Appendix E—Southeast Rockford Site Data

The Southeast Rockford site has been the location of environmental investigations performed in the late 1980's and early 1990's (Camp, Dresser and McKee, Inc., 1992, 1994). The USGS investigation that forms the basis for most of this discussion involved drilling and testing of boreholes BH1, BH2, and BH3 in the eastern part of the site during the winter of 1992-93 (fig. 26)(table 13). Detailed discussion of the methods used for, and results of, the hydrogeologic investigation performed by the USGS is presented in Kay and others (1994). Geologic and hydrologic data collected by Camp, Dresser and McKee, Inc. (1992, 1994) also was analyzed for this investigation. For ease of discussion, the data collected as part of other investigations are integrated into the discussion of the specific methods, rather than as a separate discussion of the previous investigations.

Topographic Analysis

Analysis of land-surface topography during site visits and from topographic maps did not indicate the presence of fracture traces or sinkholes at the Southeast Rockford site. It is assumed that these features were not identified because they are not present. However, the thick (40-150 ft) unconsolidated deposits present beneath most of the Southeast Rockford site may be masking the presence of secondary-permeability features in the Galena-Platteville dolomite. Comparison of surface topography with bedrock topography indicates that topographic highs correspond to bedrock highs, whereas topographic lows correspond to areas where the bedrock was more extensively eroded.

Quarry Visits

The Galena-Platteville dolomite is exposed about 0.75 mi south of borehole BH2 (fig. 26). About 5 ft of the Wise Lake Formation is present at the top of the quarry with the Dunleith Formation exposed below. The quarry did not extend below the Dunleith Formation at the time of this study. Vertical fractures also were observed in the dolomite, but their orientation was not measured.

Lithologic Logs

Lithologic logs were completed for the boreholes drilled for each of the environmental investigations performed at the Southeast Rockford site. Lithologic logs for boreholes BH1, BH2, and BH3 indicate that the Galena-Platteville dolomite primarily is competent rock interspersed with small intervals of fractures and vugs. Each of the boreholes produced substantial quantities of water during drilling, indicating moderate or high aquifer permeability. Lithologic logging identified various possible fractures in each of the boreholes (table 15), but only the feature at about 600-606 FANGVD29 in borehole BH1 (table 16) was described as being associated with an increase in water return during drilling.

Geophysical Logs

A variety of geophysical logs were run in boreholes BH1, BH2, and BH3. These logs improved the understanding of the geology of the Southeast Rockford site and provided additional foundation for the hydraulic framework.

Borehole Camera

A borehole-camera log was run in borehole BH3 (table 15). Camera logging showed competent rock with large fractures just below the bottom of the casing at about 650 FANGVD29. Subhorizontal bedding-plane partings were present throughout the borehole, with these features concentrated between 610-631 and 566-587 FANGVD29. Prominent individual subhorizontal bedding-plane partings were observed at about 580, 590, 597, 626, and 650 FANGVD29. Vuggy intervals were observed at about 572, 581, 589, 594-610, 627, and 633-638 FANGVD29.

Caliper

Three-arm caliper logs show enlargements in the borehole diameter of about 1 in. below the bottom of the casing at about 625, 743, and 652 FANGVD29 in boreholes BH1, BH2, and BH3, respectively. Smaller (0.5 in. or less) but distinct enlargements in the borehole diameter also were observed at 563, 591, 603, and 607 FANGVD29 at borehole BH1; 543, 600, and 663 FANGVD29 in borehole BH2; and at about 626 FANGVD29 in borehole BH3. The caliper log for borehole BH3 indicates that the borehole is enlarged at altitudes similar to those of the bedding-plane partings identified by the borehole camera logging (table 15).

