Prepared in cooperation with the United States Nuclear Regulatory Commission

Flow-Log Analysis for Hydraulic Characterization of Selected Test Wells at the Indian Point Energy Center, Buchanan, New York

Open-File Report 2008–1123

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

Cover. Photograph by Thomas J. Nicholson (U.S. Nuclear Regulatory Commission) of bedrock quarry southwest of Indian Point Energy Center, Buchanan, New York.

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Conversion Factors and Datum

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Specific capacity	
gallon per minute per foot [(gal/min)/ft)]	0.2070	liter per second per meter [(L/s)/m]
	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:

$$°F=(1.8×°C)+32$$

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 1929).

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.

Abbreviations

ATV	Acoustic televiewer
GAI	Geophysical Applications, Inc.
GZA	GZA GeoEnvironmental, Inc.
NRC	Nuclear Regulatory Commission
OTV	Optical televiewer
USGS	U.S. Geological Survey

Flow-Log Analysis for Hydraulic Characterization of Selected Test Wells at the Indian Point Energy Center, Buchanan, New York

By John H. Williams

Abstract

Flow logs from 24 test wells were analyzed as part of the hydraulic characterization of the metamorphosed and fractured carbonate bedrock at the Indian Point Energy Center in Buchanan, New York. The flow logs were analyzed along with caliper, optical- and acoustic-televiewer, and fluid-resistivity and temperature logs to determine the character and distribution of fracture-flow zones and estimate their transmissivities and hydraulic heads. Many flow zones were associated with subhorizontal to shallow-dipping fractured zones, southeast-dipping bedding fractures, northwest-dipping orthogonal fractures, or combinations of bedding and orthogonal fractures. Flow-log analysis generally provided reasonable first-order estimates of flow-zone transmissivity and head differences compared with the results of conventional hydraulic-test analysis and measurements. Selected results of an aquifer test and a tracer test provided corroborating information in support of the flow-log analysis.

Introduction

Radionuclides have been detected in ground water sampled from metamorphosed and fractured carbonate bedrock at the Indian Point Energy Center in southeastern New York. In 2007, the U.S. Geological Survey (USGS) conducted a flow-log analysis of selected test wells to help characterize the hydraulics of fractured zones in the bedrock. The work was completed in cooperation with the U.S. Nuclear Regulatory Commission (NRC), which provided technical oversight of the investigation of ground-water contamination conducted by Entergy, Inc., the owner and operator of the site. This report describes and presents the flow-log method and integrated analysis of the flow logs with other supporting geophysical log and aquifer- and tracer-test data. The transmissivity and hydraulic head of flow zones estimated by the flow-log method are compared with those determined from hydraulic tests and measurements in corresponding test-well intervals isolated by inflatable straddle packers or as completed monitoring-well installations.

Description of Study Area and Hydrogeologic Setting

The Indian Point Energy Center is the site of a nuclear-power plant in the Village of Buchanan in Westchester County, New York (figs. 1, 2, and 3). The site is within the Hudson Highlands physiographic province and is bordered on the west by the Hudson River. Land-surface altitude ranges from about 10 ft near the river to 140 ft above the National Geodetic Vertical Datum 1929 (NGVD 1929) in the eastern part of the site.

The site is underlain by the Inwood Marble; these metamorphosed dolostones and limestones of Cambro-Ordovician age were extensively blast-excavated during plant construction. The Manhattan Schist unconformably overlies the Inwood Marble near the northern and eastern borders of the site. Bedding in the carbonate bedrock generally dips 30 to 70 degrees to the southeast (figs. 4 and 5). Many fractures are oriented along bedding and orthogonal to bedding. Subhorizontal fractured zones commonly are present in the upper part of the bedrock. The shallow-dipping fractured zones, southeast-dipping bedding fractures, and northwest-dipping orthogonal fractures along with other fractures with a range of orientations form an interconnected permeable network for ground-water flow. Where present, faults, including a north-south trending high-angle feature identified by Dames and Moore (1975), Ratcliffe and others (1983), and Barvenik and others (2008), locally may enhance or impede ground-water flow depending on the presence of clay-rich gouge.

Description of Wells

Twenty-four test wells installed under the direction of GZA GeoEnvironmental, Inc. (GZA), consultant to Entergy, Inc., were selected by GZA for geophysical logging. Information on these test wells, including construction and water level, pumped rate, and drawdown at the time of logging, is presented in table 1. Well locations are shown in figures 2 and 3. The test wells were constructed as open holes below steel casing that was set into competent bedrock.

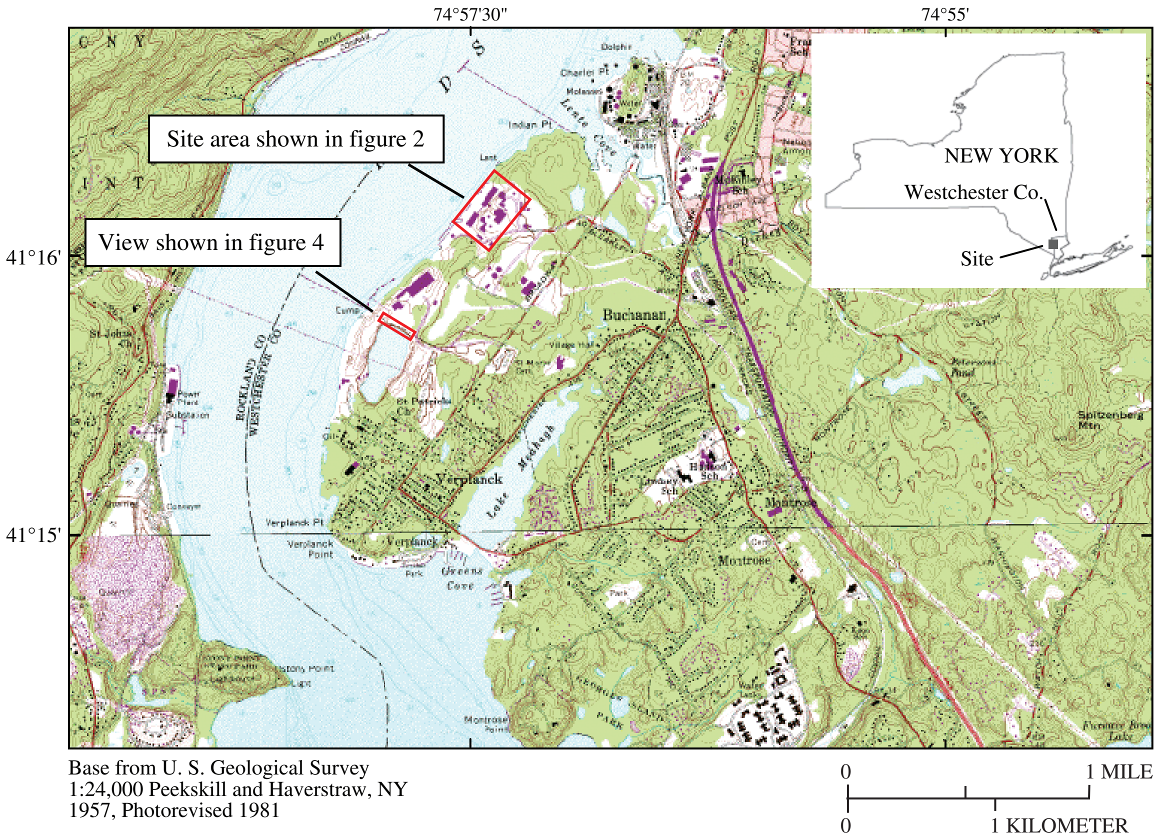


Figure 1. Location of Indian Point Energy Center site, Buchanan, New York.

The test wells ranged from 30 to 340 ft deep, and had 4 to 40 ft of casing. The test wells were cored 3.8 to 4 inches in diameter, except RW-1, which was drilled 6 inches in diameter. Hydrogeologic descriptions of the recovered core are presented in Barvenik and others (2008). After geophysical logging was completed, each test well was converted to a single- or multiple-interval monitoring-well installation by GZA. Hydraulic tests were completed by GZA either in the test well or in the completed monitoring-well installation.

Description of Logs

The geophysical logs were collected from November 2005 to July 2007 by Geophysical Applications, Inc. (GAI) under the direction of GZA and included caliper, optical- and acoustic-televiewer, fluid-resistivity, temperature, and flow logs (app. 1). Information on geophysical logs and logging for ground-water investigations is presented in Keys (1990). The geophysical logs collected and analyzed in the present investigation are described briefly below.

Caliper logs record the diameter of the borehole. Changes in borehole diameter are related to drilling and construction procedures and competency of bedrock. The caliper logs were collected with a spring-loaded, three-arm averaging tool, and were used to confirm test-well casing depths and diameters and to delineate fractures.

Optical-televiewer (OTV) and acoustic-televiewer (ATV) logs record 360-degree magnetically oriented images of the wellbore wall (Williams and Johnson, 2000). The OTV and ATV logs were used to characterize the distribution and orientation of planar fracture and bedding features intersected by the test wells. Planar fracture and bedding features were picked by GAI and their orientations were calculated and corrected for well deviation, which was determined from the three-axis fluxgate magnetometers and vertical inclinometers incorporated in the OTV and ATV tools. Dip azimuth and angle of the fracture and bedding features corrected from magnetic to true north are shown in tadpole plots and lower-hemisphere stereonet diagrams (app. 1). It should be noted that fracture delineation from OTV and ATV logs of near-vertical wells oversample low-angle fractures and undersample high-angle fractures.

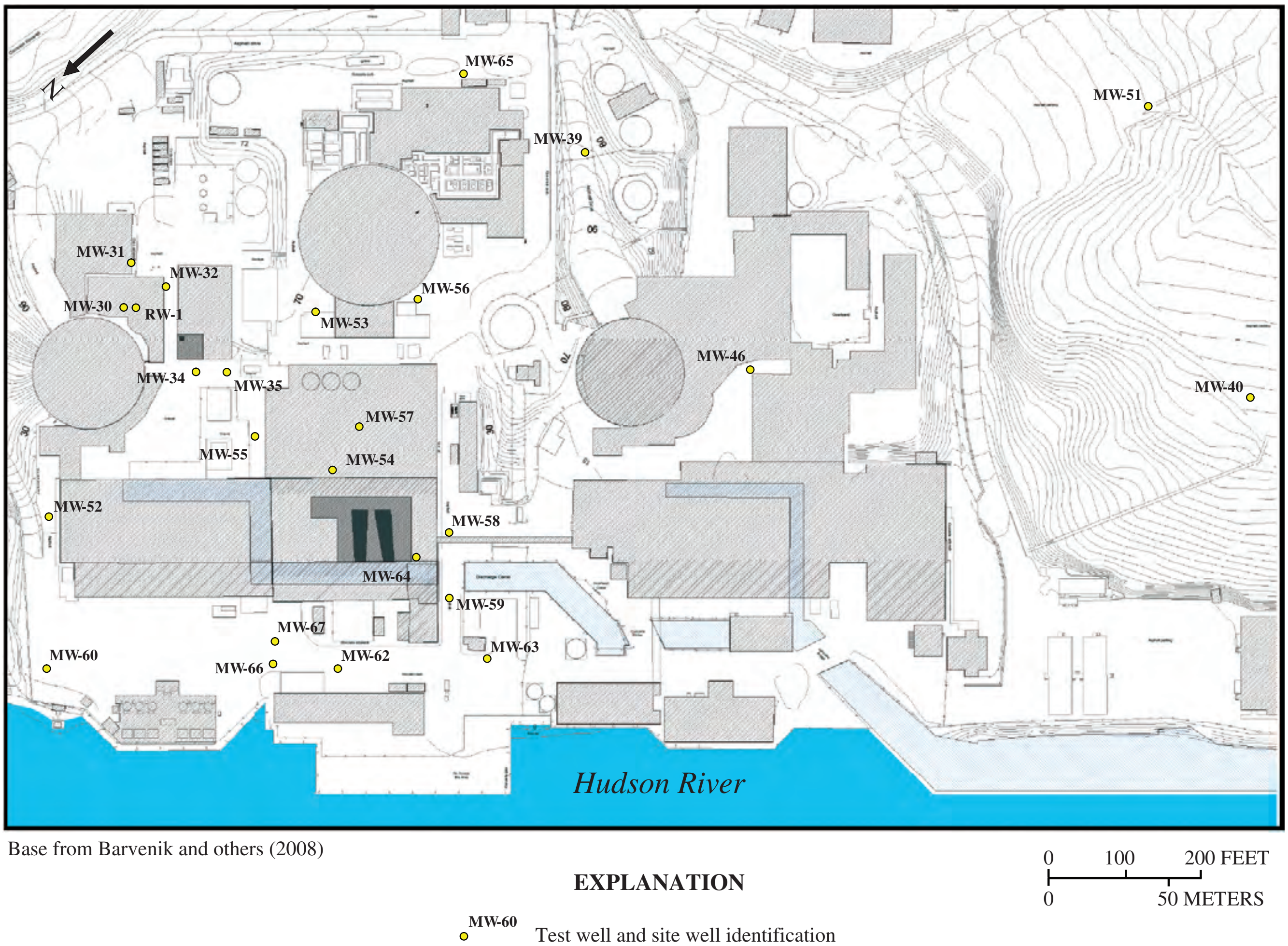
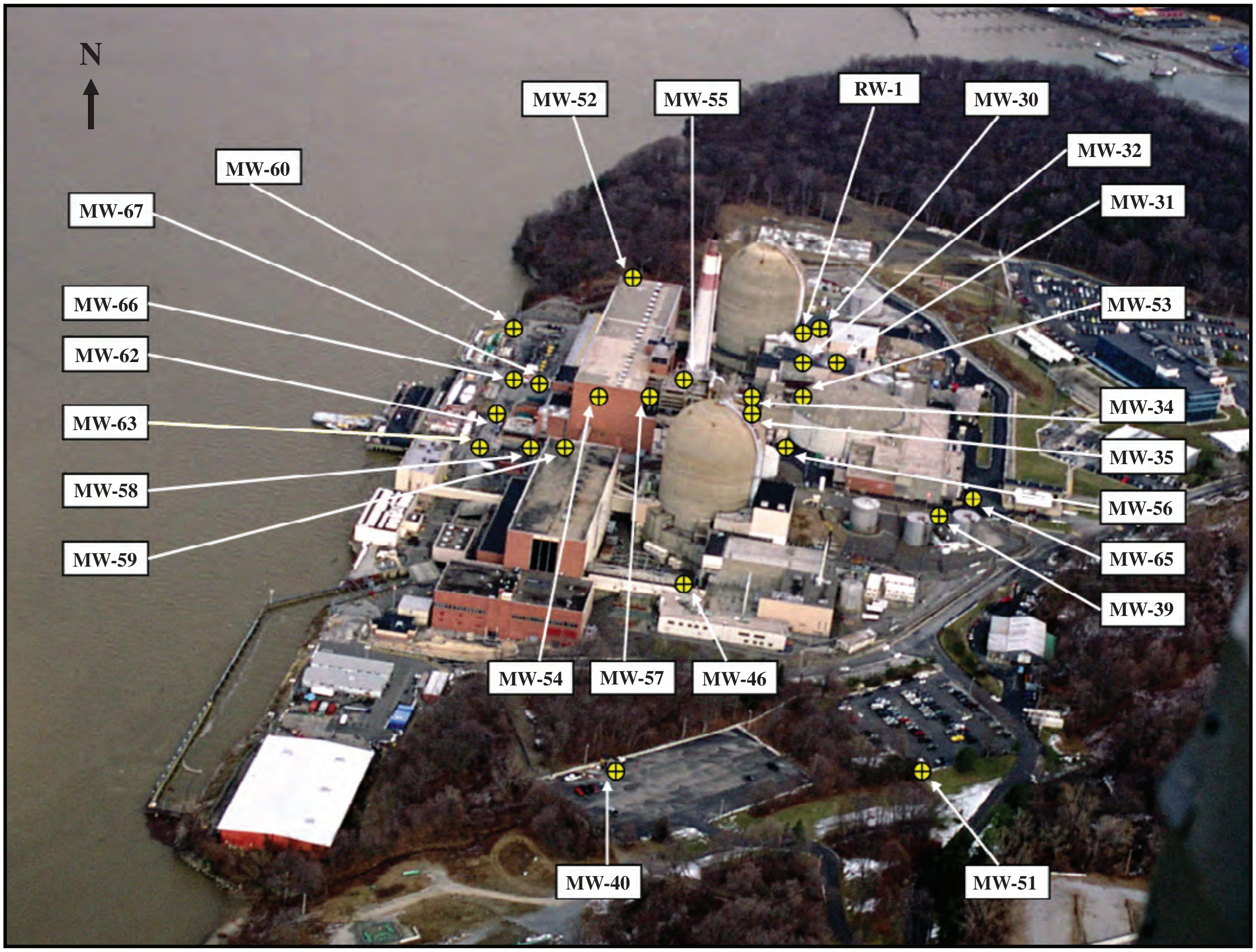


