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Hydrogeologic and Ground-Water-Quality Data for Belvidere, Illinois, and Vicinity, 2001–02

Open-File Report 03-206

U.S. Department of the Interior
U.S. Geological Survey

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By P.C. Mills *and* R.T. Kay

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Urbana, Illinois
2003

U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.590	square kilometer
	Flow rate	
gallon per minute (gal/min)	3.785	liter per day
	Hydraulic conductivity*	
foot per day (ft/d)	0.3048	meter per day
	Transmissivity**	
foot squared per day (ft^2/d)	0.3048	meter squared per day

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$°F = (1.8 \times °C) + 32$

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Altitude, as used in this report, refers to distance above or below sea level.

Horizontal datum used in this report is the North American Datum of 1927.

***Hydraulic conductivity:** The standard unit for hydraulic conductivity is cubic foot per day per square foot of aquifer cross-sectional area $(ft^3/d)/ft^2$. In this report, the mathematically reduced form, foot per day (ft/d), is used for convenience.

****Transmissivity:** The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness $[(ft^3/d)/ft^2]ft$. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Abbreviated water-quality units used in this report: Organic- and inorganic-constituent concentrations, water temperature, and other water-quality measures are given in metric units. Constituent concentrations are given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter are considered equivalent to parts per million at the reported concentrations. Micrograms per liter are considered equivalent to parts per billion at the reported concentrations.

Specific conductance of water is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm). The unit is equivalent to micromhos per centimeter at 25 degrees Celsius (µmho/cm), formerly used by the U.S. Geological Survey.

Dissolved oxygen is given in milligrams per liter (mg/L).

Oxidation-reduction potential is given in millivolts (mv).

Turbidity is given in nephelometric turbidity units (NTU).

HYDROGEOLOGIC AND GROUND-WATER-QUALITY DATA FOR BELVIDERE, ILLINOIS, AND VICINITY, 2001–02

By P.C. Mills *and* R.T. Kay

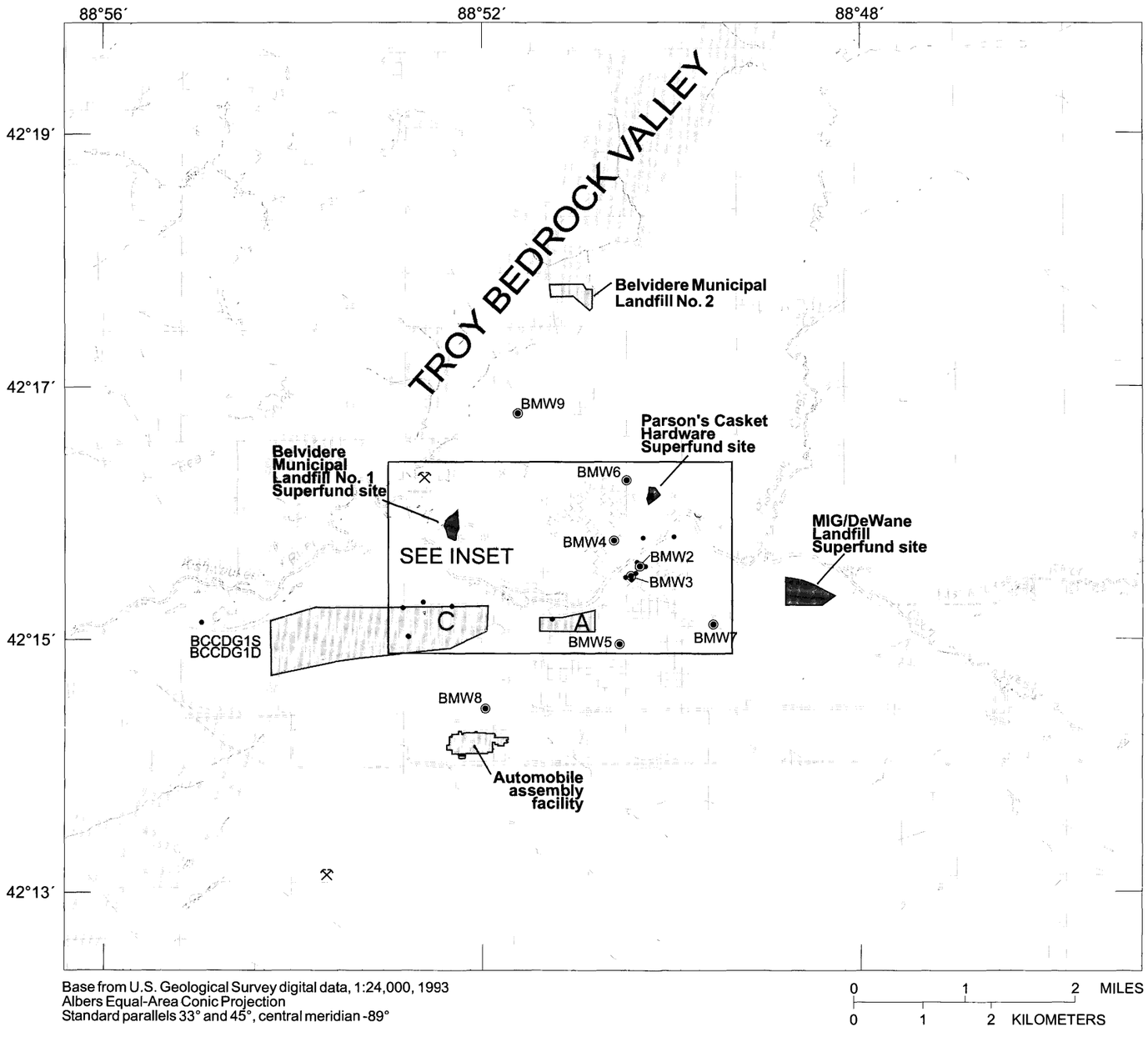
Abstract

This report presents miscellaneous geologic, hydrologic, and ground-water-quality data collected in and near Belvidere, Ill. during May 2001-November 2002. The data were collected for two studies conducted by the U.S. Geological Survey during 1990-2002, but subsequent to publication of the final interpretive reports for the studies. The cooperative studies with the U.S. Environmental Protection Agency and Illinois Environmental Protection Agency evaluated the hydrogeology, ground-water-flow system, and distribution of contaminants in the glacial drift and bedrock (primarily Galena-Platteville) aquifers underlying the vicinity of Belvidere, including the Parson's Casket Hardware Superfund site. Data presented in the report include lithologic descriptions, geophysical logs, water levels, hydraulic characteristics, field-measured characteristics of water quality, and laboratory analyses of volatile organic compounds, major ions, trace elements, nutrients, and herbicides.

INTRODUCTION

The city of Belvidere in Boone County, Ill. (fig. 1), is a community of about 21,000 residents (City of Belvidere, 2003). Volatile organic compounds (VOC's) have been detected in samples from municipal and private water-supply wells open to the glacial drift and bedrock aquifers underlying Belvidere, Ill. and vicinity (fig. 2) (Brown and Mills, 1995; Mills and others, 1998; 1999; 2002a, b) and also appear to discharge to the Kishwaukee River (Roy F. Weston, Inc., 1988; Mills and others, 1999), that flows through Belvidere (fig. 1). VOC's and other contaminants periodically have been disposed of at industrial and commercial facilities and at three landfills in the area (fig. 1). Presently (2003), the Parson's Casket Hardware site (hereafter referred to as the Parson's site) and two landfills are included on the National Priorities List, established by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and Superfund Amendment and Reauthorization Act of 1986 (SARA). With ground water the sole source of public-water supply for the area and expectations of increasing water demand (Belvidere's population has increased about 35 percent since 1990; City of Belvidere, 2003), ground-water-quality remediation and protection are a high priority.

In 1990, the U.S. Geological Survey (USGS) initiated a study of the Parson's site in cooperation with the U.S. Environmental Protection Agency (USEPA) and the Illinois Environmental Protection Agency (IEPA). The principal objectives of the study were to (1) determine the distribution and factors affecting the occurrence and distribution of VOC's in the bedrock aquifers underlying the site, primarily the Galena-Platteville aquifer, and (2) to assess other characteristics of ground-water quality in this carbonate aquifer to determine the potential for natural or assisted (by human factors) attenuation of the organic contaminants. Data collected and analyzed during 1992-2002 are presented in a series of reports that describe the hydrogeology and ground-water quality of bedrock aquifers underlying the site (Mills, 1993a, b, c; Kay and others, 2000; Kay, 2001).



EXPLANATION

Parson's Casket Hardware Superfund site — APPROXIMATE LOCATION OF SUPERFUND SITE AND DESIGNATION

A — APPROXIMATE LOCATION OF AN INDUSTRIAL AREA OR FACILITY AND DESIGNATION

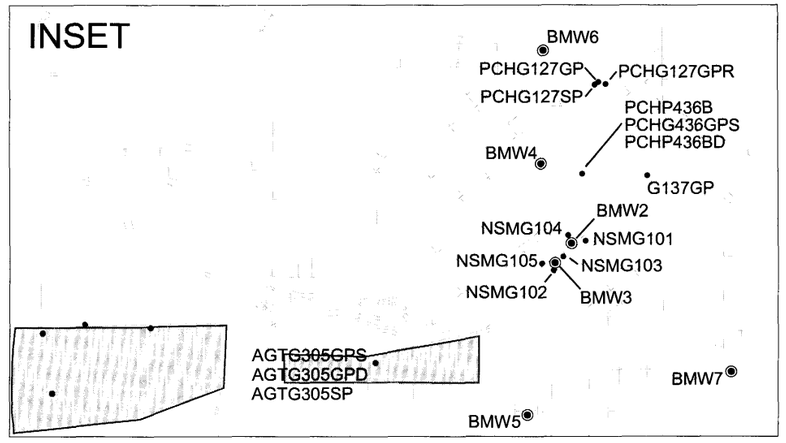
QUARRY

RAILROAD

BMW4 — MUNICIPAL WATER-SUPPLY WELL AND DESIGNATION

NSMG104 — PRIVATE WELL AND DESIGNATION

UNDESIGNATED PRIVATE WELL WITH DETECTION OF VOLATILE ORGANIC COMPOUNDS



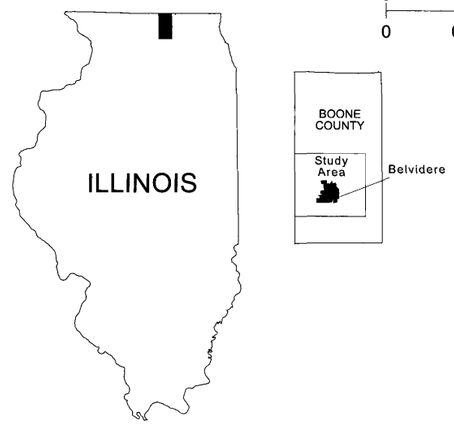


Figure 1. Study area, Superfund sites, industrial areas, municipal water-supply wells, and selected private wells near Belvidere, Ill.

SYSTEM	ROCK-STRATIGRAPHIC UNIT		HYDRO-GEOLOGIC UNIT		LOG	THICK-NESS (FEET)	DESCRIPTION
QUATERNARY	Undesignated		Glacial drift aquifer and confining unit			0-385	Unconsolidated glacial deposits-pebbly clay (till), silt, sand and gravel Alluvial silts and sands of Holocene age along streams
						Fissure fillings	Shale, sandy, brown to black
ORDOVICIAN	Maquoketa Shale Group		confining unit			0-45	Shale, silty, dolomitic, greenish gray, weak (Upper unit) Dolomite and limestone, white, light gray, interbedded shale (Middle unit) Shale, dolomitic, brown, gray (Lower unit)
	Galena Group		Galena-Platteville aquifer	Ordovician aquifer system		0-300	Dolomite and/or limestone, cherty (Lower unit) Dolomite, shale partings, speckled Dolomite and/or limestone, cherty, sandy at base
	Platteville Group						
	Glenwood Formation	Ancell Group	confining unit			0-55	Dolomite, sandstone; silty
	St. Peter Sandstone		St. Peter aquifer			180-290	Sandstone, fine to coarse grained; locally cherty red shale at base
CAMBRIAN	Potosi Dolomite		confining unit	Cambrian-Ordovician aquifer system		40-120	Dolomite, light colored, sandy, thin sandstones
							Dolomite, fine-grained, gray to brown, drusy quartz
	Franconia Formation					60-100	Dolomite, sandstone and shale, glauconitic, green to red, micaceous
	Ironton Sandstone		Ironton-Galesville aquifer			115-160	Sandstone, fine to coarse grained, well sorted; upper part dolomitic
	Galesville Sandstone						
	Eau Claire Formation		confining unit			115-380	Shale and siltstone, dolomitic, glauconitic; sandstone, dolomitic, glauconitic
	Elmhurst Sandstone Member		Elmhurst-Mt. Simon aquifer			about 1,600	Sandstone, coarse grained, white, red in lower half; lenses of shale and siltstone, red, micaceous in upper part
	Mt. Simon Sandstone						
			confining unit (?)			unknown	Shale and siltstone (?)
PRECAM-BRIAN							Granitic rocks

(A)

GROUP	FORMATION
Galena	Dubuque
	Wise Lake
	Dunleith
Platteville	Quimbys Mill
	Nachusa
	Grand Detour
	Mifflin
	Pecatonica

(B)

Figure 2. Classification of (A) rock-stratigraphic and hydrogeologic units of Quaternary through Pre-Cambrian age and (B) detailed stratigraphy of Galena and Platteville Groups in the vicinity of Belvidere, Ill. (figure modified from Woller and Sanderson, 1974, fig. 1).

During January-February 2002, various additional geophysical, hydrogeologic, and ground-water-quality data were collected from a newly installed borehole (G137GP) located across the Kishwaukee River from the Parson's site (fig. 1). Results of the geophysical logging and packer testing were included in a written communication to USEPA (Robert Kay, U.S. Geological Survey, written commun., 2002), but not in the final USGS interpretive report (Kay, 2001) for the Parson's-site study.

In 1992, the USGS initiated a cooperative ground-water study with the USEPA and IEPA of an 80-mi^2 area that includes Belvidere (fig. 1). The objectives of the study were to (1) determine the regional distribution and hydrogeologic factors affecting the occurrence and distribution of contaminants in the aquifers, with emphasis on explaining the presence of VOC's in water withdrawn by five of the eight municipal wells serving Belvidere, (2) assess the effect of ground-water contamination associated with non-Superfund hazardous-waste sites on investigations and remediation options at Superfund sites, and (3) provide the necessary data and analysis to assist other agencies and organizations in developing strategies for remediation of ground-water contamination and protection of the ground-water supplies of the area. Data collected and analyzed during 1992-2002 are presented in a series of reports that describe the hydrogeology and ground-water quality of Belvidere and vicinity (Brown and Mills, 1995; Mills and others, 1998, 1999, 2002a, b) and a ground-water-flow model of the area (Mills and others, 2002a, b).

During May 2001-November 2002, various additional hydrogeologic and ground-water-quality data were collected in and near Belvidere. These data were not included in the final USGS interpretive report (Mills and others, 2002b) for the Belvidere-area study.

Purpose and Scope

This report presents miscellaneous hydrogeologic and ground-water-quality data collected during May 2001-November 2002, subsequent to the final interpretive reports for the USGS ground-water studies of the Parson's Casket Hardware Superfund site and the vicinity of Belvidere, Ill. Lithologic descriptions, geophysical logs, water levels, hydraulic characteristics, field-measured characteristics of water quality, and laboratory analyses of VOC's and other organic and inorganic constituents are given in tables, figures, and a written communication.

Description of the Study Area

The study area comprises much of southern Boone County and includes the city of Belvidere and the Parson's Casket Hardware Superfund site (fig. 1). The Kishwaukee River flows westward though the central part of the study area, with land-surface altitude at the river channel about 750 ft, the Parson's site about 780 ft, and the northern and southern uplands about 900 ft. Ground-water discharge is primarily to the Kishwaukee River and its principal tributaries.

The Troy Bedrock Valley transects the western part of the study area, with one of its tributary valleys adjacent to the Parson's site. The glacial drift aquifer, Galena-Platteville aquifer, and sandstone aquifers of the Cambrian-Ordovician aquifer system (including the uppermost St. Peter aquifer) compose the transmissive units of the ground-water-flow system (fig. 2). The glacial drift aquifer, as much as 260-ft thick within the Troy Bedrock Valley, thins to lenses of sand and gravel within thicker till deposits beyond the valley and north of the Kishwaukee River. East and south of the Kishwaukee River the aquifer generally is not present. One municipal well is open to the glacial drift aquifer (BMW9; fig. 1).

The approximately 300-ft thick Galena-Platteville aquifer consists of fractured dolomite that yields up to 40 gal/min to private wells (Berg and others, 1984). Six municipal wells (BMW2-BMW7; fig. 1) are open, in part, to this aquifer and, in part, to the deeper bedrock aquifers. Hydraulically active bedding-plane partings and inclined fractures have been identified as the principal locations of ground-water flow within the Galena-Platteville aquifer and possible migration routes of VOC's into area water-supply wells (Mills and others, 2002a). The sandstone aquifers of the Cambrian-Ordovician

aquifer system are the principal source of water to the municipal wells open to bedrock aquifers. One municipal well (BMW8; fig. 1) is open only to the sandstone aquifers. Principal confining units include fine-grained deposits within the glacial drift aquifer, the approximately 35-ft thick Glenwood confining unit, and at least two 40-300-ft thick units of dolomite, shale, or siltstone that separate the sandstone aquifers (fig. 2a). The reader is referred to Brown and Mills, 1995 and Mills and others, 1998, 1999, 2002a, b (Belvidere area) and Mills, 1993a, b, c; Kay and others, 2000; and Kay, 2001 (Parson's site) for additional detail on the hydrogeology of the Belvidere and Parson's study areas.