Natural Gamma

Natural-gamma logs run in boreholes BH1, BH2, and BH3 showed consistent response (fig. E1) and indicated about 1 degree of dip toward the east. The lack of detailed stratigraphic information at the Southeast Rockford site prevented comparison of the natural-gamma logs with the local Galena-Platteville stratigraphy. However, natural-gamma logs correlated with stratigraphy at the ACME/WRL site show good correlation with the natural-gamma logs for boreholes BH1, BH2, and BH3, allowing stratigraphy to be determined from the natural-gamma logs from these boreholes. The natural-gamma log for borehole BH2 indicates that the Dunleith Formation is present above about 637 FANGVD29, the Guttenberg, Specht's Ferry, Quimbys Mill, and Nachusa Formations are very thin or absent, the Grand Detour Formation is present at about 595-637 FANGVD29, the Mifflin Formation is present at 572-595 FANGVD29, and the Pecatonica Formation is present from about 542 to 572 FANGVD29.

Acoustic Televiewer

Acoustic-televiewer logs identified subhorizontal bedding-plane partings through the entire thickness of boreholes BH1, BH2, and BH3 (fig. E2). Bedding-plane partings were identified at about 549-555, 560, 587, 597-607, and 611-625 FANGVD29 in borehole BH1 (table 15). Bedding-plane partings were identified at about 537, 550, 558, 565, 589, 591-600, 617-669, 695, and 731-743 FANGVD29 in borehole BH2. Bedding-plane partings were identified at about 569, 577, 582, 586, 592-600, 608-615, 620-630, and 638-642 FANGVD29 in borehole BH3. Some of the partings correlate between at least two of boreholes (fig. E2). Trends in the altitude of many bedding-plane partings show a good correlation with trends in the natural-gamma logs, indicating stratigraphic control on the distribution of the bedding-plan partings (compare figures E1 and E2). Bedding-plane partings correspond to areas of both high and low counts per second on the natural-gamma logs, indicating that many of them are not wash outs of shale partings.

Acoustic-televiewer logs identified an inclined fracture at about 551 FANGVD29 at borehole BH2. This feature is interpreted to be a subhorizontal fracture that appears to be inclined on the televiewer log because of borehole deviation.

Acoustic-televiewer logs identified vuggy intervals in each of the boreholes. Vuggy intervals tended to concentrate in the less argillaceous parts of the dolomite.

Short-Normal Resistivity

As expected, short-normal resistivity logs typically showed an inverse relation with the natural-gamma logs. Short-normal resistivity logs showed no clear response to possible secondary-permeability features identified with lithologic, borehole camera, caliper, or acoustic-televiewer logging (table 15).

Water-Level Measurements

Single, periodic, and continuous water-level measurements were collected as part of the investigations of the Southeast Rockford site.

Periodic Measurements

Water levels were measured in monitoring wells open at various depths in the Galena-Platteville aquifer three times in 1991, once in 1993, and once in 1994 (Camp Dresser and McKee, Inc., 1992, 1994). Measurements indicate that flow in the aquifer is from east to west, from the uplands toward the Rock River (fig. 28). Flow directions were consistent between measurements. Although horizontal hydraulic gradients were not calculated, visual inspection of the water-level altitude in the Galena-Platteville aquifer indicates low gradients in the northeastern part of the Southeast Rockford site and much of the area near borehole BH3 west of Alpine Road. These might be areas of elevated aquifer permeability. Higher horizontal hydraulic gradients are present in the western part of the study area defined by the 717.7 and 769.9 FANGVD29 water levels (fig. 28). There is no clear correlation between the configuration of the potentiometric surface of the Galena-Platteville aquifer and the configuration of the top of the Galena-Platteville dolomite (compare figures 27 and 28).

Water levels in the upper part of the Galena-Platteville aquifer typically exceed water levels in the middle or deeper parts of the aquifer by less than 5 ft, indicating good vertical hydraulic interconnection between the upper and middle parts of the aquifer beneath most of the Southeast Rockford site. However, water levels in the upper and middle part of the aquifer at the MW103 well cluster (fig. 29) were about 20 ft higher than water levels at the base of the aquifer, indicating lower vertical hydraulic conductivity in the lower part of the aquifer at this location. Water levels at the top of the Galena-Platteville aquifer near the MW106 well cluster (fig. 29) were about 105 ft higher than the water level at the top of the St. Peter Sandstone aquifer. This large difference in water level indicates low vertical hydraulic conductivity within the Galena-Platteville aquifer or the Glenwood semiconfining unit beneath the Southeast Rockford site.

