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Geophysical Logs of Selected Wells at the Diaz Chemical Superfund Site in the Village of Holley, New York, 2009

Data Series–500

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

Cover: The Diaz Chemical Superfund Site in the Village of Holley, New York, in 2006.

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By David A.V. Eckhardt and J. Alton Anderson

Data Series–500

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia 2010

Suggested citation:
Eckhardt, D.A.V., and Anderson, J.A., 2010, Geophysical logs of selected wells at the Diaz Chemical Superfund Site in the Village of Holley, New York, 2009: U.S. Geological Survey Data Series–500,16 p., at *http://pubs.usgs.gov/ds/500*.

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Conversion Factors and Datum

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre (ac)	4,047	square meter (m^2)
acre (ac)	0.4047	hectare (ha)
	Volume	
gallon (gal)	3.785	liter (L)
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Transmissivity*	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

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

$$°F=(1.8\times°C)+32$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).
Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).
Altitude, as used in this report, refers to distance above the vertical datum.
*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.
Fluid conductivity (specific conductance) is given in microSiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

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Abstract

Geophysical logs were collected and analyzed to define the bedrock fracture patterns and flow zones penetrated by three wells at the Diaz Chemical Superfund Site in the Village of Holley in Orleans County, New York. The work was conducted in December 2009 as part of the investigation of contamination by organic compounds in the shale, mudstone, and sandstone bedrock at the Site. The geophysical logs include natural-gamma, caliper, borehole image, fluid properties, and flowmeter data. The orientation of fractures in the boreholes was inferred from the log data and summarized in stereo and tadpole plots; when possible, the transmissivity and hydraulic head was also determined for fracture zones that were observed to be hydraulically active through the flowmeter logs. The data are intended, in part, for use in the remediation of the site.

Introduction

Volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) have been detected in groundwater sampled at the Diaz Chemical Superfund Site in the Village of Holley in Orleans County, N.Y. (fig. 1). The area was declared a Superfund Site by the U.S. Environmental Protection Agency (USEPA) and listed on the National Priorities List (*http://www.epa.gov/superfund/sites/npl/*) in 2004.

In June and July 2006 and December 2009, the U.S. Geological Survey (USGS) and the USEPA collected advanced borehole-geophysical logs at selected well sites as part of the investigation of VOC and SVOC contamination in the unconsolidated deposits and bedrock aquifer that underlie the site. The USGS analyzed the geophysical logs, along with core samples and outcrops of the bedrock, to define the rock fractures and groundwater flow zones penetrated by the wells. Log data collected in 2006 were previously published (Eckhardt and Anderson, 2007). This report describes the geophysical methods and presents the three sets of borehole logs collected in December 2009. The logs are available upon request in *wcl* format (WellCAD, version 4.1), which allows the logs to be viewed in a tabular form or displayed and printed at user-specified vertical scales.

Study Area

The Diaz Chemical Superfund site occupies about 6 acres in the Village of Holley in eastern Orleans County, New York (fig. 1). The area is within a lowland region that lies along Lake Ontario between the cities of Rochester to the east and Buffalo to the west. The site and its history are described by Lockheed Martin Technology Services (2005), New York State (2002), and Haley & Aldrich of New York, Inc. (2000).

