

# RELATION OF AQUIFER CONFINEMENT AND LONG-TERM GROUNDWATER-LEVEL DECLINE IN THE FLORIDAN AQUIFER SYSTEM

Lester J. Williams,<sup>1</sup> Alyssa D. Dausman,<sup>2</sup> and Jason C. Bellino<sup>3</sup>

AUTHORS: <sup>1</sup>Hydrologist, U.S. Geological Survey, Georgia Water Science Center, Peachtree Business Center, Suite 130, 3039 Amwiler Road, Atlanta, GA 30360; <sup>2</sup>Hydrologist, U.S. Geological Survey, Florida Water Science Center, 3110 SW 9th Avenue, Fort Lauderdale, FL 33315; <sup>3</sup>Hydrologist, U.S. Geological Survey, Florida Water Science Center, 10500 University Center Dr., Tampa, FL 33612.

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**Abstract.** The rate and magnitude of long-term groundwater-level decline in the Floridan aquifer system in the Southeastern United States (Fig. 1) was evaluated to gain a better understanding of hydrologic responses to groundwater pumping and the effects of confinement on recharge rates in the aquifer system. Because of the large geographic area and widely varying time periods covered, a simple screening approach was used. To conduct the analysis, water-level data from monitoring wells with at least 20 years of record were analyzed by using linear regression to determine the slope of water-level change—a negative slope indicates a decreasing water-level trend and a positive slope indicates an increasing water-level trend. The slopes were then converted to a 10-year rate-of-decline coefficient and were subsequently used for mapping decline patterns in the aquifer system (Fig. 1A). The period covered by the analysis, 1970–2010, was a period of substantial growth in irrigated agriculture and municipal and domestic water use across the region. Twenty-three percent of the wells used for the evaluation had water-level data covering the entire 40-year period; 52 percent had water-level data covering a 30-year period, 75 percent had water-level data covering a 25-year period, and 100 percent had water-level data covering a 20-year period.

The rate-of-decline map, developed by using the linear-interpolation screening approach, assumes the following: (1) the long-term declining (or increasing) trends in the aquifer can be described with a simple linear-regression equation, and the slope of a best-fit line through the data points is a good measure of the actual water-level decline; (2) the varying time periods available for individual wells does not substantially influence the overall decline patterns mapped in the aquifer; and (3) the spatial distribution of the data points is adequate to describe the spatial patterns. To test these assumptions the time periods were varied from the longest of 40 years (Fig. 1A) down to the shortest of 5 years (not shown). Analysis of the shorter periods of time between 5 and 20 years provided useful information on the shorter-term trends but the 40-year period provided the best spatial distribution used to identify decline patterns and the relation of declines to aquifer confinement.

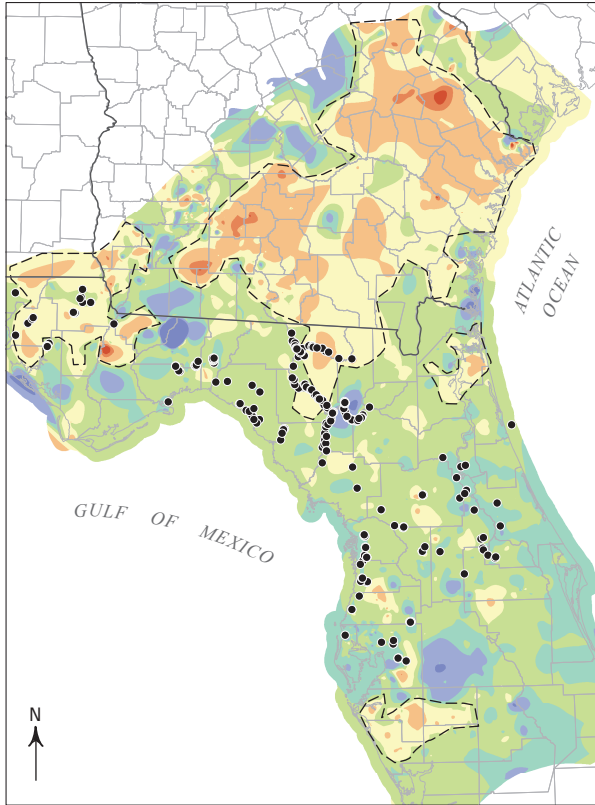
The results of the study indicate that areas with the greatest 10-year rate-of-decline coefficients generally coincide with confined areas of the aquifer system (compare Fig. 1A to 1B). One exception to this is a rising trend in a confined area of the aquifer in the southeastern coastal region of Georgia where reductions in groundwater withdrawals over the past 10 years has probably resulted in increasing water levels in that area. Another exception is an area of decreasing trends located in the unconfined portion of the aquifer in Alabama; the reason for those declines is not known at this time, however, rocks that compose the upper confining unit probably vary greatly in thickness and lithology and locally influence the leakage rate in that area.