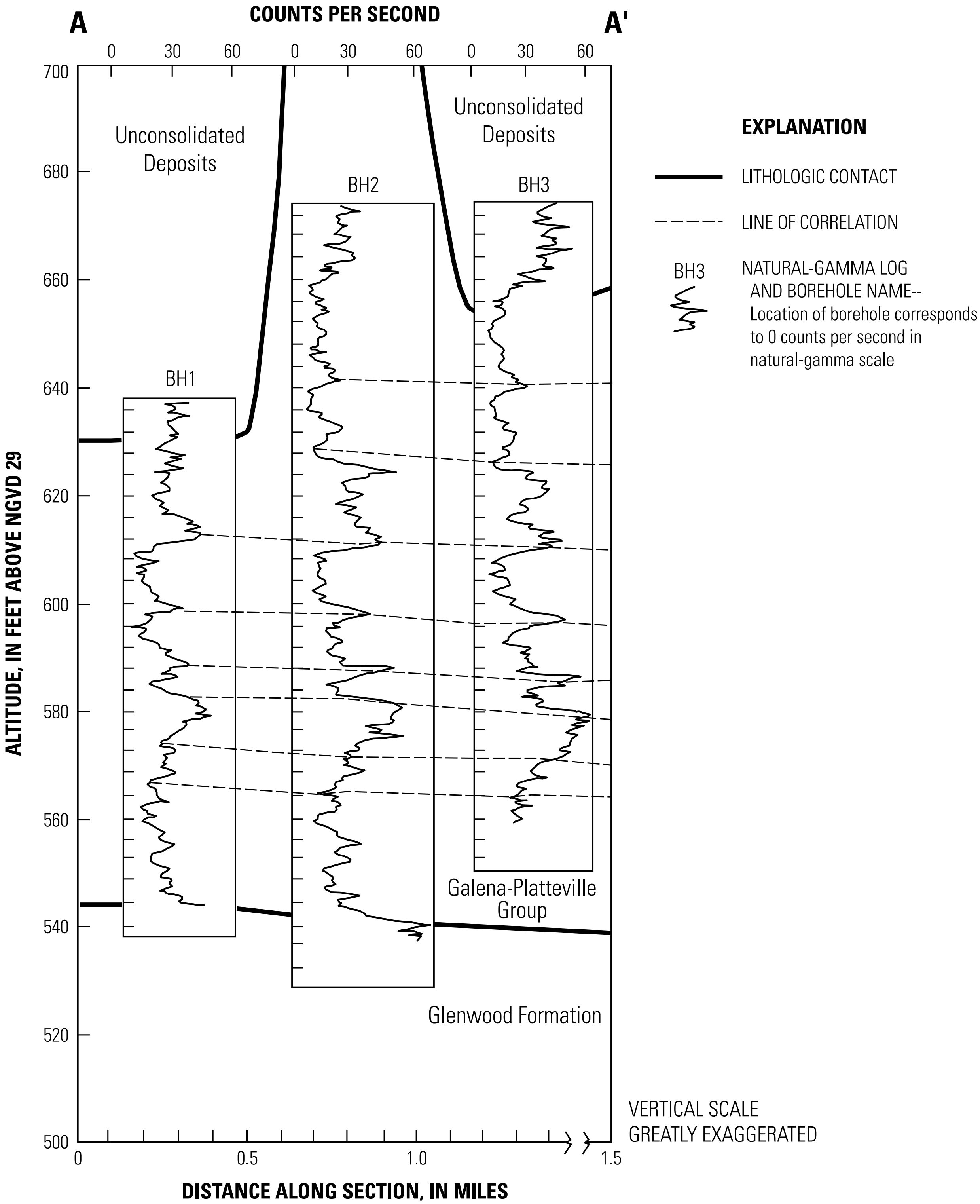

Figure E1. Correlation of natural-gamma logs along line of section A-A’ at the Southeast Rockford site, Ill. (line of section A-A’ shown in figure 26.)