Acknowledgments

Various persons, public agencies, and companies are thanked for their contribution to the study. Jim Grimes, Superintendent, Water and Sewer Department, Belvidere, Ill., Daniel Kane; Executive Director, Boone County Conservation District; and Mr. and Mrs. William Finedore provided property access for ground-water sampling. William Morrow, U.S. Geological Survey, and Douglas Yeskis, formerly with the U.S. Environmental Protection Agency, Office of Superfund, Chicago, Ill., assisted with ground-water sampling and other aspects of data collection. Jim Ursic, U.S. Environmental Protection Agency, Office of Superfund, Chicago, Ill., performed geophysical logging. Tetra Tech, Inc. installed the test borehole and The Pillsbury Company allowed property access for the installation.

HYDROGEOLOGIC AND GROUND-WATER-QUALITY DATA

Miscellaneous hydrogeologic and ground-water-quality data collected for studies of the Parson's Casket Hardware Superfund site and the Belvidere area are presented in the following sections of the report. Methods used to collect the various data from the test borehole, monitoring, and water-supply wells are described in U.S. Geological Survey and U.S. Environmental Protection Agency (1993), Wilde and others (1997 to present), and Mills and others (1998, 1999). Included in the reports are descriptions of procedures used to collect and analyze quality-assurance samples. Quality-assurance analytical results for the present study can be obtained from the USGS, Illinois District office, on request.

Parson's Casket Hardware Superfund site

Previous studies at the Parson's Casket Hardware Superfund site (Kay, 2001; Mills and others, 2002b) have indicated that VOC's from the site might be moving south of the Kishwaukee River though one or more hydraulically active bedding-plane partings in the Galena-Platteville aquifer. To evaluate that possibility, a test borehole (G137GP) was drilled on the south bank of the river (fig. 1; table 1) during January 2001. Borehole construction, test descriptions, and data interpretation presented in the written communication to USEPA (Robert Kay, U.S. Geological Survey, written commun., 2002) are included in this report as appendix 1. Tests, conducted during February 2002, included geophysical logging (caliper, natural gamma, acoustic televiewer, heat-pulse flow, and others) and packer isolation of discrete intervals of the borehole for analysis of vertical differences in hydraulic characteristics and water quality of the aquifer. Water-quality data included field characteristics (temperature, pH, specific conductance, dissolved oxygen, and oxidation-reduction potential) and VOC's on the USEPA Target Compound List (U.S. Environmental Protection Agency, 2003a). VOC analyses were performed by a laboratory managed under the USEPA Contract Laboratory Program. The processed geophysical logs are on file at the USGS, Illinois District office and copies can be obtained, on request; the unprocessed (raw data) geophysical logs are given in this report as appendix 2. Water levels, measured to determine vertical flow gradients, and results of slug tests, to estimate hydraulic characteristics (horizontal conductivity and transmissivity), are given in appendixes 3 and 4, respectively.

Table 1. Description of selected wells and types of water-quality data collected near Belvidere, Ill., 2001-02

Aquifer to which well is open: GD, glacial drift aquifer; GP, Galena-Platteville aquifer; SP, St. Peter aquifer; OR, Ordovician aquifer system (Galena-Platteville and St. Peter aquifers); CO, Cambrian-Ordovician aquifer system (Galena-Platteville, St. Peter, Ironton-Galesville, and (or) Elmhurst-Mt.Simon aquifers)

Open or screened interval of well: in feet below land surface

Sampled for: Y, yes; N, no

Type of well: M, monitoring; B, Belvidere, Ill., municipal water supply; T, test borehole; P, piezometer

Well designation	Latitude	Longitude	Aquifer to which well is open	Open or screened interval of well	Sampled for major ions	Sampled for trace elements	Sampled for volatile organic compounds	Sampled for nutrients	Sampled for herbicides	Type of well
AGTG305GPS	42°15'08"	88°51'16"	GP	110.0-115.0	N	N	Y	N	N	M
AGTG305GPD	42°15'08"	88°51'16"	GP	246.4-251.4	N	N	Y	N	N	M
AGTG305SP	42°15'08"	88°51'16"	SP	352.8-357.8	N	N	Y	N	N	M
BCCDG1S	42°15'06"	88°54'59"	GD	17.6-22.6	Y	Y	Y	Y	Y	M
BCCDG1D	42°15'06"	88°54'59"	GD	50.8-55.8	Y	Y	Y	N	N	M
BMW2	42°15'34"	88°50'19"	CO	50-1,860	N	N	Y	N	N	B
BMW3	42°15'30"	88°50'25"	CO	55-1,800	N	N	Y	N	N	B
BMW4	42°15'47"	88°50'36"	CO	152-1,800	N	N	Y	N	N	B
BMW5	42°14'58"	88°50'34'	OR	151.8-610	N	N	Y	N	N	B
BMW6	42°16'15"	88°50'28"	CO	110-868	N	N	Y	N	N	B
BMW7	42°15'06"	88°49'33"	CO	192-969	N	N	Y	N	N	B
BMW8	42°14'27"	88°51'58"	CO	362-875; 995-1,390	N	N	Y	N	N	B
BMW9	42°16'49"	88°51'39"	GD	70-90; 115-120	N	N	Y	N	N	B
NSMG101	42°15'34"	88°50'16"	GD	32.9-37.9	N	N	N	N	N	M
NSMG102	42°15'28"	88°50'24"	GD	44.6-49.6	N	N	Y	N	N	M
NSMG103	42°15'32"	88°50'22"	GD	49.9-54.9	N	N	Y	N	N	M
NSMG104	42°15'36"	88°50'21"	GD	54.1-59.0	N	N	Y	N	N	M
NSMG105	42°15'30"	88°50'27"	GD	42.8-47.8	N	N	Y	N	N	M
PCHG127GPR	42°16'08"	88°50'13"	GP	[1]255-265	N	N	Y	N	N	M
PCHG127SP	42°16'08"	88°50'13"	SP	370.7-375.7	N	N	Y	N	N	M
PCHG128GPS	42°16'15"	88°50'27"	GP	16.0-121.0	N	N	Y	N	N	M
PCHG128GPD	42°16'15"	88°50'27"	GP	253.5-258.5	N	N	Y	N	N	M
G137GP	42°15'46"	88°49'58"	GP	58-275	N	N	Y	N	N	T
PCHP436B	42°15'48"	88°50'18"	GP	30.0-35.0	N	N	Y	N	N	P
PCHG436GPS	42°15'48"	88°50'18"	GP	102.3-107.3	N	N	Y	N	N	M
PCHP436BD	42°15'48"	88°50'18"	GP	195.0-200.0	N	N	Y	N	N	P

[1]Estimated; based on available information (Jason Thorpe, Illinois Environmental Protection Agency, oral commun., 2002).

Belvidere Area

The Troy Bedrock Valley, located about 1.5 mi west of Belvidere (fig. 1), has been identified as an important part of the ground-water system that may (1) contribute substantial recharge and contaminants (with future development of the rural area) to the underlying St. Peter aquifer and (2) be under-used as a source for public-water supply (Mills and others, 2002b). Sand-and-gravel deposits up to 260-ft thick infill the valley. Limited data are available on the hydraulic characteristics and water quality of the valley-fill deposits that locally compose the glacial drift aquifer. To provide additional data, two vertically nested monitoring wells (BCCDG1S, BCCDG1D; fig. 1, table 1) were installed in the southern part of the valley where the sand-and-gravel deposits seem to be thickest and almost vertically continuous to land surface. The wells were installed during June 2001 using a hollow-stem auger by methods described in Mills and others (1998). A lithologic description for the site of the nested wells is given in appendix 5. During June 13-September 10, 2001, water levels were measured hourly in well BCCDG1S to examine temporal trends. Measurements were made using a pressure transducer and automatic data logger. The hydrograph for these data is given in appendix 6.

Slug tests were conducted at wells BCCDG1S and BCCDG1D to estimate horizontal hydraulic conductivity of the glacial drift aquifer. The method used for the falling- and rising-head tests is described in Mills and others (1998). The aquifer at the test locations yielded an under-dampened response. During the tests, water levels oscillated above and below the static level and recovered to the static level within less than 0.5 minute (appendix 7). Although quantitative analyses of the data were not done, these hydraulic characteristics indicate conductivities that are in the range of 100's of feet per day.

Since 1993, ground-water-quality samples have been collected on a near-annual basis from a network of 15 monitoring wells and 8 municipal wells (table 1; fig. 1) (Mills and others, 1999, 2002a, b). Routinely, field characteristics of sample water quality (temperature, pH, specific conductance, and dissolved oxygen, and (or) oxidation-reduction potential) have been measured and the samples analyzed for VOC's; other organic, inorganic, and radiometric constituents have been analyzed for selectively. Until 2001, only about one-half of the wells in the network had been included in each annual sampling, with the selected wells rotated from year to year. In September 2001 and November 2002, samples were collected from essentially all of the network wells, plus a replacement well in the network (PCHG127GPR) and the two vertically nested wells (BCCDG1S, BCCDG1D) (fig. 1). As part of the sampling effort in 2001-02, ground-water levels were measured at each of the monitoring wells (appendix 8).

Field characteristics of water quality were measured for all water samples collected in 2001-02. Samples also were analyzed for VOC's on the USEPA Target Compound List (U.S. Environmental Protection Agency, 2003a) and other selected compounds. However, VOC results for samples collected in 2001 were rejected because of problems with the laboratory-analytical equipment. Samples collected in 2001 from wells BCCDG1D and (or) BCCDG1S were analyzed for major ions, trace elements (including metals), cyanide, nutrients (ammonium, ammonium plus organic nitrogen, nitrate, nitrite plus nitrate, and orthophosphate), herbicides, and herbicide-transformation products. Analytical water-quality results are given in appendixes 9-14.

VOC and trace-element analyses were performed primarily by laboratories managed under the USEPA Contract Laboratory Program. Analyses for 1,4-dioxane and tetrahydrofuran were by the USEPA Region 5 Central Regional Laboratory. Major-ion and nutrient analyses were done by the USGS National Water-Quality Laboratory in Denver, Colo., using methods described in Fishman and Friedman (1989). Herbicides and their transformation products were analyzed by the USGS Organic Geochemistry Research Laboratory in Lawrence, Kans., using methods described in Zimmerman and Thurman (1999), Zimmerman and others (2000), Kish and others (2000), and Lee and others (2001, 2002).

From about 1993 to 2002, ground-water-quality data have been collected by the USGS at two locations in the study area in which possible trends in water quality are identified. Water-quality and related data compiled from the USGS Belvidere

study and other studies in the vicinities of monitoring well AGTG305SP, and municipal wells BMW2 and BMW3 (Voelker and others, 1989; Illinois Environmental Protection Agency, 1988) (fig. 1) are presented in appendixes 15 and 16, respectively. Until 2002, trichloroethene (TCE) concentrations in samples from well AGTG305SP, open to the St. Peter aquifer and within about 0.5 mi of municipal well BMW5, increased steadily. Possible explanations for the presence of this and other VOC's in samples from the St. Peter aquifer at this location are discussed in Mills and others (2002a). Since sampling for VOC's in Belvidere municipal wells began in 1985, TCE and tetrachlorethene (PCE) have been detected in samples from wells BMW2 and BMW3, open to the Galena-Platteville aquifer and deeper sandstone aquifers (fig. 2). In 1988, these and other VOC's first were detected in at least three nearby monitoring wells (NSMG103-NSMG105) open to the glacial drift aquifer (Illinois Environmental Protection Agency, 1988). During 1993-95, use of wells BMW2 and BMW3 was suspended because the concentrations of TCE and PCE exceeded maximum contaminant levels established for protection of public-water supplies (U.S. Environmental Protection Agency, 2003b). In 1996, the supply wells were returned to service, with the withdrawn ground water treated for public distribution by routing through an air stripper (Jim Grimes, Water and Sewer Department, Belvidere, Ill., oral commun., 1997). Concentrations of TCE plus PCE in the glacial drift and bedrock aquifers supplying water to wells BMW2 and BMW3 are fluctuating (appendix 16), possibly in response to changes in ground-water levels and flow paths associated with the periodic use of the wells. Possible sources and flow paths for the VOC's in the area are discussed in Mills and others (2002a, b).

SUMMARY

Volatile organic compounds have been detected in samples from municipal and private water-supply wells open to the glacial drift and bedrock aquifers underlying Belvidere, Ill. and vicinity. This report presents miscellaneous geologic, hydrologic, and ground-water-quality data collected in and near Belvidere, Ill. during May 2001-November 2002. The data were collected for two studies conducted by the U.S. Geological Survey (USGS) during 1990-2002, but subsequent to publication of the final interpretive reports for the studies. The studies by the USGS, in cooperation with the U.S. Environmental Protection Agency and Illinois Environmental Protection Agency evaluated the hydrogeology, ground-water-flow system, and distribution of contaminants in the glacial drift and bedrock aquifers underlying the vicinity of Belvidere, including the Parson's Casket Hardware Superfund site.

Lithologic descriptions, geophysical logs, water levels, and hydraulic characteristics are presented from packer tests of a borehole open to the Galena-Platteville aquifer and two vertically nested wells open to the glacial drift aquifer that composes the Troy Bedrock Valley near Belvidere. Field-measured characteristics of water quality and laboratory analysis of volatile organic compounds are presented for samples collected from a network of 15 monitoring wells and 8 public-water supply wells, the test borehole, and the vertically nested wells. Analyses of major ions, trace elements, nutrients, and herbicides also are presented for the two vertically nested wells, as are water levels for the monitoring-well network and trends in water quality at two locations in Belvidere.

REFERENCES CITED

Berg, R.C., Kempton, J.P., and Stecyk, A.N., 1984, Geology for planning in Boone and Winnebago Counties: Illinois State Geological Survey Circular 531, 69 p.

Bouwer, Herman, and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: Water Resources Research, v. 12, p. 423-428.

Brown, T.A., and Mills, P.C., 1995, Well-construction, hydrogeologic, and ground-water-quality data in the vicinity of Belvidere, Boone County, Illinois: U.S. Geological Survey Open-File Report 94-515, 34 p.

City of Belvidere, 2003: accessed March 10, 2003, at URL http://www.ci.belvidere.il.us/bodyframeset.html

Fishman, M.J., and Friedman, L.C., eds., 1989, Methods for the determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Illinois Environmental Protection Agency, 1988, CERCLA screening site inspection report for the Belvidere public water supply wells No. 2 and No. 3, Belvidere, Illinois: U.S. Environmental Protection Agency [variously paged].

Kay, R.T., 2001, Geology, hydrology, and ground-water quality of the Galena-Platteville aquifer in the vicinity of the Parson's Casket Hardware Superfund site, Belvidere, Illinois, 1999: U.S. Geological Survey Water-Resources Investigations Report 00-4152, 34 p.

Kay, R.T., Yeskis, D.J., Lane, J.W., Jr., Mills, P.C., Joesten, P.K., Cygan, G.L., and Ursic, J.R., 2000, Geology, hydrology, and ground-water quality of the upper part of the Galena-Platteville aquifer at the Parson's Casket Hardware Superfund site in Belvidere, Illinois: U.S. Geological Survey Open-File Report 99-4138, 43 p.

Kish, J.L., Thurman, E.M., Scribner, E.A., and Zimmerman, L.R., 2000, Methods of analysis by the U.S. Geological Survey Organic Research Group–Determination of selected herbicides and their degradation products in water using solid-phase extraction and gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 00-385, 13 p.

Lee, E.A., Kish, J.L., Zimmerman, L.R., and Thurman, E.M., 2001, Methods of analysis by the U.S. Geological Survey Organic Geochemistry Research Group–Update and additions to the determination of chloroacetanilide herbicide degradation compounds in water using high-performance liquid chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 01-10, 17 p.

Lee, E.A., Strahan, A.P., and Thurman, E.M., 2002, Methods of analysis by the U.S. Geological Survey Organic Geochemistry Research Group–Determination of glyphosate, aminomethylphosphonic acid, and glufosinate in water using online solid-phase extraction and high-performance liquid chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 01-454, 13 p.

Mills, P.C., 1993a, Vertical distribution of hydraulic characteristics and water quality in three boreholes in the Galena-Platteville aquifer at the Parson's Casket Hardware Superfund site, Belvidere, Illinois, 1990: U.S. Geological Survey Open-File Report 93-402, 36 p.

———1993b, Hydrogeology and water quality of the Galena-Platteville aquifer at the Parson's Casket Hardware Superfund site, Belvidere, Illinois, 1991: U.S. Geological Survey Open-File Report 93-403, 86 p.

———1993c, Hydrogeology and water quality of the Galena-Platteville aquifer at the Parson's Casket Hardware Superfund site, Belvidere, Illinois, 1991-92: U.S. Geological Survey Open-File Report 93-404, 29 p.

Mills, P.C., Yeskis, D.J., and Straub, T.D., 1998, Geologic, hydrologic, and water-quality data from selected boreholes and wells in and near Belvidere, Illinois, 1989-96: U.S. Geological Survey Open-File Report 97-242, 151 p.

Mills, P.C., Thomas, C.A., Brown, T.A., Yeskis, D.J., and Kay, R.T., 1999, Potentiometric levels and water quality in the aquifers underlying Belvidere, Ill., 1993-96: U.S. Geological Survey Water-Resources Investigations Report 98-4220, 106 p.

Mills, P.C., Nazimek, J.E., Halford, K.J., and Yeskis, D.J., 2002a, Hydrogeology and simulation of ground-water flow in the aquifers underlying Belvidere, Illinois: U.S. Geological Survey Water-Resources Investigations Report 01-4100, 103 p.

Mills, P.C., Halford, K.J., Cobb, R.P., and Yeskis, D.J., 2002b, Delineation of the Troy Bedrock Valley and particle-tracking analysis of ground-water flow underlying Belvidere, Illinois: U.S. Geological Survey Water-Resources Investigations Report 02-4062, 46 p.

