ANALYSIS OF GROUND-WATER WITHDRAWALS FROM A CRYSTALLINE-ROCK AQUIFER NEAR LAWRENCEVIILLE, GEORGIA

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Abstract. Because of the increased demand for water in northern Georgia, many city and county governments are investigating ground-water availability from crystalline-rock aquifers to supplement surface-water supplies. The U.S. Geological Survey and the city of Lawrenceville, Ga., began a cooperative investigation in December 1994 to improve the understanding of crystalline-rock aquifers in the Piedmont area of northern Georgia. Continuous ground-water-level data were analyzed during various pumping conditions to determine local and areal effects of ground-water withdrawals. Two bedrock observation wells, located about one mile from the production well, responded to pumping within about 8 to 13 hours. Water levels in a regolith well, located about 950 feet from the production well, responded to pumping within about 8 hours.

INTRODUCTION

As the population of northern Georgia increases at a rapid pace, the need for water supplies has escalated. Several communities in the Atlanta Metropolitan area are exploring ground-water resources to supplement current surface-water supplies. The U.S. Geological Survey and the city of Lawrenceville, Ga., began a cooperative investigation in December 1994 to improve the understanding of crystalline-rock rock aquifers in the Piedmont region of northern Georgia. The city of Lawrenceville presently uses about 2 million gallons of water per day (Mgal/d) for public supply, of which about 0.25 Mgal/d is withdrawn from ground-water sources (Juan Ruiz, E&C Consulting Engineers, Inc., oral commun., 1995). The city is seeking additional ground-water resources to meet future demands and reduce dependence on surface-water supplies.

Long-term, continuous, ground-water-level monitoring, combined with recent advances in surface and borehole geophysical methods, have provided hydrogeologists with improved methods to characterize the hydrologic and physical properties of crystalline-rock aquifers. These advances, coupled with detailed geologic mapping, have greatly enhanced the ability to evaluate the development potential of ground-water resources of the Atlanta Metropolitan area and better define a conceptual model of ground-water systems in crystalline-rock settings. This paper describes the response of a highly fractured crystalline-rock aquifer during various pumping conditions, and provides information useful for the management of the ground-water resources of the study area.

Study-Area Description

The city of Lawrenceville, Ga., is located about 20 miles northeast of Atlanta in central Gwinnett County (Figure 1). The study area encompasses about 44 square miles in the Piedmont and Blue Ridge ground-water regions (Heath, 1984). The Rhodes Jordan wellfield, located in the Alcovy River drainage basin, and the Maltbie Street and Pike Street observation wells, located in the Yellow River drainage basin are three ground-water-level monitoring sites in the study area (Figure 1). A recreational lake is located about 100 feet (ft) northwest of the wellfield.

The first local-scale hydrogeologic study was conducted at the Rhodes Jordan wellfield (Figure 1), which includes a production well (14FF10) and nine observation wells, five of which tap crystalline-rock. The bedrock observation wells are located at distances of 10, 100, and 250 ft from the production well.

The aquifer is a sheared and highly jointed amphibolite overlain by about 25 ft of regolith. The production well taps fracture zones in the amphibolite and is pumped at about 230 gallons per minute (gal/min) for public supply (Juan Ruiz, E&C Consulting Engineers, Inc., oral commun., 1995). Each of the bedrock observation wells near the production well yield more than 100 gal/min. The Maltbie Street well (14FF08) (Figure 1), is a second proposed production well which taps the amphibolite; and the Pike Street observation well (14FF27) taps granitic gneiss, quartzite/schist, amphibolite, and button schist.