Figure 2. Location of selected test wells at the Indian Point Energy Center site.

Fluid-resistivity and temperature logs record the electrical resistivity and temperature of water in the test wells. Fluid resistivity is inversely related to the concentration of dissolved solids in the water. Slope changes in fluid-resistivity and temperature logs, which were collected under ambient conditions, helped delineate zones of inflow to or outflow from the test wells. Collection of fluid-resistivity and temperature logs under pumped conditions would have provided an additional level of enhancement in flow-zone delineation.

Flow logs record the direction and rate of vertical flow in the well. Vertical flow occurs in wells that penetrate two or more flow zones under differing hydraulic head. Flow is from zones of higher head to zones of lower head. The water levels measured in the open-hole test wells are composite head values that reflect the transmissivity-weighted average of the hydraulic heads of the intersected flow zones (Bennett and others, 1982). Heads in inflow zones are higher than the composite water level, and outflow zones are lower than the composite water level.

Flow at selected depths in the test wells was measured with a heat-pulse flowmeter (Hess, 1982), which determines vertical flow based on the travel time of a thermal pulse between a set of upper and lower thermistors. To channel flow through the measurement throat, the flowmeter was used with a flexible rubber diverter fitted to the nominal well diameter. The heat-pulse flowmeter configured with a fully fitted diverter has a measurement range of 0.005 to 1.0 gal/min. Flow logs were collected in the test wells under ambient and pumped conditions, and the quasi-steady-state drawdown under the short-term pumped conditions was measured, which allowed for quantitative analysis and estimation of flow-zone transmissivity and head (Paillet, 1998 and 2000). In test wells MW-35 and MW-52, constant pumped rates and quasi-steady-state drawdowns were not obtained as a result of rapidly declining water levels. Although not attempted in the present investigation, quantitative flow-log analysis could have been applied in these test wells by use of the recovery and flow normalization method described by Paillet (2004).



EXPLANATION

MW-60 ⊕ Test well and site well identification

Figure 3. Aerial view looking north of the Indian Point Energy Center site and location of selected test wells. (Photograph provided by Entergy, Inc.)

Flow-Log Analysis

The distribution and character of fracture-flow zones intersected by the test wells were determined by the integrated analysis of the caliper, optical- and acoustic-televiewer, fluid-resistivity, temperature, and flow logs (app. 1). One or more fracture features within each zone were designated as the hydraulically active fracture or fractures contributing to the measured ambient and pumped flows. Many flow zones were associated with subhorizontal to shallow-dipping fractured zones, southeast-dipping bedding fractures, northwest-dipping orthogonal fractures, or combinations of bedding and orthogonal fractures (fig. 5).

The transmissivity and hydraulic head of the flow zones were estimated by the flow-log analysis method described by Paillet (1998 and 2000). In this method, a best-fit match is developed between measured and simulated ambient and pumped flows by iterative adjustment of flow-zone transmissivity and head in a numerical model. A unique inversion for zone transmissivity and hydraulic-head values is determined given two sets of flow logs and associated water levels collected under ambient and quasi-steady-state pumped conditions.

The transmissivity and hydraulic-head differences determined by the flow-log analysis were compared with the results of hydraulic testing and hydraulic-head measurements reported by Barvenik and others (2008). The hydraulic tests

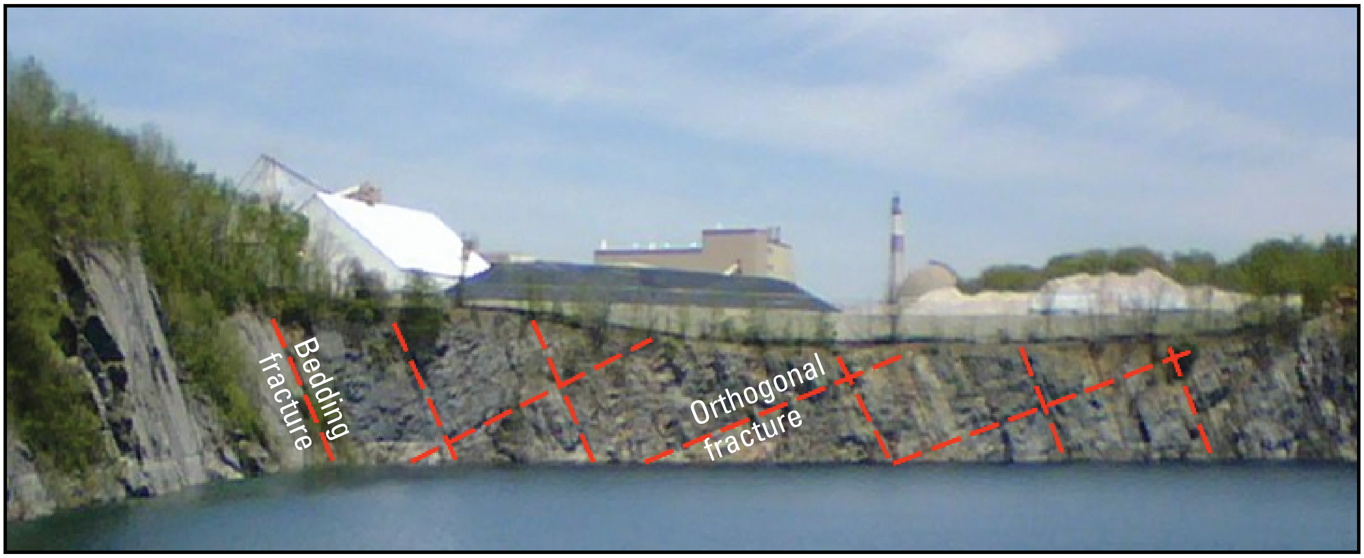


Figure 4. View looking northeast of quarry exposure of carbonate bedrock with bedding and orthogonal fractures, Indian Point Energy Center site. (Photograph by Thomas J. Nicholson, NRC)

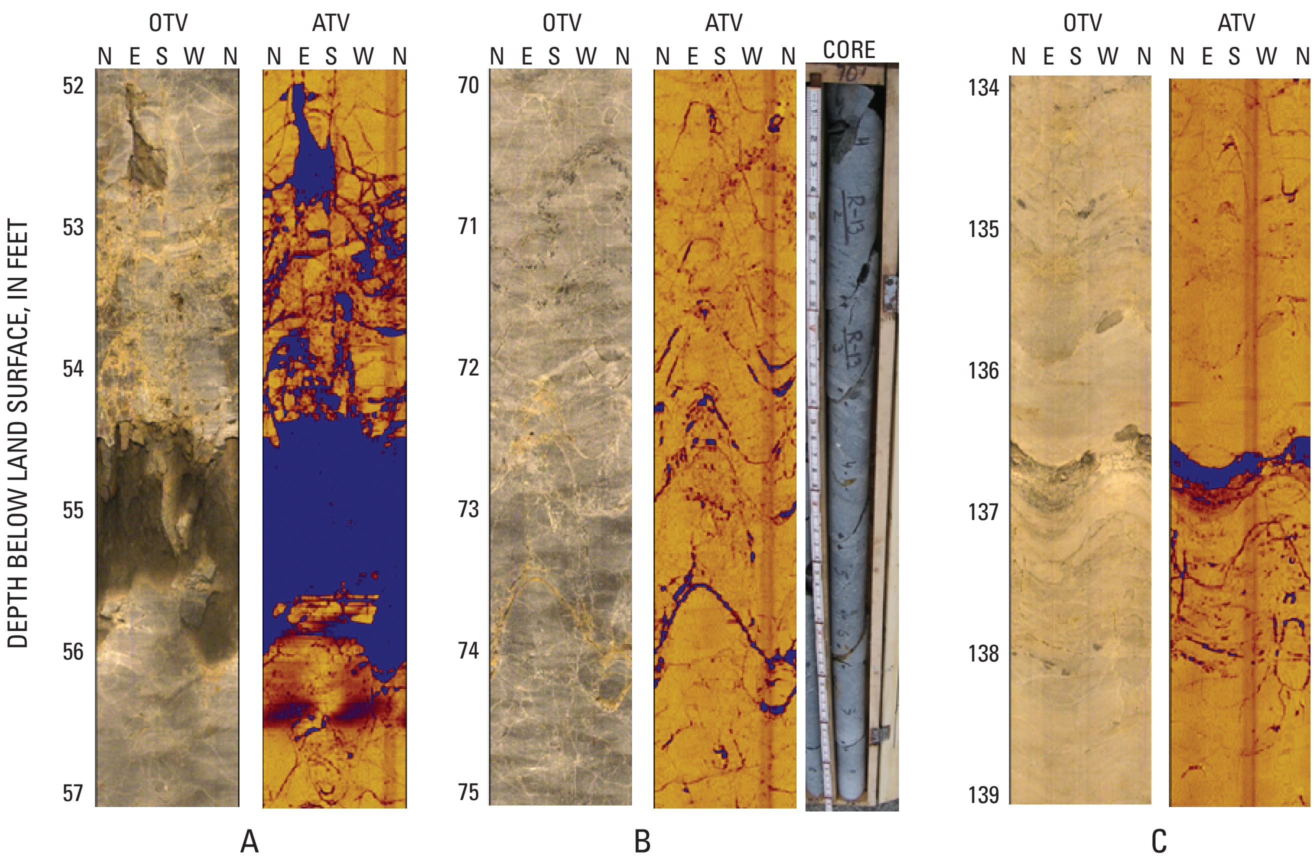


Figure 5. Optical-televiewer (OTV) and acoustic-televiewer (ATV) logs of test well MW-60 at the Indian Point Energy Center site: *(A)* interval from 52 to 57 feet below land surface, showing subhorizonal fractured zone, *(B)* interval from 70 to 75 feet below land surface (with core sample from same interval), showing northwest-dipping orthogonal fractures, and *(C)* interval from 134 to 139 feet below land surface, showing southeast-dipping bedding fracture.

were conducted in test-well intervals isolated by inflatable straddle packers or as completed monitoring-well installations. More than 90 percent of the 76 hydraulic tests used in the comparison were slug tests analyzed by the Hvorslev (1951) method, and the rest were extraction tests analyzed by the Theis (1935) method. The hydraulic-test data and their analysis are presented in more detail by Barvenik and others (2008). The hydraulic heads used in the comparison were measured in the completed monitoring-well installations. Average hydraulic heads on February 12, 2007 (Barvenik and others, 2008) were used in the comparison for all monitoring-well installations except MW-63 and MW-67. Average hydraulic heads on June 1, 2007, and August 28, 2007 (Barvenik and others, 2008), respectively, were used for wells MW-63 and MW-67 because complete sets of head measurements were not available for February 12, 2007.

When compared with the hydraulic-test results, the flow-log analysis detected 74 percent of flow zones where transmissivities were within two orders of magnitude of the most transmissive zone penetrated by each given test well. This comparison of results from hydraulic-test and flow-log methods is consistent with that reported by Paillet (1998) for crystalline bedrock at the USGS fractured-aquifer research site in Mirror Lake, New Hampshire.