Roy F. Weston, Inc., 1988, Remedial investigation report for Belvidere municipal No. 1 landfill site, Belvidere, Illinois: Illinois Environmental Protection Agency [variously paged].

U.S. Geological Survey and U.S. Environmental Protection Agency, 1993, Sampling and analysis plan for Belvidere, Illinois area ground-water synoptic study: Unpublished report on file in Illinois District of U.S. Geological Survey [variously paged].

U.S. Environmental Protection Agency, 2003a: accessed May 5, 2003, at URL http://www.epa.gov/superfund/programs/clp/vtarget.htm

———2003b: accessed January 13, 2003, at URL http://www.epa.gov/safewater/mcl.html

van der Kamp, G., 1976, Determining aquifer transmissivity by means of well response tests: The underdampened case: Water Resources Research, v. 12, no. 1, p. 71-77.

Voelker, D.C., Oberg, D.J., and Grober, M.J., 1989, Water-quality from the observation-well network in Illinois: U.S. Geological Survey Open-File Report 87-538, 725 p.

Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., 1997 to present, National field manual for the collection of water-quality data, chaps. A1-A6, 2 vol.: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9 [variously paged].

Woller, D.M., and Sanderson, E.W., 1974, Public ground-water supplies in Boone County: Illinois State Water Survey Bulletin 60-6, 12 p.

Zimmerman, L.R., Hostetler, K.A., and Thurman, E.M., 2000, Method of analysis by the U.S. Geological Survey Organic Geochemistry Research Group–Determination of chloroacetanilide herbicides in water using high-performance liquid chromatography-diode array detection and high-performance liquid chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 00-182, 30 p.

Zimmerman, L.R., and Thurman, E.M., 1999, Method of analysis by the U.S. Geological Survey Organic Geochemistry Research Group–Determination of triazine and chloroacetanilide herbicides in water by solid-phase extraction and capillary-column gas chromatography/mass spectrometry with selected ion monitoring: U.S. Geological Survey Open-File Report 98-634, 21 p.

APPENDIXES

APPENDIX 1: DATA AND INTERPRETATIONS FROM BOREHOLE G137GP, NEAR THE PARSON'S CASKET HARDWARE SUPERFUND SITE, BELVIDERE, ILL.

Water Resources Division
1420 Sycamore Road
DeKalb, Illinois 60115
(815) 756-9207
Fax (815) 756-9214

March 22, 2002

Mr. Jon Peterson
U.S. Environmental Protection Agency
Region V
SE-6J
77 W. Jackson Blvd.
Chicago, Il 60604

Dear Jon:

As you know, the U.S. Geological Survey, in cooperation with the U.S. Environmental Protection Agency (USEPA), Illinois Environmental Protection Agency, and Tetra Tech EM, Inc., performed packer testing in borehole G137GP near the Parson's Casket Hardware Superfund site in February of 2002. The results of the packer testing are detailed in this letter and its attachments. All depths are measured relative to the top of the protective casing for the borehole.

The altitude of the top of the protective casing at borehole G137GP was surveyed to be 764.84 feet above mean sea level (famsl). The altitude of land surface at this location is about 762 famsl. The latitude of the well is 42°15'46" and the longitude is 88°49'58".

The well was drilled under Tetra Tech's supervision to a total depth of about 278 feet. The well was cased to a depth of about 61 feet and was open to the Galena-Platteville dolomite bedrock from about 487 to 704 famsl. The well was developed by Tetra Tech four days prior to the start of sampling. The well was open during that time interval.

Geophysical logging performed by Jim Ursic and Steve Peterson of the USEPA indicated that the geologic conditions at borehole G137GP were similar to those identified in boreholes G124GP, G130GP, G133GP, G134GP, and G136GP as described by Kay (2001). The well terminates in the middle of the Mifflin Formation at an elevation of about 490 famsl. The contact between the Mifflin and the overlying Grand Detour Formation corresponds to a low counts per second (cps) part of the natural gamma log at about 501 famsl (depth about 263 feet). The Grand Detour Formation is present from 501 to about 543 famsl. The hydraulically active horizontal fracture in the upper part of the Grand Detour Formation identified at the other wells also was identified at an altitude of about 524 famsl (depth about 241 feet) at borehole G137GP.

The Nachusa Formation is present from about 543 to 552 famsl. The Quimbys Mills Formation is present from about 552 to 566 famsl. The Dunleith Formation is present from about 566 to 634 famsl. A hydraulically active feature was identified in the Dunleith Formation at about 578 famsl (depth of about 187 feet). The undifferentiated Dubuque and Wise Lake Formations are present from about 634 to 712 famsl at the site. There is a prominent clay bed in the Dubuque/Wise Lake at about 658 famsl (depth about 106 feet) at this borehole, which serves as a marker throughout the site. Hydraulically active features also were identified in the Dubuque/Wise Lake at about 647 famsl (depth about 118 feet) and in an interval immediately below the bottom of the casing at about 699-704 famsl (depth 61 to 66 feet).

Based on the results of the geophysical logging, it was decided to test--

1. The hydraulically active fracture at about 524 famsl by packing off the interval between 516 and 526 famsl in the borehole (test interval C),
2. The hydraulically active fracture at about 578 famsl by packing off the interval between 575 and 585 famsl in the borehole (test interval D),
3. A hydraulically inactive zone by packing off the interval between 595 and 605 famsl in the borehole (test interval E),
4. The hydraulically active feature at about 647 famsl by packing off the interval between 645 and 655 famsl in the borehole (test interval B),
5. The hydraulically active feature beneath the bottom of the casing between about 699 and 704 famsl by packing off the interval between 695 and 704 famsl in the borehole (test interval A).

Water levels in the open borehole varied from about 736 famsl to about 740 famsl on January 28. Water levels in the packed intervals varied substantially over short periods of time in the borehole, particularly in those parts of the test intervals open to the deeper parts of the borehole. This variation is consistent with the results of water-level measurements in boreholes G124GP, G130GP, G133GP, G134GP, and G136GP and indicates that the hydraulically active features in the middle and deeper parts of the Galena-Platteville aquifer are responding to pumping in nearby water-supply wells. Water levels above, within, and below the individual test intervals consistently showed the potential for downward flow in the three shallowest test intervals (A, B and E) (table 1), with water level elevations below the packed interval typically being substantially lower than those within and above the test interval. Water levels above, within, and below the individual test intervals consistently showed the potential for downward flow from the upper to the lower part of the aquifer in the two deepest test intervals (C and D) (table 1), but showed variable potential for upward and downward flow between the middle and deeper parts of the aquifer. These variations are likely due to the influence of pumping in nearby water-supply wells on the flow system in the lower part of the Galena-Platteville aquifer. Slug tests performed in four of the five test intervals (A, B, C, and D) confirmed the presence of permeable, hydraulically active features in these intervals (table 2). A minimum of two rising and falling head slug tests were performed in each test interval (except interval E) to increase the likelihood of obtaining data not impacted by changing water levels. Analysis of slug-test data from all of the tests in test intervals A, B, C, and D gave consistent results. The one slug test performed in interval E failed to produce analyzable data. Slug-test data from zones A, B, and D were analyzed by use of the method of Bouwer and Rice (1976). Slug-test data from zone C were analyzed by use of the van der Kamp method (1976). Slug test data indicate that the fracture at about 524 famsl is the most permeable feature in the borehole.

Water-quality sampling performed in the test intervals indicated that the water temperature tended to be warmest at the top of the borehole and at the bottom, with intermediate temperature in the middle (table 3). These trends are somewhat inconsistent with the results of the temperature logging, which indicated a general decrease in temperature with depth in the borehole. pH showed generally consistent values over the depth of the borehole. Oxidation-reduction potential (ORP) values were in the negative range over the entire borehole, indicating comparatively reducing conditions. However, the ORP values from the four uppermost test intervals were consistent at about -85 mv, whereas the ORP for the deepest test interval (E) were somewhat higher at -35 mv. These trends are somewhat consistent with trends in dissolved oxygen concentration, which indicate anoxic conditions except at test interval E. Specific conductance showed no clear trends with depth, but the specific conductance of water in the deepest test interval (E) was lower than that of three of the four overlying intervals.

With the exception of less than 1 microgram per liter of trichloroethene in the sample from test interval C, volatile organic compounds (VOC's) were not detected in water from this borehole (table 4). The presence of detectable concentrations of a VOC related to the Parsons site indicates that contaminants are migrating from the site south beneath the Kishwaukee River and have the potential to migrate to the water-supply wells south of the river and potentially beyond. The pathway for this VOC migration appears to be the fracture present at about 524 famsl, which has been identified as being present and hydraulically active beneath much of Belvidere. Pumping in nearby water-supply wells, including Belvidere Municipal Wells 4 and 6 and nearby industrial-supply wells enhances water movement through this fracture. It also should be noted that the effect of vertical flow in the borehole in the days prior to the packer testing is likely to have resulted in the dilution of the water in test interval with uncontaminated water derived from the upper part of the Galena-Platteville deposits. VOC concentrations in the well installed subsequent to the packer testing, which is open to the fracture at about 524 famsl, may be substantially higher than were detected during our effort. It is also worth noting that TCE and PCE were detected in water from industrial-supply wells location within about one-quarter mile of borehole G137GP (Mills and others, 1999).

Feel free to call me at 815-756-9207 or e-mail me at rtkay@usgs.gov if you have any questions or comments.

signed

Robert T. Kay
Hydrologist

cc: Martin
Hayes

APPENDIX 2: UNPROCESSED (RAW DATA) GEOPHYSICAL LOGS FROM BOREHOLE G137GP NEAR THE PARSON'S CASKET HARDWARE SUPERFUND SITE, BELVIDERE, ILL.

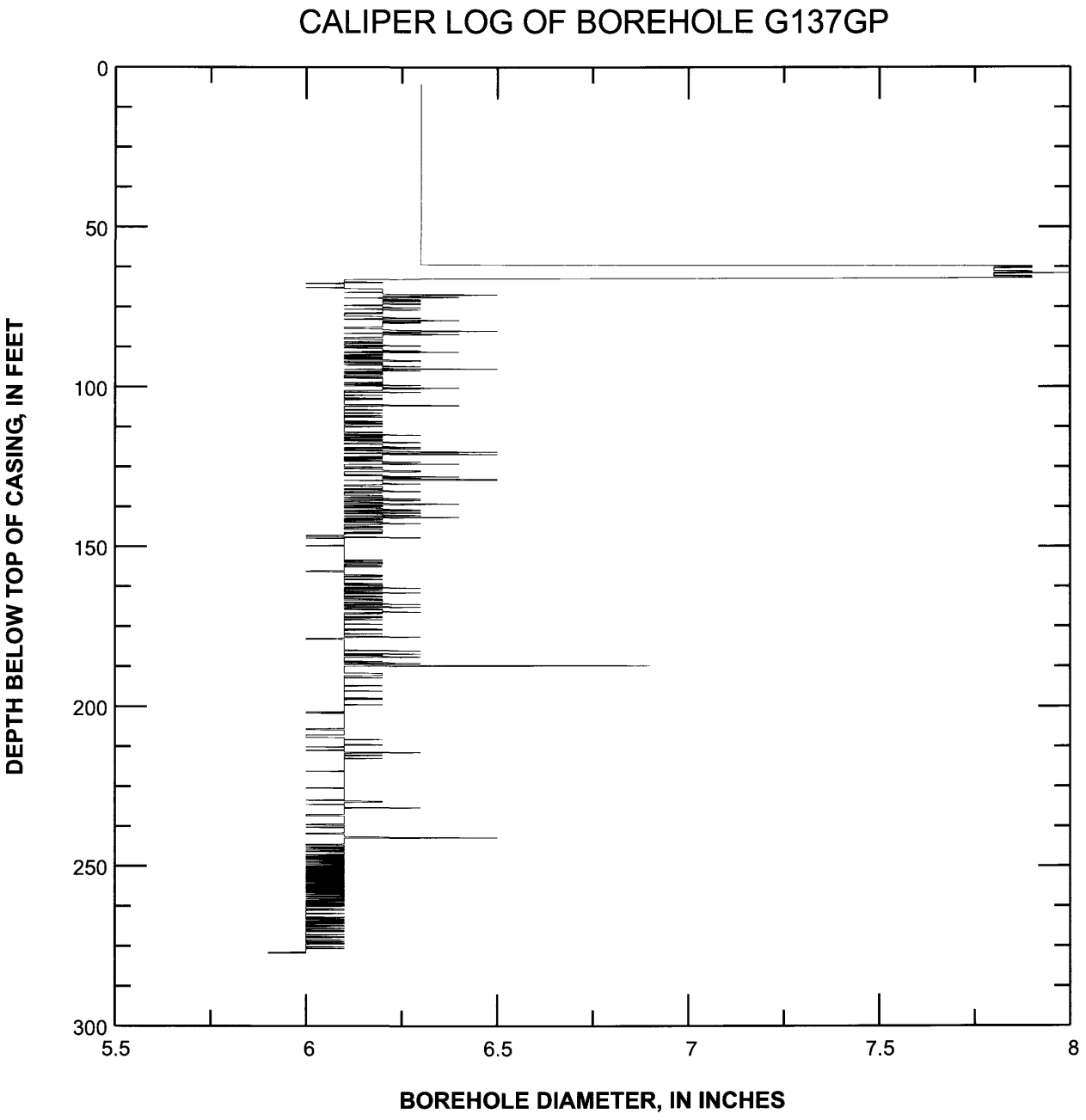
The following geophysical logs were taken on January 28, 2002, from test borehole G137GP, open to the Galena and Platteville Groups from about 58 to 275 ft below land surface (703.84 to 486.84 ft above sea level). All log measurements in the 6-inch diameter borehole are from the top of the temporary surface casing. Top of casing altitude is 764.84 ft. Land-surface altitude is about 762 ft. Two fluid-resistivity logs are provided from differently configured multiple-parameter logging tools.

These logs represent the unprocessed (raw) data. The processed digital data were not available for this report. Paper copies of the processed geophysical logs, including an additional acoustic-televiewer log, are on file at the USGS, Illinois District office and copies can be obtained, on request. Logging was performed by Jim Ursic, U.S. Environmental Protection Agency, Office of Superfund, Chicago, Ill.