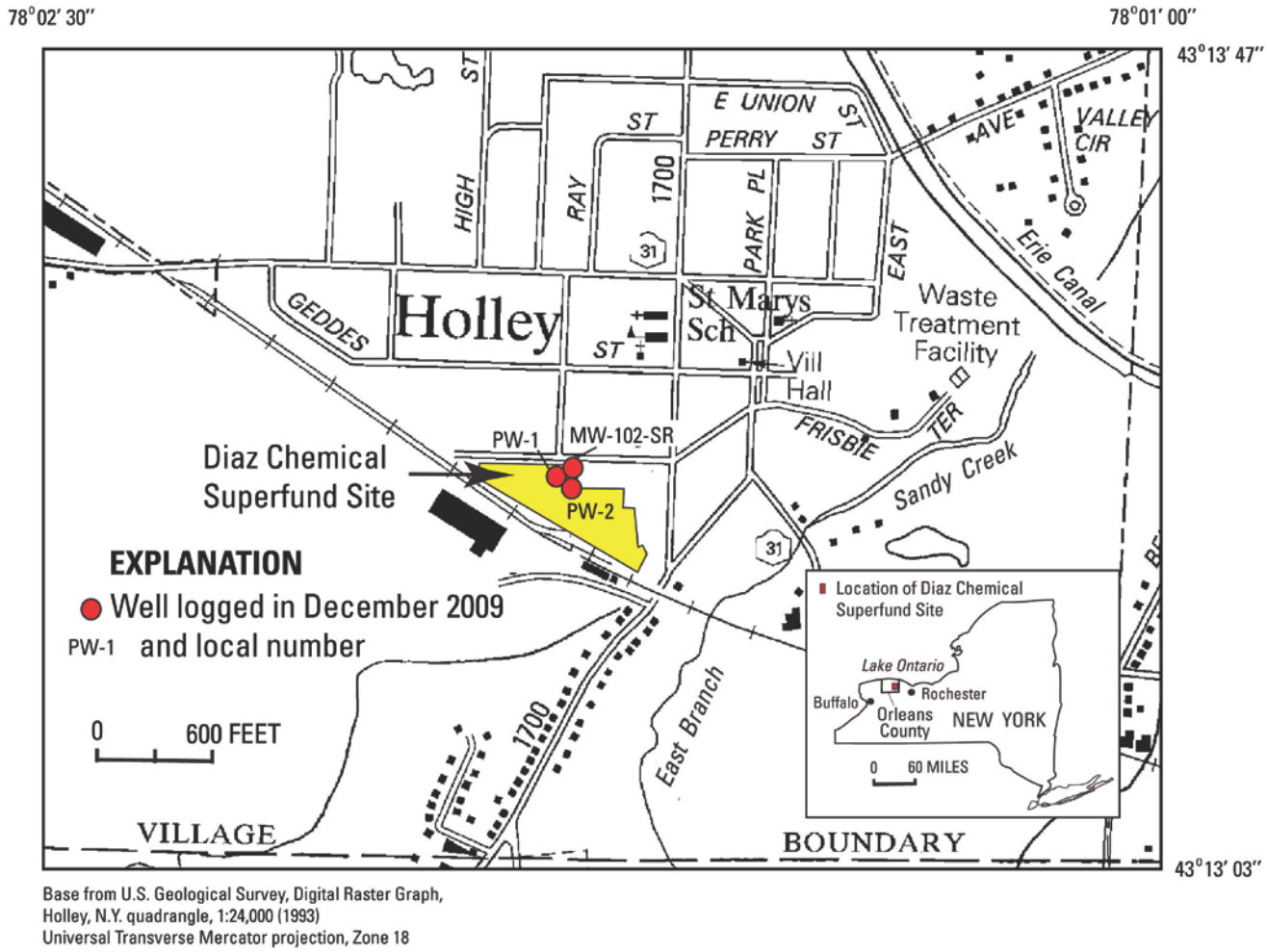

Figure 1. Map showing location of study area and wells that were logged at the Diaz Chemical Superfund Site, Village of Holley, N.Y., 2009.

The local topography consists of relatively flat terrain that is transected by a 40-ft-deep channel of East Branch Sandy Creek about 500 ft east of the site (fig. 1). The site is underlain by unconsolidated lacustrine silt and clay with some interbedded sand. The unconsolidated deposits range in thickness from 10 to 35 ft and overlie the Queenston Formation of upper Ordovician age, which consists of shales and subordinate fine-grained sandstones devoid of fossils (Brett and others, 1994; Goodman, 2005). At the site, the Queenston Formation consists of mudstone with some thin-bedded sandstone. The upper part of the shallow bedrock near its contact with the unconsolidated deposits is weathered into red clay. The deeper zones of unweathered rock are dense and have low permeability. The mudstone and sandstone layers are relatively flat lying, and the highest hydraulic permeability is likely along nearly horizontal bedding planes and possibly along some sets of moderate- to high-angle fractures. The site is adjacent to an inferred spur of the Clarendon-Linden fault system, which is a series of north-striking, east-dipping normal faults in western New York (Fakundiny and Myers, 1978; Cannon and Noll, 2004).