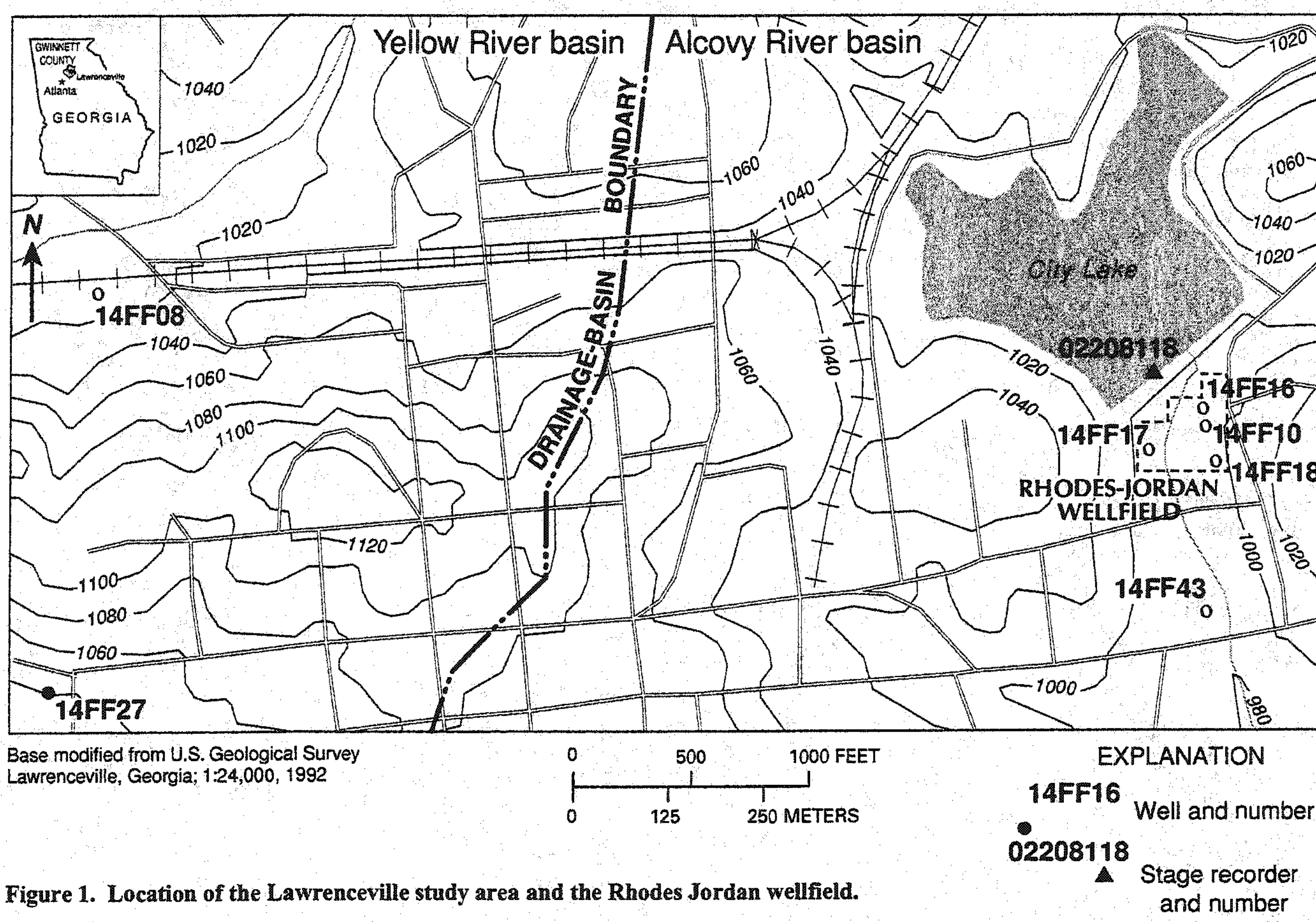

Figure 1. Location of the Lawrenceville study area and the Rhodes Jordan wellfield.

Methods of Data Collection

To evaluate the effects of ground-water withdrawals and any interconnection between wells, ground-water levels were continually monitored at 30-minute intervals at the Rhodes Jordan wellfield since March 1995. Three bedrock wells and two regolith wells were equipped with 50, 75, and 100 pounds per square inch (psi) pressure transducers to record continuous water levels. In addition, a 15 psi transducer was installed in the Rhodes Jordan Park Lake (02208118) (City Lake, Figure 1) in November 1996, to monitor changes in stage of the lake. A precipitation gage and a barometer were installed at well 14FF16 during August 1996 near the production well 14FF10 (Figure 1). Data from these recorders were used to evaluate the effects of precipitation on bedrock and regolith wells. Water-level recorders also were installed on wells 14FF08 (Maltbie Street, February 1996) and 14FF27 (Pike Street, November 1995) to determine the areal influence of ground-water withdrawals from the Rhodes-Jordan wellfield.