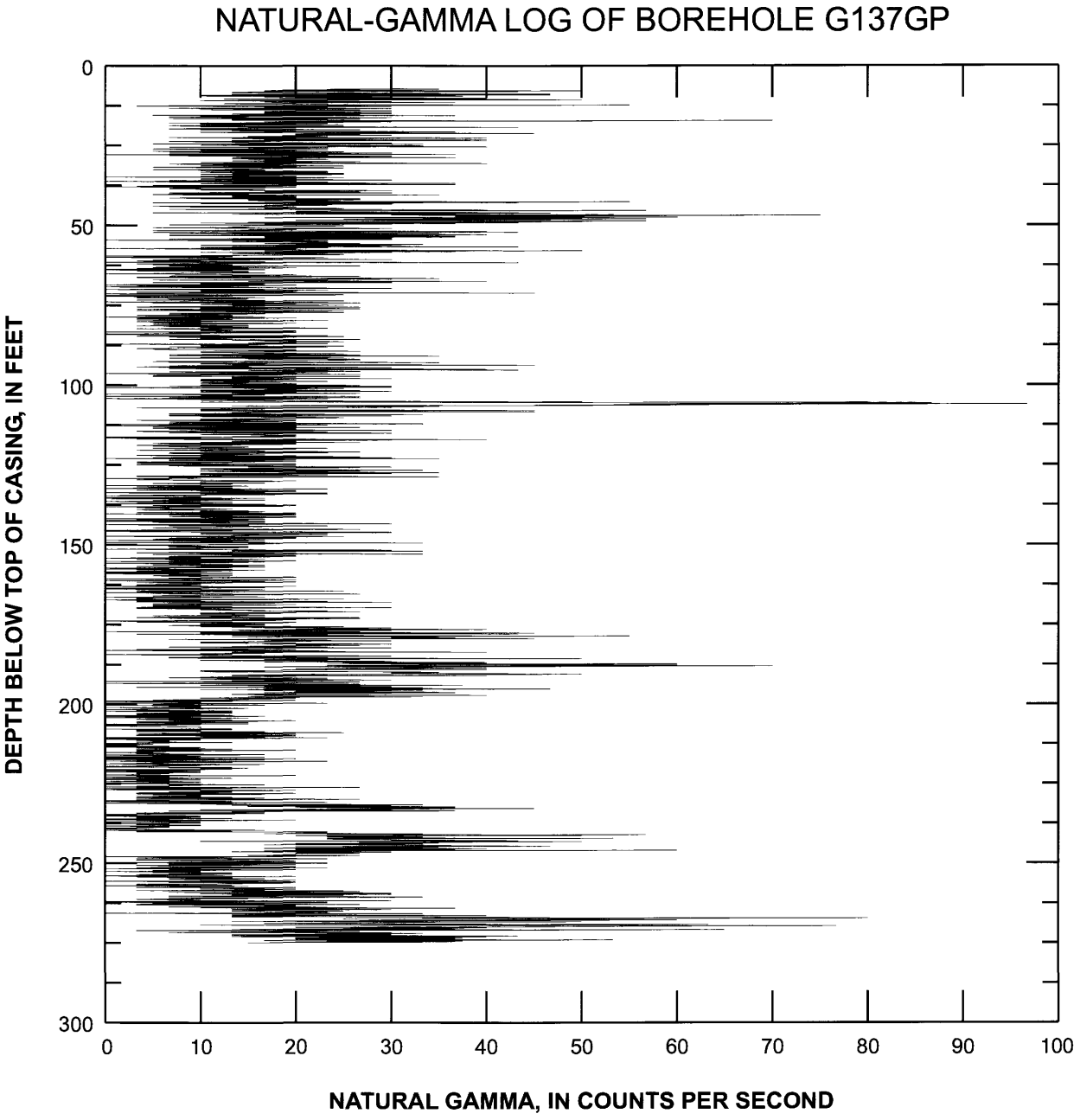
ORDER OF LOGS, AS PRESENTED

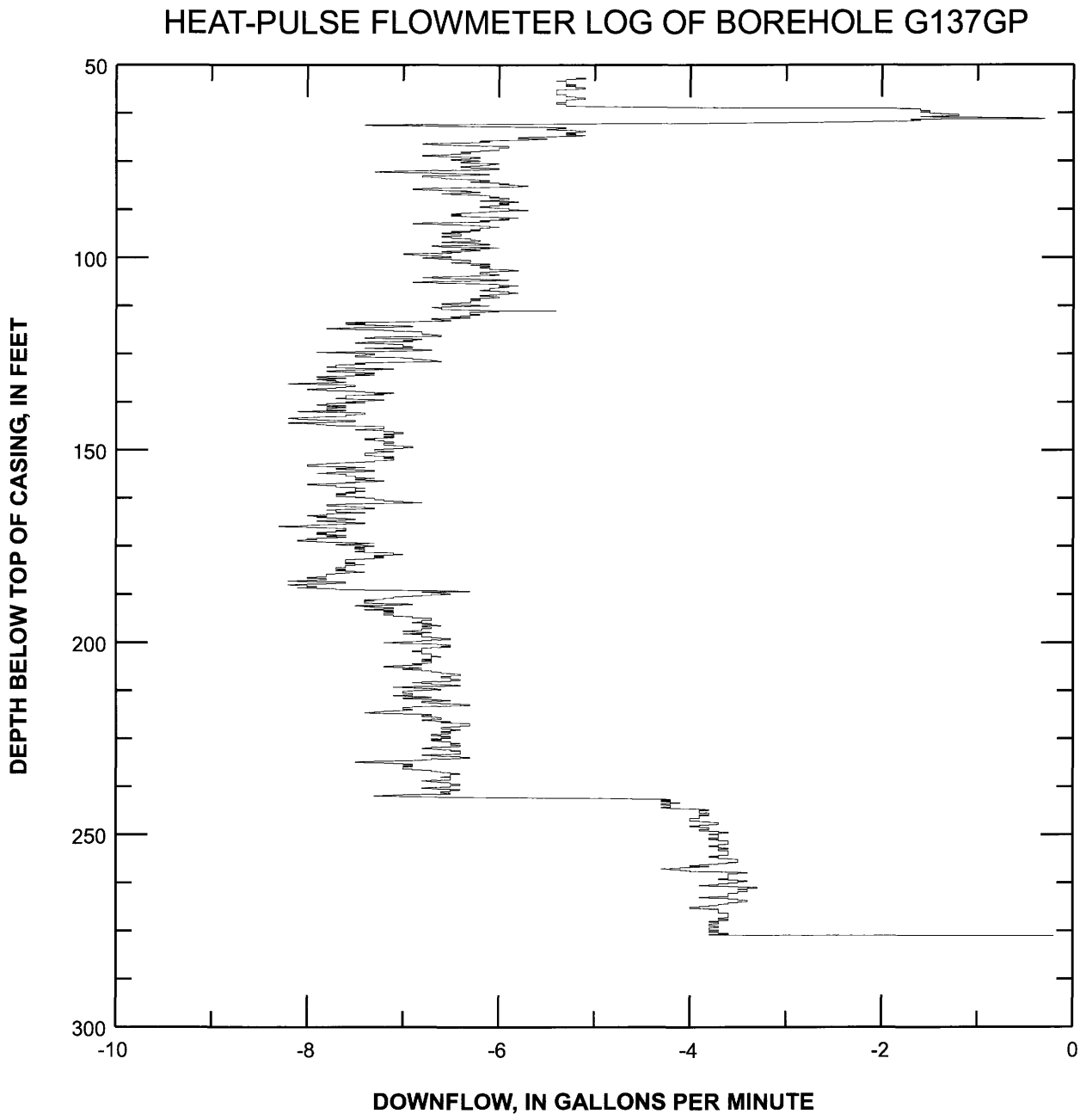
Caliper
Natural Gamma
Heat-Pulse Flowmeter
Temperature
Fluid Resistivity-1
Fluid Resistivity-2
Resistivity (16-inch normal)
Resistivity (64-inch normal)
Lateral Resistivity
Resistance
Spontaneous Potential

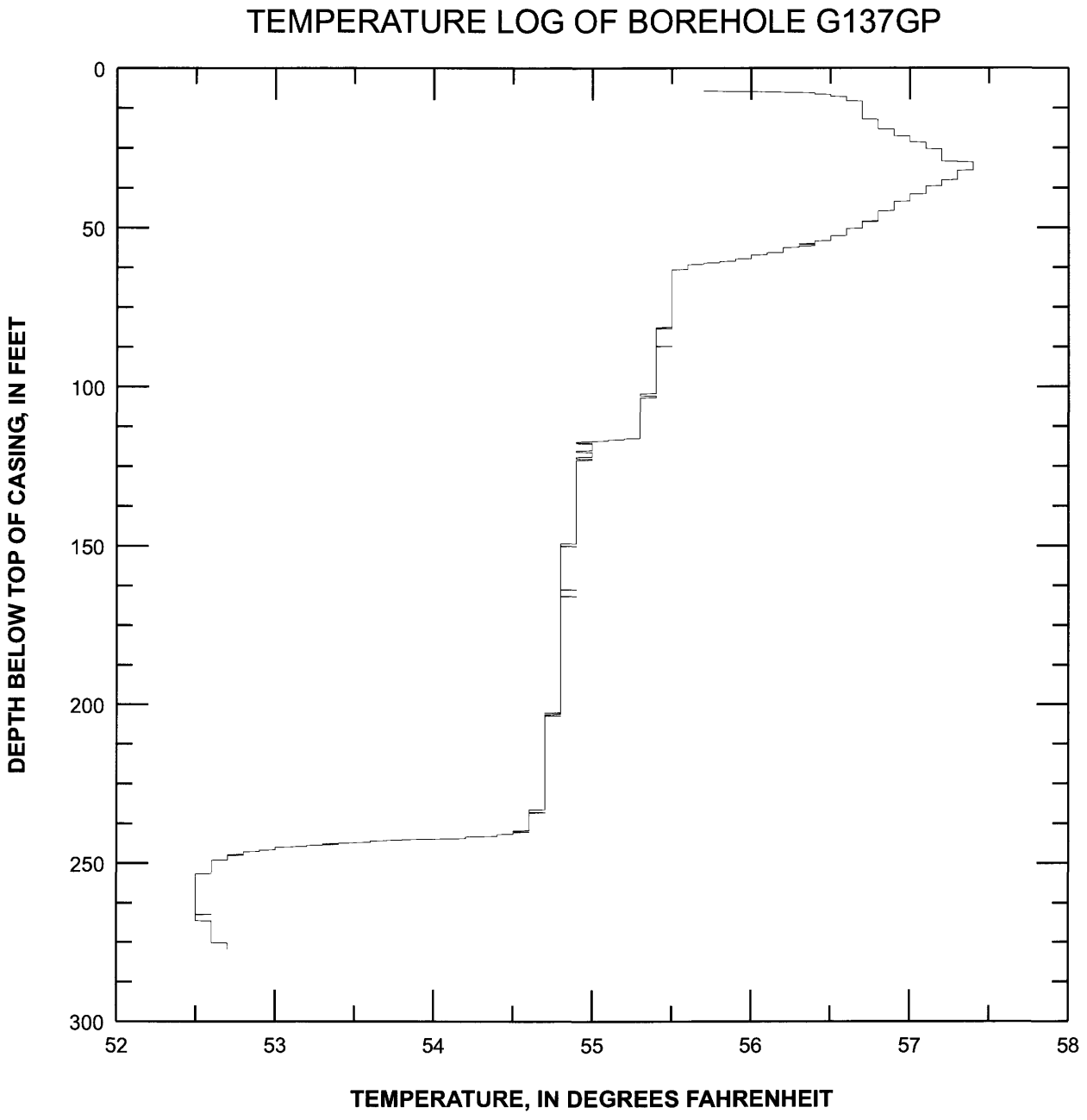
APPENDIX 2: UNPROCESSED (RAW DATA) GEOPHYSICAL LOGS FROM BOREHOLE G137GP NEAR THE PARSON'S CASKET HARDWARE SUPERFUND SITE, BELVIDERE, ILL.—*Continued*

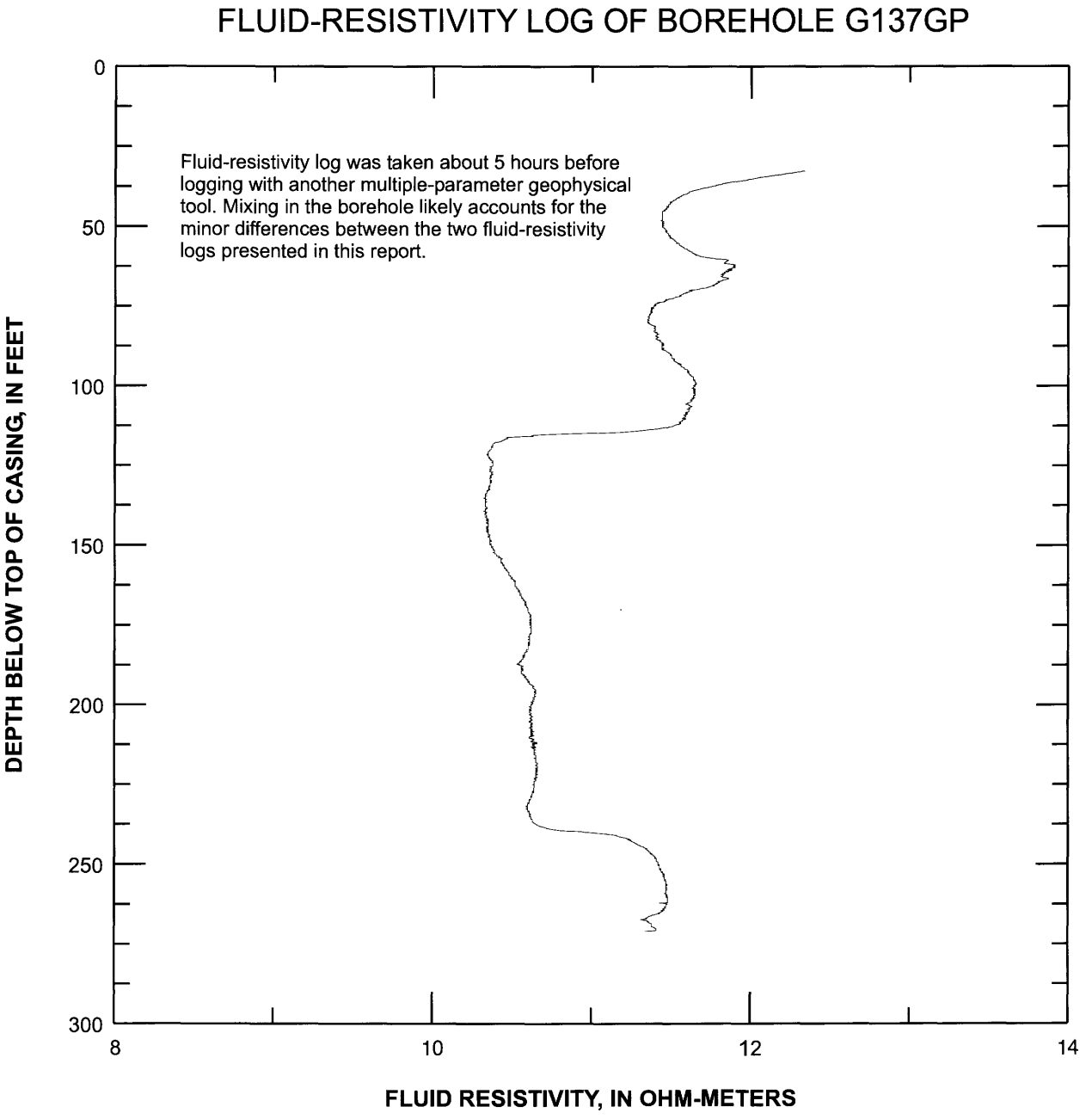


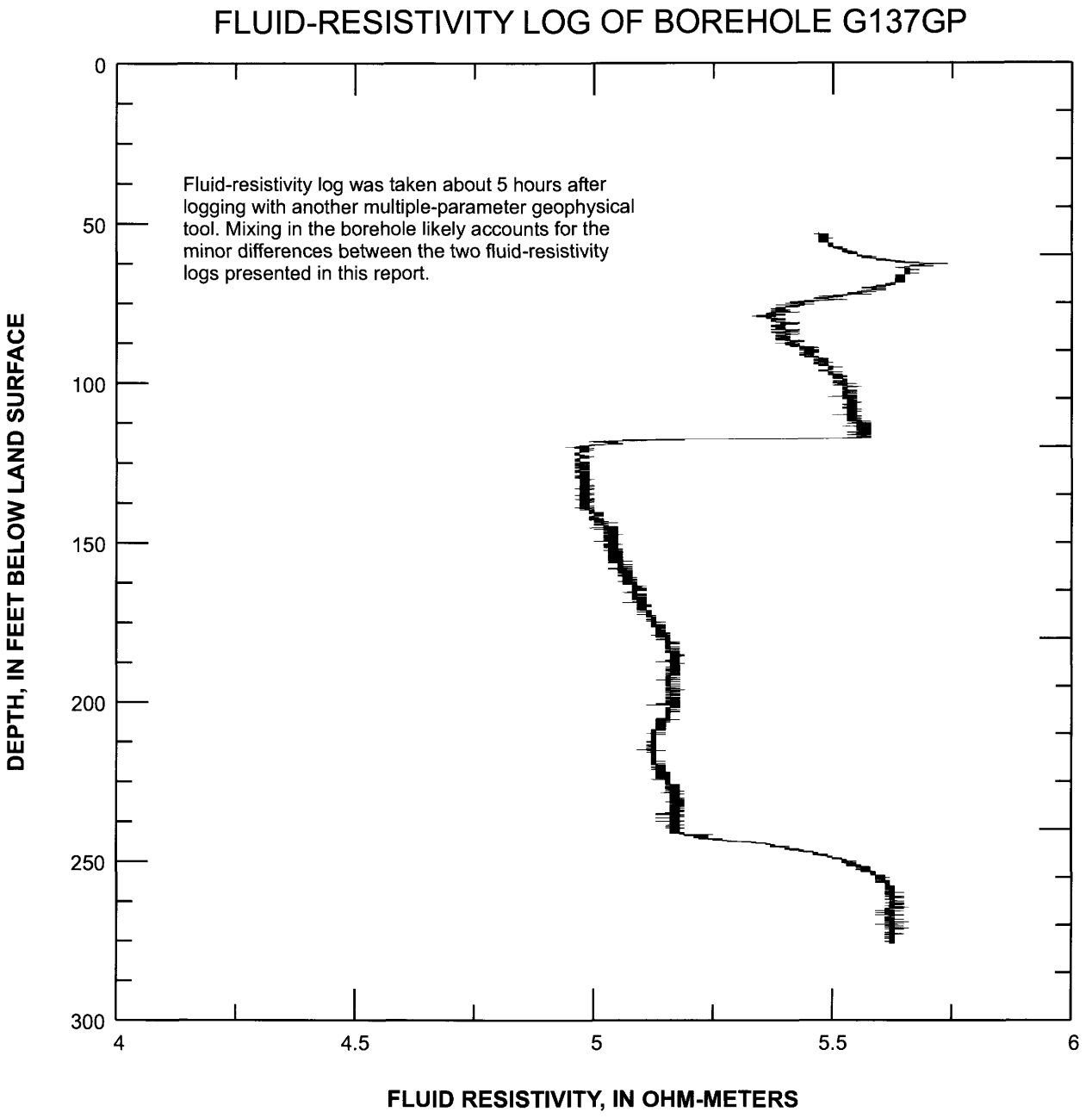
APPENDIX 2: UNPROCESSED (RAW DATA) GEOPHYSICAL LOGS FROM BOREHOLE G137GP NEAR THE PARSON'S CASKET HARDWARE SUPERFUND SITE, BELVIDERE, ILL.—*Continued*

