Changes in the Availability of Freshwater along the South Carolina and Georgia Coast due to Potential Climate Change Scenarios

Paul A. Conrads[1], Edwin A. Roehl Jr[2], Ruby Daamen[2], John B. Cook[2], Jessica Whitehead[3], Daniel Tufford[4], Greg Carbone[4], and Kirstin Dow[4]

AUTHORS: [1]U.S. Geological Survey, Columbia, SC, [2]Advanced Data Mining International, LLC, Greer, SC, [3]SC Sea Grant Consortium, Charleston, SC, [4]University of South Carolina, Columbia, SC

ABSTRACT. Saltwater intrusion into freshwater aquifers and drainage basins can threaten the biodiversity of freshwater tidal marshes and the contamination of municipal, industrial, and agricultural water supplies (Bear and others, 1999). The balance between hydrological flow conditions within a coastal drainage basin and sea level governs the magnitude, duration, and frequency of salinity intrusion into coastal rivers. Future climate change is likely to aggravate the problems of salinity intrusion in the East Coast of the U.S., as increased air temperatures, changes in regional precipitation regimes, and potential sea-level rise alter these hydrologic balances. This study examines saltwater intrusion at two municipal surface-water intakes on the Atlantic Intracoastal Waterway (AIW) and the Waccamaw River near Myrtle Beach along the Grand Strand of the South Carolina Coast (fig. 1) and illustrates how future sea-level rise and a reduction in streamflows can potentially affect salinity intrusion and threaten the municipal water supply and the biodiversity of freshwater tidal marshes (Furlow and others, 2002).

An updated salinity intrusion model of the Pee Dee River Basin (Conrads and Roehl, 2007) was used to evaluate the potential effects of climate change on salinity intrusion. The model was developed using data-mining techniques, including multi-layer perceptron (MLP) artificial neural network (ANN) models (Rosenblatt, 1958; Jensen, 1994).

The USGS maintains a real-time streamgaging network of streamflow, water-level and specific conductance recorders in the Pee Dee and Waccamaw River Basins (fig. 1). Streamflow data records exceeding 50 years and specific conductance data records of up to 25 years are available. During the past 25 years of data collection, the estuarine system has experienced various extreme conditions including large 24-hour rainfalls, the passing of tropical systems and major offshore hurricanes, and record drought conditions.

The ANN models were developed using data from a subset of this network. The models predict specific conductance at seven coastal gaging stations using data from five upland streamflow recorders, tidal water levels at the north end of the AIW, and wind speed and direction from a coastal meteorological station. The models were validated using historic measurements of specific conductance at selected coastal stream gaging stations.

To simulate the effects of sea-level rise, the mean coastal water levels were incremented by 0.5-foot (ft) to simulate sea-level rises of up to 3 ft. To simulate the effect of reduced streamflow to the coast, the daily historical streamflows were reduced by increments of 5 percent to simulate reduction of up to 25 percent. Daily
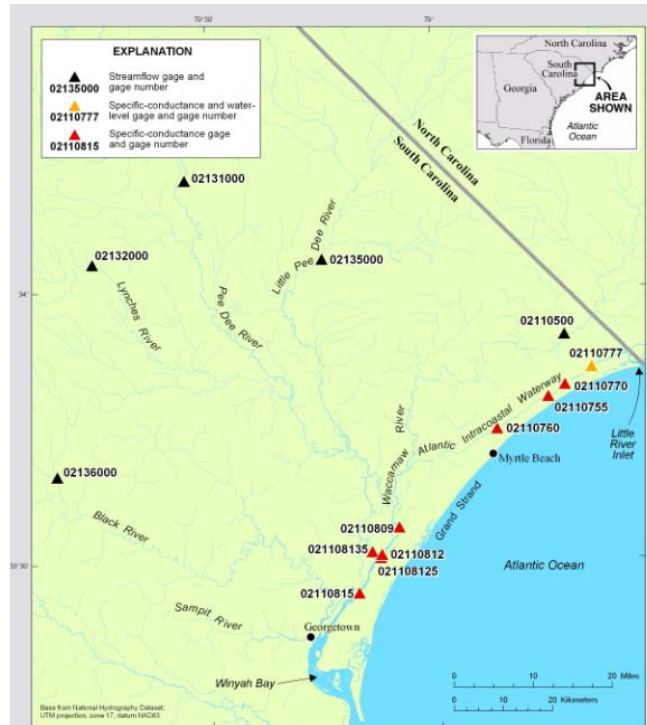

