ESTABLISHMENT OF A GROUNDWATER AND SURFACE-WATER MONITORING NETWORK TO ASSESS THE POTENTIAL EFFECTS OF GROUNDWATER DEVELOPMENT IN AN IGNEOUS AND METAMORPHIC ROCK AQUIFER, AND PRELIMINARY DATA, LAWRENCEVILLE, GEORGIA, 2003-2004

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Abstract. During 2002, a cooperative study between the U.S. Geological Survey and the City of Lawrenceville, Georgia, was initiated to monitor groundwater levels and streamflow in areas of potential groundwater-resource development. Little is known about the effects of pumping on groundwater levels and streamflow in Piedmont regolith-fractured bedrock hydrogeologic settings. Therefore, a monitoring network of observation wells and streamgaging stations was installed to collect hydrologic data from two watersheds: one 9.95 square miles (mi^2) in area; and another 7.5 mi^2 in area, near Lawrenceville. Monitoring data will be collected both before and after groundwater pumping is initiated in an attempt to determine the sustainability of groundwater and surface-water resources within these watersheds. From the data collected thus far, stream baseflow trends are similar to groundwater level trends in the aquifer; and climate-induced water-level declines in the aquifer appear to parallel baseflow trends in streams, especially in upland reaches near surface-water divides. Continued monitoring of these streams and wells will be important in determining the potential effects of pumping on groundwater and surface-water resources in a regolith-fractured bedrock hydrogeologic setting.

INTRODUCTION

The City of Lawrenceville plans to begin pumping groundwater from two new well fields in igneous and metamorphic rock aquifers during 2006 and 2007 (Mr. Mike Bowie, City of Lawrenceville Water Department, oral commun., January 2005). These well fields, located in the Redland/Pew Creek and upper Alcovy River watersheds (Fig. 1), will provide part of the city's future water needs. The potential effects of groundwater pumping on igneous and metamorphic-rock aquifers and streams in this area are poorly understood. Information on groundwater levels and streamflow is necessary to assess these potential effects on the hydrologic system and to properly manage this important resource. During 2002, the U.S. Geological Survey (USGS), in cooperation with the City of Lawrenceville, established a groundwater-level and streamflow monitoring network to provide the data needed to properly manage and optimize withdrawals of groundwater and compute water budgets.

Description of the Study Area

Lawrenceville is located approximately 26 miles northeast of Atlanta, Georgia, in the Piedmont physiographic province (Fig. 1). Currently, Lawrenceville obtains approximately 6 percent of its drinking water from groundwater (Mr. Mike Bowie, City of Lawrenceville Water Department, oral commun., 2002). In the near future, Lawrenceville will increase this percentage by bringing online additional municipal wells installed in two watersheds near the city beginning in 2006.

The upper Alcovy River watershed, 9.95 mi^2 in area, is located northeast of the city, whereas the Redland–Pew Creek River watershed (7.5 mi^2) is located southwest of Lawrenceville. Streamflow and groundwater levels will |be measured in the upper Apalachee River watershed (5.68 mi^2), and these data will serve as background control (Fig. 1) for data collected in the two watersheds where pumping is planned.