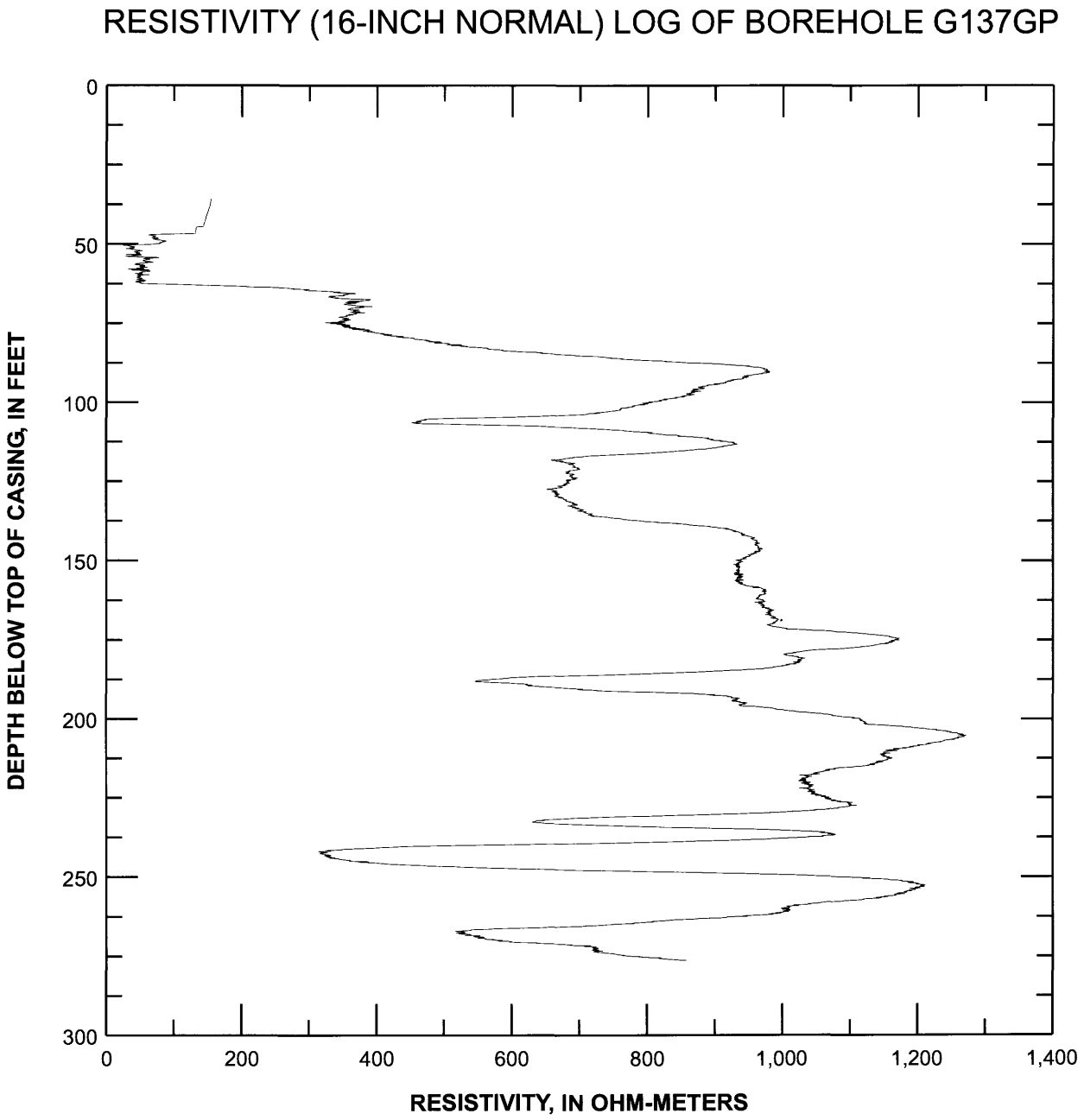


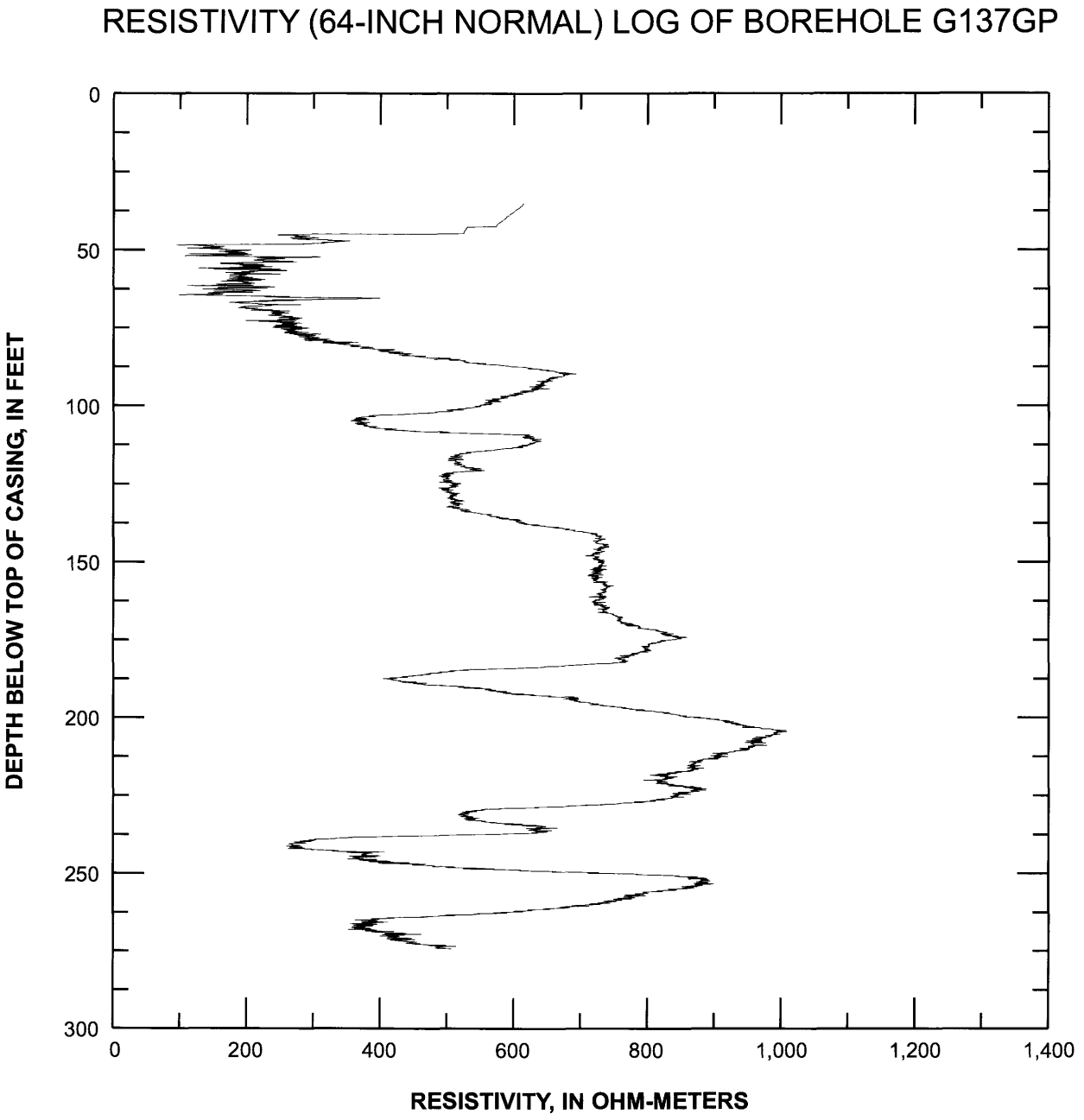

HEAT-PULSE FLOWMETER LOG OF BOREHOLE G137GP
DEPTH BELOW TOP OF CASING, IN FEET
50
100
150
200
250
300
-10
-8
-6
-4
-2
0
DOWNFLOW, IN GALLONS PER MINUTE

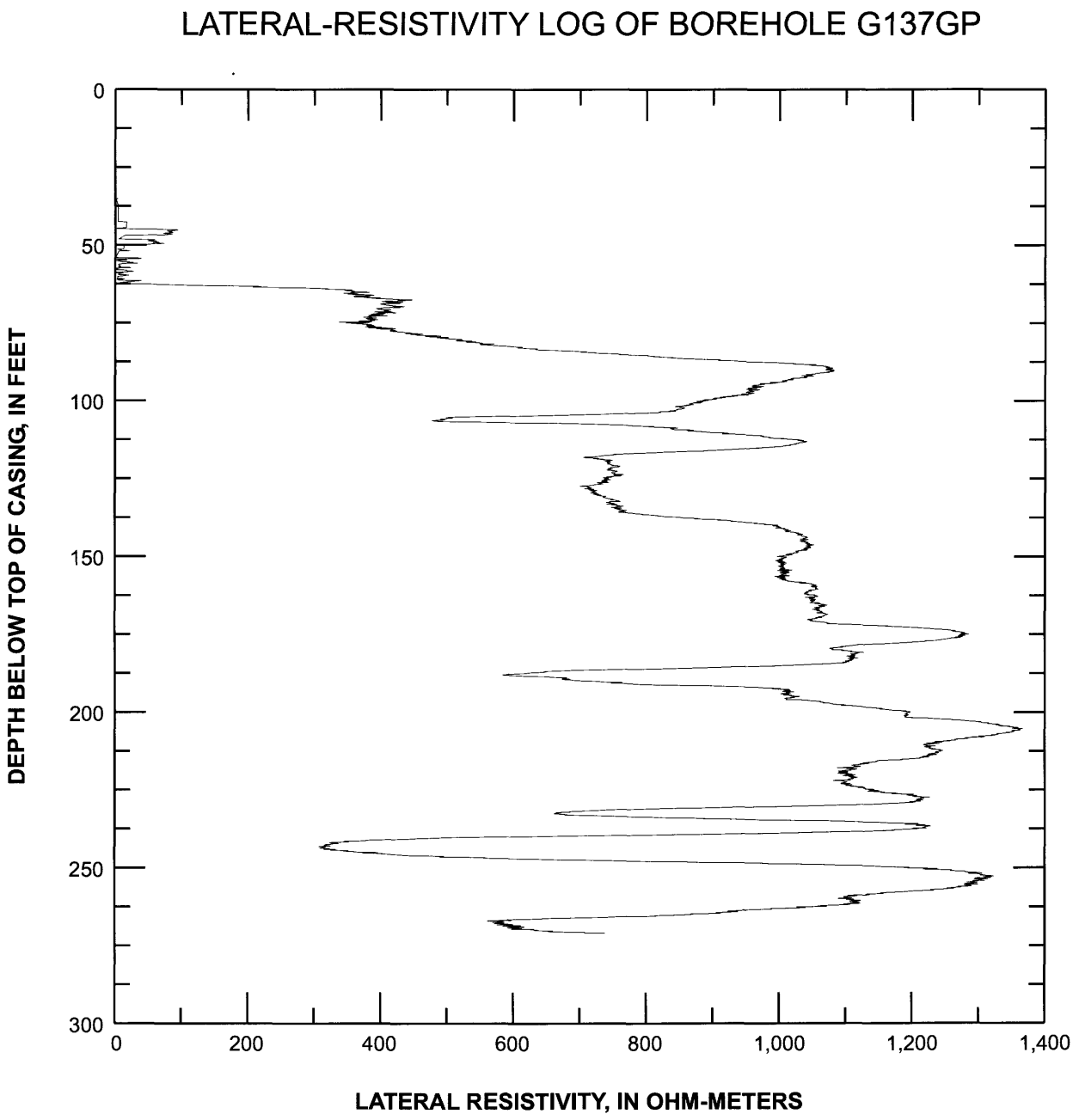

TEMPERATURE LOG OF BOREHOLE G137GP
DEPTH BELOW TOP OF CASING, IN FEET
0
50
100
150
200
250
300
52
53
54
55
56
57
58
TEMPERATURE, IN DEGREES FAHRENHEIT

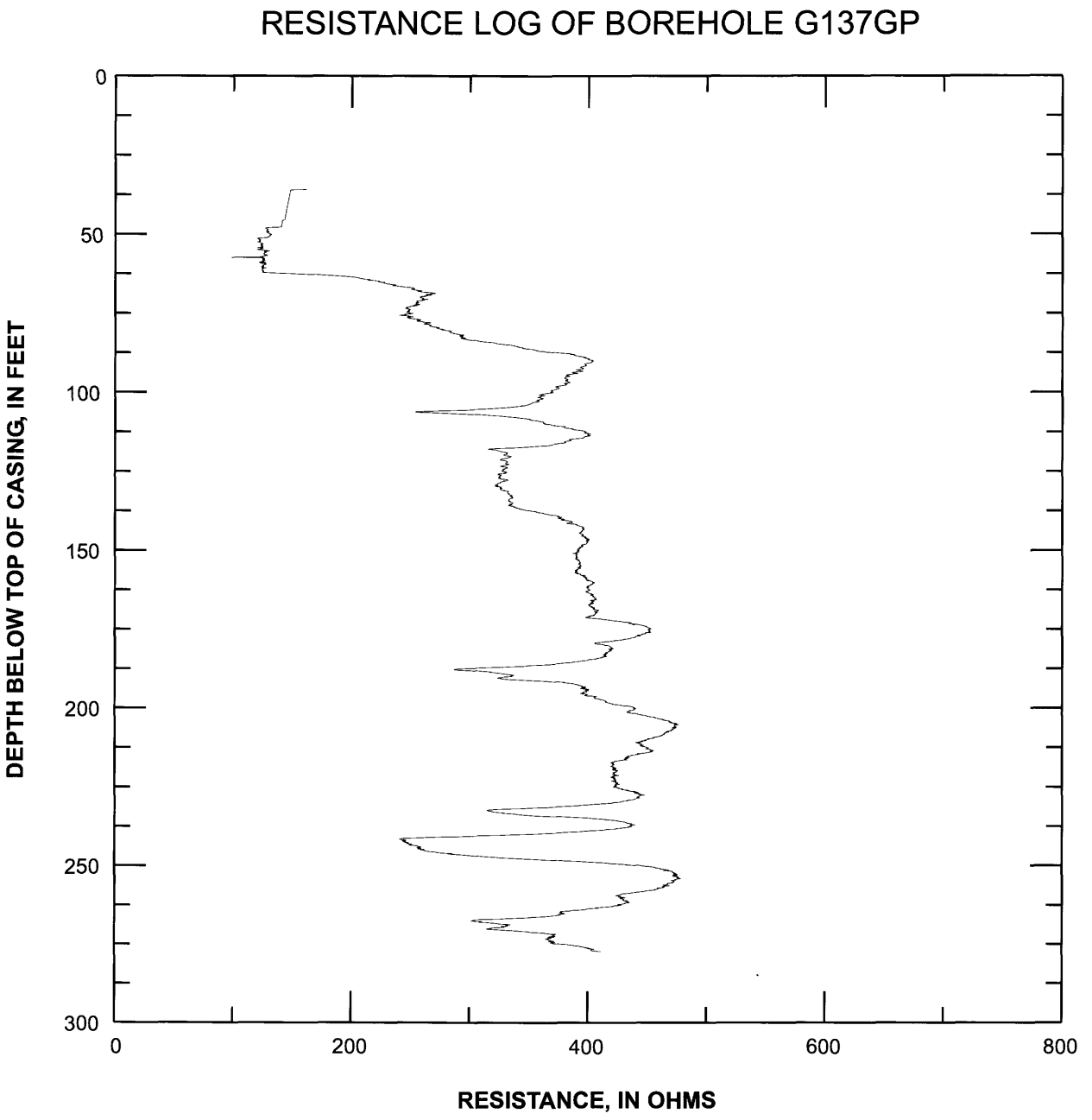

FLUID-RESISTIVITY LOG OF BOREHOLE G137GP
Fluid-resistivity log was taken about 5 hours before logging with another multiple-parameter geophysical tool. Mixing in the borehole likely accounts for the minor differences between the two fluid-resistivity logs presented in this report.
DEPTH BELOW TOP OF CASING, IN FEET
0
50
100
150
200
250
300
8
10
12
14
FLUID RESISTIVITY, IN OHM-METERS

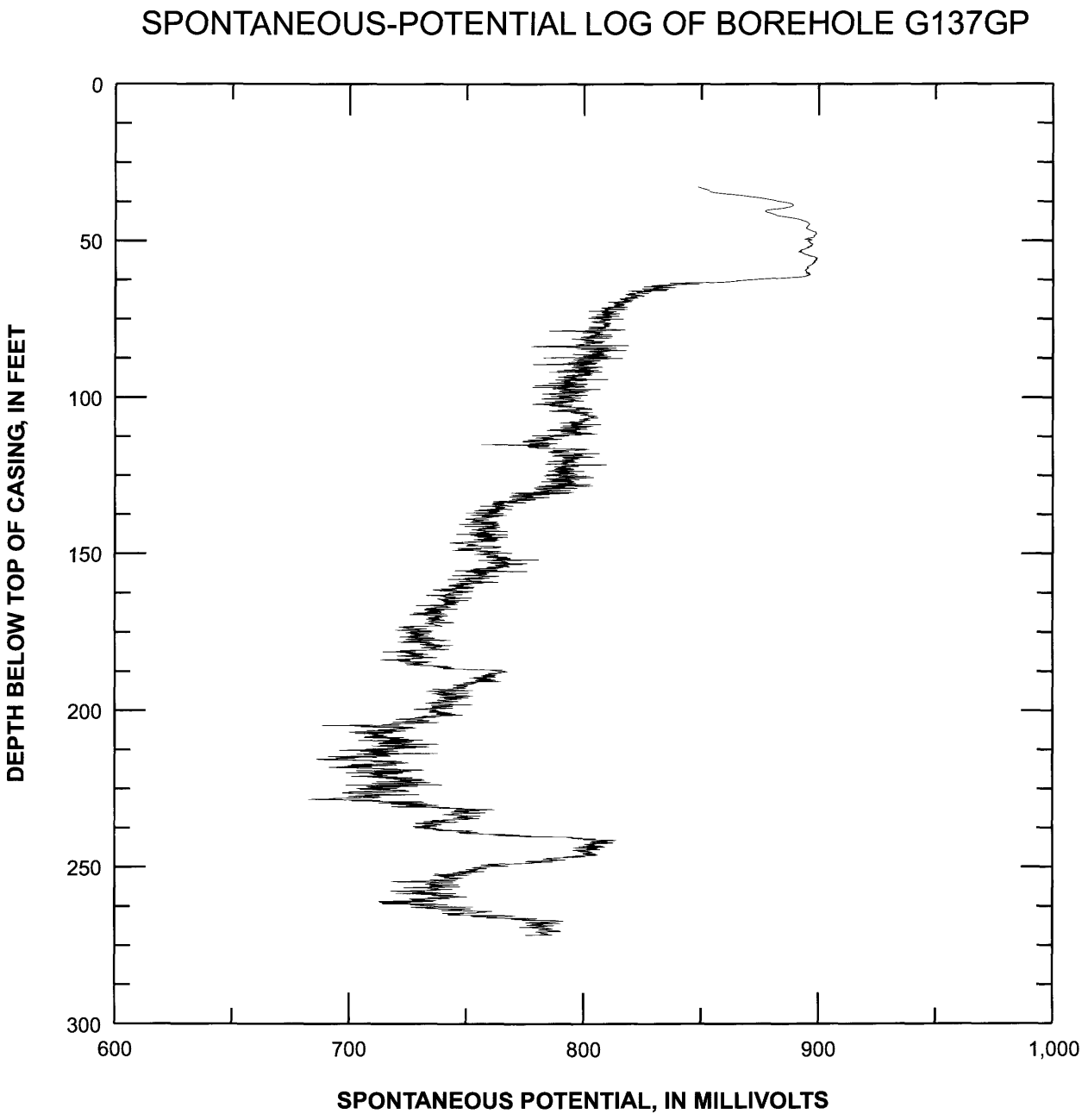

FLUID-RESISTIVITY LOG OF BOREHOLE G137GP
Fluid-resistivity log was taken about 5 hours after logging with another multiple-parameter geophysical tool. Mixing in the borehole likely accounts for the minor differences between the two fluid-resistivity logs presented in this report.
DEPTH, IN FEET BELOW LAND SURFACE
0
50
100
150
200
250
300
4
4.5
5
5.5
6
FLUID RESISTIVITY, IN OHM-METERS


