Ground-Water/Surface-Water Interaction During Runoff Events in Maple Creek, Nebraska

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Abstract

The relation between ground water and surface water in Maple Creek near Nickerson, Nebraska, is currently under investigation as part of the U.S. Geological Survey's National Water-Quality Assessment Program on the transport and fate of agricultural chemicals. Maple Creek, a tributary to the Elkhorn River within the lower Platte River basin, drains 370 mi^2. Components of this study include the collection of hydraulic head measurements and water-quality data at a variety of depths below the streambed and in the stream. Instrumentation includes pressure transducers, temperature loggers, and water-quality monitors deployed in and beneath the stream and in two shallow monitoring wells located in the wooded riparian zone. The wells' screened intervals are centered at 16 and 37 ft beneath land surface, respectively, corresponding to 0.4 ft above and 21.6 ft beneath the mean streambed elevation. Under base-flow conditions, provisional data show that, at most locations in the 394-ft study reach, Maple Creek is a gaining stream with hydraulic head differences ranging from 0.03 to 0.85 ft. This study site provides an opportunity to look at the influence of runoff events on the relation between ground water and surface water in and near Maple Creek. Data collection began in late 2003, and included two large runoff events (water levels 5 and 8 ft higher, respectively, than base-flow conditions). During these two events, water-level changes in the shallow riparian-zone monitoring wells matched the shape of the Maple Creek hydrograph, suggesting a direct relation between ground water and surface water in this reach.

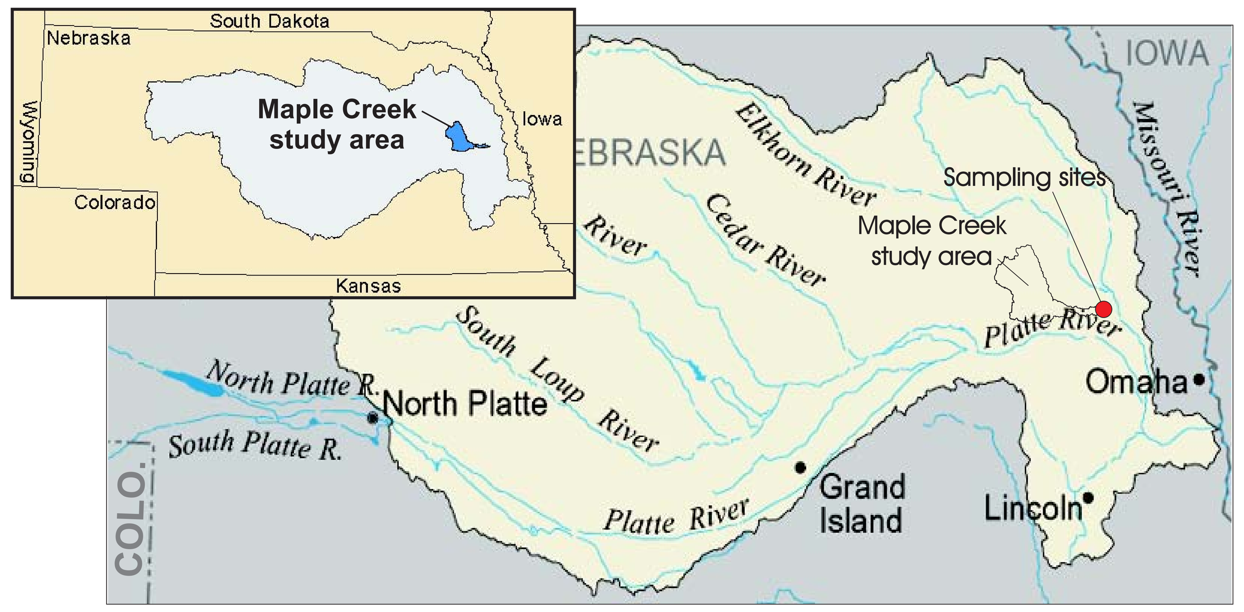

Figure 1. Location of Maple Creek study area and sampling sites within Central Nebraska Basins study unit of the National Water-Quality Assessment Program.