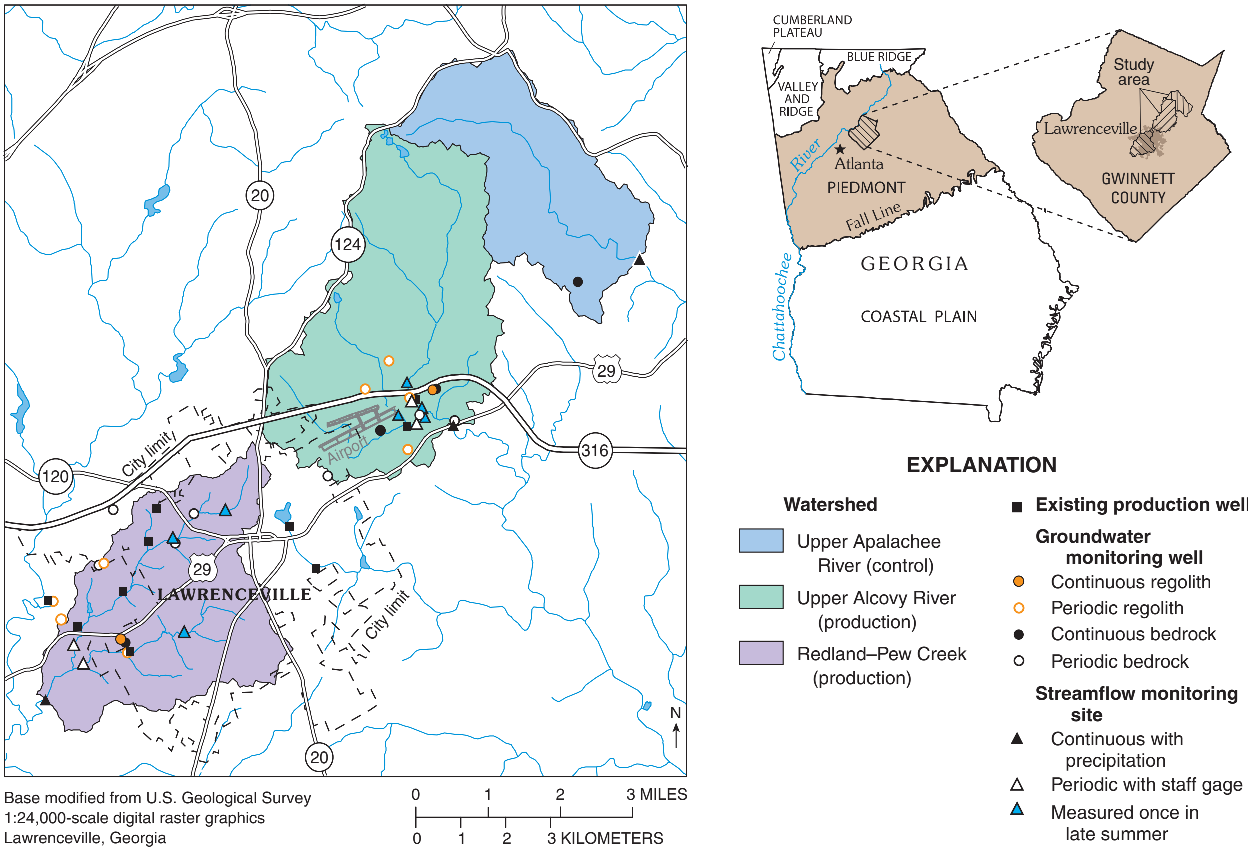

Figure 1. Study area location, production wells, and selected groundwater wells and streamflow monitoring sites near Lawrenceville, Georgia.

HYDROLOGIC MONITORING NETWORK

To collect baseline data, a monitoring network was established to monitor groundwater levels and streamflow in both watersheds where groundwater withdrawal will occur. Eight production wells, two in the upper Alcovy River watershed and six in or near the Redland–Pew Creek watershed (Fig. 1), are scheduled to start pumping during 2006 and 2007 (Mr. Mike Bowie, City of Lawrenceville Water Department, oral commun., 2005). Some of these production wells currently serve as observation wells (14FF63; 13FF16; 13FF18; and 13FF22) in the groundwater monitoring network.

A total of 29 observation wells in a monitoring network will record groundwater levels in the area (Fig. 1). Eleven observation wells were installed during the summer of 2003 and combined in a monitoring network along with 18 other existing wells. Of the 29 total wells, 10 are completed in the regolith and 19 are completed in bedrock. Six well clusters, each cluster consisting of a regolith well and a bedrock well, are in the network; data from these clusters will be used to identify vertical gradients between the regolith and the bedrock. These gradients will be monitored before and after pumping begins. Weekly groundwater-level measurements were collected from 23 of these wells throughout 2004. Continuous water-level measurements were collected from one well cluster in each watershed (14FF65, 14FF66, 13FF30, and 13FF31), from well 14FF42 in the upper Alcovy River watershed, and from an observation well (14GG02) in the upper Apalachee River control watershed.

Continuous streamflow gaging stations were installed at the outlet of each of the two study watersheds (Figs. 2 and 4, stations 02208050 and 02205522). An existing continuous gaging station was already at the outlet of the Apalachee River control watershed (station 02218565). Weekly streamflow measurements and staff gage readings were collected from the Alcovy River at Georgia Highway 316 (station 02208047), Cedar Creek at Cedars Road (station 02208048), Redland Creek at U.S. Highway 29 (station 02205520), and from Pew Creek at Sugarloaf Parkway (station 02205508).

In addition, seepage measurements were made to determine the groundwater (either discharge or recharge) along selected reaches of the Alcovy River, Cedar Creek, Redland Creek, and Pew Creek when streams were at baseflow conditions during the late summer. Either the gain or loss in streamflow is calculated by subtracting an upstream streamflow measurement from a downstream measurement.

UPPER ALCOVY RIVER WATERSHED DATA FOR 2003–2004

Based on the examination of current and historical stream hydrograph data, streams usually are at baseflow conditions in the fall. Discharge measurements were made in the fall of 2003 and 2004 along the Alcovy River and Cedar Creek (Fig. 2) to determine groundwater seepage (either the gain or loss of water) along selected reaches in the vicinity of proposed future municipal wells. Results from streamflow measurements show that streams generally gain water downstream; however, some stream reaches show a loss of streamflow and are losing segments where discharge is less downstream than upstream.