RESISTIVITY (16-INCH NORMAL) LOG OF BOREHOLE G137GP
DEPTH BELOW TOP OF CASING, IN FEET
0
50
100
150
200
250
300
0
200
400
600
800
1,000
1,200
1,400
RESISTIVITY, IN OHM-METERS


RESISTIVITY (64-INCH NORMAL) LOG OF BOREHOLE G137GP
DEPTH BELOW TOP OF CASING, IN FEET
0
50
100
150
200
250
300
0
200
400
600
800
1,000
1,200
1,400
RESISTIVITY, IN OHM-METERS


LATERAL-RESISTIVITY LOG OF BOREHOLE G137GP
DEPTH BELOW TOP OF CASING, IN FEET
0
50
100
150
200
250
300
0
200
400
600
800
1,000
1,200
1,400
LATERAL RESISTIVITY, IN OHM-METERS


RESISTANCE LOG OF BOREHOLE G137GP
DEPTH BELOW TOP OF CASING, IN FEET
0
50
100
150
200
250
300
0
200
400
600
800
RESISTANCE, IN OHMS


SPONTANEOUS-POTENTIAL LOG OF BOREHOLE G137GP
DEPTH BELOW TOP OF CASING, IN FEET
0
50
100
150
200
250
300
600
700
800
900
1,000
SPONTANEOUS POTENTIAL, IN MILLIVOLTS

APPENDIX 3: WATER LEVELS IN INTERVALS ISOLATED WITH A PACKER ASSEMBLY AT BOREHOLE G137GP, NEAR THE PARSON'S CASKET HARDWARE SUPERFUND SITE, BELVIDERE, ILL., JANUARY 29–FEBRUARY 2, 2002

[Borehole open to the Galena-Platteville aquifer; na, not applicable]

Test interval	Depth of test interval, in feet below top of temporary casing	Altitude of test interval, in feet above sea level	Date of measurement	Water-level altitude, in feet above sea level		
				Above packed interval	In packed interval	Below packed interval
A	61-70	695-704	02-01-02	na	752.24	732.14
B	110-120	645-655	02-01-02	752.38	749.45	732.46
E	160-170	595-605	01-31-02	752.12	748.92	729.94
D	180-190	575-585	01-31-02	752.22	729.79	729.60
C	239-249	516-526	01-30-02	747.11	731.96	732.57

APPENDIX 4: HYDRAULIC ESTIMATES FROM SLUG TESTS IN INTERVALS ISOLATED WITH A PACKER ASSEMBLY AT BOREHOLE G137GP NEAR THE PARSON'S CASKET HARDWARE SUPERFUND SITE, BELVIDERE, ILL.

[Borehole open to the Galena-Platteville aquifer; nc, not calculated]

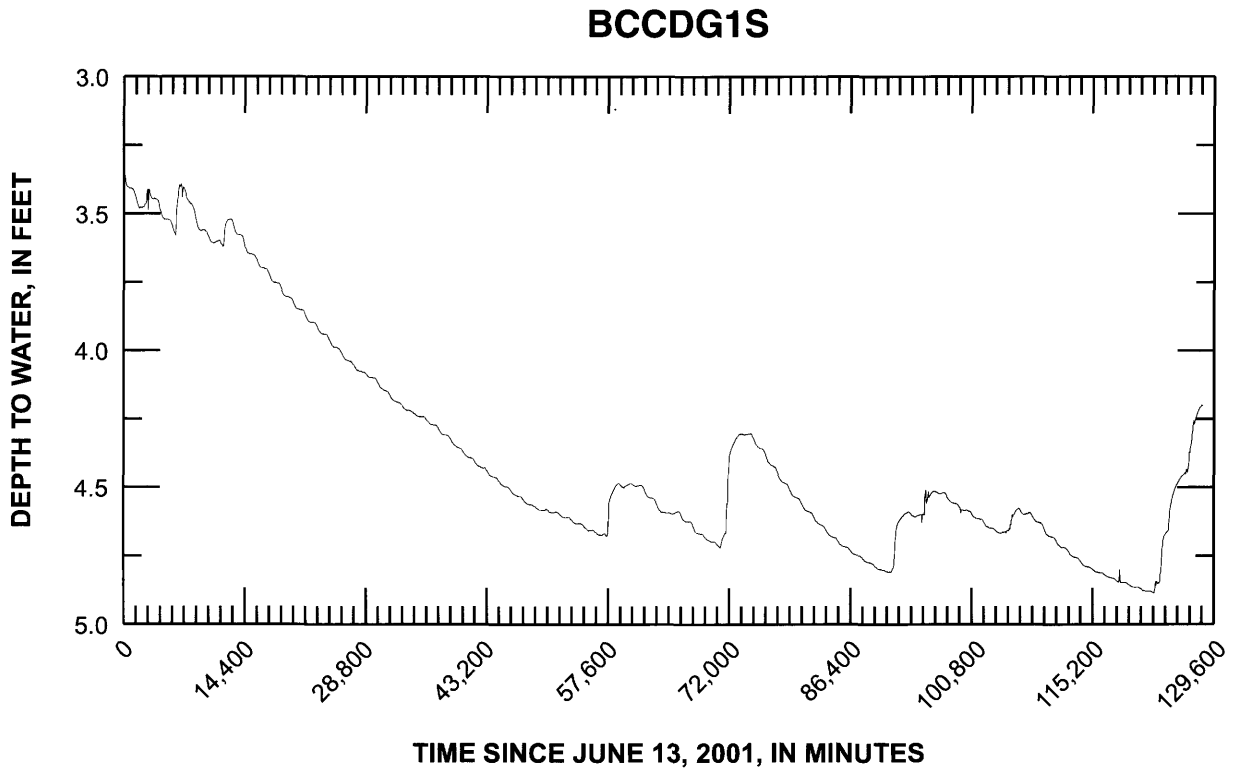
Test interval	Depth of test interval, in feet below top of temporary casing	Altitude of test interval, in feet above sea level	Test number	Horizontal hydraulic conductivity, in feet per day	Transmissivity, in feet squared per day
			Bouwer and Rice (1976) method		
A	61-70	695-704	13	50.7	nc
	61-70	695-704	14	46.6	nc
B	110-120	645-655	9, 10, 11	8.2	nc
E	160-170	595-605	8	nc	nc
D	180-190	575-585	5	20.1	nc
	180-190	575-585	7	19.2	nc
			van der Kamp (1976) method		
C	239-249	516-526	0	nc	1,026
	239-249	516-526	1	nc	1,333
	239-249	516-526	2	nc	663
	239-249	516-526	3	nc	1,649

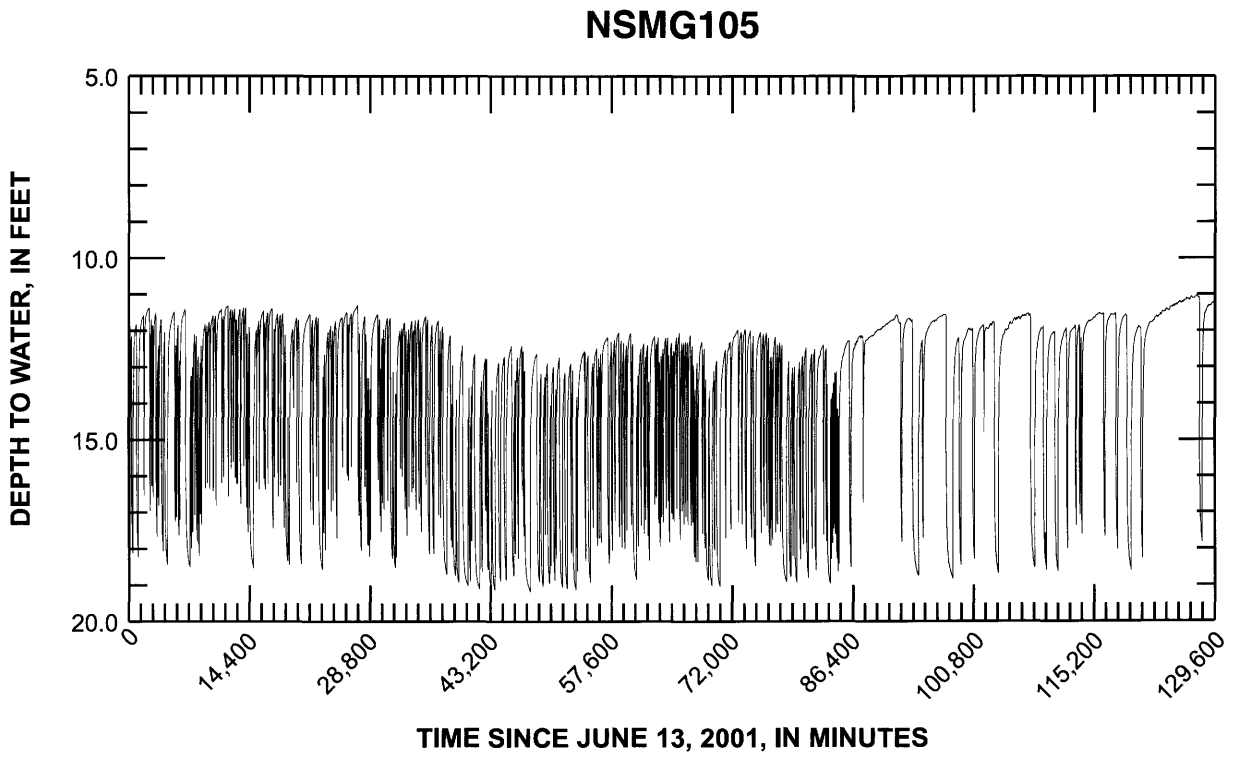
APPENDIX 5: LITHOLOGIC LOG FROM DRILLING AT THE LOCATION OF WELLS BCCDG1S AND BCCDG1D, BELVIDERE, ILL.

Depth below land surface, in feet	Lithologic description
0-1	**Gravel fill and top soil**
1-38.5	**Silty, pebbly sand;** light brown; quartz sand with 0.25-0.5-inch diameter cobbles of carbonate and igneous composition; few woody, organic fragments; common high-spired turritella-like freshwater gastropods about 0.1-0.25 inch in length
38.5-53.5	**Silty, gravely sand;** light brown; quartz sand with up to 1-inch diameter cobbles; gradational particle size from above unit; few woody, organic fragments; common high-spired turritella-like freshwater gastropods about 0.1-.25 inch in length

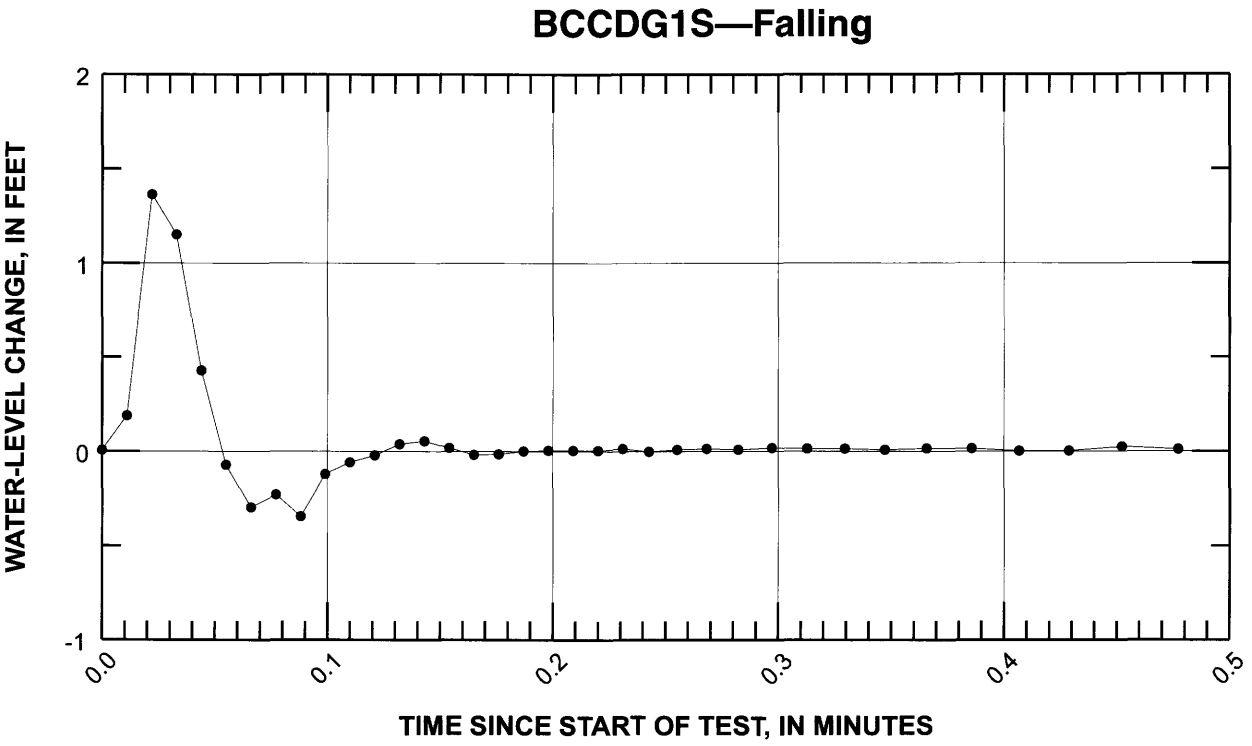
APPENDIX 6: WATER LEVELS IN WELLS BCCDG1S AND NSMG105 NEAR BELVIDERE, ILL., JUNE 13–SEPTEMBER 10, 2001

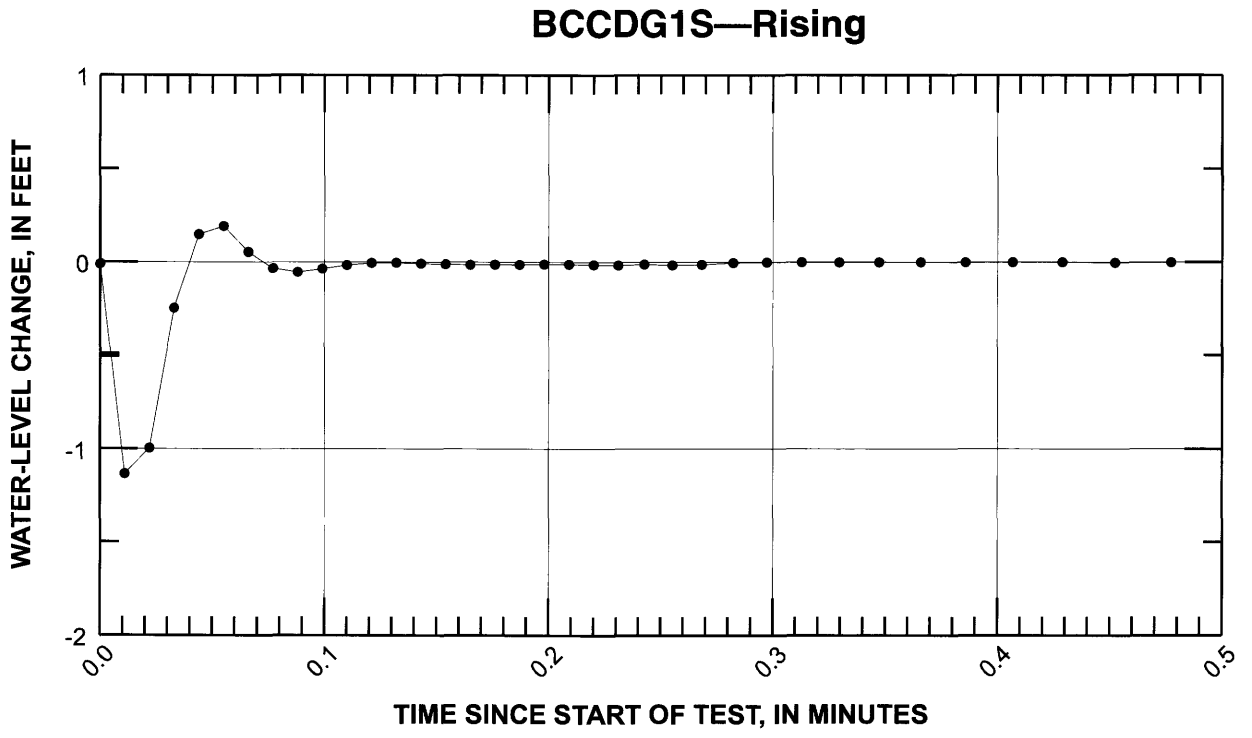
[Depth to water measured from top of well casing. Well BCCDG1S: measuring-point altitude is 733.97 ft, land-surface altitude is 734.2 ft. Well NSMG105: measuring-point altitude is 763.18 ft, land-surface altitude is 760.8 ft. Measurements were made in well BCCDG1S at 60-minute intervals and in well NSMG105 at 5-minute intervals.]