Description of Wells

Geophysical logs were collected from one test well and two abandoned production wells (locations shown in fig. 1). Well-construction information at the time of logging and the types of geophysical logs collected at the wells are given in table 1. One of the wells (MW-102-SR) was constructed as a 4-inch-diameter test well with an open borehole below steel casing that terminated in bedrock. Two of the wells were 6-inch-diameter abandoned production wells; one production well (PW-1) had an open borehole below steel casing set in bedrock, and the other (PW-2) had a steel screen that was open to weathered bedrock and unconsolidated overburden. After completion of logging, well PW-1 was converted to a 2-inch-diameter monitor well with a grouted PVC casing and a screened, sand-packed interval.

Table 1. Well construction information and types of geophysical logs collected from test wells at the Diaz Chemical Superfund Site, Village of Holley, New York, 2009.

[Site locations shown in fig. 1. Local number assigned by U.S. Environmental Protection Agency. USGS well number assigned by U.S. Geological Survey; OL, Orleans County; ft, feet; in, inches; Mech cal, mechanical caliper; Acou cal, acoustic caliper; ATV, acoustic televiewer; OTV, optical televiewer; HPFM, heat-pulse flowmeter; Cond, fluid electrical conductivity; Temp, temperature; amb, ambient; rec, recovery]

Local well number	USGS well number	Casing depth (ft)	Well depth (ft)	Well diameter (in)	Type of Log										
					Natural gamma	Mech cal	Acou cal	ATV	OTV	HPFM		Cond		Temp	
										amb	rec	amb	rec	amb	rec
PW-1	OL 49	29	49.5	6	X	X	X	X	X	X	X	X	X	X	X
PW-2	OL 50	20	23.5	6	X							X		X	
MW-102-SR	OL 51	28.5	38.5	4	X	X	X	X				X	X	X	X

Low well yields (less than 0.2 gal/min) at PW-1 and MW-102-SR prevented collection of borehole geophysical data under steady-state pumped conditions; therefore, some logs were collected during water-level recovery after pumping had ceased in these wells. The measured flow rates were then normalized to represent a steady drawdown level. Flow and fluid-property (specific conductivity and temperature) logs were completed at production well PW-1 for ambient hydraulic conditions and during water-level recovery. A wellbore constriction at 29 ft below land surface in test well MW-102-SR prevented collection of flow logs, but fluid-property logs were collected for the full well depth for ambient and recovery conditions. The screen in production well PW-2 allowed only the natural-gamma and fluid-property logs to be completed under ambient conditions.

Description of Logs

The geophysical logs collected from the wells are presented in appendix 1 and include natural-gamma, caliper, borehole-image, fluid-conductivity and temperature, and heat-pulse-flowmeter data. The caliper logs were collected by mechanical and acoustical methods. Borehole-image logs were collected with an acoustic televiewer (ATV) and an optical televiewer (OTV). Borehole-deviation logs were collected with three-axis fluxgate magnetometers and vertical inclinometers that are incorporated in the ATV probe. Fluid-property logs included fluid-conductance and temperature measurements of the borehole water. Flowmeter logs were collected by heat-pulse methods. The types and sources of geophysical logs collected in each well are listed in table 1. Applications of these types of geophysical logs in groundwater studies are described by Williams and Lane (1998) and Keys (1990). The geophysical logs used in this investigation are described briefly below.

Natural-gamma logs measure the gamma radiation of the rock units penetrated by the borehole. Major gamma emitters are uranium, thorium, and daughter products of potassium-40. Sedimentary rocks with relatively high gamma radiation when compared to other lithologic units include shales, mudstones, bentonites, and other argillaceous units, as well as phosphate-rich zones. The gamma tool has a vertical resolution of 1 to 2 ft. Gamma logs collected in open boreholes and through steel casing may be used for lithologic identification and stratigraphic correlation.

Mechanical (Mech) and acoustic (Acou) caliper logs record the diameter of the borehole. Changes in borehole diameter are related to drilling and construction procedures and competency of lithologic units, fractures, and solution features. Mechanical-caliper logs were collected with a spring-loaded, three-arm averaging tool; acoustic-caliper logs were calculated from acoustic traveltimes collected with the ATV tool. Caliper logs were used in the delineation of fractures, solution features, and lithology, and to confirm well and casing depths and diameters.

Acoustic-televiewer (ATV) logs record a 360-degree acoustic image of the borehole wall (Williams and Johnson, 2000). ATV logs can be collected in clear or turbid water. Features with widths greater than 0.01 ft can be identified, and their strike and dip can be characterized relative to magnetic north. Acoustic-televiewer logs were used to characterize bedding and lithology, fracture aperture and orientation, solution features, and borehole-wall rugosity.