LOCAL EFFECTS OF PUMPING

Ground-water levels in the vicinity of Rhodes Jordan wellfield are affected significantly by pumping well 14FF10, and bedrock observation wells respond quickly (within 10 minutes) to withdrawals from the production well. The degree to which ground-water levels are affected is controlled by the pumping rate, the length of time of continuous pumping, and length of time the well is allowed to recover. Well 14FF10 typically is pumped on a 5-day cycle, Monday through Friday, and allowed to recover for 2 days over the weekend. The daily volume of pumping varies between 0.11 and 0.33 Mgal/d (Alex Kuzovkov, E&C Consulting Engineers, Inc., written commun., 1996). During February 1996, when the daily volume of pumping was low and ground-water levels were high, the water level in a nearby observation well (14FF18) declined about 51 ft on February 4, which was the first day of the 5-day pumping cycle (Figure 1). When pumping was terminated for the day, the water level recovered only about 17 ft. However, each successive day of pumping produced less drawdown (the pumping rate and length of time the pump was operated were held constant). The magnitude of ground-water recovery also is lessened each successive day (Figure 2). At the termination of pumping on February 7, the fourth day of the 5-day pumping cycle, the water level recovered about 14 ft. During this 5-day pumping cycle, the ground-water level declined about 73 ft, and by the beginning of the next pumping cycle (Monday, February 12), the water level had recovered about 58 ft. The observed recovery response suggests that part of the ground water that is pumped is being removed from aquifer storage. During subsequent 5-day-on and 2-day-off cycles, the magnitude of drawdown observed during the 5-day cycle is reduced about 60 ft. In addi-

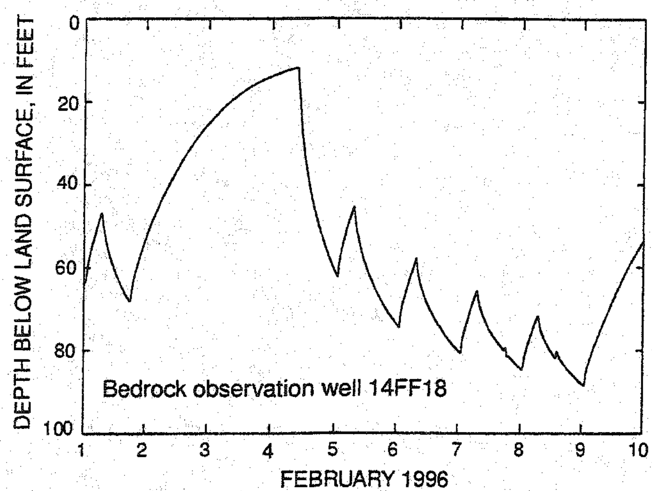

Figure 2. Hydrograph for well 14FF18 showing the weekly pumping cycle, February 2 to 10, 1996.

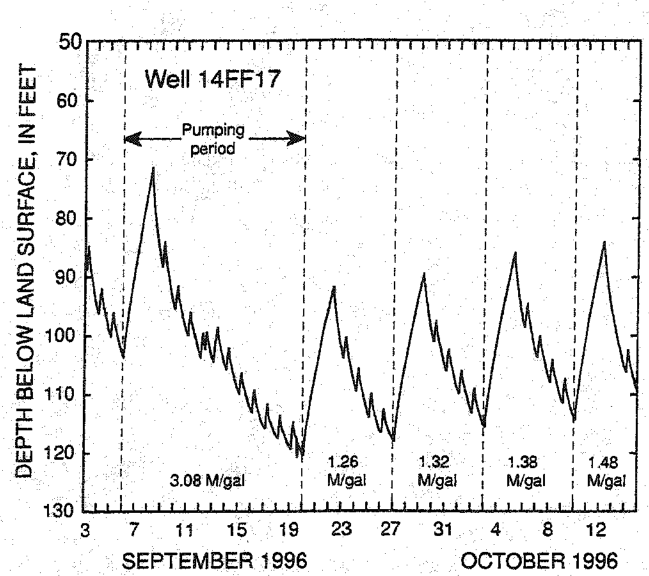

Figure 3. Hydrograph of well 14FF17 showing an extended pumping period, September 2 to October 17, 1996.

tion, during these cycles the magnitude of the 2-day recovery approximates the 5-day drawdown.