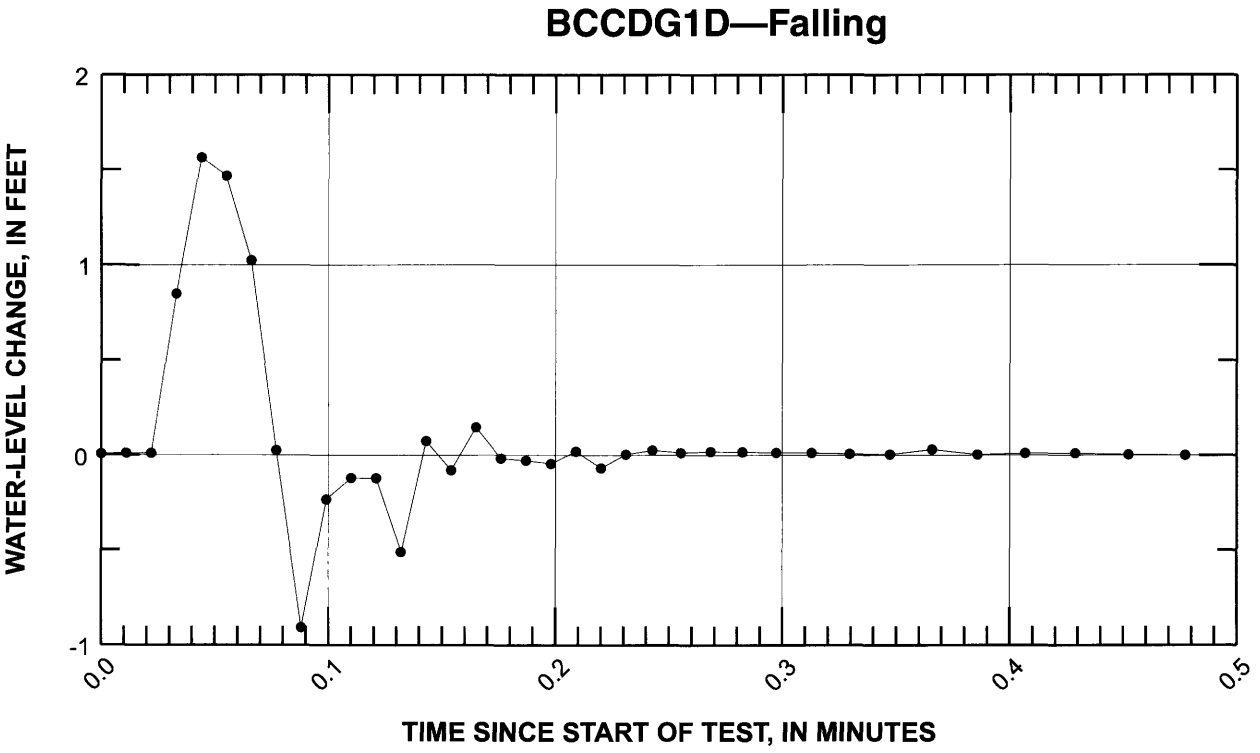


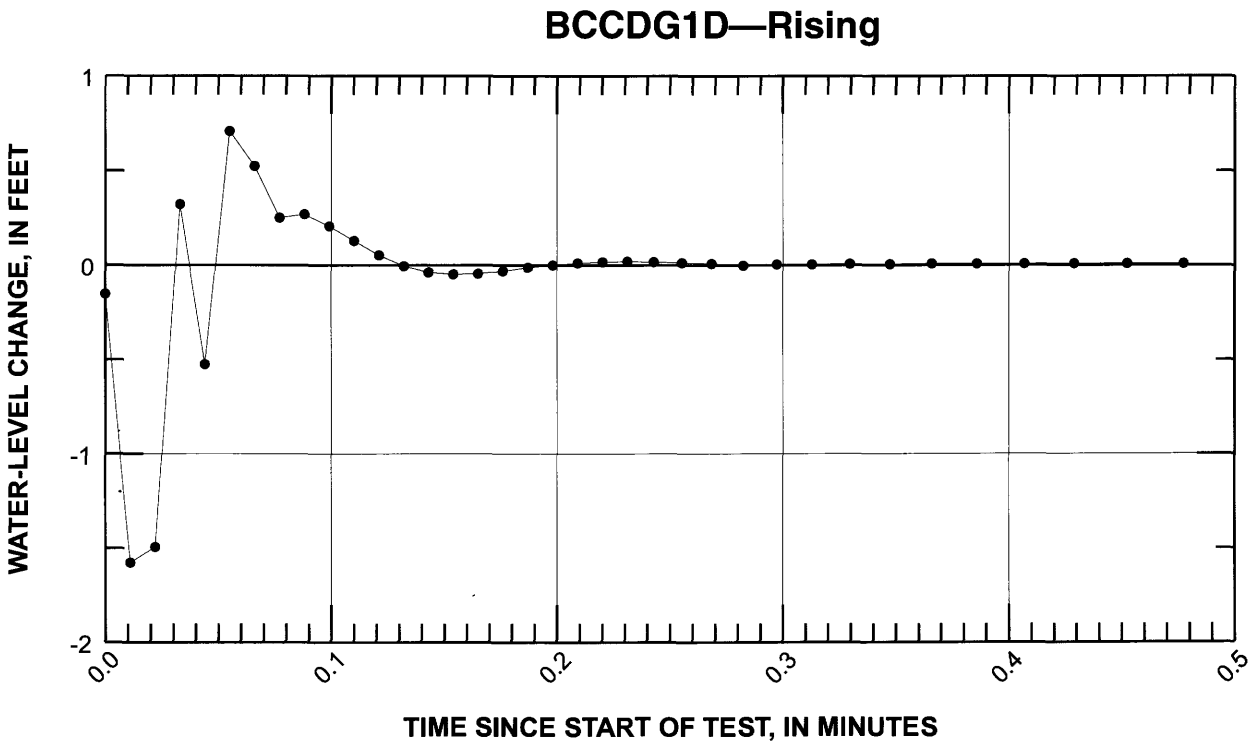
APPENDIX 7: FALLING- AND RISING-HEAD SLUG TESTS IN WELLS BCCDG1S AND BCCDG1D NEAR BELVIDERE, ILL., JUNE 13, 2001





APPENDIX 7: FALLING- AND RISING-HEAD SLUG TESTS IN WELLS BCCDG1S AND BCCDG1D NEAR BELVIDERE, ILL., JUNE 13, 2001—*Continued*





APPENDIX 8: WATER LEVELS IN SELECTED WELLS NEAR BELVIDERE, ILL., SEPTEMBER 2001 AND NOVEMBER 2002

Well designation	Date measured	Depth to water, in feet below top of casing	Water-level altitude, in feet above sea level
AGTG305GPS	09-11-01	34.35	745.89
do.	11-18-02	34.32	745.92
AGTG305GPD	09-11-01	43.40	736.50
do.	11-18-02	49.87	730.03
AGTG305SP	09-11-01	68.40	711.20
do.	11-18-02	65.85	713.75
BCCDG1S	09-10-01	4.17	729.80
do.	11-22-02	4.26	729.71
BCCDG1D	09-10-01	4.17	729.80
do.	11-22-02	4.29	729.68
NSMG101	09-10-01	12.87	751.43
NSMG102	09-10-01	21.78	752.10
do.	11-19-02	23.09	750.79
NSMG103	09-11-01	11.14	752.51
NSMG104	09-11-01	15.10	752.57
do.	11-20-02	[1,2]11.16	749.27
NSMG105	09-11-01	10.64	752.54
do.	11-20-02	[2]14.0	[3]749.2
PCHG127GPR	09-12-01	57.10	[3]728
do.	11-20-02	54.52	[3]730
PCHG127SP	09-11-01	65.29	719.99
do.	11-20-02	65.33	719.95
PCHG128GPS	09-10-01	46.77	738.28
do.	11-21-02	62.66	722.39
PCHG128GPD	09-10-01	47.15	737.59
do.	11-21-02	58.41	726.33
PCHP436B	09-11-01	13.25	754.11
do.	11-20-02	13.91	753.45
PCHG436GPS	09-11-01	13.68	753.68
do.	11-20-02	14.53	752.83
PCHP436BD	09-11-01	21.39	745.97
do.	11-22-02	23.42	743.94

[1]Height of measuring point (top of well casing) changed between water-level measurements.
[2]Water level fluctuated during measurement.
[3]Altitude of measuring point is estimated.

APPENDIX 9. FIELD-MEASURED CHARACTERISTICS OF WATER QUALITY OF SAMPLES FROM SELECTED WELLS NEAR BELVIDERE, ILL., 2001–02

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; mv, millivolts; mg/L, milligrams per liter; NTU, nephelometric turbidity units; clr, clear; --, not measured; cldy, slightly cloudy]

Aquifer to which well is open: GD, glacial drift aquifer; GP, Galena-Platteville aquifer; SP, St. Peter aquifer; OR, Ordovician aquifer system (Galena-Platteville and St. Peter aquifers); CO, Cambrian-Ordovician aquifer system (Galena-Platteville, St. Peter, Ironton-Galesville, and (or) Elmhurst-Mt. Simon aquifers)

Well designation	Sample date	Aquifer to which well is open	pH (standard units)	Temperature (°C)	Specific conductance (µS/cm)	Oxidation-reduction potential (mv)	Dissolved oxygen (mg/L)	Turbidity (visual or NTU)
AGTG305GPS	09-11-01	GP	7.11	12.1	846	100	0.10	clr
do.	11-18-02	GP	6.82	11.5	915	--	.32	clr
AGTG305GPD[1]	09-11-01	GP	7.09	14.4	793	74	.24	clr[2]
do.	11-18-02	GP	6.87	11.3	808	--	.06	13
AGTG305SP	09-11-01	SP	6.74	12.5	659	20	.10	clr
do.	11-18-02	SP	6.70	11.5	708	--	[3].05	.4
BCCDG1S	09-10-01	GD	6.76	13.1	737	--	6.77	clr
do.	11-22-02	GD	6.84	12.1	644	--	.99	.72
BCCDG1D	09-10-01	GD	6.94	11.3	799	--	8.32	clr
do.	11-22-02	GD	6.94	10.3	771	--	1.84	clr
BMW2	09-12-01	CO	6.66	12.9	1,161	--	[4].89	clr
do.	11-19-02	CO	6.77	12.3	1,200	--	[5]1.28	clr
BMW3	09-12-01	CO	6.63	13.8	1,276	--	2.83	clr
do.	11-21-02	CO	6.77	13.6	1,330	--	2.81	clr
BMW4	09-12-01	CO	6.75	11.8	823	--	3.24	clr
do.	11-19-02	CO	6.91	11.6	797	--	[6]4.26	clr
BMW5	09-12-01	OR	6.81	12.4	795	--	6.53	clr
do.	11-21-02	OR	6.91	11.5	821	--	.29	clr
BMW6	11-19-02	OR	6.98	11.4	694	--	.95	clr
BMW7	09-12-01	CO	7.02	13.1	585	--	.28	clr
do.	11-19-02	CO	7.09	12.7	601	--	.64	clr
BMW8	09-12-01	CO	6.93	17.0	583	--	[7]1.19	clr
do.	11-17-02	CO	7.11	12.2	575	--	[8].36	clr
BMW9	09-12-01	GD	7.04	10.8	710	--	[9]1.70	clr
do.	11-21-02	GD	7.07	10.6	706	--	.89	clr
NSMG101	09-10-01	GD	6.92	13.4	1,092	158	.31	cldy[10]
NSMG102	09-10-01	GD	6.90	18.4	1,183	243	3.31	cldy[10]
do.	11-19-02	GD	6.78	14.4	1,340	--	3.97	[10]30
NSMG103	09-11-01	GD	6.70	13.8	1,299	--	[11].36	clr
do.	11-19-02	GD	6.88	12.6	1,360	--	.84	13
NSMG104	09-11-01	GD	6.57	13.1	1,157	--	.21	clr
do.	11-20-02	GD	6.83	12.5	1,290	--	[12].27	4
NSMG105	09-11-01	GD	6.46	16.9	1,590	--	[13].50	clr
do.	11-20-02	GD	6.71	14.8	1,700	--	[12].15	5

APPENDIX 9. FIELD-MEASURED CHARACTERISTICS OF WATER QUALITY OF SAMPLES FROM SELECTED WELLS NEAR BELVIDERE, ILL., 2001–02--*Continued*

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; mv, millivolts; mg/L, milligrams per liter; NTU, nephelometric turbidity units; clr, clear; --, not measured; cldy, slightly cloudy]

Aquifer to which well is open: GD, glacial drift aquifer; GP, Galena-Platteville aquifer; SP, St. Peter aquifer; OR, Ordovician aquifer system (Galena-Platteville and St. Peter aquifers); CO, Cambrian-Ordovician aquifer system (Galena-Platteville, St. Peter, Ironton-Galesville, and (or) Elmhurst-Mt. Simon aquifers)

Well designation	Sample date	Aquifer to which well is open	pH (standard units)	Temperature (°C)	Specific conductance (µS/cm)	Oxidation-reduction potential (mv)	Dissolved oxygen (mg/L)	Turbidity (visual or NTU)
PCHG127GPR	09-12-01	GP	7.19	12.8	658	-35	0.07	clr
do.	11-20-02	GP	7.05	11.3	666	-9	.13	clr
PCGG127SP	09-11-01	SP	7.11	12.5	532	-63	.06	clr
do.	11-20-02	SP	7.19	12.0	557	-2	.18	clr
do.	11-20-02	SP	do.	do.	do.	do.	do.	do.
PCHG128GPS	09-10-01	GP	6.78	12.9	743	23	2.19	clr
do.	11-21-02	GP	6.84	11.4	729	--	.47	clr
PCHG128GPD	09-10-01	GP	6.89	12.3	715	51	.41	clr
do.	11-21-02	GP	6.88	10.8	661	--	.10	clr
do.	11-21-02	GP	do.	do.	do.	do.	do.	do.
PCHG436B[14]	09-11-01	GP	6.87	13.6	1,031	--	8.39	clr
do.[14]	11-20-02	GP	6.96	12.6	1,070	--	5.87	14
PCHG436GPS	09-11-01	GP	6.91	12.9	569	--	.11	clr
do.	11-20-02	GP	6.96	11.9	586	--	.11	clr
PCHP436BD[15]	09-11-01	GP	--	--	--	--	--	clr
do.[15]	11-20-02	GP	--	--	--	--	--	clr

[1]Sampled after removal of 2.3 well volumes because of low battery voltage of sampling pump; values of temperature, specific conductance, and oxidation-reduction potential were not stabilized.

[2]Initially slightly cloudy, grayish bentonite.

[3]Values when pump intake was about 100 feet below land surface and after 3 well volumes were removed. Values when pump intake was about 200 feet below land surface and 1.5 well volumes were removed were: pH, 9.18; temperature, 11.1; specific conductance, 678; dissolved oxygen, 0.37.

[4]Value decreases to 0.89 milligram per liter (mg/L), then fluctuates between about 0.9 and 3 mg/L.

[5]Value decreases to 1.28 mg/L, then fluctuates between about 1.1 and 1.4 mg/L.

[6]Air pocket at top of flow-through cell; flow rate from sample tap was too low to discharge air.

[7]Value decreases to 1.19 mg/L, then fluctuates between about 1.2 and 2.3 mg/L. Many small air bubbles in water.

[8]Air in discharge tubing from sample tap.

[9]Value decreases to 1.70 mg/L, then fluctuates between about 2 and 8 mg/L.

[10]Reddish color.

[11]Value decreases to 0.36 mg/L, then increases to about 2.4 mg/L. A few small air bubbles in water.

[12]Water level responds to nearby withdrawals at Belvidere municipal wells BMW2 and BMW3.

[13]Value decreases to 0.50 mg/L, then fluctuates between about 1.7 and 2.5 mg/L.

[14]Sampled with a peristaltic pump using 0.25-inch outside-diameter Teflon tubing.

[15]Sampled with a manually activated inertial pump constructed of 0.25-inch outside-diameter polyethylene tubing. Sample agitated during collection.