Measurable ambient flow indicating differences in hydraulic heads in two or more penetrated flow zones was observed in 16 of the logged test wells. Flow was downward in eight wells (MW-31, -32, -40, -51, -54, -55, -58, and -65), upward in four wells (MW-59, -63, -66, and -67) and both upward and downward in four wells (RW-1 and MW-39, -56, and -57). Even though hydraulic head is transient in nature and the flow logs and head measurements were not collected at the same time, observed flow directions in the test wells generally were consistent with the subsequently measured head differences; that is, flow was from zones of higher head to zones of lower head.

Flow-log analysis generally provided reasonable first-order estimates of flow-zone transmissivity and head differences in comparison with the results of the hydraulic-test analysis and measurements. The logs of transmissivity values estimated by the flow-log analysis and those measured by the hydraulic tests are significantly correlated (fig. 6). The fitted relation is

$$\log T_{HT} = 0.34 + 0.64 \log T_{FL} , \qquad (1)$$

where

T_{HT} is transmissivity of tested interval measured by hydraulic-test methods, in feet squared per day;

and

T_{FL} is transmissivity of flow zone estimated by flow-log method, in feet squared per day.

Selected results from test wells MW-40 and MW-54, which are identified in figure 6, were deemed questionable and not included in the fitted relation. These and, most likely, an undetermined number of additional outliers are related to the limitations inherent in flow logging and in hydraulic testing using inflatable packers. The apparent overestimation of transmissivities by hydraulic testing in test well MW-54 is believed to be the result of an inability to obtain leak-tight seals between the packers and the wellbore wall, which allowed leakage into adjacent, highly fractured intervals of the wellbore. This conclusion is supported by analysis of the head response above and below the test interval. The reason for the order-of-magnitude discrepancy between the transmissivity estimates for the shallowest flow zone in test well MW-40 is unclear. Because the shallowest flow zone is near the water surface, which is not uncommon, it was not feasible to make a measurement above the zone to confirm the pumped rate. The uppermost measurement under pumped conditions indicated downward flow, so the assumption was made that all the pumped flow was contributed by the shallowest zone, which may not be valid. The transmissivity estimate from the hydraulic test, however, is lower than would be expected based on the relatively high specific capacity of the test well (table 1), indicating that the shallowest zone may have been sealed during this test.

The logs of hydraulic-head differences estimated by the flow-log method and those measured in the monitoring installations are significantly correlated (fig. 7). The fitted relation is

$$\log HD_{MM} = 0.19 + 0.68 \log HD_{FL} , \qquad (2)$$

where

HD_{MM} is hydraulic-head difference measured between monitoring-well intervals, in feet;

and

HD_{FL} is hydraulic-head difference between flow zones estimated from flow-log method, in feet.

Discrepancies between the hydraulic-head differences are, in part, due to difficulties in matching very low flows associated with poorly transmissive zones as a result of the relative insensitivity of the model head parameter under these conditions.

Selected Results of Aquifer and Tracer Tests

An aquifer test and, subsequently, a tracer test were conducted by GZA as part of the hydrogeologic site characterization. Barvenik and others (2008) present the design and analysis of these tests along with the time-series data sets of hydraulic heads and tracer concentrations. Selected results of the aquifer and tracer tests are presented in this report as corroborating information on

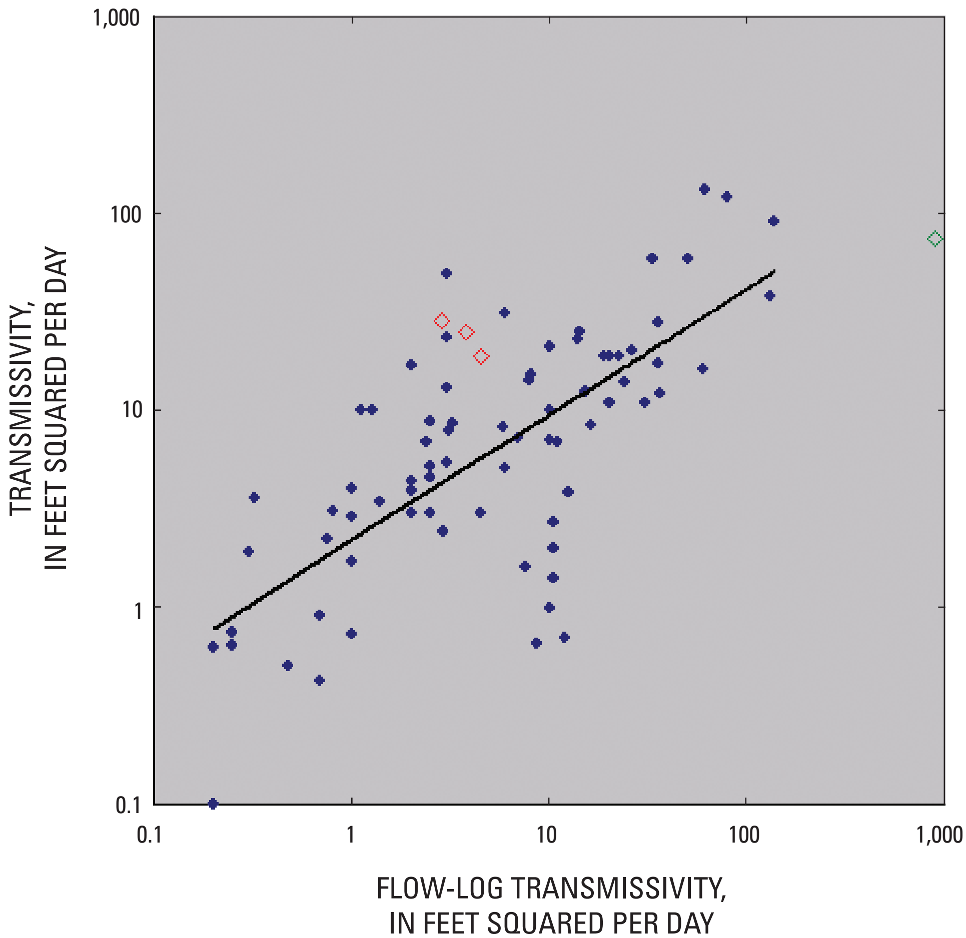


Figure 6. Relation between transmissivity of flow zones penetrated by selected test wells estimated from flow-log analysis and measured by hydraulic tests. Red and green diamonds indicate selected results for test wells MW-40 and MW-54, respectively.

flow-zone transmissivity and connectivity in support of the flow-log analysis.

The aquifer test was conducted from October 31 to November 6, 2006, and involved constant-rate pumping of well RW-1 (figs. 2 and 3) at 4 gal/min for 3 days followed by 3 days of recovery. Water levels were measured during pumping and recovery in monitoring intervals at surrounding monitoring-well installations. Maximum observed drawdown in selected monitoring-well intervals divided by the log of the horizontal distance between the pumped well and the monitoring well is presented in appendix 1.

The tracer test involved the introduction of fluorescein dye on February 8, 2007, through gravity-fed injection of a dye and water mixture into the unsaturated zone at the top of bedrock near monitoring-well installation MW-30 (figs. 2 and 3). Tracer sampling from monitoring intervals at well installations commenced prior to and continued following injection for 7 months. Peak concentration of the tracer and travel velocities for first and peak arrivals, which are defined in this report as the travel times divided by the horizontal distance between the injection point and the monitoring well, are presented for selected monitoring-well intervals in appendix 1.

Table 1. Construction and hydrologic information for selected test wells, Indian Point Energy Center site, Buchanan, New York.

[USGS well ID, test-well identification number assigned by U.S. Geological Survey ("We" indicates Westchester County); site well ID, test-well identification number assigned by site owner (RW, recovery well; MW, monitoring well); altitude, altitude of land surface, in feet above National Geodetic Vertical Datum of 1929; well depth and casing depth in feet below land surface; water-level depth, depth to water level during ambient flow logging, in feet below land surface; pumped rate, discharge rate during pumped flow logging, in gallons per minute; drawdown, quasi-steady-state drawdown during pumped flow logging, in feet; specific capacity, in gallons per minute per foot of drawdown; --, no data]

USGS well ID	Site well ID	Altitude	Well depth	Casing depth	Water-level depth	Pumped rate	Drawdown	Specific capacity
We-3472	RW-1	76	134	5	63	0.60	1.93	0.31
We-3473	MW-30	76	84	29	40.5	a	--	--
We-3474	MW-31	77	87	5.5	32	.48	b	--
We-3475	MW-32	79	196	8	37	.25	0.50	.50
We-3476	MW-34	19	30	5	8.3	.48	c	--
We-3477	MW-35	19	30	7.5	8.7	.45	d	--
We-3478	MW-39	82	199	23	54	.45	.49	.92
We-3479	MW-40	75	192	7	15	.5	.15	3.33
We-3480	MW-46	17	32	6	7	.42	2.10	.20
We-3481	MW-51	70	200	20.5	28	.75	4.58	.16
We-3482	MW-52	17	197	13	12	--	d	--
We-3483	MW-53	70	124	30	58	.44	3.75	.12
We-3484	MW-54	15	205	20.5	7	.77	1.28	.60
We-3485	MW-55	18	77	12	10	.71	.97	.73
We-3486	MW-56	70	87	30.5	47.5	.43	.92	.47
We-3487	MW-57	15	31	6	5.3	.41	.34	1.21
We-3488	MW-58	15	71	14	6	.60	2.35	.26
We-3489	MW-59	15	77	18	13	.67	.40	1.68
We-3490	MW-60	14	202	8.5	10	.52	3.75	.14
We-3491	MW-62	15	200	40.5	11.5	.43	3.94	.11
We-3492	MW-63	14	193	36	12.5	.58	.05	11.6
We-3493	MW-65	70	82	34	35.5	.15	3.95	.04
We-3494	MW-66	14	200	37.5	13	.54	.55	.98
We-3495	MW-67	15	340	32.5	13.5	.54	.52	1.04

[a]Not pumped because water was added previously for acoustic-televiewer logging.

[b]Zero drawdown reported; drawdown assumed to be 0.25 feet for flow-log analysis.

[c]Drawdown not measured.

[d]Water level dropped rapidly and pumped rate was not sustained.

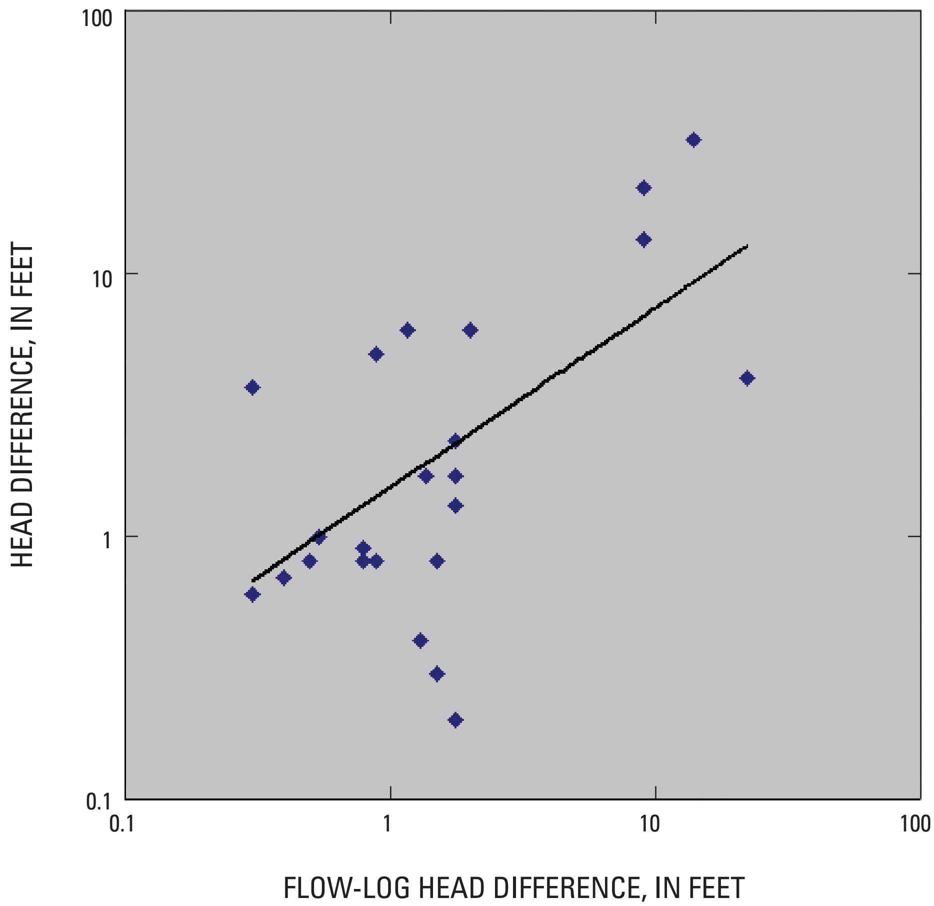


Figure 7. Relation between hydraulic-head difference of flow zones penetrated by selected test wells estimated from flow-log analysis and measured in monitoring-well intervals.

Summary

Flow logs from selected test wells at the Indian Point Energy Center in Buchanan, New York, were analyzed as part of the hydraulic characterization of the metamorphosed and fractured carbonate bedrock underlying the site. The flow logs collected under ambient and quasi-steady-state pumped conditions were analyzed along with caliper, optical- and acoustic-televiewer, fluid-resistivity, and temperature logs to determine the character and distribution of flow zones. Many flow zones were associated with subhorizontal to shallow-dipping fractured zones, southeast-dipping bedding fractures, northwest-dipping orthogonal fractures, or combinations of bedding and orthogonal fractures. The transmissivity and hydraulic head of the flow zones were estimated by matching measured and modeled ambient and pumped flows. Flow-log analysis generally provided reasonable first-order estimates of flow-zone transmissivity and head differences compared with the results of conventional hydraulic-test analysis and measurements. Selected results of an aquifer test and a tracer test provided corroborating information in support of the flow-log analysis.