Identification of the groundwater-level decline patterns provides useful insight into recharge-discharge relations on a regional scale. The presence of a fairly large contiguous area of decline in the confined parts of the aquifer system extending from south-central and southeastern Georgia into the Florida Panhandle and northeastern Florida (Fig. 1A) suggests downward leakage through the upper confining unit (or upward leakage from deeper aquifers) cannot fully satisfy pumping demand. It is theorized that as water levels have slowly declined beneath the confined part of the aquifer, broad areas of decreased water levels have expanded out into adjoining recharge (karst) areas where induced recharge is probably occurring. Numerical modeling is being conducted to test the relations of aquifer confinement and recharge on a regional scale and the potential effects on springflow and streamflow.

## REFERENCES

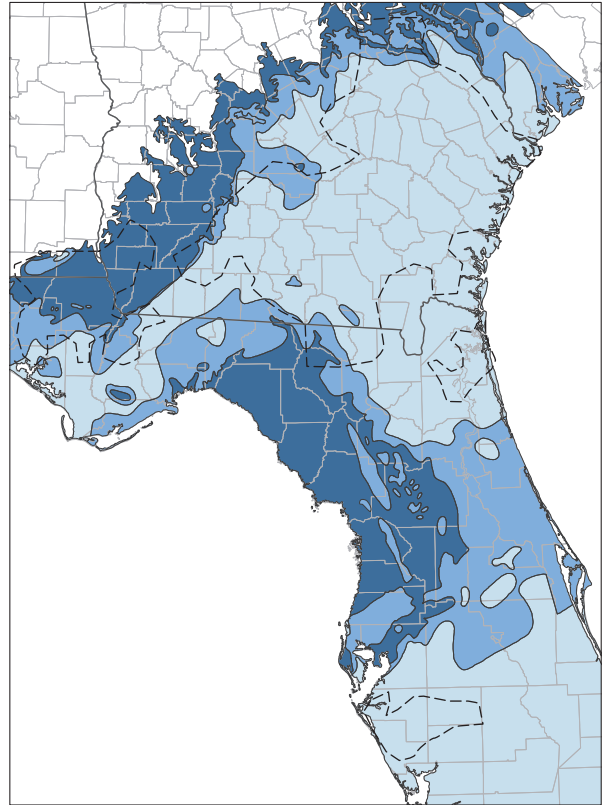
- Bush, P.W., and Johnston, R.H., 1988, Ground-water hydraulics, regional flow, and ground-water development of the Floridan aquifer system in Florida and in parts of Georgia, South Carolina, and Alabama: U.S. Geological Survey Professional Paper 1403-C, 80 p.
- Miller, J.A., 1986, Hydrogeologic framework of the Floridan aquifer system in Florida and in parts of Georgia, South Carolina, and Alabama: U.S. Geological Survey Professional Paper 1403-B, 91 p., 33 pls.

A. Composite 10-year rate of water-level decline from 1970 to 2010. Reds and yellows indicate declining trends; blues indicate increasing trends; greens indicates slightly increasing or decreasing trends in water levels.



Base modified from U.S. Geological Survey  
1:2,000,000-scale digital data

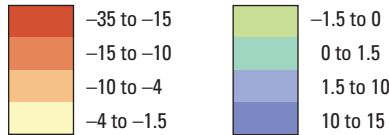
B. Relative confinement of the Floridan aquifer system. Light blue indicates confined areas and darker blues indicate thinly confined and unconfined areas respectively (modified from Bush and Johnson, 1988).



**EXPLANATION**

**Map A**

Composite 10-year rate of water-level decline, in feet, from 1970 to 2010

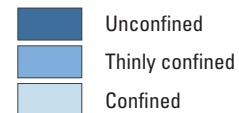


Area of greatest decline

• Spring (magnitude 1 or 2)

**Map B**

Degree of confinement



Area of greatest decline

**Figure 1. Relation between the composite 10-year rate of decline to the relative degree of confinement of the Floridan aquifer system in the Southeastern United States. The rate of decline shown on (A) is expressed in feet lost each 10 years during the period from 1970 to 2010.**