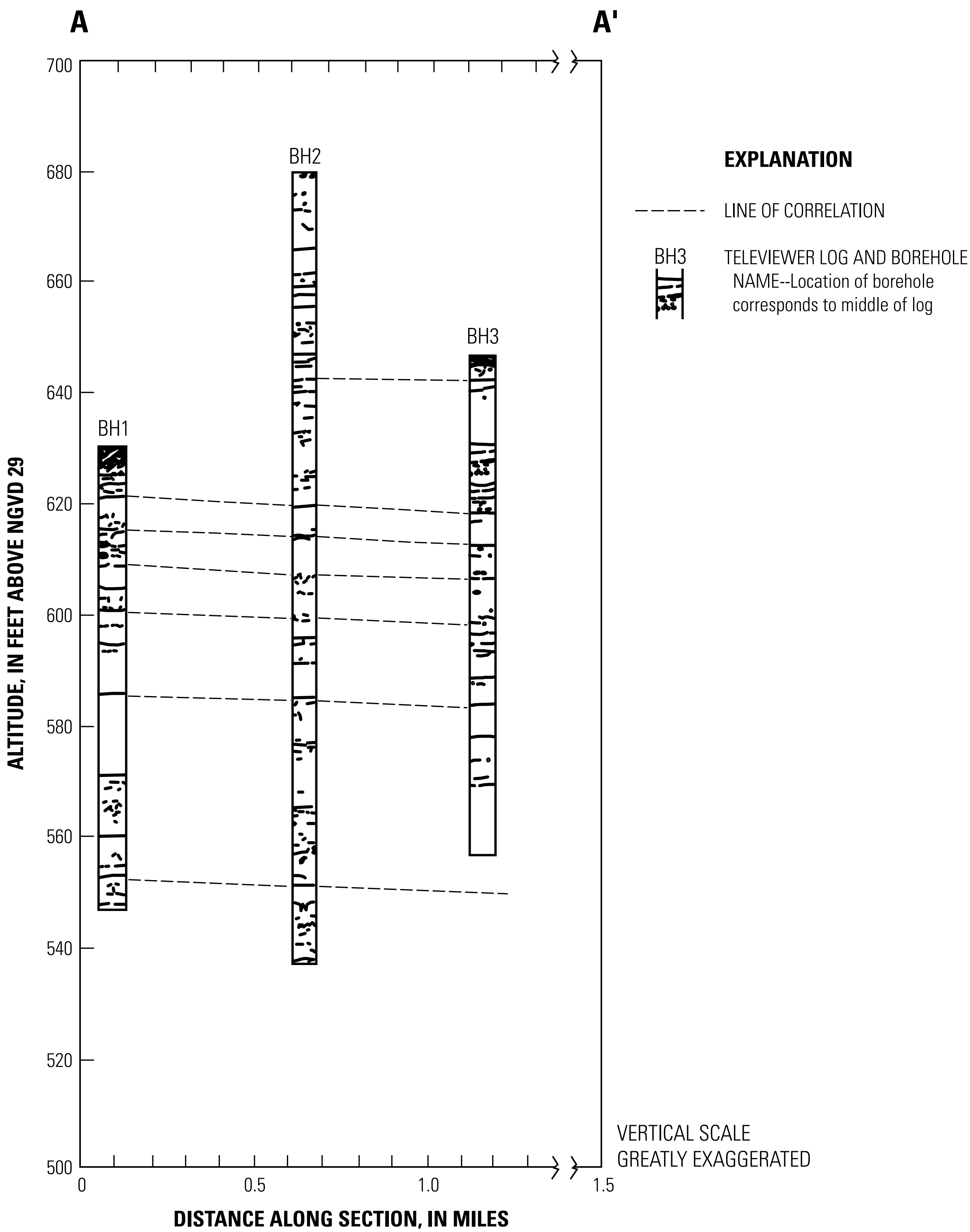

Figure E2. Correlation of acoustic-televiewer logs along line of section A-A′ at the Southeast Rockford site, Ill. (line of section A-A′ shown in figure 26.)