During August 2003, the reach showing the largest amount of gain was between stations 02208046 and 02208047 (Fig 2*B*). During September 2004, however, this same reach was losing water to the aquifer. The groundwater level in regolith well 14FF68 and bedrock well 14FF62 from 2003 to 2004, located close to the Alcovy River, indicates groundwater levels were higher during August 2003 than during August 2004. The decline in groundwater levels from 2003 to 2004 near the Alcovy River (Fig. 3) could explain the decline in baseflow during the same time period and likely indicates why baseflow during late August 2004 is much less than during late August 2003. Continuous gage height measurements at station 02208050 indicate baseflow at this location was lower during late August 2004 than during late August 2003. Groundwater levels in bedrock wells located next to streams (14FF59, 14FF62, and 14FF63) are consistently above stream stage, indicating a potential vertical gradient from the aquifer to the stream in these areas.

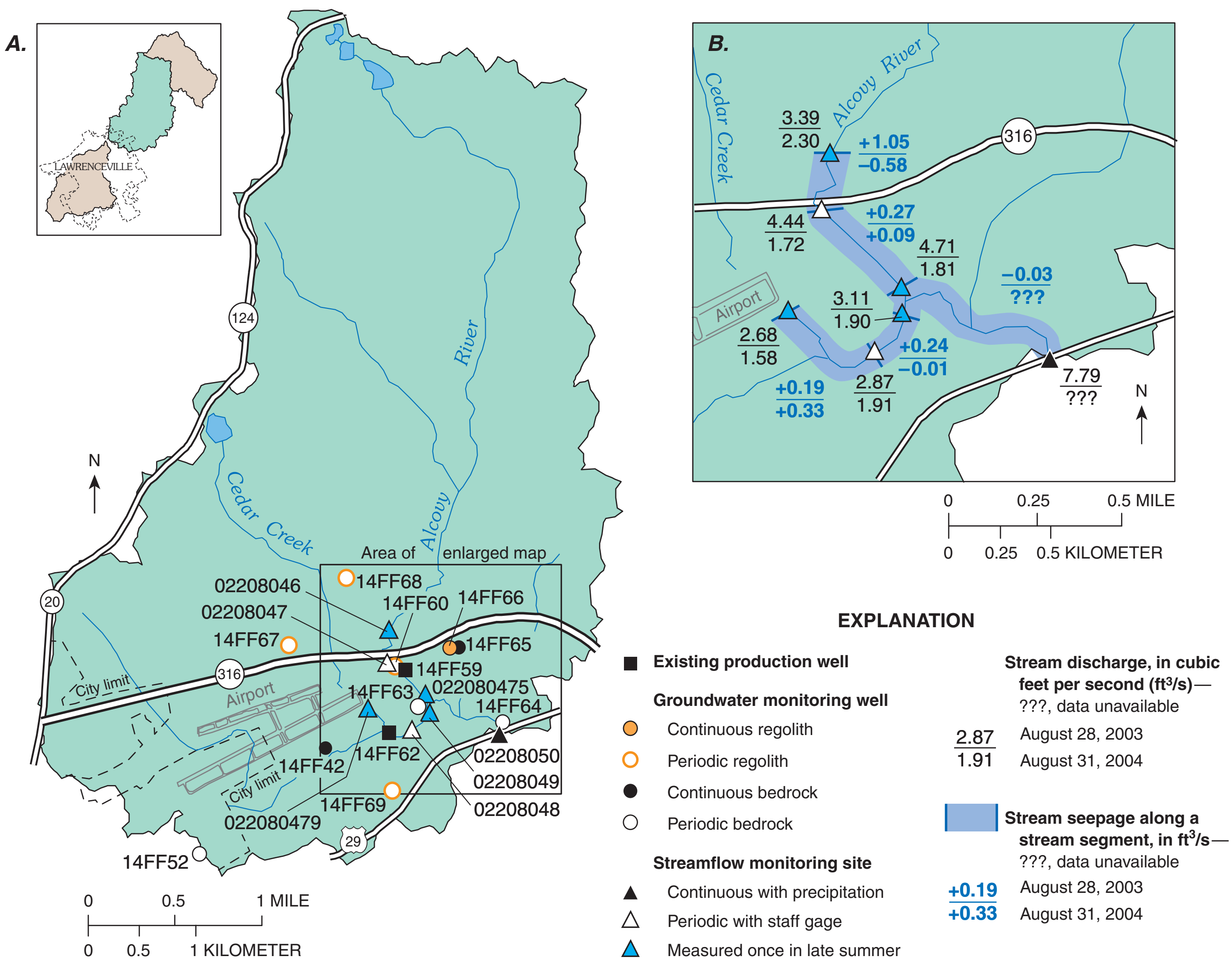

Figure 2. (*A*) Upper Alcovy River watershed, production wells, selected groundwater-level wells, streamflow monitoring sites, and discharge measurements; and (*B*) stream seepage on August 28, 2003, and August 31, 2004, along selected stream segments near Lawrenceville, Georgia.