Optical-televiewer (OTV) logs record a 360-degree magnetically oriented optical image of the borehole wall (Williams and Johnson, 2000). OTV logs can be collected above the water level in a well but only in clear water below. Optical-televiewer logs are used to characterize bedding and lithology, fracture aperture and orientation, solution features, and rock fabric.

Fluid-conductivity (Cond) logs record the electrical conductance of water in the borehole. Electrical conductance is directly related to the concentration of dissolved solids in the water. Slope changes in fluid-conductivity logs may indicate zones of inflow to or outflow from the borehole.

Temperature (Temp) logs record the temperature of air and water in the borehole. Temperature gradients that are smaller than the geothermal gradient may indicate intervals of borehole flow. Temperature logs were used with the fluid-conductivity logs to delineate the water level and possible changes in borehole flow.

Heat-pulse flowmeter (HPFM) logs record the direction and rate of vertical flow in the borehole. Vertical flow occurs in wells that penetrate more than one water-producing fracture zone under differing hydraulic head (water level). Flow in the borehole is from zones of higher head to zones of lower head. The HPFM (Hess, 1982) measures the traveltime of a thermal pulse between a set of upper and lower heat sensors (thermistors). The flowmeter was used with flexible rubber diverters fitted to the nominal borehole diameter and has a measurement range of 0.01 to 1.5 gal/min in a stationary mode. Flow logs and fluid-property logs were obtained (when possible) under (1) steady-state ambient conditions, and (2) steady-state pumping or transient recovery conditions to provide a contrast of flow-rate gain or loss at discrete fracture zones with the boreholes (Paillet, 2000; 2001).

Transmissivity (*Trans*), in square feet per day (ft^2/d), of the hydraulically active flow zones were estimated by analysis of the flowmeter data from one of the wells. Measured ambient and stressed flows were matched to simulated flows by trial-and-error adjustment of flow-zone transmissivity and hydraulic head (Paillet, 2000; 2001). The drawdown value used in the transmissivity analysis was based on the difference between the composite ambient and stressed water levels (Bennett and others, 1982).

Fracture Stereo and Strike/Dip (S/D) logs present the inferred strike and dip of fractures observed through the ATV logs. The dip azimuth (0 to 360 degrees) and the dip angle (0 to 90 degrees) are shown in tadpole plots and lower hemisphere stereo-net diagrams. The blue symbols signify fracture zones that were observed to be hydraulically active throughout the flowmeter logs; the gray symbols signify fracture zones with no indication of flow.

Acknowledgments

The authors thank the following individuals for their cooperation and assistance: Robert Alvey and John DiMartino of the USEPA; Grant Anderson of the U.S. Army Corps of Engineers; John Dougherty and Anna Richter of Camp, Dresser, and McKee, Inc.; and William M. Goodwin of RESPEC, Inc.

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Appendix 1. Geophysical logs of selected wells at the Diaz Chemical Superfund Site at Village of Holley, N.Y., 2009

Explanation

Latitude/Longitude, in degrees-minutes-seconds, North American Datum of 1983
Gamma, natural-gamma radiation in counts per second (cps)
Caliper mech, mechanical three-arm caliper borehole diameter in inches (in.)
Caliper acou, acoustic caliper borehole diameter in inches (in.)
ATV, acoustic televiewer, oriented to magnetic north (MN)
OTV, optical televiewer, oriented to magnetic north (MN)
HPFM, heat-pulse flowmeter in gallons per min (gal/min)
amb, ambient conditions; rec, recovery conditions
Fl Cond, fluid conductivity in microsiemens per centimeter (uS/cm)
Temp, air and water temperature in degrees Celsius (deg C)
Zone trans, estimated fracture transmissivity, in square feet per day (ft^2/d)
Fracture stereo and strike/dip logs show azimuth (0–360 degrees) and dip angle (0–90 degrees) of fractures observed on the ATV logs; blue symbols signify fracture zones that were observed to be hydraulically active through use of the flowmeter logs; gray symbols signify fracture zones with no indication of flow

Information on wells used in this study may be accessed online at *http://ny.water.usgs.gov* through search queries that use the following well-site identifications:

USGS well number (site name)	Site ID
OL 49	431322078014401
OL 50	431322078014402
OL 51	431322078014403