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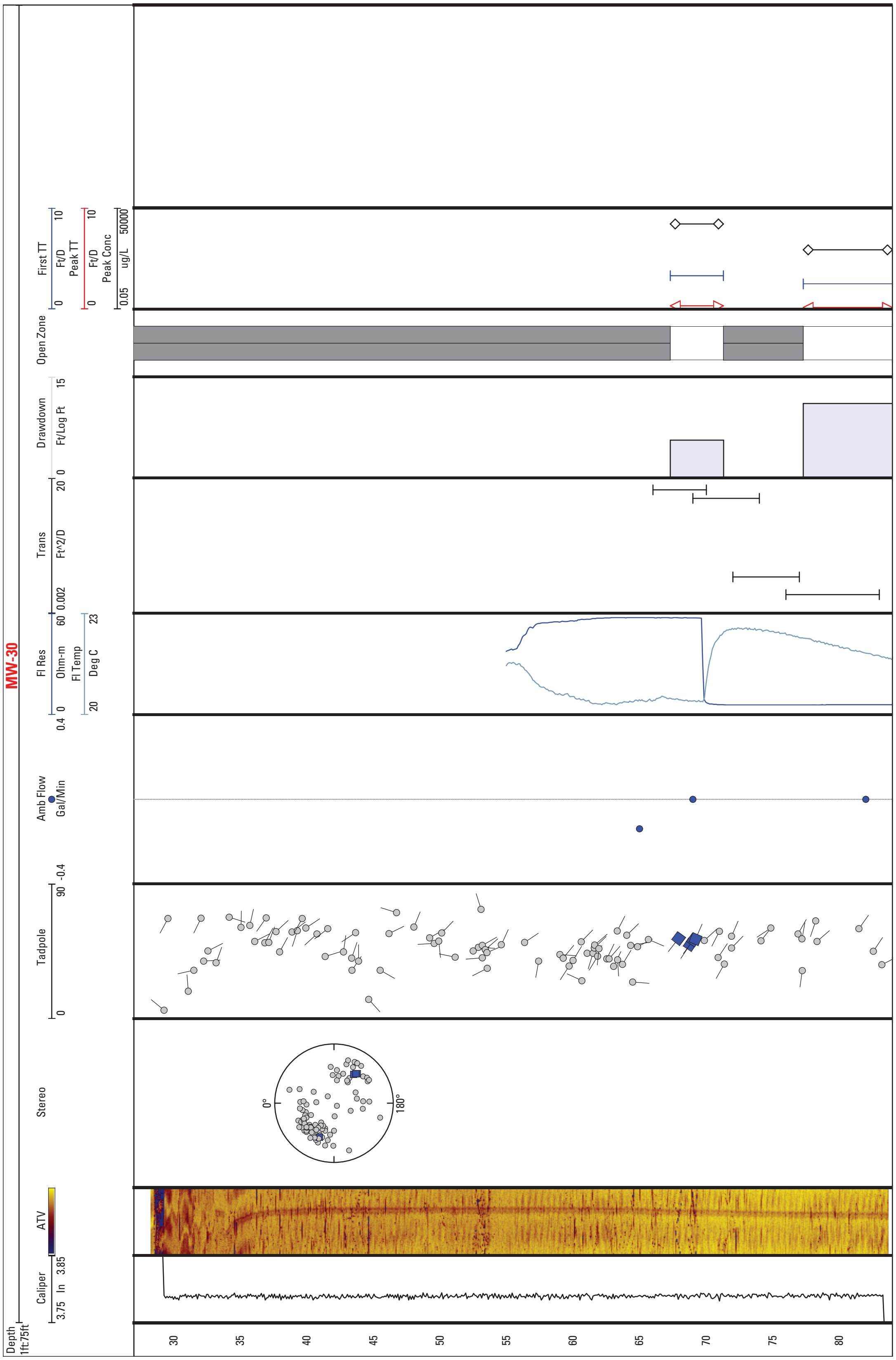
Appendix 1. Composites of Geophysical Logs, Transmissivity and Hydraulic-Head Difference Estimates and Measurements, and Selected Aquifer- and Tracer-Test Results for the Test Wells, Indian Point Energy Center Site, Buchanan, New York.

Explanation

MW-30	Site well identifier
Depth	Depth, in feet below land surface
Caliper	Caliper collected by Geophysical Applications, Inc. (GAI); borehole diameter in inches
OTV	Optical televiewer collected by GAI; 360-degree optical image of borehole wall oriented to True Geographic North
ATV	Acoustic televiewer collected by GAI; 360-degree acoustic image of borehole wall oriented to True Geographic North
Stereo	Lower-hemisphere, Schmidt stereo plot of planar fracture and bedding features oriented to True Geographic North; gray disk indicates features picked by GAI; blue box indicates hydraulically active fracture based on USGS flow-log analysis
Tadpole	Tadpole plot of planar fracture and bedding features oriented to True Geographic North; body of tadpole indicates dip angle and tail indicates dip direction; gray disk indicates features picked by GAI; blue box indicates hydraulically active fracture based on USGS flow-log analysis
Amb Flow	Ambient flow, in gallons per minute; blue disk indicates flow measurement collected by GAI with heat-pulse flowmeter at specified depth; blue line indicates modeled flow based on USGS analysis
Pmp Flow	Pumped flow, in gallons per minute; red circle indicates flow measurement collected by GAI with heat-pulse flowmeter at specified depth; red line indicates modeled flow based on USGS flow-log analysis
Fl Res	Fluid resistivity collected by GAI, in ohms per meter
Fl Temp	Temperature collected by GAI, in degrees Celsius
Trans	Transmissivity of straddle-packed or monitored-well interval as reported by Barvenik and others (2008), in feet squared per day
FL Trans	Transmissivity of flow zone based on USGS flow-log analysis, in feet squared per day
Head Diff	Hydraulic-head difference between monitored-well intervals as reported by Winslow and others (2008), in
FL Head Diff	Hydraulic-head difference between flow zones based on USGS flow-log analysis, in feet
Drawdown	Maximum observed drawdown divided by log distance between the monitoring well and the pumped well (RW-1), in feet divided by log feet; ND indicates no observed drawdown
Open Zone	Open zone of monitoring-well installation
First TT	Travel velocity of first arrival of tracer, in feet per day
Peak TT	Travel velocity of peak arrival of tracer, in feet per day
Peak Conc	Peak concentration of tracer, in micrograms per liter; ND indicates non-detect