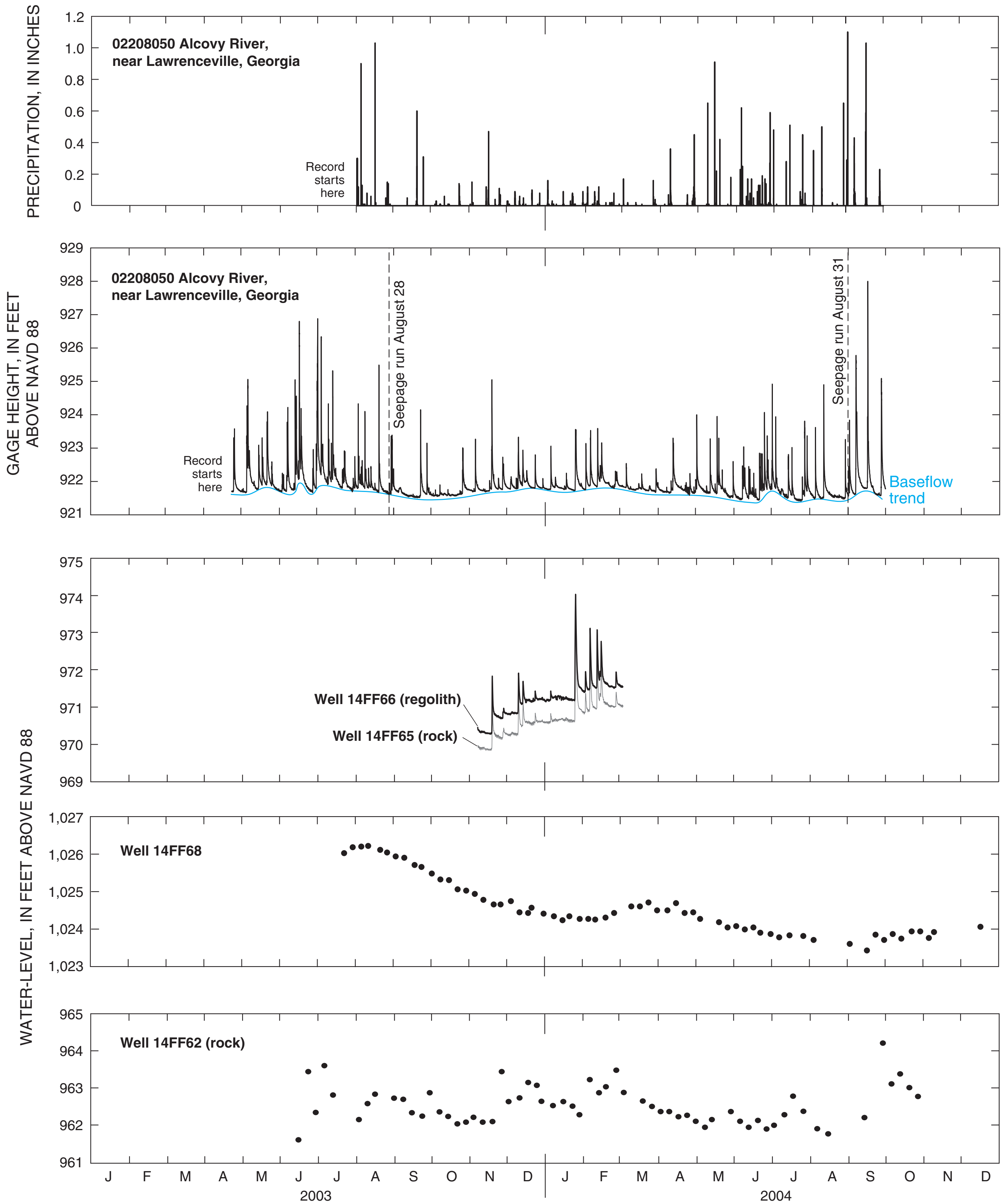

Figure 3. **Precipitation and gage height at Alcovy River near Lawrenceville, Georgia (02208050), and groundwater levels at well cluster 14FF65–14FF66 and wells 14FF62 and 14FF68 near Lawrenceville, Georgia, 2003 (see Figure 2 for location).**

REDLAND–PEW CREEK WATERSHED DATA FOR 2003–2004

During early September 2003 and late October 2004, seepage was calculated from discharge measurements at six stations in the Redland–Pew Creek watershed (Fig. 4*B*). These discharge measurements indicate that streams were gaining water on September 8, 2003, and on October 28, 2004, except in the headwaters area of Redland Creek. The largest gaining reach during 2003 and 2004 was on Pew Creek (+ 2.40 cubic feet per second [ft^3/s] during 2003, and 2.67 ft^3/s during 2004) from station 02205450 to 02205508.