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BOREHOLE GEOPHYSICAL LOG

English/Metric units E

SiteID (C1) 431322078014401	**Station name (C12)** OL 49	**Other ID** PW-1
County Orleans	**State** NY	**Log date** 12/14/2009
Owner U.S EPA (abandoned DIAZ Chemical supply well)		**Project** DIAZ0
Location description North of treatment shed		
Latitude 431322.0	**Longitude** 0780143.5	**Lat/Long datum** NAD83
Altitude LMP 539.5 ft	**Altitude datum** NAVD88	**Log measurement point (LMP)** LS
Height LMP 0	**Description of LMP** Land surface	
Borehole depth 49.5 ft	**Borehole diameter** 6 in	**Casing bottom** 29 ft
Casing diameter 6 in	**Casing type** steel	**Source of data** USGS
Logging unit Troy, NY	**Log orientiation** MN	**Magnetic declination** -11.2
Recorded by JAA	**Observed by** DAVE	
Software non-ASCII logs	**Type of log** ZZ	
Fluid type Water	**Fluid depth below LMP** 8.05 ft	**at time** 16:03

Hydrologic conditions 12/15/2009, ambient, pump for recovery test, well recovered at a rate of 0.09gal/min drawdown= 6.52ft

Tool manufacturer and model, tool serial number, log date and time, logging direction and speed, depth error after logging, log parameter(s) and date(s) of calibration check

Tool run 1 Century 9065-715, 12:48, log up 15ft/min, depth error= 0.02ft, borehole diameter - cal check 12/12/2009.

Tool run 2 Century 9042-858, 13:00, log down 15 ft/min, depth error= 0.0 ft, gamma and ambient fluid temp and cond- fluid temp cal check 10/30/09.

Tool run 3 MSI ABI-40, 3078-020906, log up 7ft/min, depth error = 0.0ft, acoustic image and deviation-cal check 12/12/2009.

Tool run 4 MSI OBI-MK4, 073612, 13:34, log up 6 ft/min, depth error= 0.0ft, optical image and deviation- in hole cal check

Tool run 5 Mount Sopris - HPFM, HFP2293, 12/15/2009 10:28, log down stationary measurments, ambient heat pulse flowmeter-in hole cal check

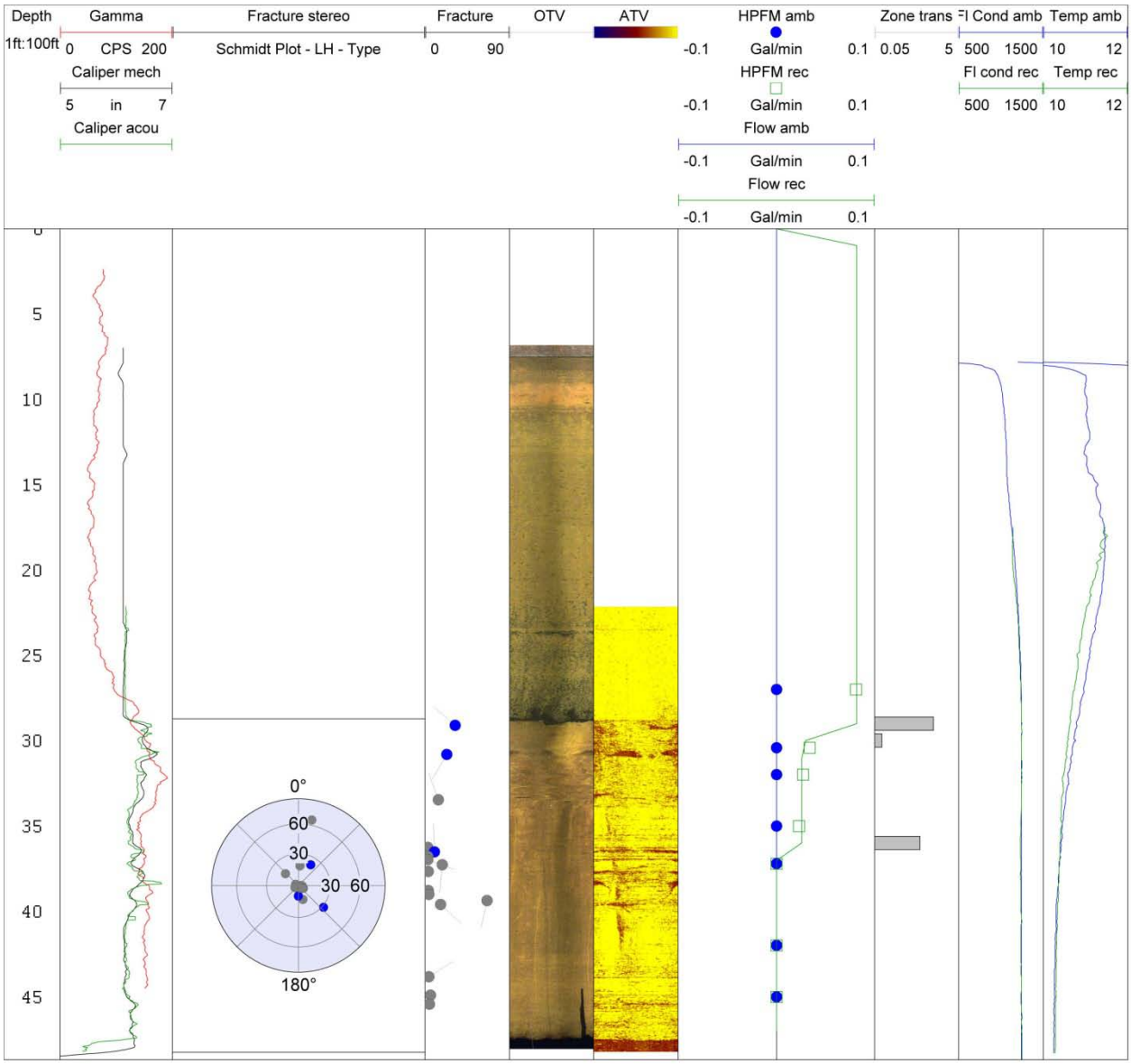
Tool run 6 Mount Sopris - HPFM, HFP2293, 12/15/2009 09:38, log up stationary measurments, recovery heat pulse flowmeter

