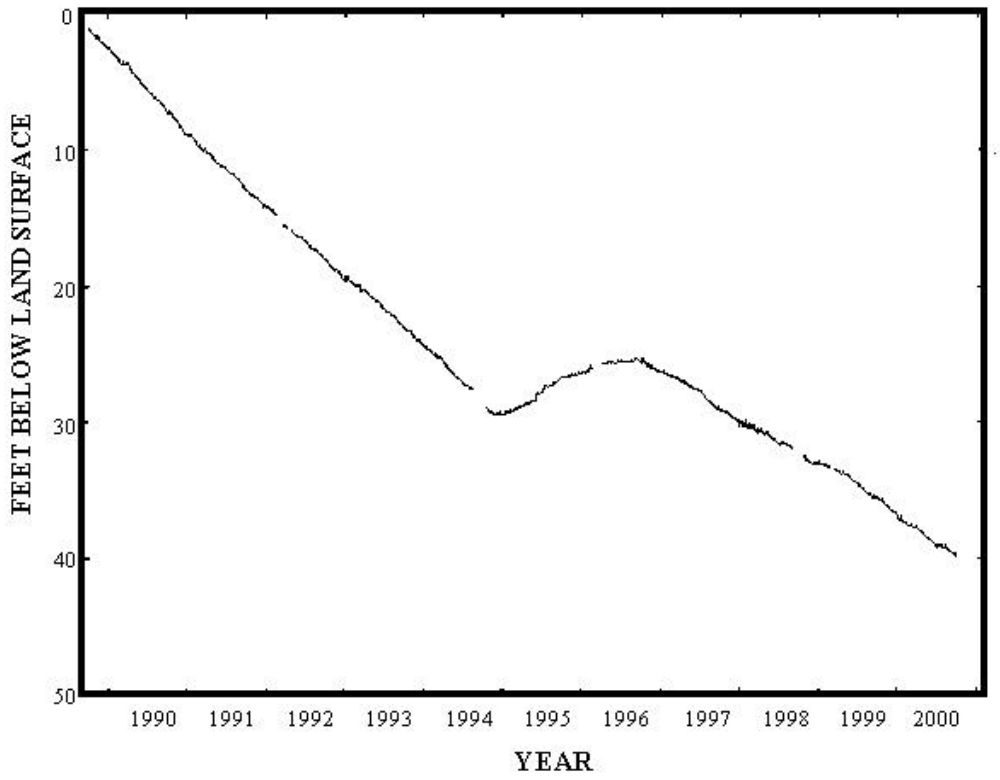

Figure 16. Hydrograph for well BDK-431.

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Recommendations for additional data to be gathered concurrently with the designation process are as follows:

1) The thickness and permeability of the shallow aquifer system vary widely throughout the Trident area. The amount of water that can be withdrawn from individual wells will also vary immensely. Pumping tests should be conducted on the shallow aquifers to calculate transmissivities (although they will vary greatly with locale) to determine the maximum "safe yield" to prevent salt-water intrusion. Water quality monitoring should also be conducted. Wells along the barrier islands (Folly Beach, Edisto Beach, etc.) have experienced problems with increased salinity.

2) Brackish water is known to exist in the Black Mingo aquifer near the coast. Therefore, salt-water contamination by inter-aquifer transfer is a problem between the Santee Limestone and the Black Mingo because of their open-hole construction. Monitoring wells should be installed at discrete intervals and strategic locations to determine the magnitude and extent of contamination. Declining water levels are also aggravating the situation. In some instances, water levels have been lowered to the point that homeowners have had to set their pump intakes lower or even have their well deepened. In others, the uncontrolled withdrawal of groundwater has resulted in sinkhole development and land surface collapse. In cooperation with DNR and others, a water-level monitoring network should be established (mostly from existing wells) to determine the growth and effect of increasing groundwater withdrawals.

3) Groundwater withdrawals from the Middendorf aquifer near Charleston have caused the development of a regional cone of depression in the potentiometric surface. With water levels below sea level (-132 feet in Mt. Pleasant) in the Middendorf aquifer, salt water is undoubtedly encroaching upon the Charleston and Mt. Pleasant area at a much higher rate. Annual, or semi-annual, water quality and water level monitoring should be conducted to determine the direction and rate of movement of the salt-water wedge. The Middendorf wells on the Isle of Palms and Sullivan's Island should be sampled regularly for chloride concentrations. Another Middendorf water-level survey should be conducted and a more detailed potentiometric map produced to determine the actual effects of Nucor's withdrawals.

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