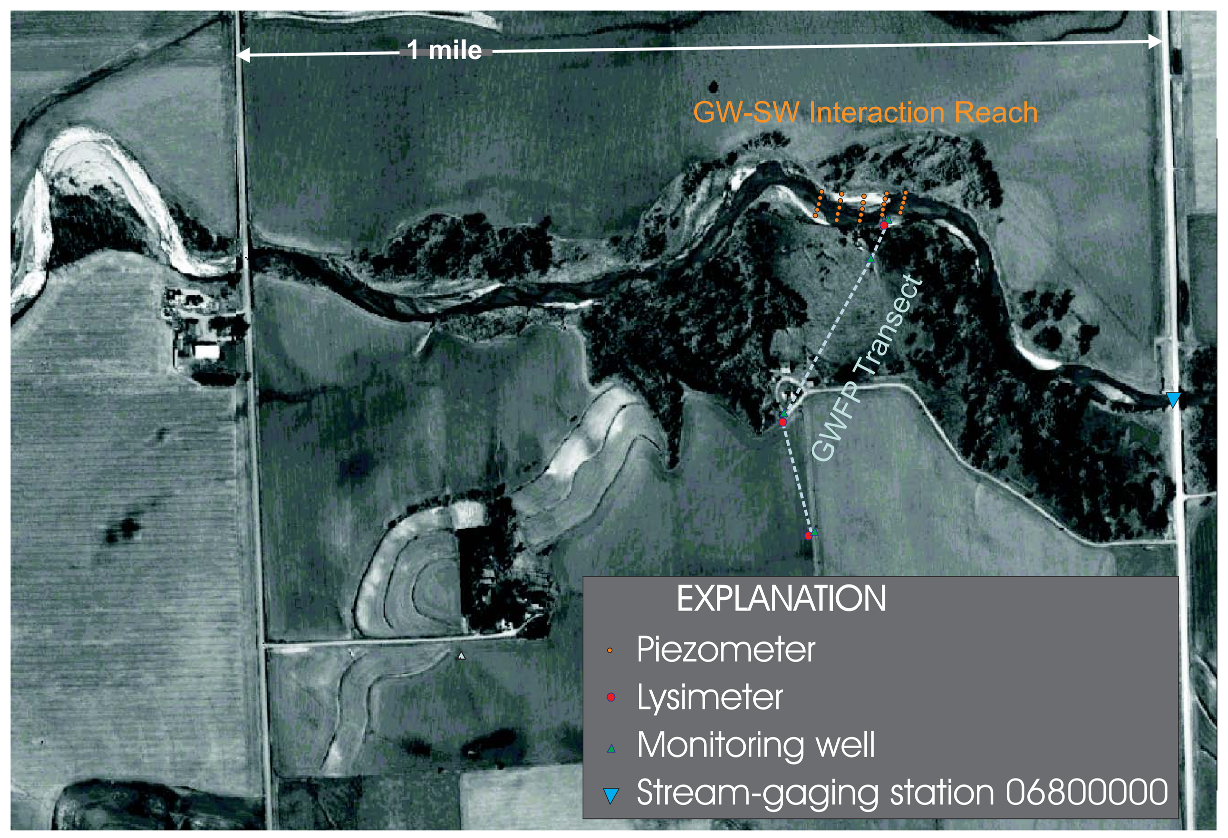

Figure 2. Aerial view of Maple Creek showing sampling sites, layout of ground-water/surface-water (GW-SW) interaction reach, and ground-water flow-path (GWFP) transect. Installations occurred from October 2003 to March 2004.