Tool run 7 Century 9042-858, 14:18, log down 15 ft/min, depth error= 0.0 ft, gamma and ambient fluid temp and cond- fluid temp cal check 10/30/09.

Tool run 8

Tool run 9

Remarks casing stickup = 1.3ft. *Altitude of LMP from topo.


Depth
1ft:100ft
Gamma
0 CPS 200
Caliper mech
5 in 7
Caliper acou
Fracture stereo
Schmidt Plot - LH - Type
Fracture
0 90
OTV
ATV
HPFM amb
-0.1 Gal/min 0.1
HPFM rec
-0.1 Gal/min 0.1
Flow amb
-0.1 Gal/min 0.1
Flow rec
-0.1 Gal/min 0.1
Zone trans
0.05 5
Fl Cond amb
500 1500
Fl cond rec
500 1500
Temp amb
10 12
Temp rec
10 12
5
10
15
20
25
30
35
40
45
0°
60
30
30 60
180°

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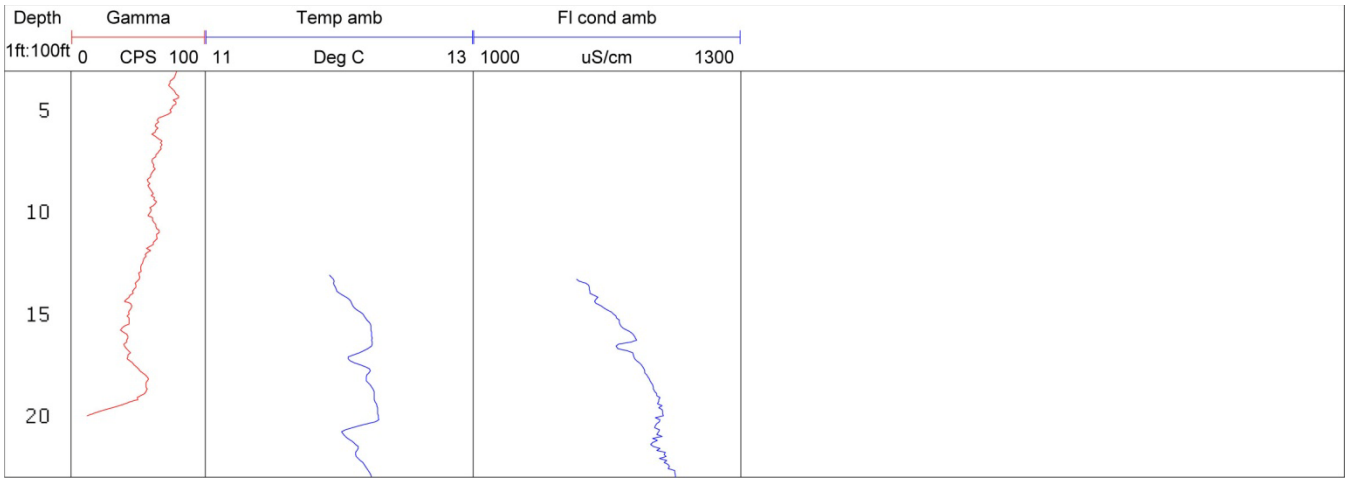
BOREHOLE GEOPHYSICAL LOG