Single Measurements

Water levels measured in test intervals isolated with a packer assembly sampled most of the saturated thickness of the aquifer at boreholes BH1 and BH2 (table E1). With the exception of the test interval B at borehole BH1, water levels in the test intervals isolated with the packer assembly indicate the potential for downward flow within the Galena-Platteville aquifer. The upward hydraulic gradient in test interval B likely is because of inadequate time allowed for the water level in the test interval to decline to its hydrostatic level, which is indicative of low aquifer permeability at this test interval. Water levels above, within, and below the test intervals typically differed by less than 5 ft at borehole BH1, but exceeded 20 ft for all but one of the test intervals in borehole BH2. Borehole BH1 is located near the center of the bedrock valley, whereas borehole BH2 is located along the bedrock ridge near the MW103 well cluster. The differences in water levels above, within, and below the test intervals in borehole BH1 tended to increase with depth, being less than 1 ft in interval F, about 2 ft in intervals A and E, and more than 4 ft in intervals B-D. The differences in water levels above, within, and below the test intervals in borehole BH2 also tended to increase with depth, being about 20 ft in intervals E and F, about 23 ft in interval D, and more than 30 ft in intervals A-C. These patterns indicate that the vertical hydraulic conductivity of the Galena-Platteville aquifer decreases with increasing depth in these areas.

Comparison of water-level measurements in test intervals and the open boreholes in borehole BH1 did not show clear trends, indicating that no one zone is substantially more permeable than any other. Water levels within the test intervals at zones E and F approximate the water level in the open borehole, indicating that the most permeable features in the borehole may be located between 601 and 617 FANGVD29. Water-level measurements from open borehole BH2 were too infrequent to allow comparison with water levels in the test intervals, but the data indicate that if one interval substantially is more permeable than any other, it is located above the top of interval A (557 FANGVD29) and below the bottom of interval F (732 FANGVD29).

Continuous Measurements

Water levels measured hourly in borehole BH3 during a 17-day period in December 1992 showed no clear correlation with pumping from a Rockford Municipal Supply well 16 (RMS16), located at the northeast corner of Alpine and Harrison Roads (fig. 26). RMS16 is cased through the Galena-Platteville aquifer and is open to the underlying Cambrian-Ordovician aquifer. The lack of water-level declines in the Galena-Platteville aquifer during pumping in the underlying aquifer indicates that the Glenwood Formation and the lower part of the Galena-Platteville aquifer has low vertical hydraulic conductivity

Table E1. Water levels in test intervals isolated with a packer assembly, Southeast Rockford site, Ill.

[NA, measurement not applicable]

			Water-level altitude			
Borehole name (fig. 26)	**Test interval**	**Altitude of test interval (feet above National Geodetic Vertical Datum of 1929)**	**Open borehole (feet above National Geodetic Vertical Datum of 1929)**	**Above test interval (feet above National Geodetic Vertical Datum of 1929)**	**Within test interval (feet above National Geodetic Vertical Datum of 1929)**	**Below test interval (feet above National Geodetic Vertical Datum of 1929)**
BH1	A	544-566	715.40	715.50	715.46	NA
	B	574-584	712.20	717.32	718.32	713.52
	C	577-587	715.36	723.84	716.04	713.13
	D	587-597	715.35	717.10	716.65	712.25
	E	601-611	715.47	716.30	715.52	714.28
	F	607-617	715.42	715.54	715.49	715.02
	G	616-626	715.47	NA	713.72	NA
BH2	A	536-557	757.67	759.60	728.85	NA
	C	582-592	NA	760.45	756.93	724.38
	B	592-602	NA	767.14	747.60	726.06
	D	652-662	NA	768.45	763.22	745.20
	E	688-698	NA	768.60	767.67	748.10
	F	732-742	763.2	NA	768.27	752.52

and is composed of competent dolomite with few or no secondary-permeability features.

