DEVELOPMENT OF AN ESTIMATED WATER-TABLE MAP FOR COASTAL GEORGIA AND ADJACENT PARTS OF FLORIDA AND SOUTH CAROLINA

Michael F. Peck[1] and Dorothy F. Payne[2]

AUTHORS: [1]Hydrologic Technician, [2]Hydrologist, U.S. Geological Survey, 3039 Amwiler Road, Suite 130, Peachtree Business Center, Atlanta, Georgia 30360-2824.

REFERENCE: *Proceedings of the 2003 Georgia Water Resources Conference*, held April 23–24, 2003, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. An estimated water-table map was constructed to provide boundary conditions for ground-water-flow models of coastal Georgia, and adjacent parts of Florida and South Carolina. A linear-regression analysis was used to describe the relation between ground-water-level elevations derived from the U.S. Geological Survey National Water Information System, and land-surface elevations derived from a digital-elevation model. The map encompasses a 37,300-square-mile area and includes 57 counties in Georgia, 7 counties in South Carolina, and 5 counties in Florida. Water-level data for wells 100 feet or less in depth were used for the analysis. In order to achieve a relatively even spatial distribution, the data were temporally unconstrained, but were spatially filtered.

INTRODUCTION

The Georgia Coastal Sound Science Initiative (CSSI) is a series of scientific studies commissioned by the Georgia Environmental Protection Division (GaEPD) to study the Floridan aquifer system. As part of the CSSI, the U.S. Geological Survey (USGS), in cooperation with GaEPD, is developing numerical models of the regional ground-water-flow system in coastal Georgia, and adjacent parts of South Carolina and Florida in order to characterize the ground-water-flow system and to serve as a tool to help evaluate various water-management scenarios (Fig. 1). The models include layers simulating flow in the upper and lower Brunswick aquifers and the Floridan aquifer system.

To support model development, a map of estimated water-table elevations is being used to define a fixed-head boundary condition on the top model layer, allowing water to flow into or out of the model, depending on the flow gradient. The map also may be used to identify the location of recharge areas for confined aquifers by comparing the water-table map with maps projecting the altitude of the top of the confined aquifer. Where a regionally confined aquifer is unconfined, the head is the water table, which is sensitive to direct recharge. Recharge areas are spatially defined where the top of the aquifer intersects the water-table surface.

Study Area

The study area encompasses a 37,300-square-mile area and includes 57 counties in Georgia, 7 counties in South Carolina, and 5 in Florida (Fig. 1). These counties are located in the Coastal Plain physiographic province where topographic relief ranges from flat in the southeastern part of the study area (altitudes ranging from sea level to as high as 100 feet), to steep in the northwestern part (altitudes as high as 300 feet).