APPENDIX 10. CONCENTRATIONS OF VOLATILE ORGANIC (

[Order of listing based on compounds of interest determined from ground-wate elow the reporting limit are estimated; --, not analyzed; samples were analyzed by a U.S. Environmental Protection Agency contract laboratory, unless otherwi

Aquifer to which well is open: GD, glacial drift aquifer; GP, Galena-Platteville-Galesville, and (or) Elmhurst-Mt. Simon aquifers); U, unknown

Well designation	Sample date	Aquifer to which well is open	Trichloroethene (µg/L)	Tetrachloroethene (µg/L)	1,1,1-Trichloroethane (µg/L)	Chloroform (µg/L)	Dibromochloromethane (µg/L)	Bromodichloromethane (µg/L)	1,2-Dichloroethane[2] (µg/L)	Chloromethane[2] (µg/L)	Acetone[2] (µg/L)	Methylene chloride[2] (µg/L)
AGTG305GPS	11-18-02	GP	0.07	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	0.3	6	<0.5
AGTG305GPD	11-18-02	GP	<.5	<.5	<.5	<.5	<.5	<.5	.9	.5	7	<.5
AGTG305SP	11-18-02	SP	12	<.5	<.5	<.5	<.5	<.5	.9	<.5	7	<.5
BCCDG1S	11-22-02	GD	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5
BCCDG1D	11-22-02	GD	<.5	<.5	<.5	<.5	<.5	<.5	<.5	.2	<.5	<.5
BMW2	11-19-02	CO	6	7	<.5	<.5	<.5	<.5	.6	<.5	5	<.5
do.	11-19-02	CO	6	7	<.5	<.5	<.5	<.5	.6	<.5	4	<.5
BMW3	11-21-02	CO	1	7	<.5	<.5	<.5	<.5	.1	.2	<.5	<.5
BMW4	11-19-02	CO	<.5	.4	<.5	<.5	<.5	<.5	.4	<.5	3	<.5
BMW5	11-21-02	OR	.2	.4	<.5	<.5	<.5	<.5	.8	<.5	5	<.5
BMW6	11-19-02	OR	<.5	.2	<.5	<.5	<.5	<.5	<.5	<.5	5	.1
BMW7	11-19-02	CO	<.5	<.5	<.5	<.5	<.5	<.5	.6	<.5	5	<.5
BMW8	11-17-02	CO	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	6	<.5
BMW9	11-21-02	GD	<.5	<.5	<.5	<.5	<.5	<.5	.6	<.5	<.5	<.5
NSMG102	11-19-02	GD	<.5	.4	<.5	<.5	<.5	<.5	<.5	<.5	7	<.5
NSMG103	11-19-02	GD	2	1	<.5	<.5	<.5	<.5	.5	<.5	4	<.5
NSMG104	11-20-02	GD	[4]11	[4]27	<.5	<.5	<.5	<.5	.4	<.5	<.5	<.5
NSMG105	11-20-02	GD	2	[4]46	<.5	<.5	<.5	<.5	.8	<.5	5	<.5
PCHG127GPR	11-20-02	GP	1	<.5	<.5	<.5	<.5	<.5	.7	.2	5	<.5
PCHG127SP	11-20-02	SP	<.5	<.5	<.5	<.5	<.5	<.5	[3].5	.1	<.5	<.5
do.	11-20-02	SP	<.5	<.5	<.5	<.5	<.5	<.5	<.5	.2	<.5	<.5
PCHG128GPS	11-21-02	GP	.2	<.5	<.5	<.5	<.5	<.5	<.5	.2	<.5	<.5
PCHG128GPD	11-21-02	GP	.6	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5
do.	11-21-02	GP	.7	<.5	<.5	<.5	<.5	<.5	<.5	.2	<.5	<.5
PCHP436B[5]	11-20-02	GP	<.5	1	<.5	.2	<.5	<.5	<.5	<.5	<.5	<.5
PCHG436GPS	11-20-02	GP	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5
PCHP436BD[6]	11-20-02	GP	.3	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5
										<.5	<.5	<.5
TAP WATER[7]	11-18-02	U	.6	.4	--	1	4	3	.6	.3	<.5	.2

[1]Sample analyzed by the U.S. Environmental Protection Agency Region 5

[2]Suspected laboratory contaminant.

[3]Estimated value.

[4]Diluted sample.

[5]Sampled with a peristaltic pump using 0.25-inch outside-diameter Teflon

[6]Sampled with a manually activated inertial pump constructed of 0.25-incl

[7]Sample tap in motel room, Rockford, Ill. Tap water from Rockford public

APPENDIX 11. CONCENTRATIONS OF MAJOR IONS IN WATER SAMPLES FROM WELLS BCCDG1S AND BCCDG1D NEAR BELVIDERE, ILL., SEPTEMBER 2001

[All concentrations of major ions represent dissolved fraction, unless otherwise noted; ANC, acid neutralizing capacity (unfiltered, represents total fraction; approximates filtered alkalinity); mg/L, milligrams per liter; GD, glacial drift aquifer; --, not analyzed; samples analyzed by a U.S. Environmental Protection Agency contract laboratory, unless otherwise noted]

Well designation	Sample date	Aquifer to which well is open	Calcium (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Silica (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	ANC (mg/L)	Hardness (mg/L)
BCCDG1S[1]	09-10-01	GD	90.9	14.1	[2]0.1	38.3	1.90	13.8	4.50	16.3	291	380
do.	09-10-01	GD	96.3	--	--	41.6	1.92	--	5.32	--	--	--
BCCDG1D	09-10-01	GD	94.5	--	--	45.0	1.61	--	9.97	--	--	--

[1]Sample analyzed by the U.S. Geological Survey National Water-Quality Laboratory, Denver, Colo.
[2]Estimated value. Reporting limit is 0.16 milligram per liter.

APPENDIX 12. CONCENTRATIONS OF TRACE ELEMENTS AND CYANIDE IN WATER SAMPLES FROM WELLS BCCDG1S AND BCCDG1D NEAR BELVIDERE, ILL., SEPTEMBER 2001

[All concentrations of trace elements represent dissolved fraction; µg/L, micrograms per liter; GD, glacial drift aquifer; <, less than, associated value represents the reporting limit; --, not analyzed; samples analyzed by a U.S. Environmental Protection Agency contract laboratory, unless otherwise noted]

Well designation	Sample date	Aquifer to which well is open	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Cobalt (µg/L)	Copper (µg/L)
BCCDG1S	09-10-01	GD	<44.0	<5.0	<4.0	44.3	<1.0	16.8	<1.0	1.1	<2.0	11.8
do.[1]	09-10-01	GD	--	--	--	--	--	19.6	--	--	--	--
BCCDG1D	09-10-01	GD	<44.0	<5.0	<4.0	47.8	<1.0	16.8	<1.0	1.1	<2.0	12.5

Well designation	Sample date	Cyanide (µg/L)	Iron (µg/L)	Lead (µg/L)	Manganese (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Silver (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
BCCDG1S	09-10-01	<1.0	<22.0	<2.0	5.5	<0.10	2.2	<5.0	<2.0	<8.0	<2.0	<3.0
do.[1]	09-10-01	--	[2]8.0	--	6.1	--	--	--	--	--	--	--
BCCDG1D	09-10-01	[3]1.1	<22.0	<2.0	2.1	<0.10	<2.0	<5.0	<2.0	<8.0	<2.0	<3.0

[1]Sample analyzed by the U.S. Geological Survey National Water-Quality Laboratory, Denver, Colo.
[2]Estimated value. Reporting limit is 10 micrograms per liter.
[3]Estimated value. Constituent detected in blank sample.

APPENDIX 13: CONCENTRATIONS OF NUTRIENTS IN A WATER SAMPLE FROM WELL BCCDG1S NEAR BELVIDERE, ILL., SEPTEMBER 2001

[All concentrations represent dissolved fraction; N, nitrogen; P, phosphorus; mg/L, milligram per liter; GD, glacial drift aquifer; <, less than, associated value represents the reporting limit; °C, degrees Celsius; sample analyzed by the U.S. Geological Survey National Water-Quality Laboratory, Denver, Colo.]

Well designation	Sample date	Aquifer to which well is open	Ammonium, as N (mg/L)	Ammonium plus organic nitrogen, as N (mg/L)	Nitrite, as N (mg/L)	Nitrite plus nitrate, as N (mg/L)	Ortho-phosphate, as P (mg/L)
BCCDG1S[1]	09-10-01	GD	<0.02	<0.10	<0.01	<0.05	<0.01

[1]Sample was analyzed about 7 days beyond recommended holding time; temperature was maintained between 0 and 4°C. Concentrations might be greater than those presented here.

APPENDIX 14. CONCENTRATIONS OF HERBICIDES AND THEIR TRANSFORMATION PRODUCTS IN A WATER SAMPLE FROM WELL BCCDG1S NEAR BELVIDERE, ILL., SEPTEMBER 2001

[All concentrations represent dissolved fraction; mg/L, microgram per liter; ESA, ethane sulfonic acid; OA, oxanilic acid; GD, glacial drift aquifer; <, less than, associated value represents the reporting limit; sample analyzed by the U.S. Geological Survey Organic Geochemistry Research Laboratory, Lawrence, Kans.]

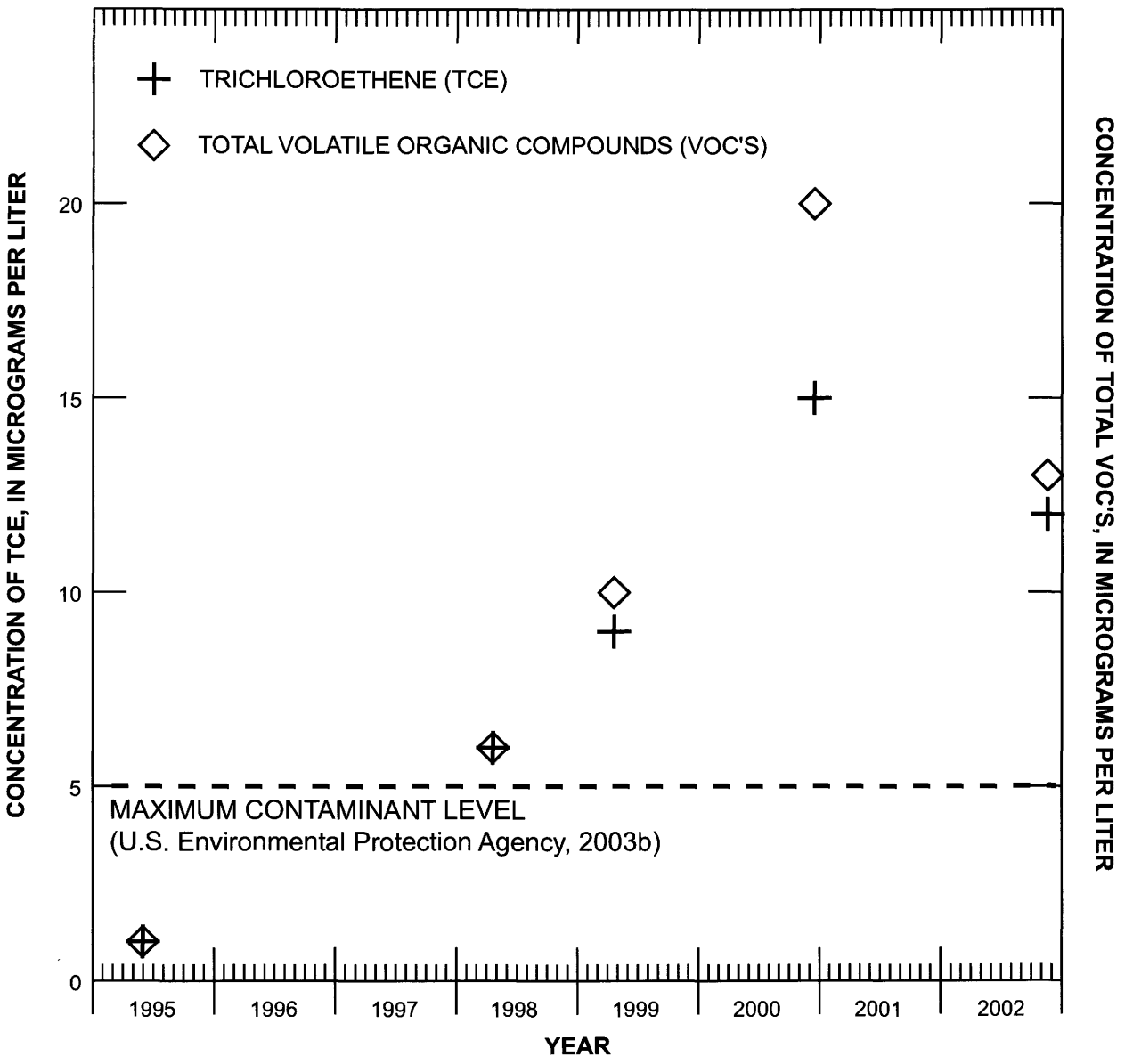
Sample date	Acetochlor (µg/L)	Acetochlor ESA[1] (µg/L)	Acetochlor OA[2] (µg/L)	Alachlor (µg/L)	Alachlor ESA (µg/L)	Alachlor OA (µg/L)	Ametryn (µg/L)	Atrazine (µg/L)	Deethyl-atrazine[2] (µg/L)	Deiso-propyl-atrazine[3] (µγ/L)	Cyanazine (µg/L)
09-10-01	<0.05	<0.05	<0.05	<0.05	0.27	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

	Cyanazine amide[2] (µg/L)	Dimeth-enamid (µg/L)	Dimethe-namid ESA (µg/L)	Dimethe-namid OA (µg/L)	Flufenacet (µg/L)	Flufen-acet ESA (µg/L)	Flufen-acet OA (µg/L)	Glypho-sate (µg/L)	AMPA[4] (µg/L)	Glufosi-nate (µg/L)	Meto-lachlor (µg/L)
do.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<0.10	<0.10	<0.05

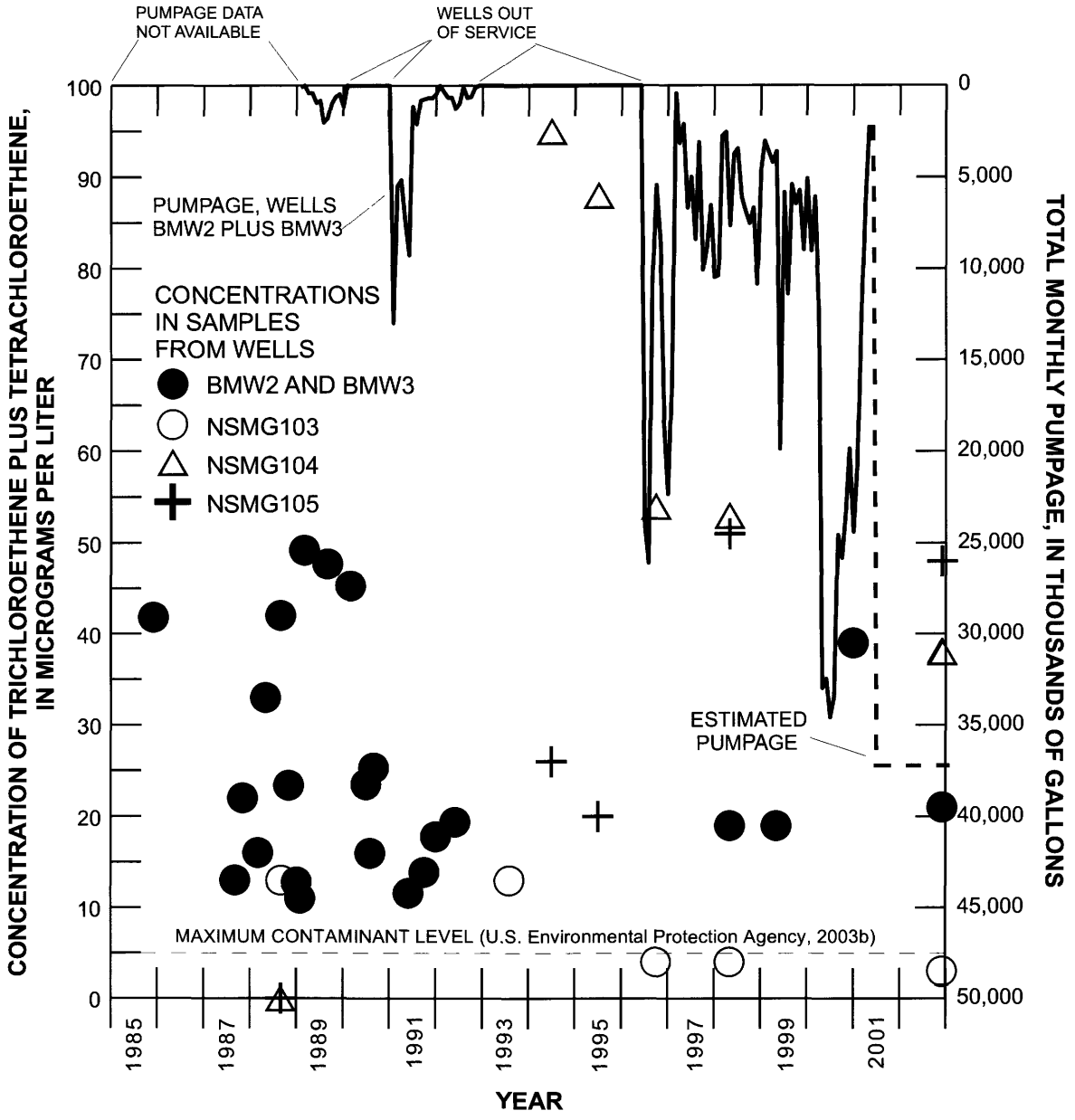
	Metolachlor ESA (µg/L)	Metolachlor OA (µg/L)	Metribuzin (µg/L)	Pendimethalin (µg/L)	Prometon (µg/L)	Prometryn (µg/L)	Propachlor (µg/L)	Propazine (µg/L)	Simazine (µg/L)	Terbutryn (µg/L)
do.	0.58	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

[1]ESA and OA compounds are transformation products of the associated herbicide.
[2]Transformation product of atrazine.
[3]Transformation product of atrazine, cynazine, and simazine.
[4]Amino methyl phosphonic acid; transformation product of glyphosate.

APPENDIX 15: CONCENTRATIONS OF TRICHLOROETHENE AND TOTAL VOLATILE ORGANIC COMPOUNDS IN SAMPLES FROM MONITORING WELL AGTG305SP, OPEN TO THE ST. PETER AQUIFER, BELVIDERE, ILL., 1995–2002



APPENDIX 16: CONCENTRATIONS OF TRICHLOROETHENE AND TETRACHLOROETHENE IN SAMPLES FROM BELVIDERE, ILL., MUNICIPAL WELLS BMW2 AND BMW3 AND NEARBY MONITORING WELLS, AND PUMPAGE OF WELLS BMW2 AND BMW3, 1985–2002 (Pumpage Data from Jim Grimes, Belvidere Water and Sewer Department, Belvidere, Ill., written commun., 2001)



REFERENCES CITED IN APPENDIXES

Bouwer, Herman, and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: Water Resources Research, v. 12, p. 423-428.

U.S. Environmental Protection Agency, 2003b: accessed January 13, 2003, at URL http://www.epa.gov/safewater/mcl.html

van der Kamp, G., 1976, Determining aquifer transmissivity by means of well response tests—The underdampened case: Water Resources Research, v. 12, no. 1, p. 71-77.

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