Figure 1. Study area including the Pee Dee and Waccamaw River Basins and Atlantic Intracoastal Waterway in South Carolina.
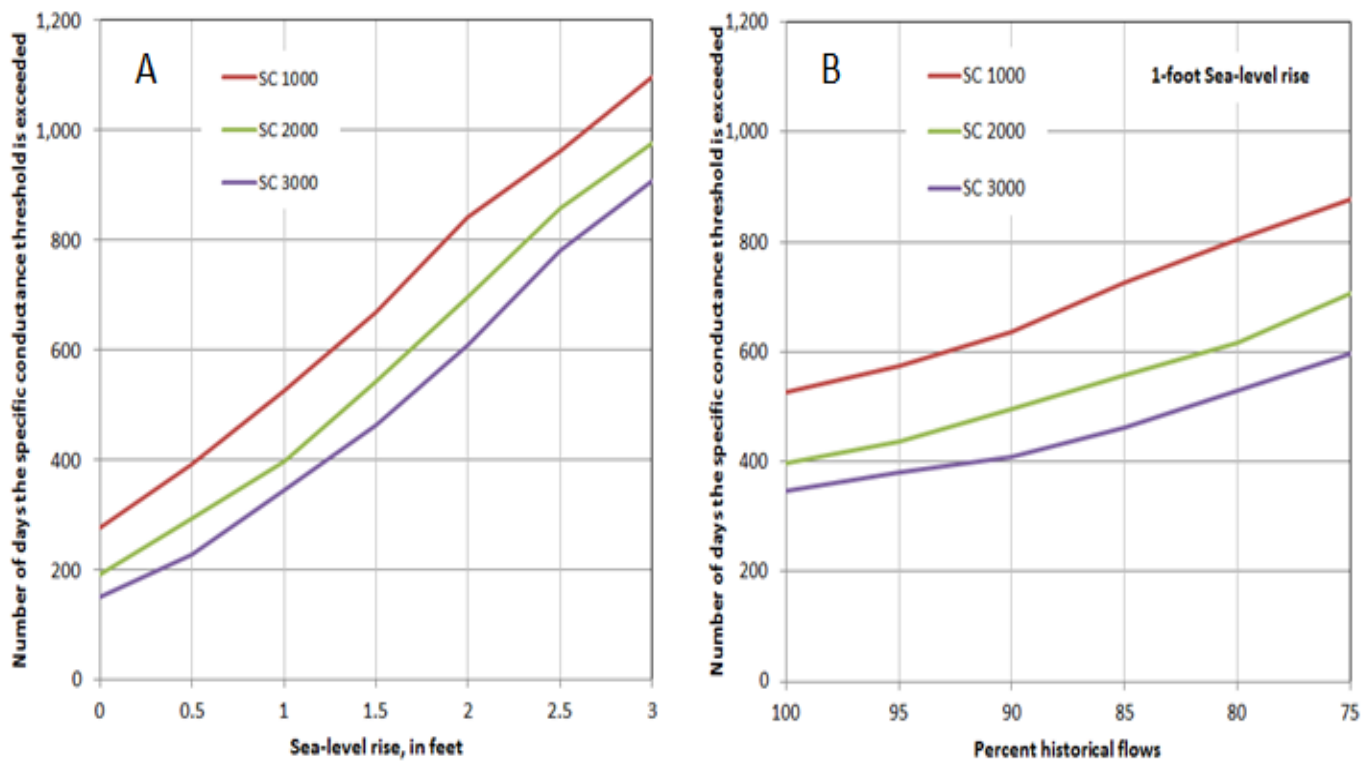
Figure 2. Nomographs showing the number of days specific conductance (SC) thresholds are exceed at the Pawleys Island gage (Station 021108125) for a) sea-level rise and for b) decreased historical flows concurrent with a 1-foot sea-level rise.

specific conductance values were simulated for the seven coastal stream gages in Figure 2 for each incremental rise in sea level and each incremental reduction in streamflow for the 14-year period of July 1995 through August 2009.

Results for the Pawleys Island stream gage (Station 021108125), just downstream from a municipal freshwater intake, were selected for this analysis (Figure 1). The model satisfactorily simulates the specific conductance in the 2,000 micro-Siemens per centimeter (µS/cm) range and accurately simulates the high intrusion events in the fall of 2002 and 2008 that exceeded 10,000 µS/cm.

It is problematic for the operations of municipal water treatment plants when the specific conductance values for source water are greater than 1,000 to 2,000 µS/cm. The higher specific conductance values cause taste problems that must be treated. Figure 2 shows the number of days the predicted specific conductance values exceeded thresholds of 1,000, 2,000, and 3,000 µS/cm for 0.5-ft incremental sea-level rises up to 3 ft for the 14-year simulation period of 1995-2009. For example, daily specific conductance greater than 2,000 µS/cm historically occurred for almost 200 days over the 14-year simulation period (Figure 2a). A 1-ft sea-level rise would double the number of days the municipal intake is unavailable to 400 days and a 2-ft rise increases the unavailability to nearly 2 years (700 days).

Changes in precipitation patterns due to changes in the climate have the potential of decreasing streamflow to the coast. Salinity intrusion in coastal rivers occurs during low streamflow periods and a decrease in streamflow combined with a sea-level rise could increase the duration of salinity intrusion along the coast. For a specific conductance threshold of 2,000 µS/cm, a 1-ft sea-level rise combined with a 10-percent decrease in historical streamflow would increase the days the intake is unavailable by 25 percent, or an additional 100 days (Figure 2b). A 25-percent reduction of streamflows increases the number of days of unavailability to over 700 days.

Although incremental increases of sea-level and decreases in streamflow show substantial effects that would have operational consequence for municipal water-treatment plants, the climate change scenarios shown in this paper would allow water-resource managers to plan for mitigation efforts to minimize the effect of increase salinity of source water. Mitigation efforts may include timing of withdrawals during outgoing tides, increased storage of raw water, timing larger releases of regulated flows appropriately to move the saltwater-freshwater interface downstream, and the blending of higher conductance surface water with lower conductance water from an alternative source such as groundwater.

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