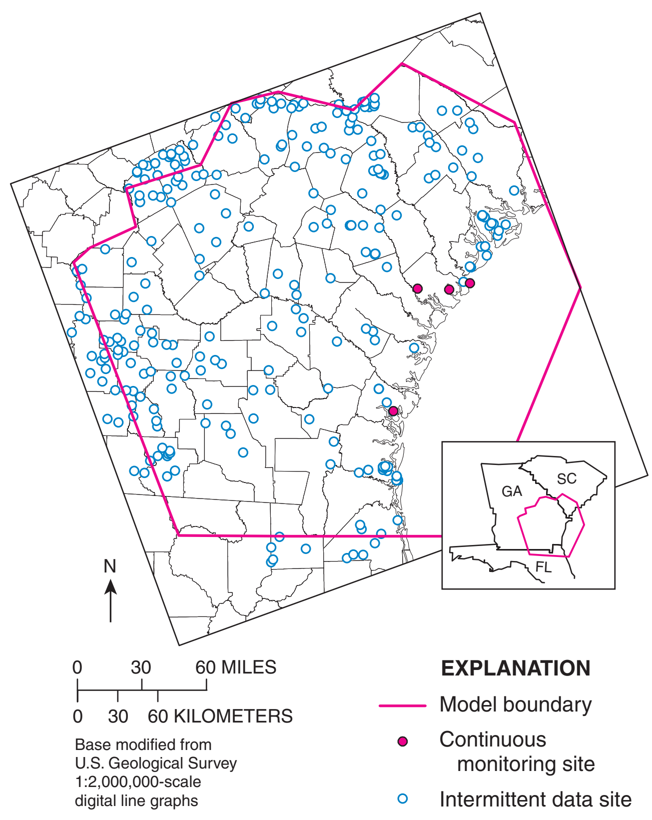

Figure 1. Model area and location of data used in the regression, including continuous monitoring and intermittent measurement sites.

The principal source of water for all uses in the coastal area is the Floridan aquifer system, consisting of the Upper and Lower Floridan aquifers (Krause and Randolph, 1989). Secondary sources of water include the surficial aquifer, and the upper and lower Brunswick aquifers (Clarke and others, 1990), consisting of sand of Miocene to Holocene age. The surficial aquifer consists of two to three distinct hydrologic zones in coastal Georgia. Clarke and others (1990) identified two zones—an unconfined water-table zone and a confined basal zone. Leeth (1999) identified three zones in the Camden County area—the water-table zone, the confined upper water-bearing zone, and the confined lower water-bearing zone. Water-level data from the water-table zone of the surficial aquifer were used to develop the estimated water-table map described in this paper.

Water-Table Data and Characteristics

The configuration of the water-table surface generally is a subdued replica of the overlying topographic surface. Discharge from the water table occurs in areas where it is in direct contact with the land surface generally in low-lying areas such as stream valleys, salt marshes or swamps, and along the coast (Krause and Randolph, 1989; Clarke and others, 1990). Recharge to the water table generally occurs in interstream areas of higher topographic elevation.

Water-level measurements are unevenly distributed in the model area and too sparse in parts of the area to effectively construct a water-table surface by contouring water-level data. A spatial function was used to estimate the water-table elevation as an empirical function of land-surface elevation, except at streams, where the water-table elevation was set equal to land-surface elevation. The estimated surface provides detail required to simulate the topographic controls on the water-table surface in the study area.

The temporal distribution of available water-level data in the model area also is too disparate to define a relation between land-surface elevation and water-table elevation for any given month, season, or year. For the estimated water-table surface, it was assumed that water levels in the surficial aquifer did not fluctuate appreciably over time, even during periods of prolonged drought. To verify this assumption a continuous water-level hydrograph for well 35P094 in Chatham County, Georgia, was examined (Fig. 2). This 15-foot-deep well is completed in the water-table zone of the surficial aquifer and has been continuously monitored from August 1942 to 2002. During 1942–2002, the water level fluctuated from a high of 0.05 feet below land surface to a low 12.28 feet below land surface, a change of 12.23 feet. During this 60-year period, short-term trends reflecting climatic changes are evident; however, the long-term range of fluctuation is consistent through the period of record.

DEVELOPMENT OF WATER-TABLE MAP

The water-table surface was constructed as follows.

1. All available water-level data were retrieved from the USGS Ground-Water Site Inventory System (GWSI) for wells that are 100 feet total depth or less in the model area. This depth criterion assumes that the wells are open to only the water-table zone of the surficial aquifer.

2. For sites with multiple water-level measurements, the median value was computed and used for the analysis. This removed bias from increased weighting of individual wells with multiple water-level measurements.