MW-30
Depth 1ft:75ft
Caliper
3.75 In 3.85
ATV
Stereo
0°
180°
Tadpole
0 90
Amb Flow
-0.4 Gal/Min 0.4
Fl Res
0 Ohm-m 60
Fl Temp
20 Deg C 23
Trans
0.002 Ft^2/D 20
Drawdown
0 Ft/Log Ft 15
Open Zone
First TT
0 Ft/D 10
Peak TT
0 Ft/D 10
Peak Conc
0.05 ug/L 50000
30
35
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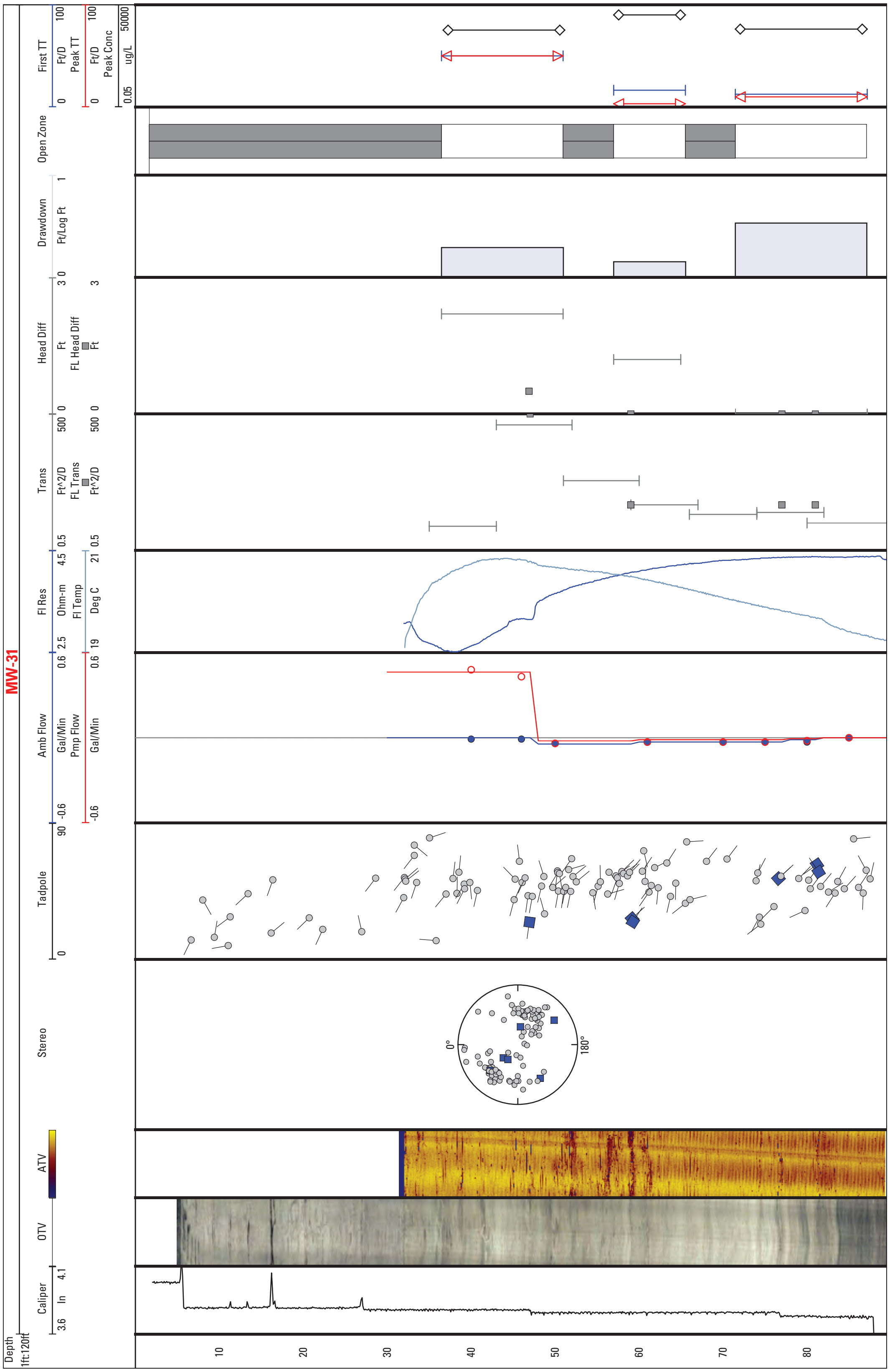
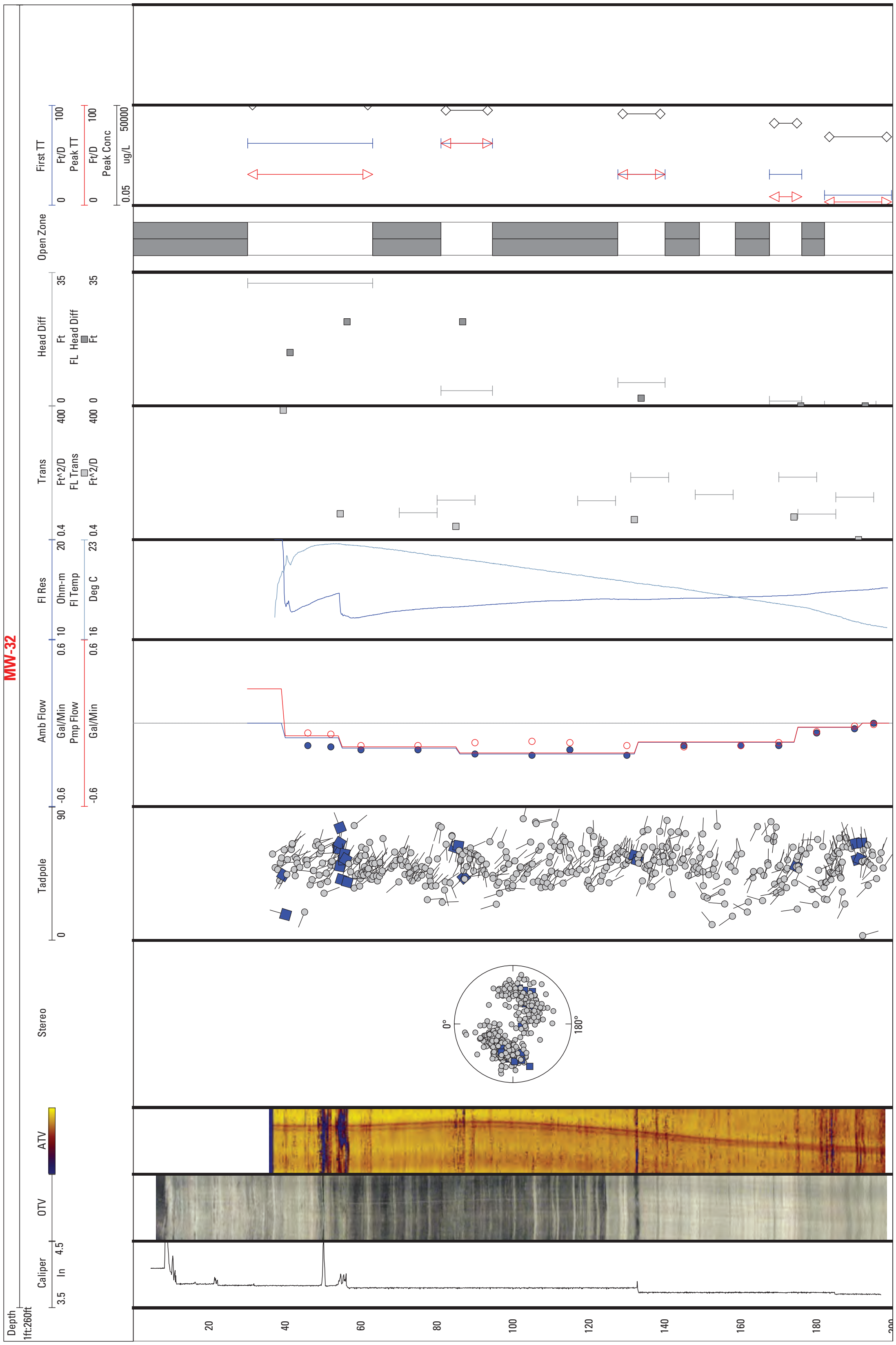
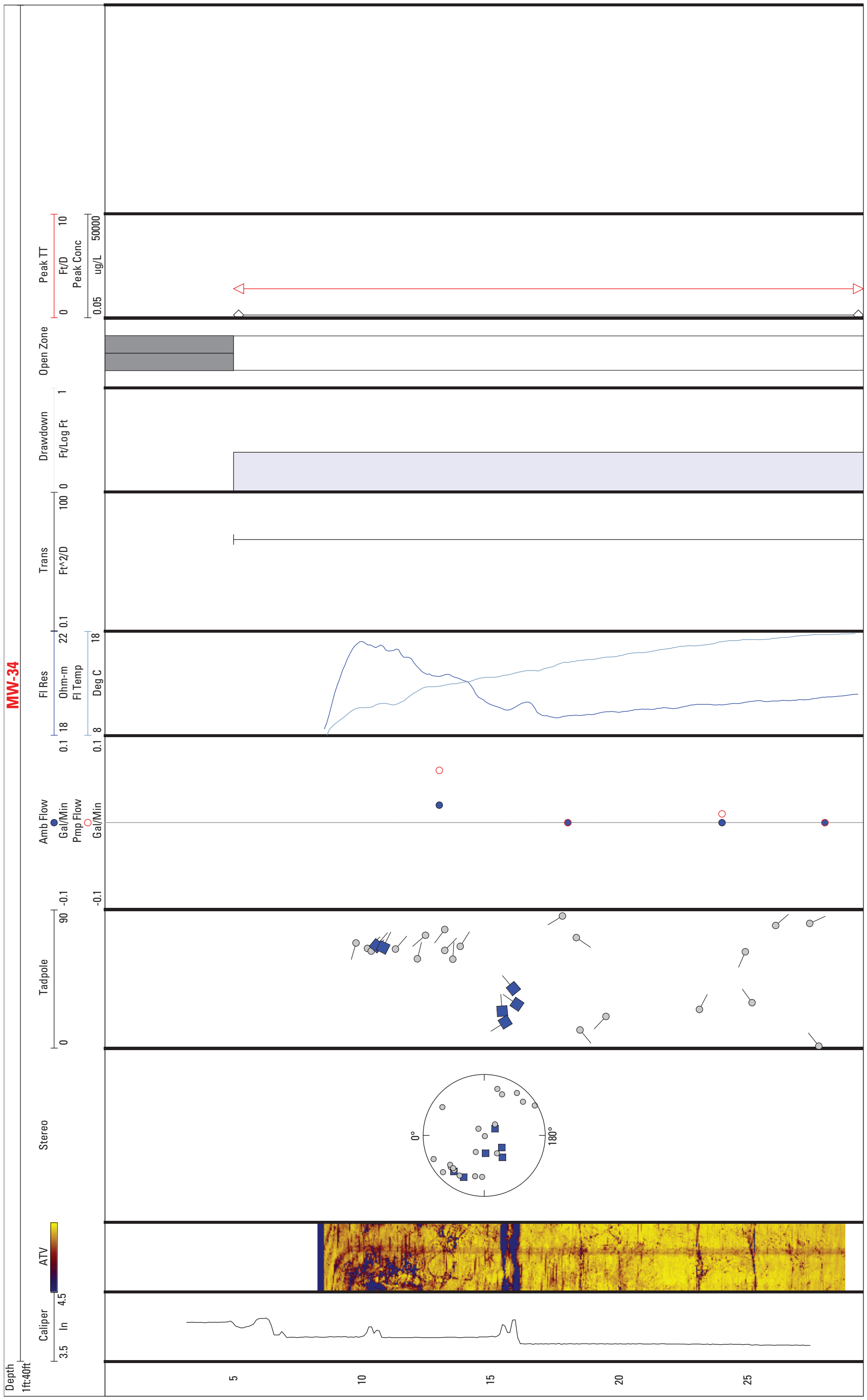
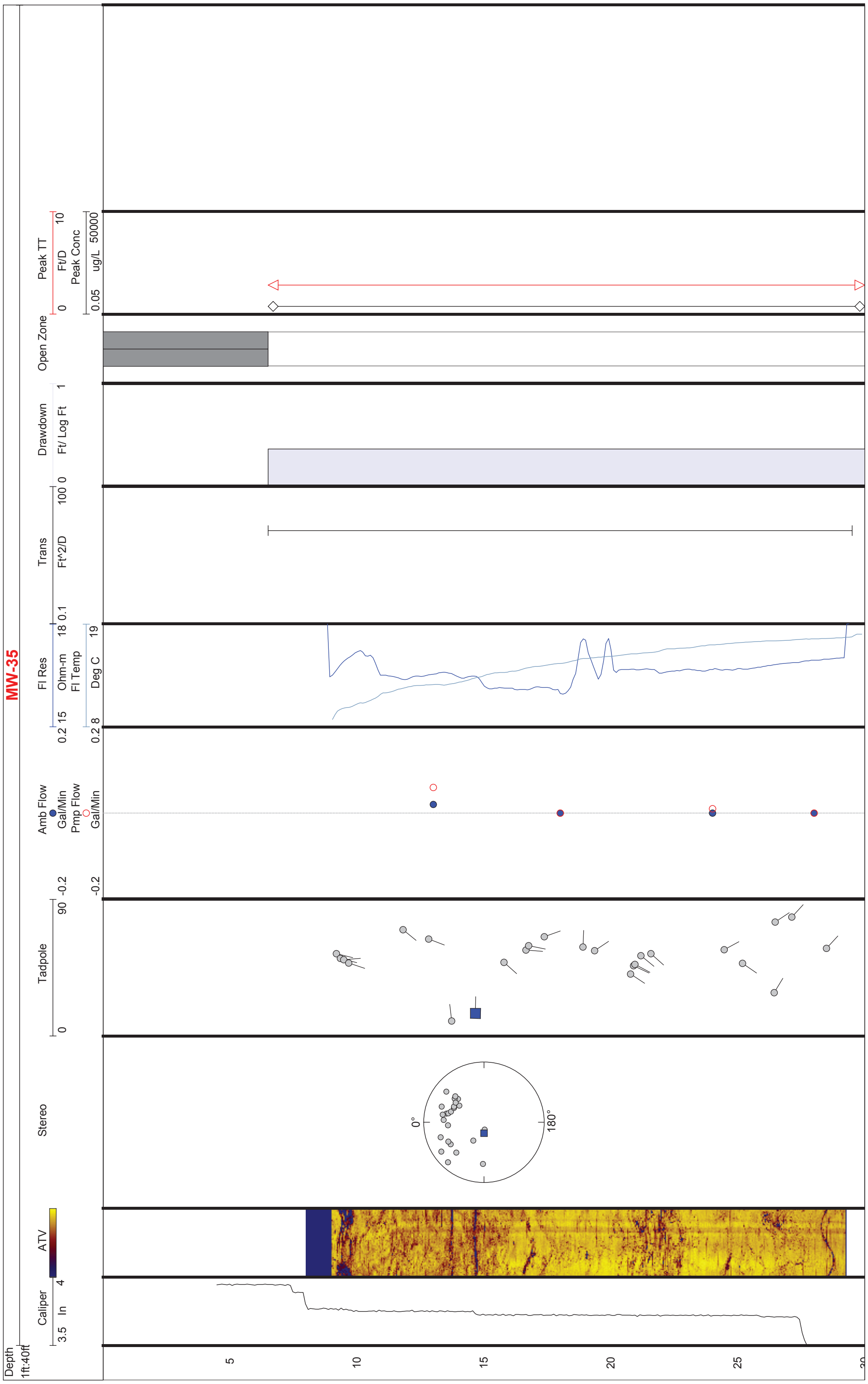
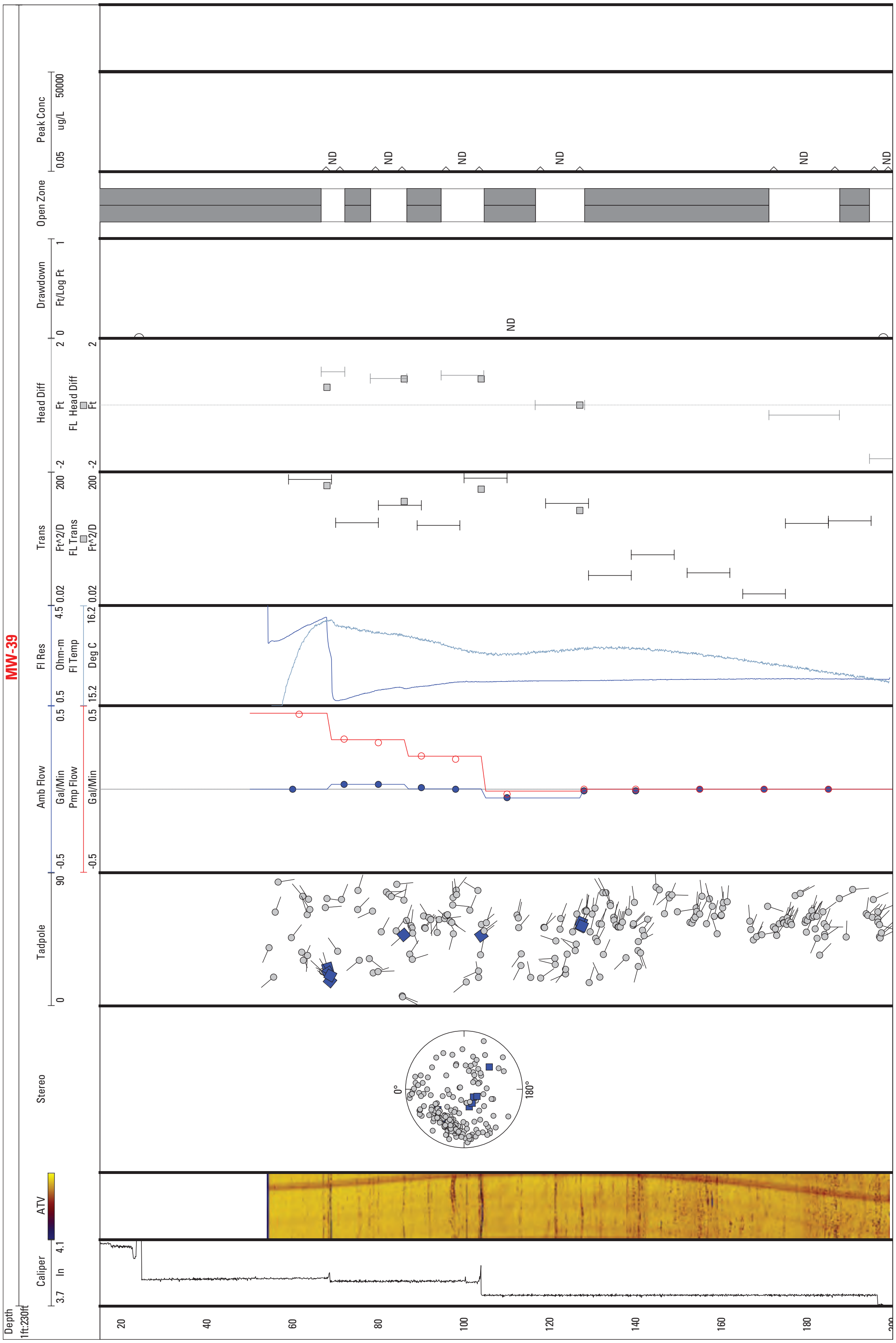
75
80


MW-31
Depth
1ft:120ft
Caliper
3.6 In 4.1
OTV
ATV
Stereo
0°
180°
Tadpole
0 90
Amb Flow
-0.6 Gal/Min 0.6
Pmp Flow
-0.6 Gal/Min 0.6
Fl Res
2.5 Ohm-m 4.5
Fl Temp
19 Deg C 21
Trans
0.5 Ft^2/D 500
FL Trans
0.5 Ft^2/D 500
Head Diff
0 Ft 3
FL Head Diff
0 Ft 3
Drawdown
0 Ft/Log Ft 1
Open Zone
First TT
0 Ft/D 100
Peak TT
0 Ft/D 100
Peak Conc
0.05 ug/L 50000
10
20
30
40
50
60
70
80