Geophysical Logs

Flowmeter logs also were run to identify the presence of permeable features in the Galena-Platteville aquifer beneath the Southeast Rockford site.

Flowmeter Logging

Impeller flowmeter logging was done under ambient-flow conditions in boreholes BH1, BH2, and BH3 (fig. E3). Downward flow was detected in each borehole. Flow rates in these boreholes exceeded 5 gal/min, above the range of detection for the heat-pulse flowmeter to be used. Because the volume of flow within the borehole is affected by the both the hydraulic conductivity of the aquifer and the vertical hydraulic gradient within the borehole, the high flow rate measured in these boreholes generally indicates high vertical hydraulic gradient and (or) Kh of the Galena-Platteville aquifer. Analysis of the water-level data indicates the high amount of flow is likely to be related to the high vertical hydraulic gradients, which indicates high vertical hydraulic conductivity, and a poorly developed network of vertically interconnected features in the aquifer.

Flowmeter logging in borehole BH1 indicates inflow from presumed subhorizontal fractures in the weathered bedrock above 620 FANGVD29, and inflow from one or more subhorizontal fractures at 601-606 FANGVD29, a subhorizontal fracture near the transition between the Grand Detour and Mifflin Formations at about 596 FANGVD29, and fractures associated with a shaley interval in the Mifflin Formation at about 587 FANGVD29. Outflow was through a vuggy interval and a subhorizontal fracture in the Pecatonica Formation at about 563-567 FANGVD29 (figs. E1, E2, E3)(table 16).

Flowmeter logging in borehole BH2 indicates inflow from a secondary-permeability feature in the Dunleith Formation at about 720 FANGVD29. Outflow was through a subhorizontal fracture associated with an argillaceous bed near the bottom of the Grand Detour Formation at about 600 FANGVD29, and through a subhorizontal fracture in the Pecatonica Formation at about 548 FANGVD29.

Flowmeter logging in borehole BH3 indicates inflow from subhorizontal fractures in the weathered bedrock above 650 FANGVD29. Outflow was identified through a subhorizontal fracture associated with a shaley bed near the transition between the Mifflin and Grand Detour Formations at about 597 FANGVD29. Variations in the flow near a fractured and vuggy area in the upper part of the Grand Detour Formation at about 628 FANGVD29 appear to be caused by the impeller getting caught on the side of the borehole. It is unclear if this zone is permeable. Flow was not detected below about 595 FANGVD29 in borehole BH3.

Aquifer tests

Slug tests and specific-capacity tests were used to quantify the hydraulic properties of the Galena-Platteville aquifer. Analysis of these tests also provided some insight into variations in the permeability of the aquifer (table 16).

Slug tests

Kh values were obtained from slug tests performed by Camp, Dresser, and McKee (1994) in 22 monitoring wells open to the Galena-Platteville aquifer at the Southeast Rockford site, including monitoring wells installed at permeable intervals in boreholes BH1 and BH2. Kh values ranged from 0.25 to 20 ft/d, with a geometric mean value of 2.6 ft/d (Camp Dresser and McKee, 1994). Kh values from slug tests done in monitoring wells installed at the permeable intervals identified with flowmeter logging in boreholes BH1 and BH2 were between 13 and 20 ft/d and were the highest values determined with the slug tests. These results confirm that the flowmeter logging identified permeable parts of the aquifer. Kh values indicate no apparent trends with areal location or proximity to the bedrock valley or bedrock uplands.