Groundwater levels in bedrock wells near streams (13FF22 and others) are consistently above the stream stage of Redland Creek, indicating a potential upward vertical gradient from the aquifer to streams at these locations. Well clusters 13FF19–13FF25 and 13FF27–13FF28 (Fig. 5) indicate a downward trend in water levels from 2003 to 2004. Well 13FF22, a bedrock well located next to Redland Creek, shows the influence of variations in streamflow. The downward trend in groundwater level in well clusters 13FF19–13FF25 shows a relation to the trend in baseflow at station 02205522 farther downstream on Pew Creek.

A downward vertical gradient also exists at well cluster 13FF27–13FF28; however, the vertical gradient changes over time. The potential vertical gradient is consistently downward and decreases to a minimum during the winter months. Inspection of hydrographs indicates recharge occurs earlier in the bedrock well than in the regolith well.

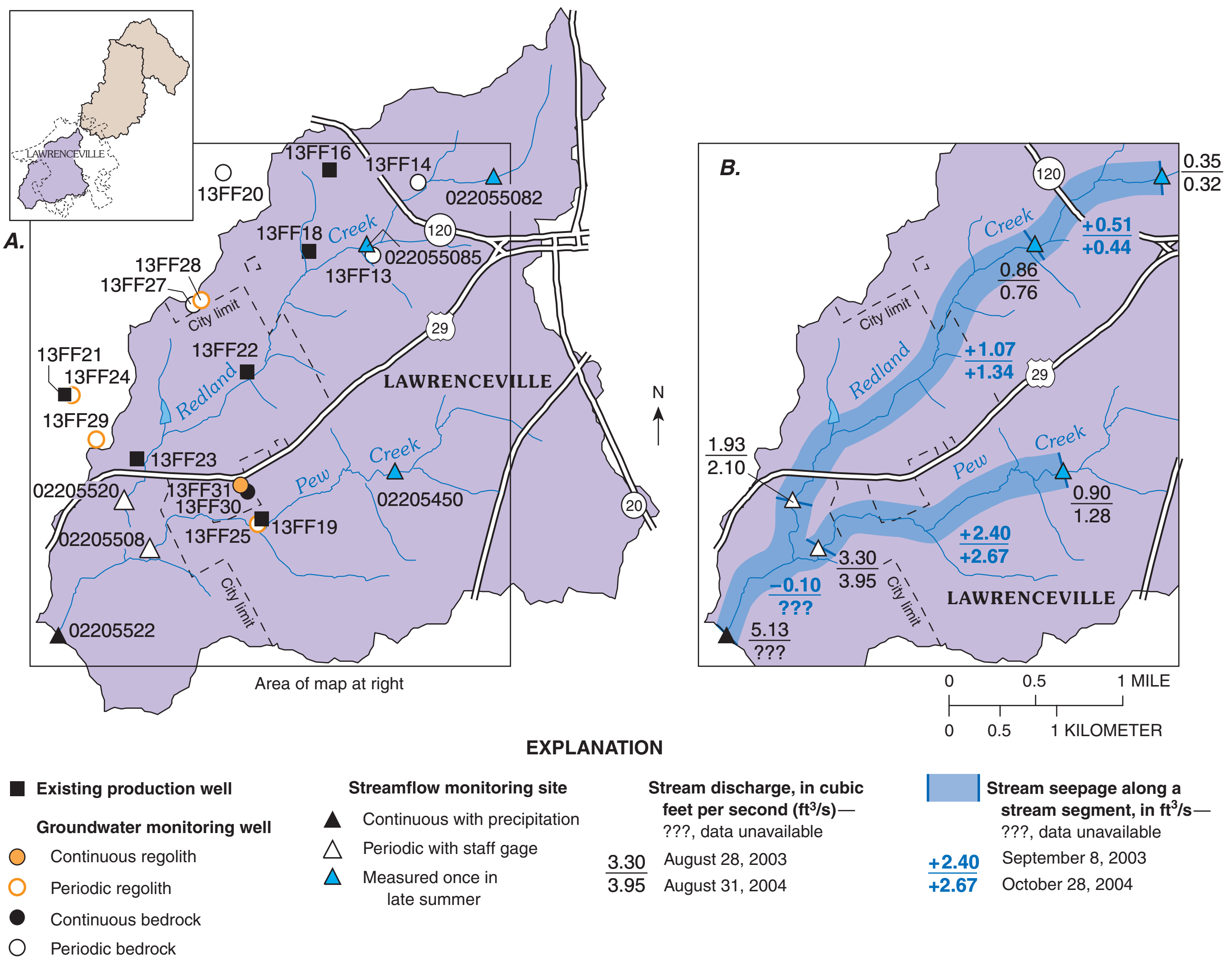

Figure 4. **(*A*) Redland–Pew Creek watershed, production wells, selected groundwater-level wells, streamflow monitoring sites, and discharge measurements; and (*B*) stream seepage on September 8, 2003, and October 28, 2004, along selected stream segments near Lawrenceville, Georgia.**

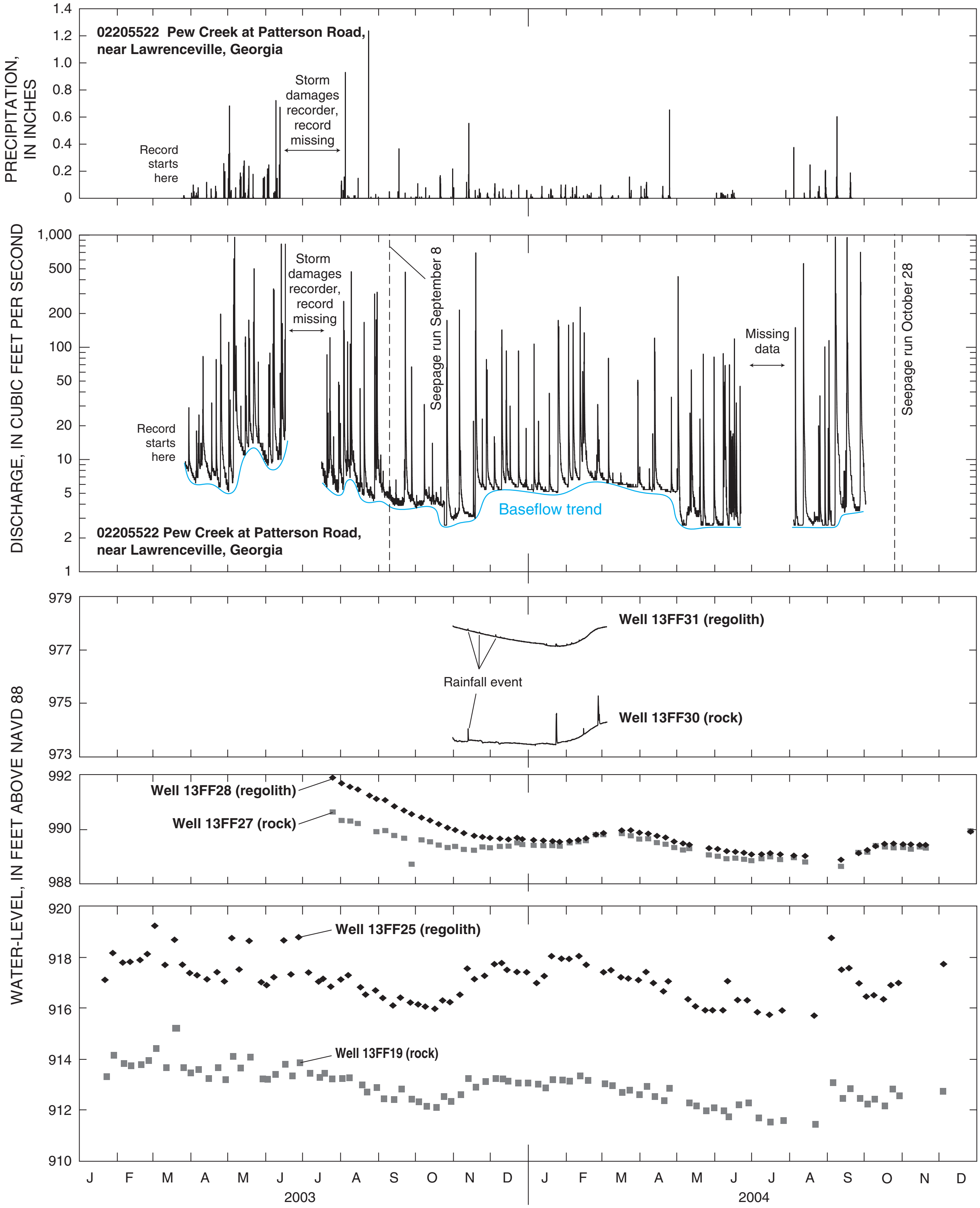

Figure 5. Precipitation and gage height at Pew Creek at Patterson Road near Lawrenceville, Georgia (02205522); and groundwater levels for well clusters 13FF30–13FF31, 13FF27–13FF28, and 13FF19–13FF25 near Lawrenceville, Georgia, 2003 (well 13FF19 is a future production well; see Figure 4 for location).