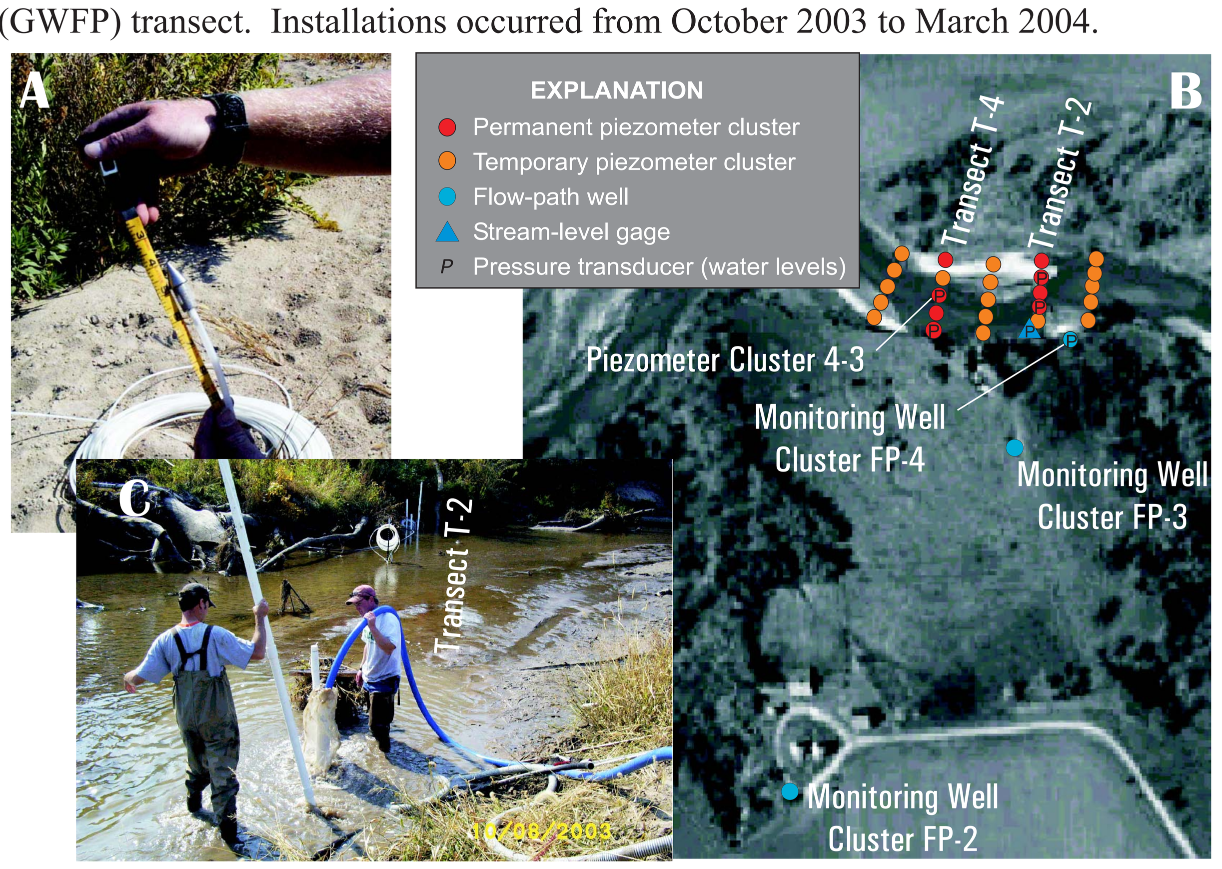

Figure 3. Sixteen mini-piezometers (A) were installed, two at each permanent piezometer site, for water sampling and head-difference measurement. Mini-piezometers were driven to the desired depth on the end of a steel pipe. Screens were positioned 3.3 and 6.6 ft beneath the streambed at each of the eight sites (B), and tubing lines were run underground to the streambanks. Eight 2-in. piezometers were installed, two at each of four permanent piezometer sites, to house pressure transducers (B) for continuously monitoring water levels. At each site, screens were set 3.3 and 6.6 ft beneath the streambed, respectively. Installation of the 2-in. piezometers in the streambed (C) was aided by jetting water into the sandy bed.

Figure 4. View upstream through piezometer transect T-4 showing locations of the four "permanent" 2-in. piezometers, located as two clusters of two each with screens set 3.3 and 6.6 ft beneath the streambed.

Figure 5. View downstream through piezometer transect T-2 showing initial locations of the four 2-in. piezometers, nested as on transect T-4.