Specific-capacity tests

Specific-capacity tests were done in boreholes BH1, BH2, and BH3 in conjunction with borehole development. Specific-capacity analysis resulted in calculated transmissivity values of 6.8 X 10^3, 1.0 X 10^3, and 7.4 X 10^2 ft^2/d for boreholes BH1, BH2, and BH3, respectively. If the transmissivity value is divided by the length of the open interval at each borehole, the Kh of the Galena-Platteville aquifer is estimated to be 77 ft/d at borehole BH1, 5.3 ft/d and borehole BH2, and 8.0 ft/d at borehole BH3. Specific-capacity test results indicate that the Galena-Platteville aquifer substantially is more permeable at borehole BH1, located near the center of the bedrock valley, than at boreholes BH2 and BH3, which are located in areas where the bedrock surface is higher. However, the availability of only three data points limits the certainty of this conclusion.

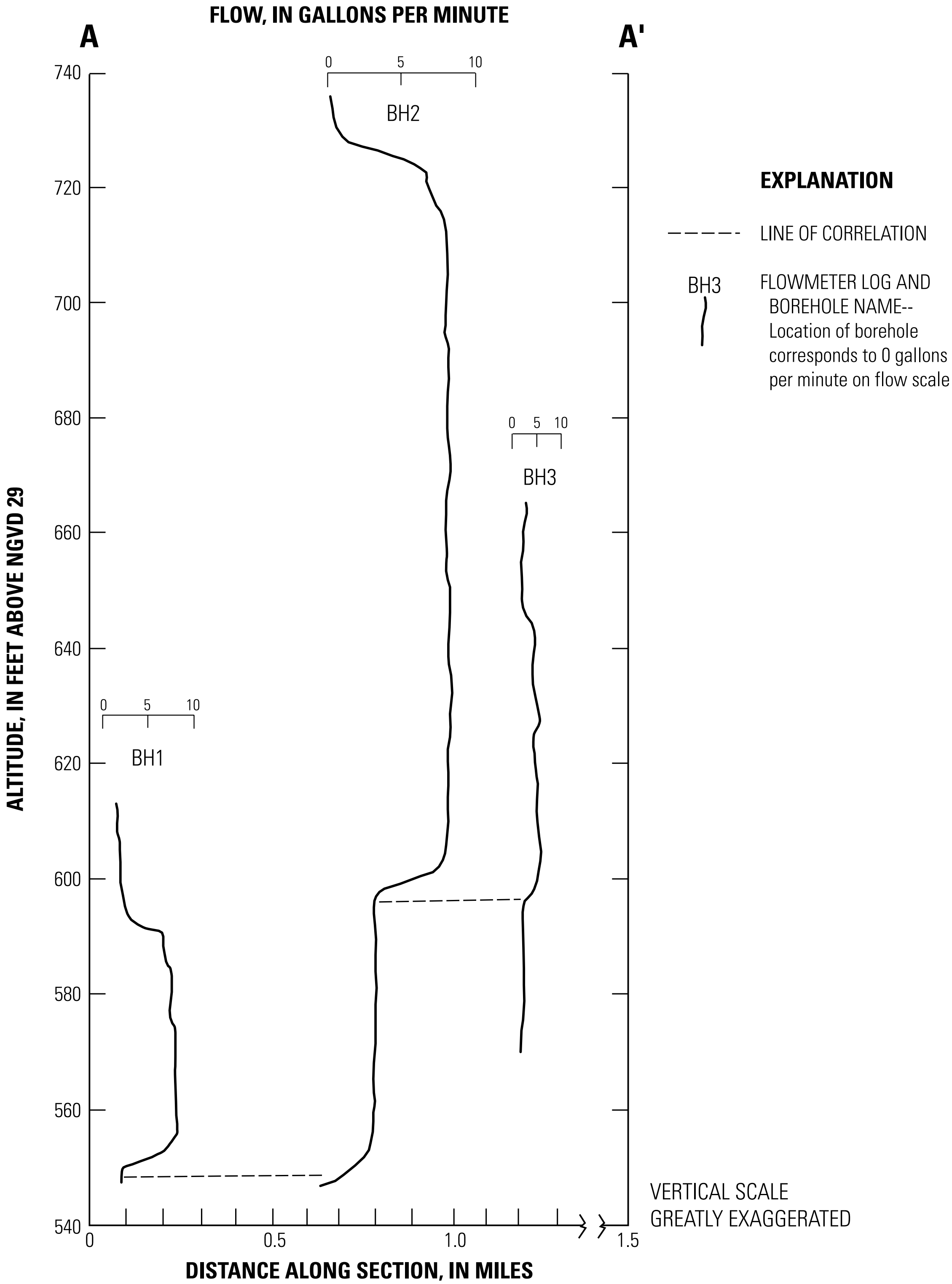

Figure E3. Correlation of flowmeter logs along line of section A-A' at the Southeast Rockford site, Ill. (line of section A-A' shown in figure 26.)

Location of Contaminants

The concentration and distribution of VOC's in ground water beneath the Southeast Rockford site was determined by sampling water quality from test intervals isolated with a packer assembly (Kay and others, 1994) and from monitoring wells (Camp Dresser and McKee, 1992, 1994). VOC's were detected in all but one of the test intervals isolated with a packer assembly in boreholes BH1, BH2, and BH3 (table E2), indicating vertical hydraulic connection within the aquifer. This interpretation is contrary to the conclusion, made from analysis of the vertical distribution of water levels, that there is low vertical hydraulic interconnection within the deeper part of the aquifer. It is possible that the presence of VOC's in the deeper parts of the aquifer results from nonaqueous phase liquids in the aquifer or vertical flow within the boreholes transporting VOC's from the top to the bottom of the aquifer.