APALACHEE RIVER WATERSHED DATA FOR 2003–2004

Seasonal trends in precipitation, streamflow, and groundwater levels in well 14GG02 in the control watershed (Fig. 6) follow a similar pattern as those of the “production” watersheds. Precipitation events do not necessarily cause peaks in groundwater levels (Fig. 7). The groundwater level in the control well is influenced by nearby pumping. This may present a problem because this well is to be used as a background control to groundwater levels in the production watersheds; however, groundwater levels do recover once the well pump is turned off. The overall trend in groundwater level in the control well is similar to the overall trend in baseflow at station 02218565.

SUMMARY

Groundwater and streamflow data collected during 2003-2004 indicate that seasonal trends in stream stage and groundwater levels are similar in the three watersheds being monitored. Groundwater-level data indicate that, generally, groundwater levels in wells located away from streams decreased from early 2003 to August 2004. Baseflow in streams also trends downward from early 2003 to late 2004. This is likely because of the long-term downward trend in groundwater levels attributed to effects of climate, which is evident in wells in all three watersheds. The long-term monitoring of baseflow in streams will be important to resource managers to observe whether any changes in baseflow occur after pumping begins.

Most well cluster water-level data indicate a potential downward gradient to the igneous and metamorphic rock aquifer. This is evident in well clusters 13FF19–13FF25 and 13FF30–13FF31. Well cluster 13FF19–13FF25, located on the bank of Pew Creek, indicates a potential downward gradient; however, seepage data indicate this reach to be gaining. This may indicate that (1) the stream is losing water in this short section next to the well cluster, but gaining overall; (2) the gradient is downward but, there is no connection between the stream and the aquifer at this location; and (3) only the regolith is contributing water to the stream in the upper reaches near divides and potential gradients between the regolith and the aquifer may not necessarily indicate a connection between the stream and aquifer.

Seepage measurements generally indicate that streams are gaining during the baseflow periods measured, meaning there is a net positive contribution of groundwater to streamflow. This is important because annual seepage measurements will be collected both before and after pumping begins to observe the long-term effects of pumping on the groundwater contribution to streamflow. Water levels in many bedrock wells located near streams are consistently higher than the stream stage, indicating a potential upward gradient from the aquifer to streams. These upward gradients show the potential for water to flow from the aquifer to streams; this water sustains streamflow in times of little or no precipitation, such as during drought conditions. The data collected thus far in this study define prepumping conditions in the hydrologic system and will be compared to conditions after pumping begins.

Seepage data collected once during 2003 and once during 2004 indicate upland stream reaches close to surface-water divides are the first to be affected by decreased groundwater levels. The upper reach of Redland Creek and the northernmost measured reach on the Alcovy River both had less seepage during 2004 than during 2003. The upper reach on the Alcovy River changed from a gaining reach to a losing reach under climate-induced declining groundwater-level conditions. Continued monitoring of these streams will be important in determining pumping effects on streamflow.

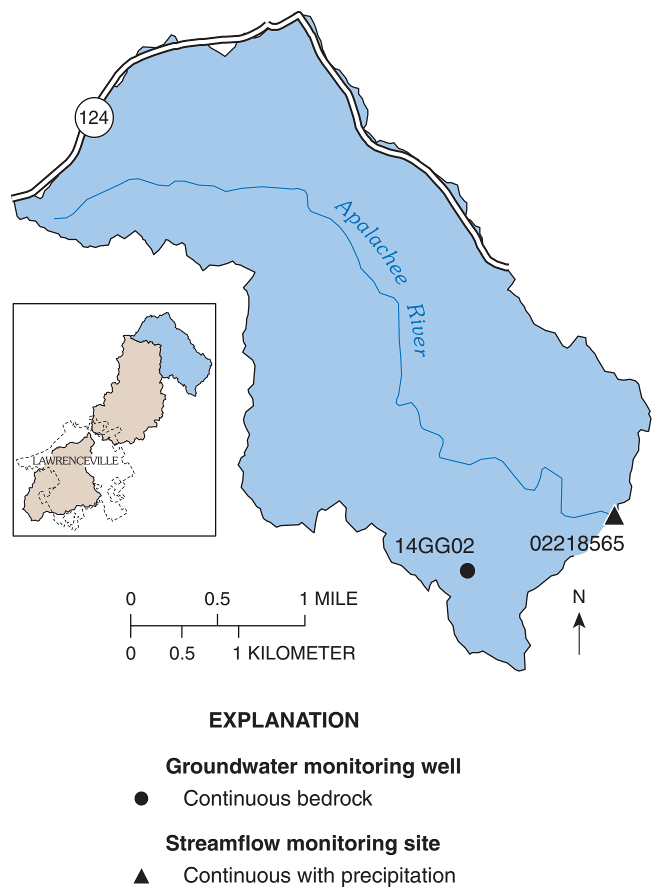

Figure 6. Upper Apalachee River watershed (control), and selected groundwater well and streamflow monitoring site near Lawrenceville, Georgia.