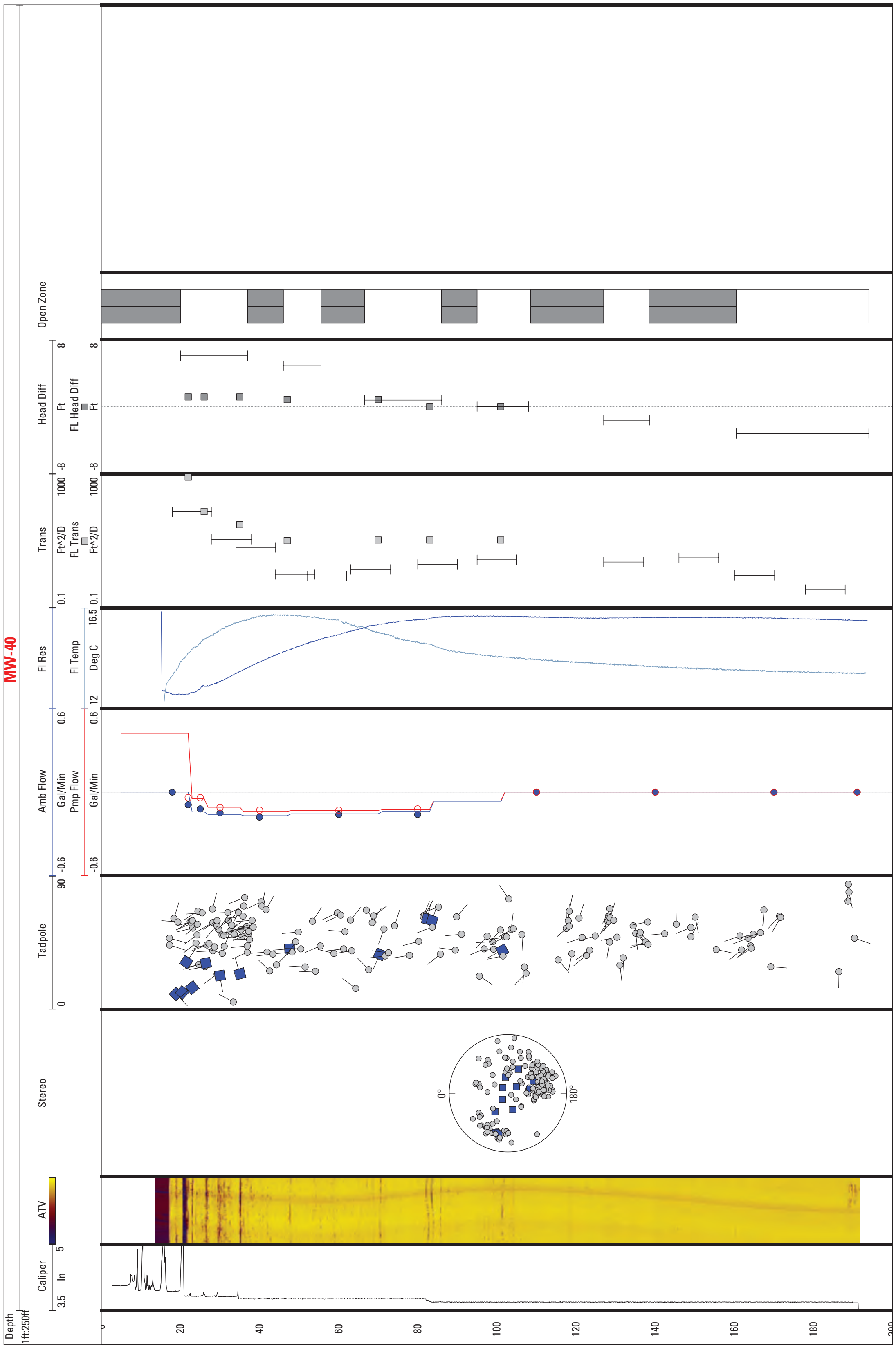

MW-32
Depth
1ft:260ft
Caliper
3.5 In 4.5
OTV
ATV
Stereo
0°
180°
Tadpole
0 90
Amb Flow
-0.6 Gal/Min 0.6
Pmp Flow
-0.6 Gal/Min 0.6
Fl Res
10 Ohm-m 20
Fl Temp
16 Deg C 23
Trans
0.4 Ft^2/D 400
FL Trans
0.4 Ft^2/D 400
Head Diff
0 Ft 35
FL Head Diff
0 Ft 35
Open Zone
First TT
0 Ft/D 100
Peak TT
0 Ft/D 100
Peak Conc
0.05 ug/L 50000
20
40
60
80
100
120
140
160
180

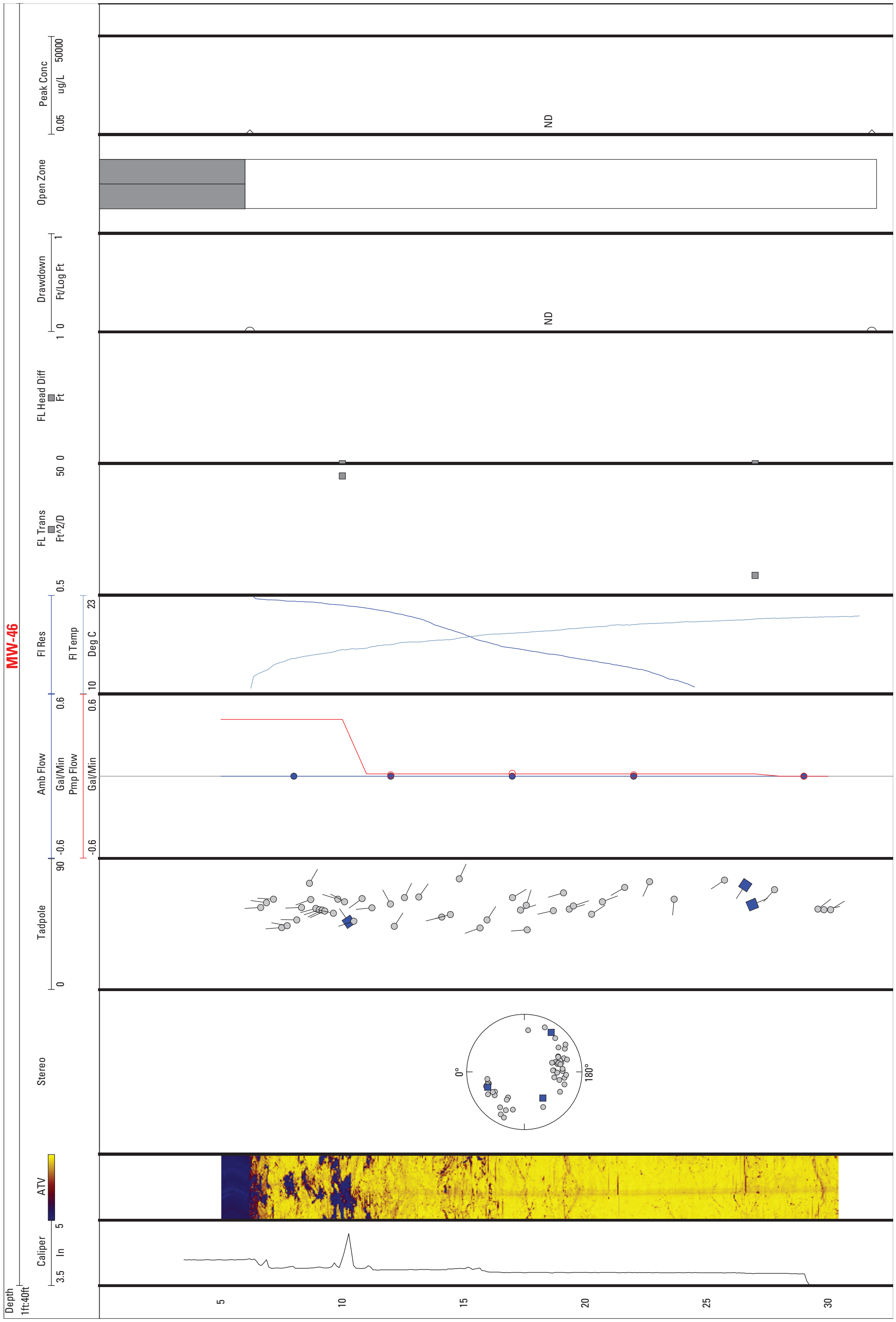

MW-34
Depth
1ft:40ft
Caliper
In
3.5
4.5
ATV
Stereo
0°
180°
Tadpole
0
90
Amb Flow
Gal/Min
Pmp Flow
Gal/Min
0.1
-0.1
Fl Res
Ohm-m
0.1
18
22
Fl Temp
Deg C
8
18
Trans
Ft^2/D
0.1
100
Drawdown
Ft/Log Ft
0
1
Open Zone
Peak TT
Ft/D
0
10
Peak Conc
ug/L
0.05
50000
5
10
15
20
25

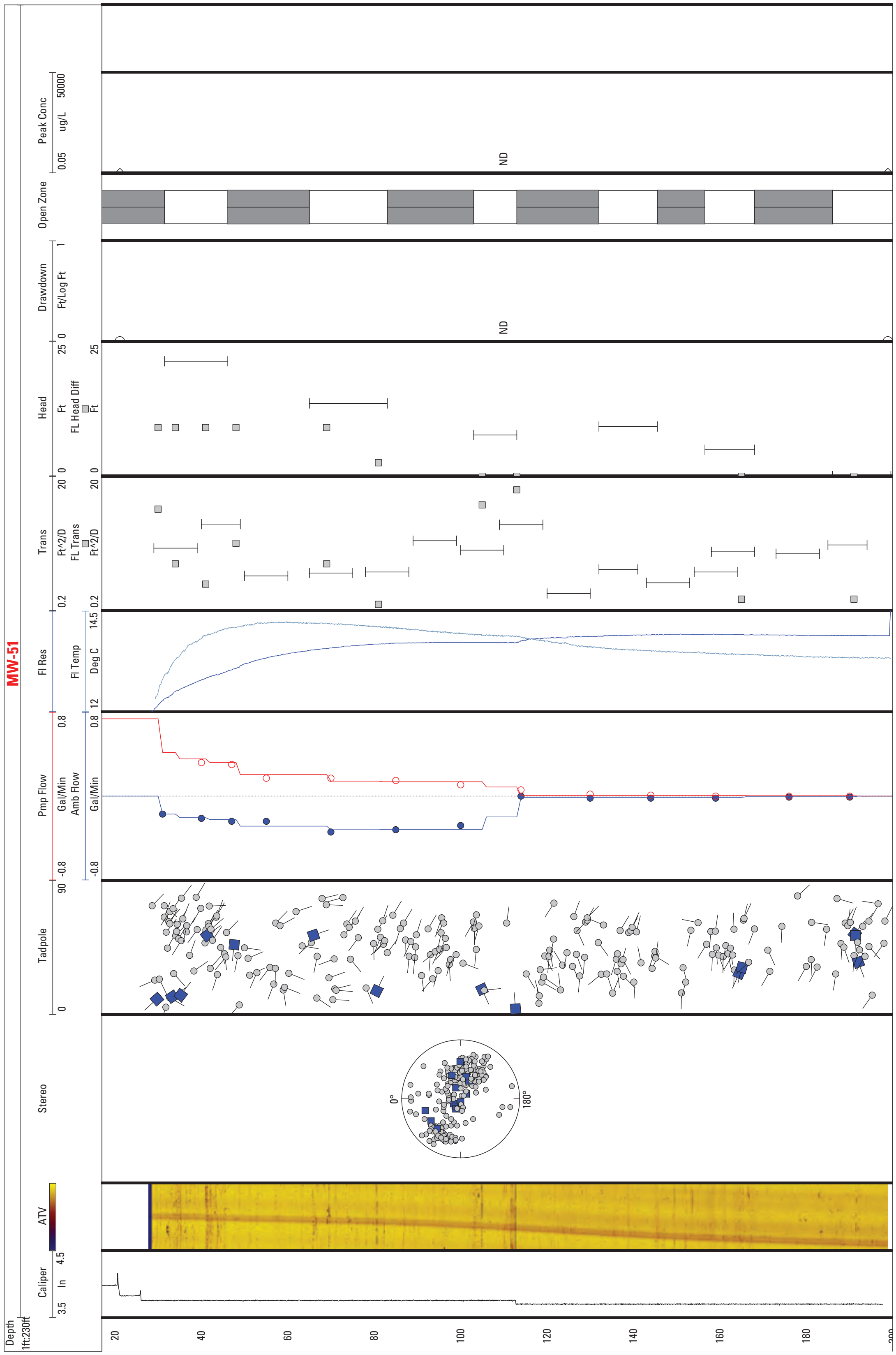

MW-35
Depth 1ft:40ft
Caliper
3.5 In 4
ATV
Stereo
0°
180°
Tadpole
0 90
Amb Flow Gal/Min
Pmp Flow Gal/Min
-0.2 0.2
Fl Res Ohm-m 0.2 15 18
Fl Temp Deg C 8 19
Trans Ft^2/D 0.1 100
Drawdown Ft/ Log Ft 0 1
Open Zone
Peak TT Ft/D 0 10
Peak Conc ug/L 0.05 50000
5
10
15
20
25
30