Ground-water-quality data obtained from monitoring wells indicates two VOC plumes in the Galena-Platteville aquifer emanating from separate areas at the Southeast Rockford site (fig. 29). Both of these plumes appear to move along the primary direction of ground-water flow as identified with the water-level measurements. Water-quality data collected prior to this investigation indicated that these plumes may have been absent in the Galena-Platteville aquifer and the overlying unconsolidated aquifer in the vicinity of the MW105 and MW107 well clusters. Borehole BH3 is located approximately midway between wells open to the Galena-Platteville aquifer at the MW105 and MW107 clusters, and borehole BH3 is located hydraulically downgradient from these wells. The open interval of the monitoring wells was based on their approximate location (top, middle, bottom) within Galena-Platteville aquifer, rather than the locations of identified permeable features. The presence of VOC's in borehole BH3, identified by intensive characterization of the aquifer in this area, indicates that the plumes may be connected west of Alpine Road (fig. 29). Detection of VOC's in permeable parts of the aquifer in an area thought not to contain VOC's based on sampling results from the monitoring wells indicates that ground-water-flow pathways in this area may be complex, with more flow through permeable features and less flow through more impermeable parts of the aquifer. This interpretation appears to be confirmed by the apparent presence of VOC's only in permeable intervals in borehole BH3.

Table E2. Results of water-quality sampling from test intervals isolated with a packer assembly, Southeast Rockford site, Ill.

Borehole name (fig. 26)	Test interval	Altitude of test interval (feet above National Geodetic Vertical Datum of 1929)	Total concentration of volatile organic compounds (micrograms per liter)
BH1	A	571-592	2,185
	B	600-610	2,173
	C	604-614	208
	D	613-623	2,690
	E	627-637	6,510
	F	633-643	2,370
	G	643-653	1,798
BH2	A	536-557	414
	C	582-592	2,840
	B	592-602	1,446
	D	652-662	1,502
	E	688-698	2,780
	F	732-742	3,870
BH3	B	560-577	0
	A	587-597	42
	D	623-633	35
	C	641-651	13

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