English/Metric units E

SiteID (C1) 431322078014402	**Station name (C12)** OL 50	**Other ID** PW-2	
County Orleans	**State** NY	**Log date** 12/15/2009	**Log time** 12:43
Owner U.S. EPA (abandoned DIAZ Chemical supply well)		**Project** DIAZ0	
Location description East of treatment shed			
Latitude 431321.9	**Longitude** 0780143.6	**Lat/Long datum** NAD83	
Altitude LMP 542.2 ft	**Altitude datum** NAVD29	**Log measurement point (LMP)** LS	
Height LMP 0	**Description of LMP** Land surface		
Borehole depth 23.5 ft	**Borehole diameter** 6 in	**Casing bottom** 20 ft	
Casing diameter 6 in	**Casing type** steel screen 23.5 ft	**Source of data** USGS	
Logging unit Troy, NY	**Log orientiation**	**Magnetic declination**	
Recorded by JAA	**Observed by** DAVE		
Fluid type Water	**Fluid depth below LMP** 12.89 ft		
Hydrologic conditions ambient			
Software non-ASCII logs	**Type of log** ZF		
Tool manufacturer and model Century 9042		**Tool serial number** 858	
Logging direction down	**Logging speed** 10	**Depth error after logging** 0.0	
Log parameter(s) and date(s) of calibration check gamma, fluid temp and cond - cal check 10/30/2009.			
Remarks Casing stickup =0.6ft. Unable to obtain full logging suite due to well screen			


Depth
1ft:100ft
Gamma
0
CPS
100
Temp amb
11
Deg C
13
Fl cond amb
1000
uS/cm
1300
5
10
15
20

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BOREHOLE GEOPHYSICAL LOG

English/Metric units E

SiteID (C1) 431322078014403	**Station name (C12)** OL 51	**Other ID** MW-102-SR
County Orleans	**State** NY	**Log date** 12/15/2009
Owner U.S. EPA (Diaz Chemical monitor well)		**Project** DIAZ0
Location description Northeast corner of facility		
Latitude 431321.9	**Longitude** 0780143.6	**Lat/Long datum** NAD83
Altitude LMP 539.1 ft	**Altitude datum** NAVD88	**Log measurement point (LMP)** LS
Height LMP 0.0	**Description of LMP** Land surface	
Borehole depth 38.5 ft	**Borehole diameter** 4 in	**Casing bottom** 28.5 ft
Casing diameter 4 in	**Casing type** steel	**Source of data** USGS
Logging unit Troy, NY	**Log orientiation** MN	**Magnetic declination**
Recorded by JAA	**Observed by** DAVE	
Software non-ASCII logs	**Type of log** ZZ	
Fluid type Water	**Fluid depth below LMP** 8.95 ft	**at time** 14:30

Hydrologic conditions ambient, pump for recovery test, well recovered at a rate of 0.17 gal/min; drawdown= 5.1ft

Tool manufacturer and model, tool serial number, log date and time, logging direction and speed, depth error after logging, log parameter(s) and date(s) of calibration check

Tool run 1 Century 9065-715, 14:04, log up 15ft/min, depth error= 0.0ft, borehole diameter - cal check 12/12/2009.

Tool run 2 Century 9042-858, 14:18, log down 15 ft/min, depth error= 0.0 ft, gamma and ambient fluid temp and cond- fluid temp cal check 10/30/09.