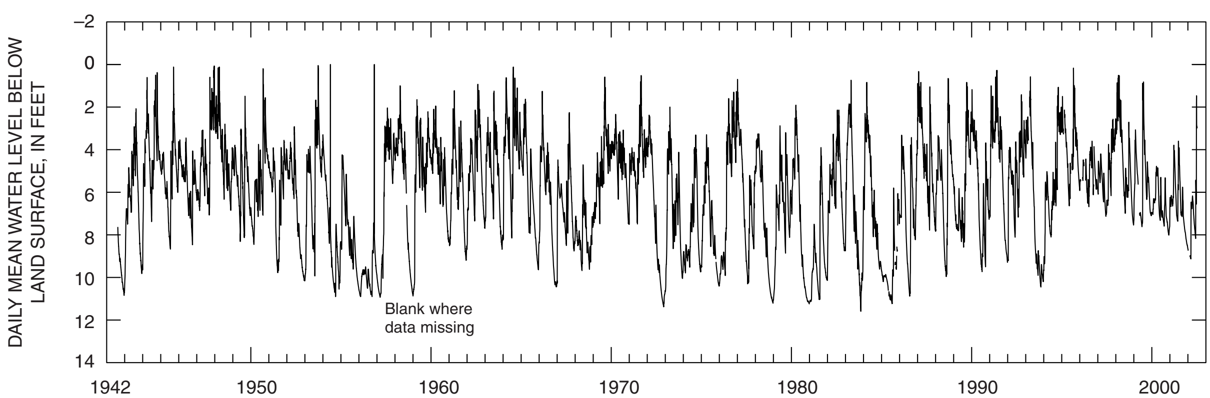

Figure 2. Hydrograph for well 35P094, Chatham County, showing no apparent long-term trend, 1942–2002. Location of well shown in Figure 4.

3. To remove any bias resulting from areas with increased spatial data density, data were selected to develop an even data distribution across the study area (Fig. 1).

4. Using the culled water-level dataset, a linear regression was performed using land-surface elevation as the independent variable and water-table elevation as the dependent variable (Fig. 3).

5. The regression model was then incorporated into a spatial function using a Geographic Information System (GIS) that computed the water table as equal to (1) land-surface elevation at streams and (2) the linear function of land-surface elevation as derived from the regression model between streams. USGS 30- x 30-meter resolution Digital Elevation Model data (Georgia GIS Data Clearinghouse, 2001) having a resolution of 30 square meters were used for the analysis; thus, the resulting water-table map has the same resolution.

RESULTS AND SUMMARY

The estimated water-table map generally is a subdued replica of land surface throughout the model area (Fig. 4). The water table is deepest in areas of high relief, shallower along major streams and rivers, and almost coincident with land surface near the coast. Elevation of the estimated water table ranges from sea level along the coastline to greater than 300 feet along the northwestern border of the study area.

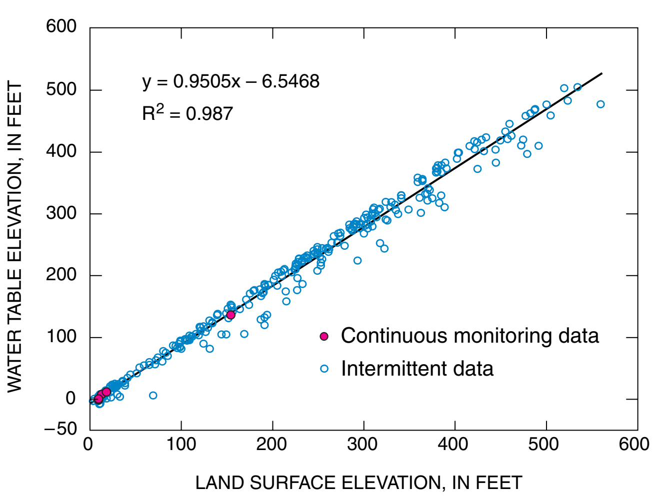

Figure 3. Water-level elevations and land-surface elevations in feet, and the linear regression of the data; the equation of the line was used in the spatial calculation of the water table.