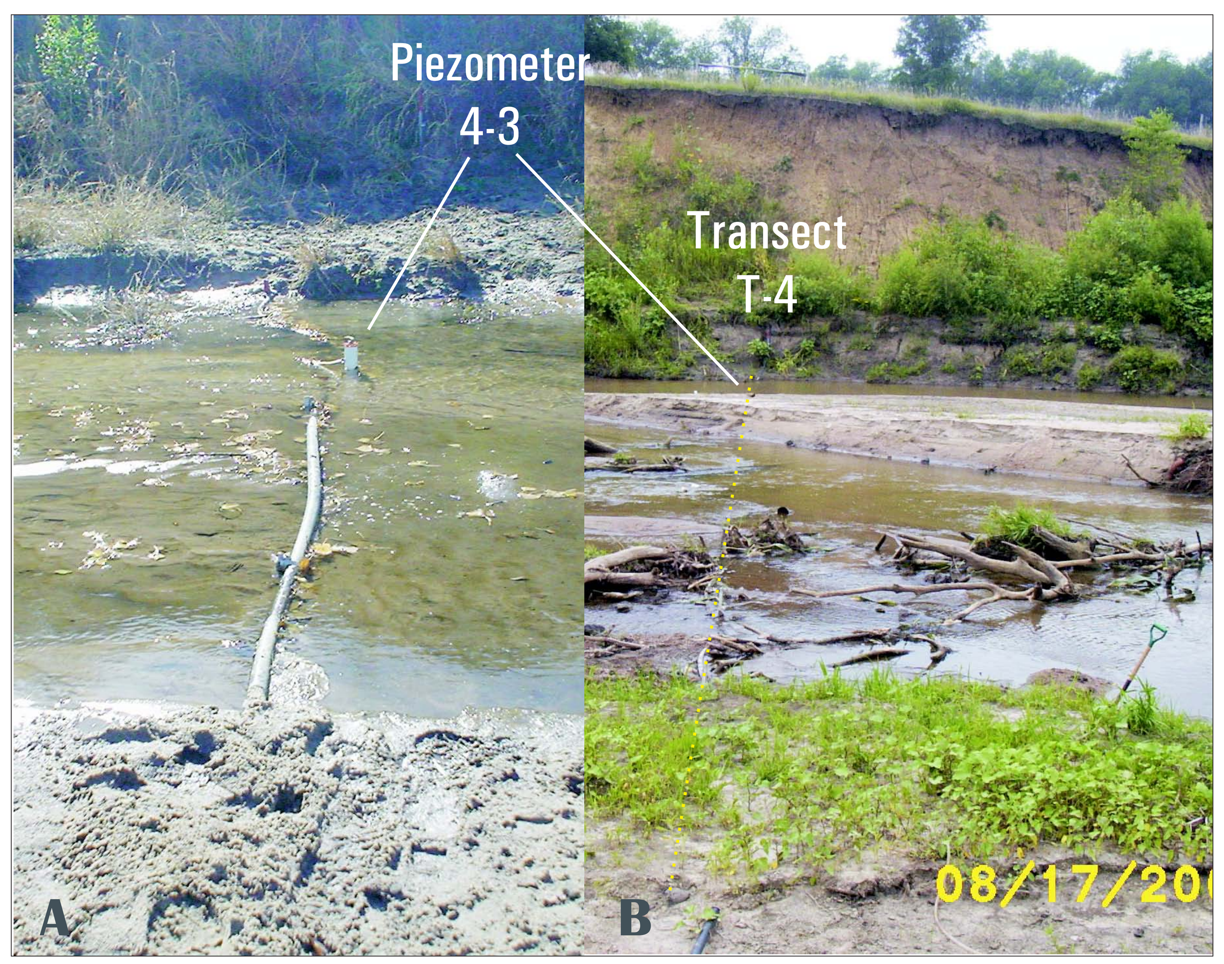

Figure 6. (A) The vented 2-in. piezometers were cut off slightly above the streambed and capped to complete the October 2003 installation. (B) By August 2004, bars and bedforms had shifted so that piezometer 4-3 shown in (A) was buried beneath the medial bar shown in (B).