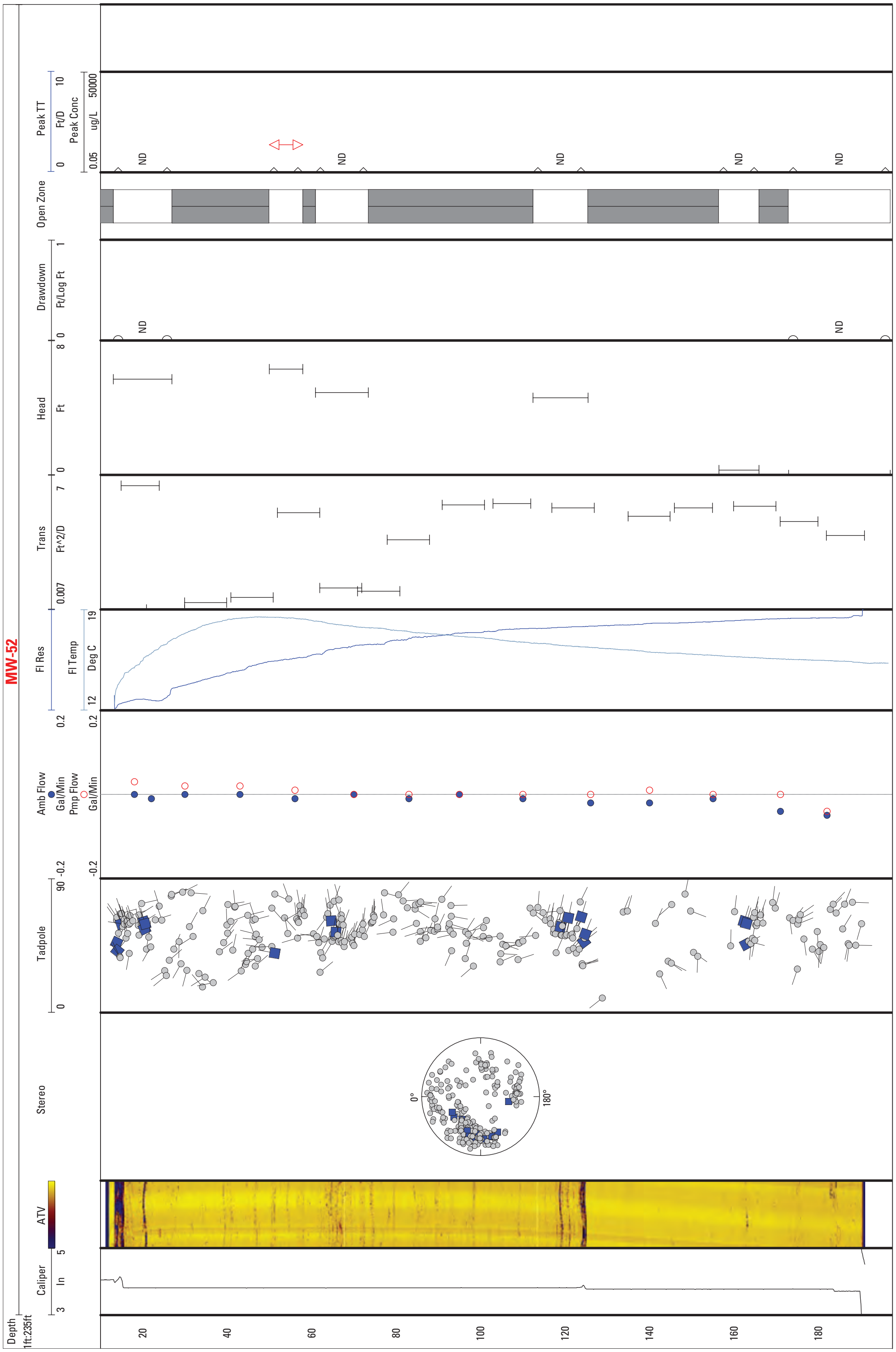


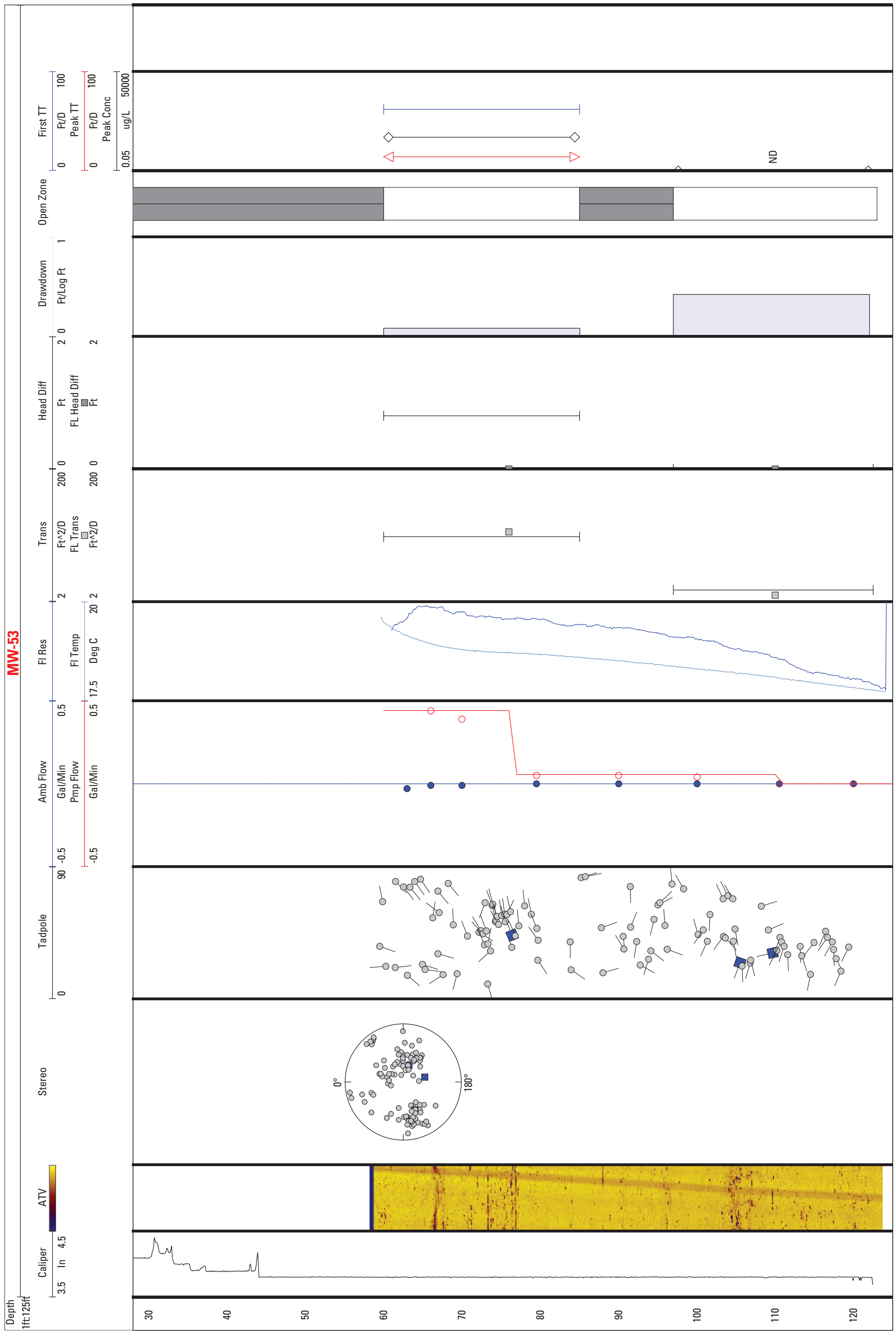
MW-39
Peak Conc
ug/L
0.05
50000
ND
Open Zone
Drawdown
Ft/Log Ft
Head Diff
Ft
FL Head Diff
Trans
Ft^2/D
FL Trans
Fl Res
Ohm-m
Fl Temp
Deg C
Amb Flow
Gal/Min
Pmp Flow
Tadpole
Stereo
0°
180°
ATV
Caliper
In
Depth
1ft:230ft

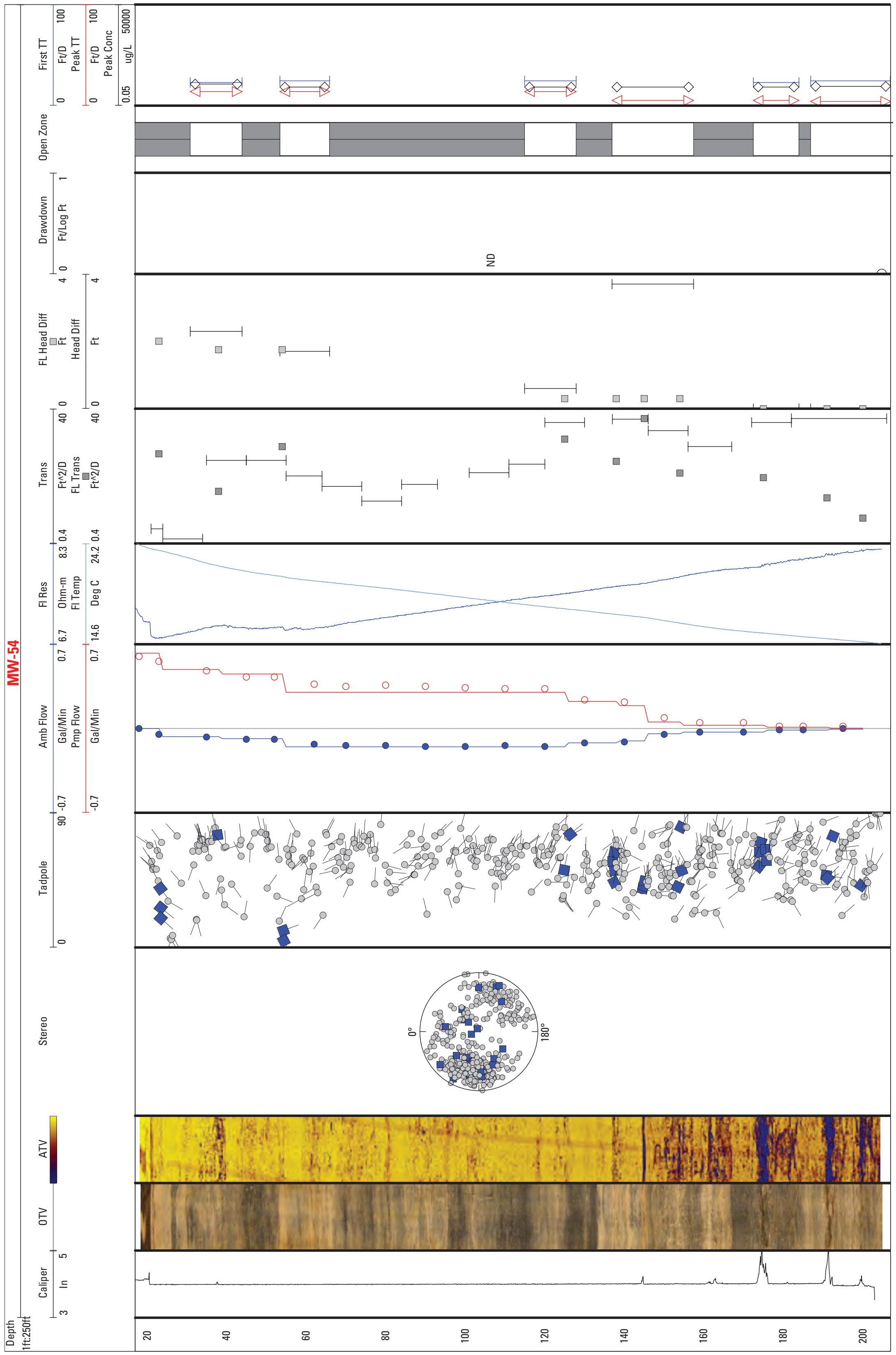

MW-40
Depth
1ft:250ft
Caliper
3.5 In 5
ATV
Stereo
0°
180°
Tadpole
0 90
Amb Flow
-0.6 Gal/Min 0.6
Pmp Flow
-0.6 Gal/Min 0.6
Fl Res
Fl Temp
12 Deg C 16.5
Trans
0.1 Ft^2/D 1000
FL Trans
0.1 Ft^2/D 1000
Head Diff
-8 Ft 8
FL Head Diff
-8 Ft 8
Open Zone
20
40
60
80
100
120
140
160
180

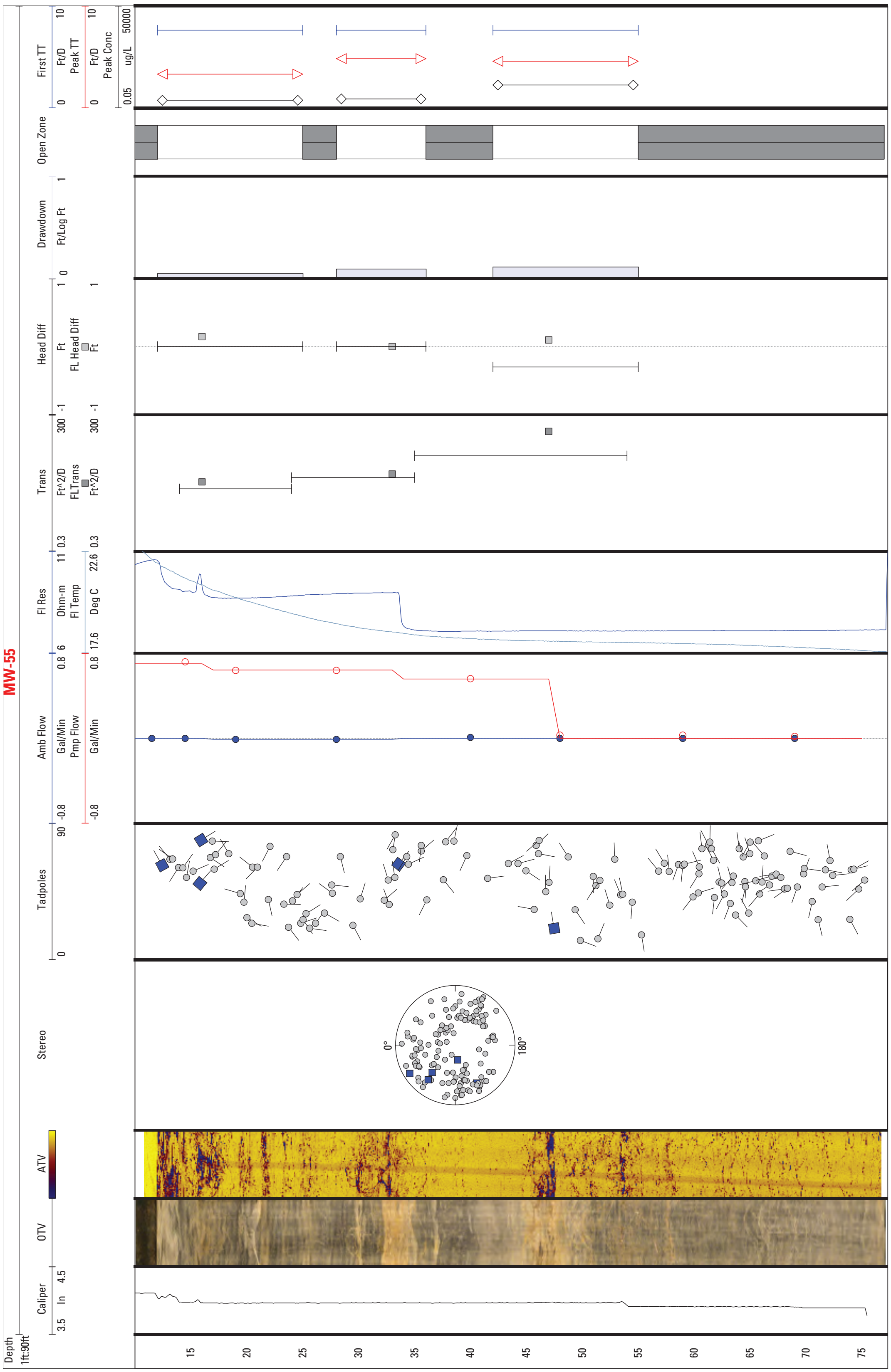

MW-46
Depth
1ft:40ft
Caliper
3.5 In 5
ATV
Stereo
0°
180°
Tadpole
0 90
Amb Flow
Gal/Min
-0.6 0.6
Pmp Flow
Gal/Min
-0.6 0.6
Fl Res
Fl Temp
Deg C
10 23
FL Trans
Ft^2/D
0.5 50
FL Head Diff
Ft
0
Drawdown
Ft/Log Ft
1 0 1
ND
Open Zone
Peak Conc
ug/L
0.05 50000
ND
5
10
15
20
25
30