During the summer, when the demand for water supply is at a maximum, the pumping cycle for well 14FF10 may be extended to as many as 18 days, and the daily pumping volume may increase. Beginning on September 9, 1996, well 14FF10 was pumped for 12 consecutive days at an average rate of about 0.26 Mgal/d (Alex Kuzovkov, E&C Consulting Engineers, Inc., written commun., 1996). Throughout this 12-day cycle the well was allowed to recover for only a few hours each day. The water level in a nearby observation well (14FF17) declined about 49 ft (Figure 3). At the conclusion of the 12-day cycle the well was allowed to recover for the normal 2-day period. On the following Monday, September 23, a 5-day pumping cycle was resumed at a volume of about 1.26 million gallons per week, and weekly withdrawals gradually increased to 1.38 million gallons per week during the week of October 7. During this 3-

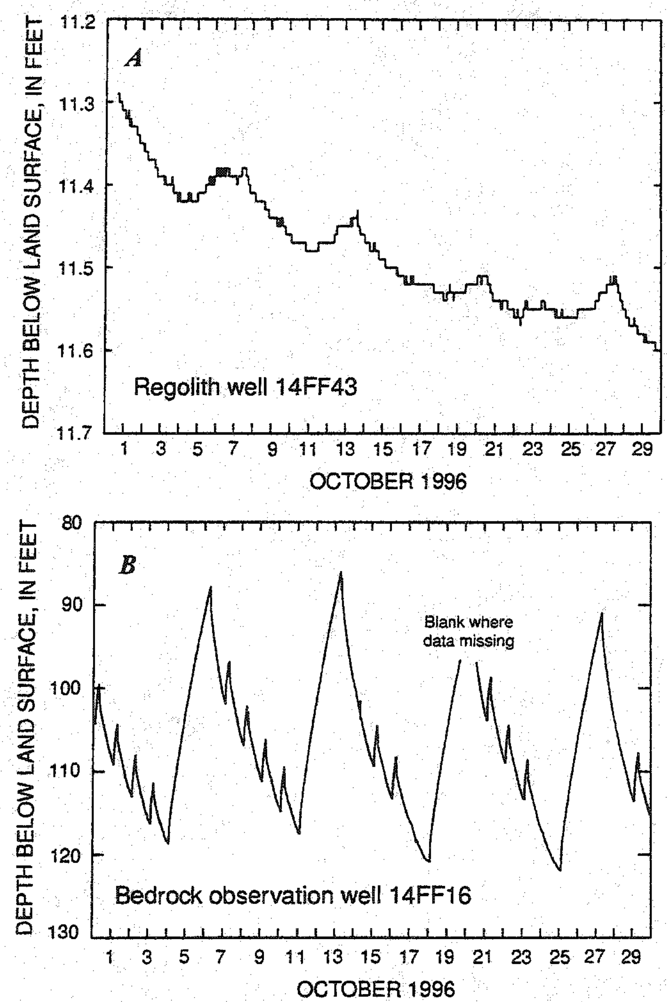

Figure 4. Hydrographs of well 14FF43 (*A*) and 14FF16 (*B*) showing water-level response to pumping cycles from well 14FF10, October 1996.

week period, the net ground-water level did not gradually decline, as observed during previous periods of withdrawal. Instead, the net effect on ground-water levels was recovery from the more extensive 12-day pumping period.

Continuous water-level data also indicate that ground-water withdrawals from the Rhodes Jordan wellfield affect water levels in the overlying regolith near the production well. Weekly pumping cycles are evident in the hydrograph (Figure 4A) of regolith well 14FF43, located about 950 ft southwest of well 14FF10 (Figure 1). The time lag for the response of water levels in well 14FF43 (Figure 4A) to the pumping of well 14FF10 averaged about 8 hours. During a 5-day pumping cycle, the water levels in well 14FF43 declined a maximum of 0.11 ft, whereas the water level in nearby bedrock well 14FF16, located about 250 ft away, declined as much as 35 ft (Figure 4B).