Monitoring wells were installed along the ground-water flow-path transect (fig. 2) as clusters of three wells to monitor vertical differences in water quality. The wells were installed using either hollow-stem auger or direct-push technology (as shown here at FP-3).

Figure 7. Maple Creek at flood stage about 2.5 mi downstream from the study site on April 30, 2003, when peak stage at the USGS gage (fig. 2) was about 8 ft above typical base-flow stage. On May 23, 2004, peak stage at the gage was 0.7 ft higher than the 2003 peak. Similar conditions as shown here correspond to the peak periods of hydrographs in figures 9 and 12.

Figure 8. View toward right bank in August 2004, showing proximity of monitoring well cluster FP-4 to piezometer transect T-2, where stream water levels are compared in figure 9 with ground-water levels of FP-4.

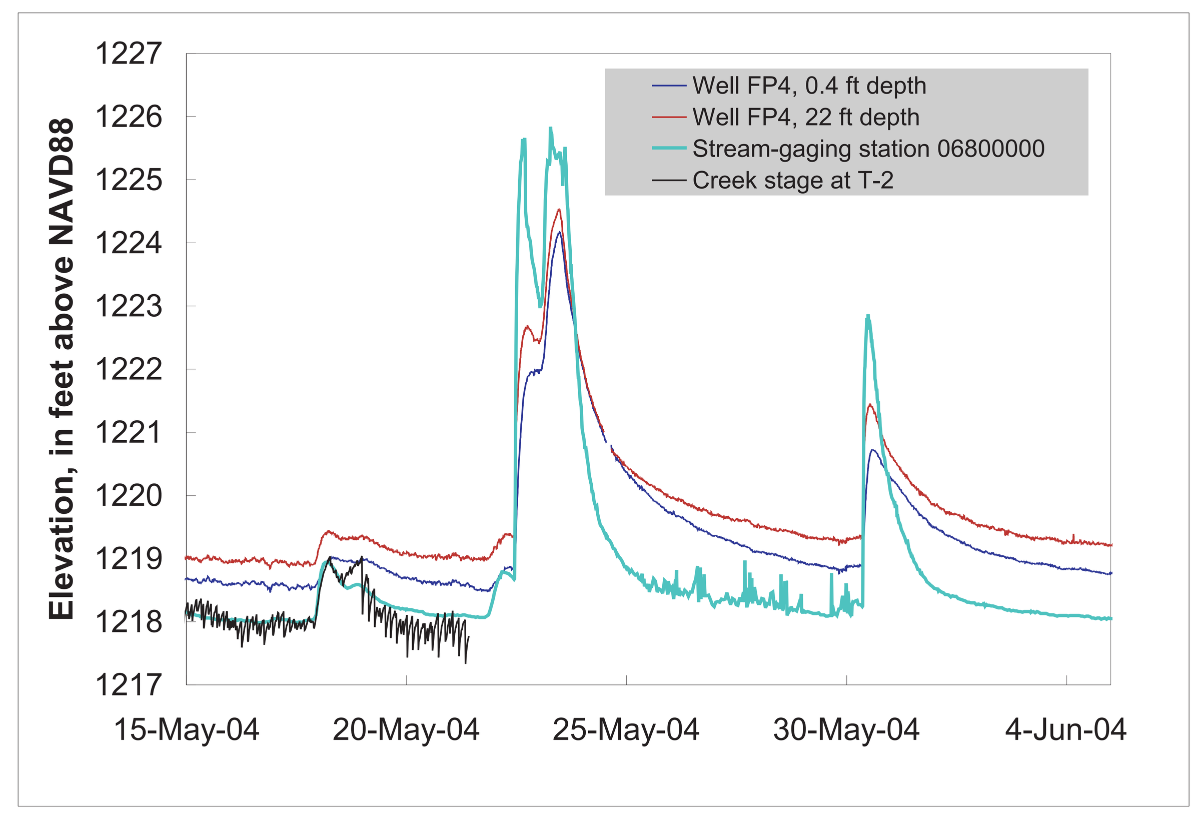

Figure 9. Hydrographs during storm events of late May and early June 2004 show rapid shallow ground-water response to rises in Maple Creek stage. The storm event of May 23, 2004, destroyed the stream water-level recorder at transect T-2, preventing subsequent comparisons of ground-water levels with stream levels at transect T-2. The gaging station is a less reliable indicator of conditions at T-2 because channel geometry differs between the gaged section and the channel cross-section at T-2. (Screen depths are relative to mean streambed elevation.)