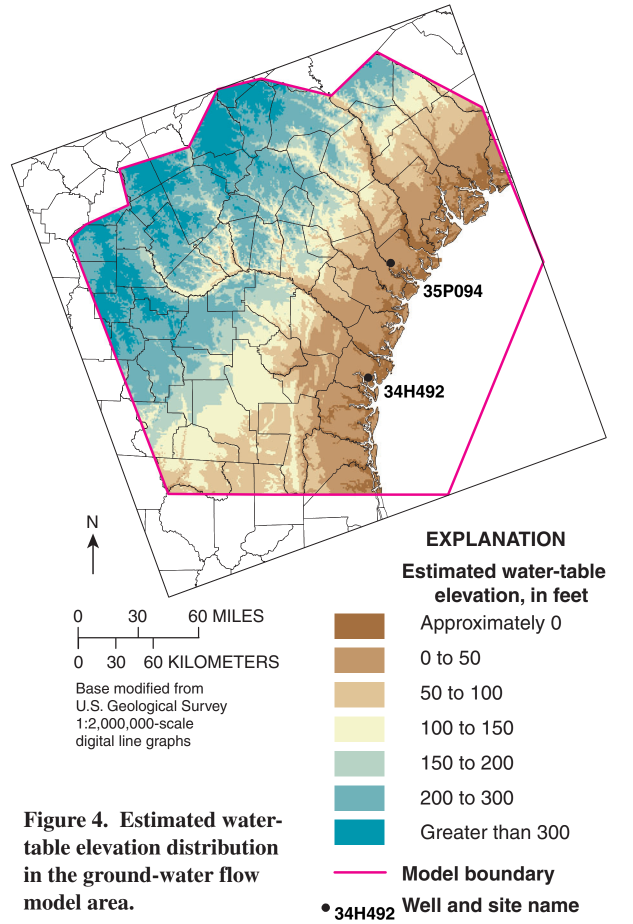

Figure 4. Estimated water-table elevation distribution in the ground-water flow model area.

For two continuous recorder sites with surveyed land-surface elevation data, the water table predicted by the regression falls within the water-table elevation ranges for the respective periods of record. At well 34H492, in Glynn County, Georgia (Fig. 4), the predicted water-table elevation is 5.37 feet, and the recorder data show a range from 2.4 to 6.6 feet for the period of record, 1992–2002. At well 35P094 in Chatham County, Georgia (Fig. 4), the predicted water-table elevation is 11.20 feet, and the recorder data show a range of 0.05–12.28 feet for the period of record, 1942–2002.

The estimated water-table map is being used to provide boundary conditions for ground-water flow models of coastal Georgia, and adjacent parts of Florida and South Carolina. Using the estimated water table, locations of recharge to the major confined aquifers can be defined, and the water-table elevations can be used as prescribed heads for the models. The paucity and irregularity of water-table measurement data preclude the creation of a water-table surface deterministically using these data alone. Because of the relation between water-table elevation and topographic features, including land-surface elevation and stream locations, an empirical and spatial function can be used to estimate the water-table elevations for the ground-water model area. The water table is estimated as a linear function of land-surface elevation in areas away from streams, and is equal to land-surface elevation at streams.

LITERATURE CITED

Clarke, J.S., C.M. Hacke, and M.F. Peck. 1990. Geology and ground-water resources of the coastal area of Georgia. Georgia Geologic Survey Bulletin 113, 106 pp.

Georgia GIS Data Clearinghouse. 2001. Publicly available GIS data for the State of Georgia. Administered by the University of Georgia Information Technology Outreach Services, web based statewide GIS coordination and data storage. (Accessed on January 2000, at URL: http://www.gis.state.ga.us/Clearinghouse/clearinghouse.html.)

Krause, R.E., and R.B. Randolph. 1989. Hydrology of the Floridan aquifer system in southeast Georgia and adjacent parts of Florida and South Carolina. U.S. Geological Survey Professional Paper 1403-D, 65 pp.

Leeth, D.C. 1999. Hydrogeology of the surficial aquifer in the vicinity of a former landfill, Naval Submarine Base Kings Bay, Camden County, Georgia. U.S. Geological Survey Water-Resources Investigations Report 98-4246, 28 pp.