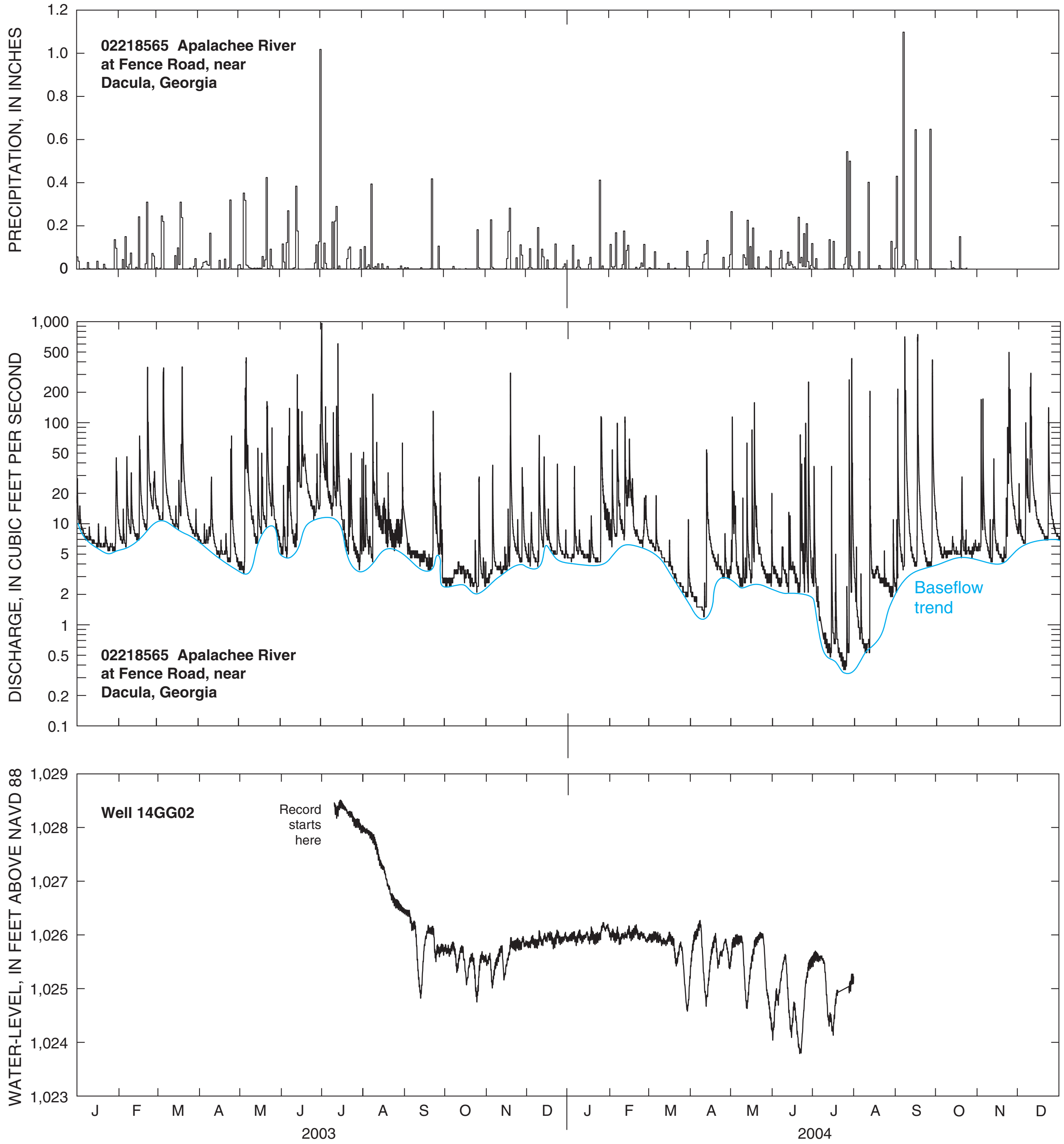

Figure 7. Precipitation and gage height at Apalachee River at Fence Road near Dacula, Georgia (02218565); and groundwater levels at well 14GG02 near Lawrenceville, Georgia, 2003 (see Figure 6 for location).