Calibration of continuous water-level data used both taped measurements in wells and piezometers, and manometer measurements (shown here) of the hydraulic-head difference between stream water and hyporheic water at a specific screened depth.

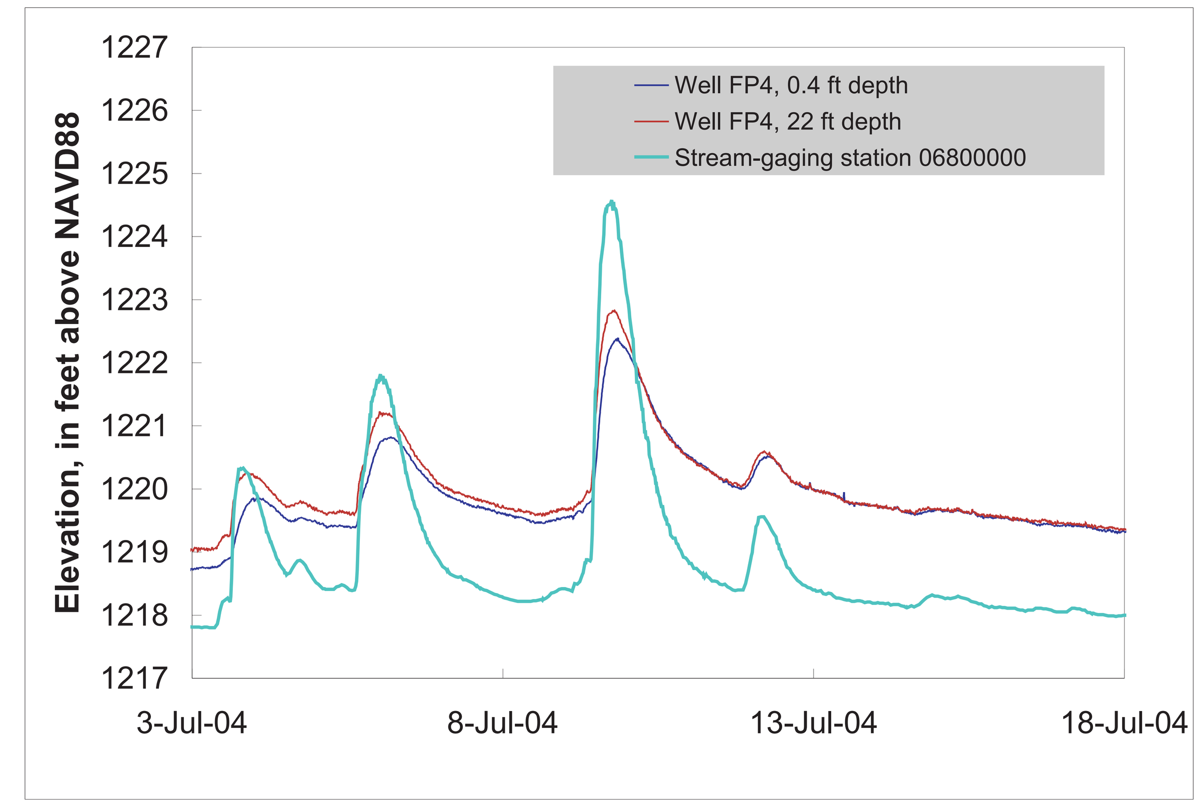

Figure 10. Hydrographs during July 2004 confirm both the rapid ground-water response to streamflow events, and the reversal of hydraulic gradient between stream and ground water during peak stage periods only. (Screen depths are relative to mean streambed elevation.)