AREAL EFFECTS OF PUMPING

Continuous ground-water-level data indicate that pumping at the Rhodes Jordan wellfield directly affects water levels in the Maltbie Street well (14FF08, located about 0.9 miles

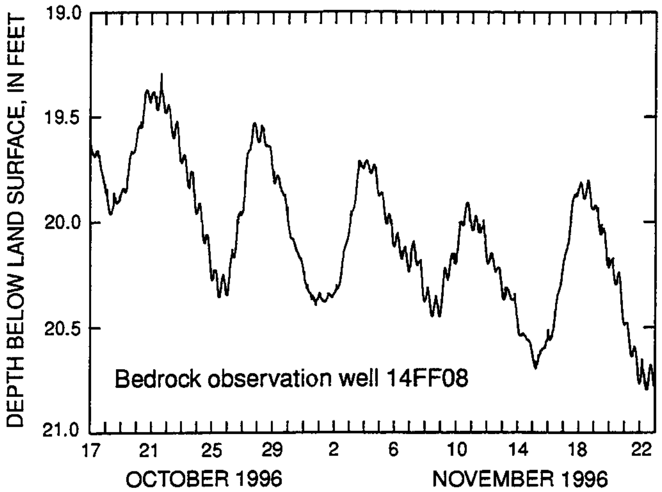

Figure 5. Hydrograph of well 14FF08 showing areal drawdown, October 18, to November 25, 1996.

N80W); and the Pike Street well (14FF27, located about 1.0 miles S80W) (Figure 1). A time-lag analysis of the ground-water-level data was used to quantify the areal effects of pumping. The evaluation of the time lag between the Rhodes Jordan wellfield and the proposed Maltbie Street production well is necessary in order to determine the potential for interference between the two cones of depression should these two wells be pumped simultaneously. The average time lag for well 14FF10 to affect water levels in well 14FF08 was about 10 hours from October 18, to November 25, 1996 (Figure 5). During the same pumping period, continuous ground-water-level data from the Pike Street well (14FF27) indicate a slower response compared to the Maltbie Street well (14FF08). Well 14FF27 responded to pumping at the Rhodes Jordan wellfield in about 10.5 to 11 hours. However the magnitude of drawdown in well 14FF27 was much less than in well 14FF08. During 1996, well 14FF27 had about 1 ft of drawdown whereas well 14FF08 had about 4 ft of drawdown.

The area of influence of pumping at the Rhodes Jordan wellfield has been observed across a watershed divide. The Rhodes Jordan wellfield is in the Alcovy River drainage basin, and wells 14FF08 and 14FF27 are in the Yellow River drainage basin (Figure 1). These observations suggest that ground-water-recharge areas may not be limited to watershed basins and indicates the presence of connecting fracture systems between the wells at a distance of at least one mile.

SUMMARY

A cooperative study between the U.S. Geological Survey and the city of Lawrenceville, Ga., has coupled continuous water-level monitoring with a detailed analysis of ground-water withdrawals. Ground-water levels were analyzed during various pumping conditions in order to determine the local and areal effects of ground-water withdrawals. Production well pumping schedules vary from 5-day to 18-day pumping cycles, and ground-water levels respond to changes in the pumping schedule. Bedrock monitoring wells at a distance of about one mile from the production well are affected between 8 to 13 hours after pumping begins. Water levels in a nearby regolith monitoring well located about 950 ft from the production well are also influenced by pumpage of the production well. Furthermore, the influence of pumping has been observed in bedrock observation wells located across a watershed divide, suggesting the presence of a connecting fracture system. The understanding of the effects of withdrawals from the crystalline-rock aquifers in this area is essential to the management of the ground-water resources.

LITERATURE CITED

Heath, R.C., 1984, Ground-water regions of the United States: U.S. Geological Survey Water-Supply Paper 2242, 78 p.