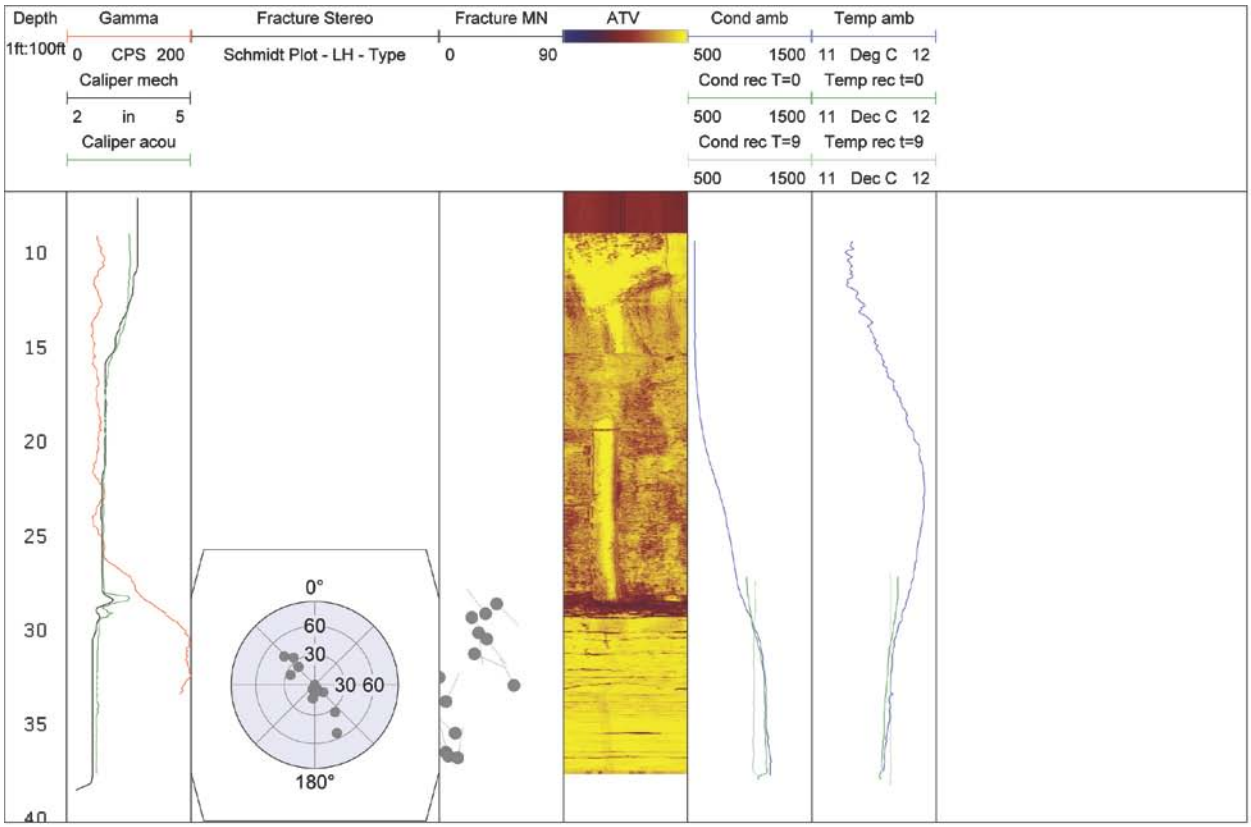
Tool run 3 MSI ABI-40, 3078-020906, 14:40, log up 7ft/min, depth error = 0.04ft, acoustic image and deviation-cal check 12/12/2009.

Tool run 4 Century 9042-858, 15:11, log down 15 ft/min, depth error= 0.0 ft, gamma and recovery fluid temp and cond 0 min after pumping.

Tool run 5 Century 9042-858, 15:20, log down 15 ft/min, depth error= 0.0 ft, gamma and recovery fluid temp and cond 9 min after pumping.

Tool run 6

Remarks stickup = 1.0ft. Unable to obtain flowmeter logs due to wellbore constriction at 29ft.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Gamma
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Caliper mech
2 in 5
Caliper acou
Fracture Stereo
Schmidt Plot - LH - Type
Fracture MN
0 90
ATV
Cond amb
500 1500
Cond rec T=0
500 1500
Cond rec T=9
500 1500
Temp amb
11 Deg C 12
Temp rec t=0
11 Dec C 12
Temp rec t=9
11 Dec C 12
10
15
20
25
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35
40
0°
60
30
30 60
180°

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