Figure 11. Inspection of a pressure transducer prior to redeployment in a piezometer at transect T-4. A continuous water-quality monitor also partly shown was deployed in the same 2-in. diameter piezometer.

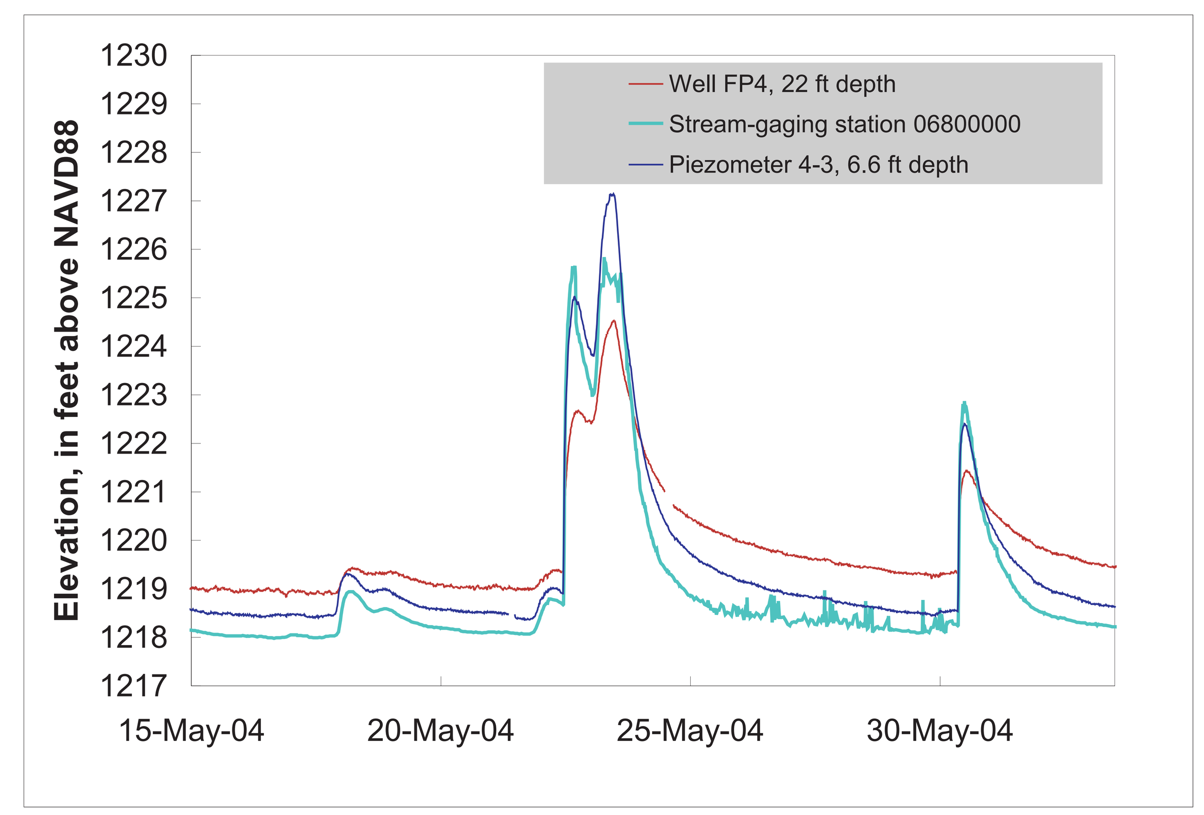

Figure 12. Hydrographs from late May to early June 2004 show that hyporheic water levels responded synchronously with the stream stage and with greater correlation than ground-water levels. (Screen depths are relative to mean streambed elevation.)

Conclusions

Provisional data show the strong synchrony between water levels in the stream, hyporheic zone, and shallow ground water beneath the riparian zone. The hydraulic gradient, generally favoring flow from the saturated zone to the stream, reverses during the peak stage period of storm events, but returns to a gaining stream relatively early in the recessional period.

Acknowledgments

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