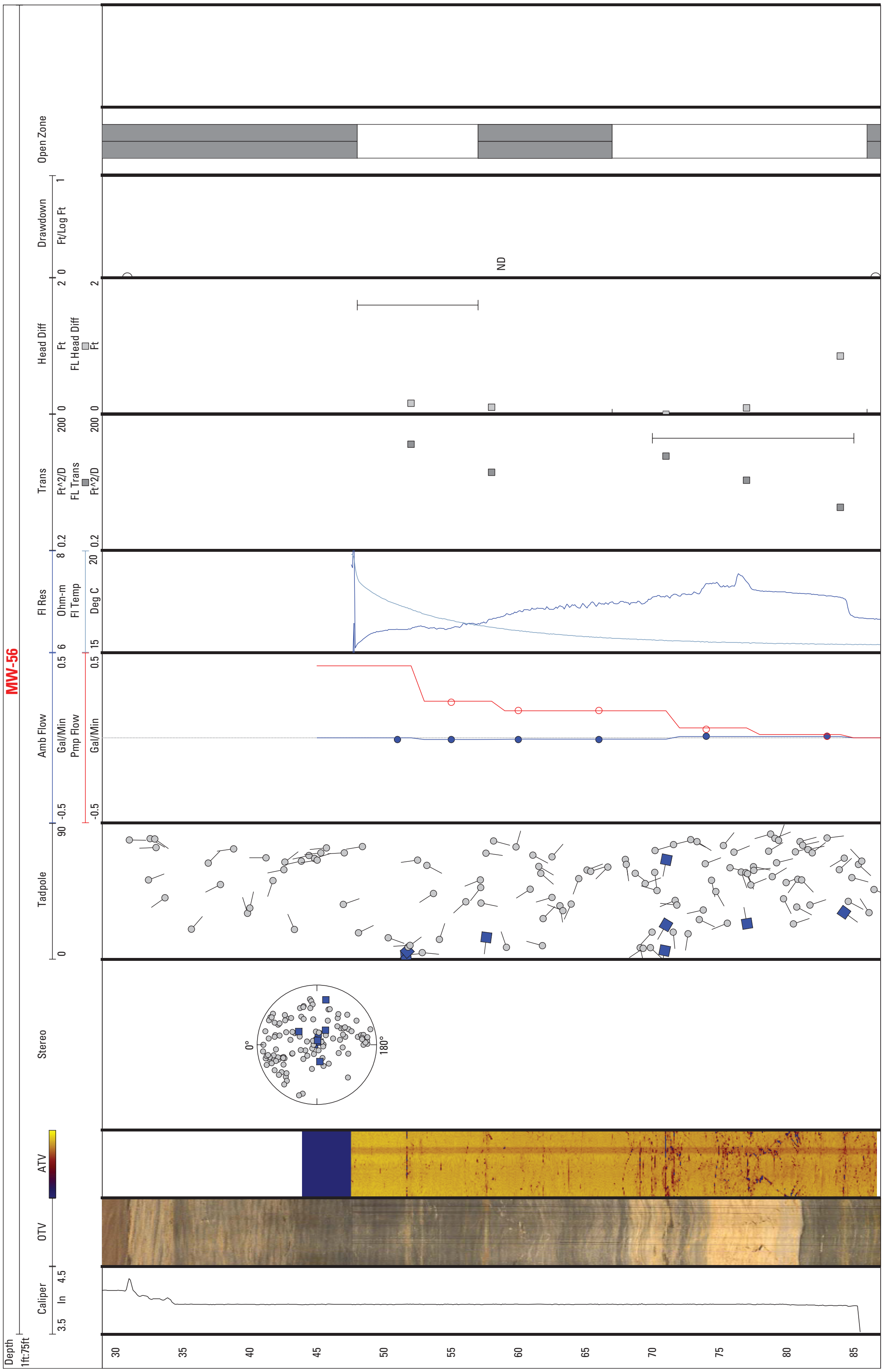

MW-51
Depth 1ft:230ft
Caliper 3.5 In 4.5
ATV
Stereo
0°
180°
Tadpole 0 90
Pmp Flow -0.8 Gal/Min 0.8
Amb Flow -0.8 Gal/Min 0.8
Fl Res
Fl Temp 12 Deg C 14.5
Trans 0.2 Ft^2/D 20
FL Trans 0.2 Ft^2/D 20
Head 0 Ft 25
FL Head Diff 0 Ft 25
Drawdown 0 Ft/Log Ft 1
ND
Open Zone
Peak Conc 0.05 ug/L 50000
ND
20
40
60
80
100
120
140
160
180

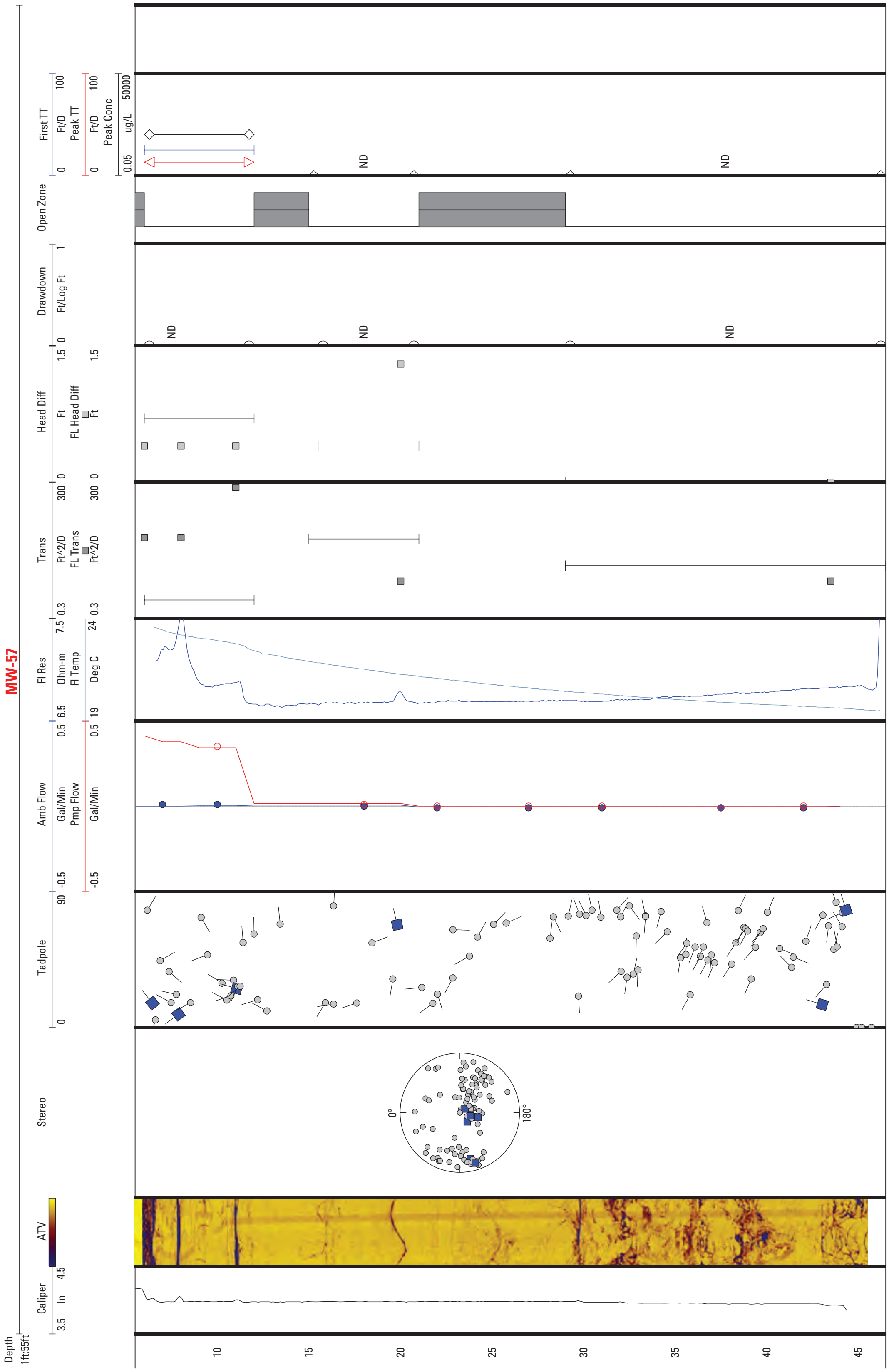

MW-52
Depth
1ft:235ft
Caliper
In
3
5
ATV
Stereo
0°
180°
Tadpole
0
90
Amb Flow
Gal/Min
Pmp Flow
Gal/Min
-0.2
0.2
Fl Res
Fl Temp
Deg C
12
19
Trans
Ft^2/D
0.007
7
Head
Ft
0
8
Drawdown
Ft/Log Ft
0
1
Open Zone
Peak TT
Ft/D
Peak Conc
ug/L
0.05
50000
10
ND
20
40
60
80
100
120
140
160
180

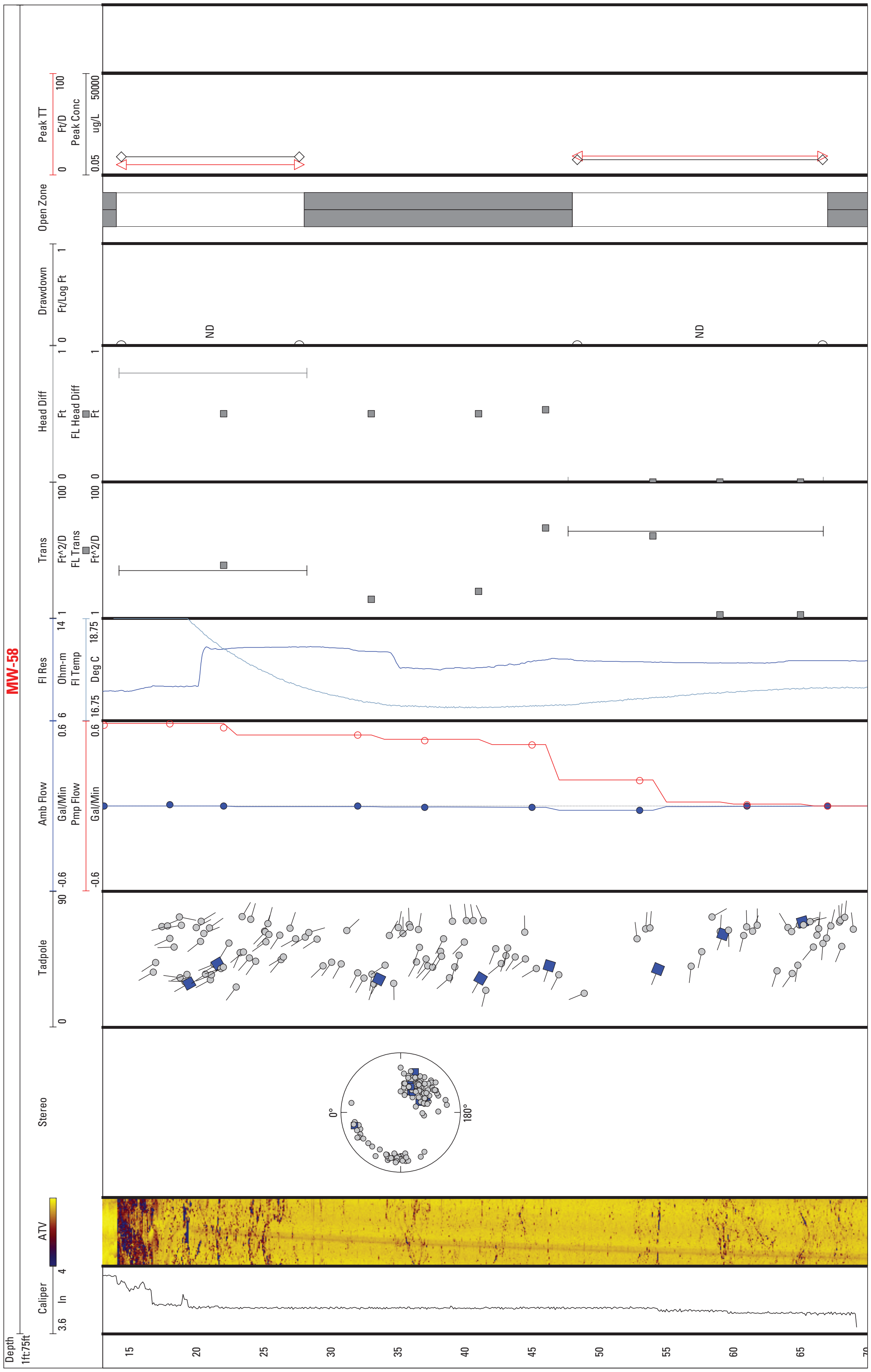

MW-53
Depth 1ft:125ft
Caliper 3.5 In 4.5
ATV
Stereo
0°
180°
Tadpole 0 90
Amb Flow -0.5 Gal/Min 0.5
Pmp Flow -0.5 Gal/Min 0.5
Fl Res 0.5 2
Fl Temp 17.5 Deg C 20
Trans 2 Ft^2/D 200
FL Trans 2 Ft^2/D 200
Head Diff 0 Ft 2
FL Head Diff 0 Ft 2
Drawdown 0 Ft/Log Ft 1
Open Zone
First TT 0 Ft/D 100
Peak TT 0 Ft/D 100
Peak Conc 0.05 ug/L 50000
ND
30
40
50
60
70
80
90
100
110
120

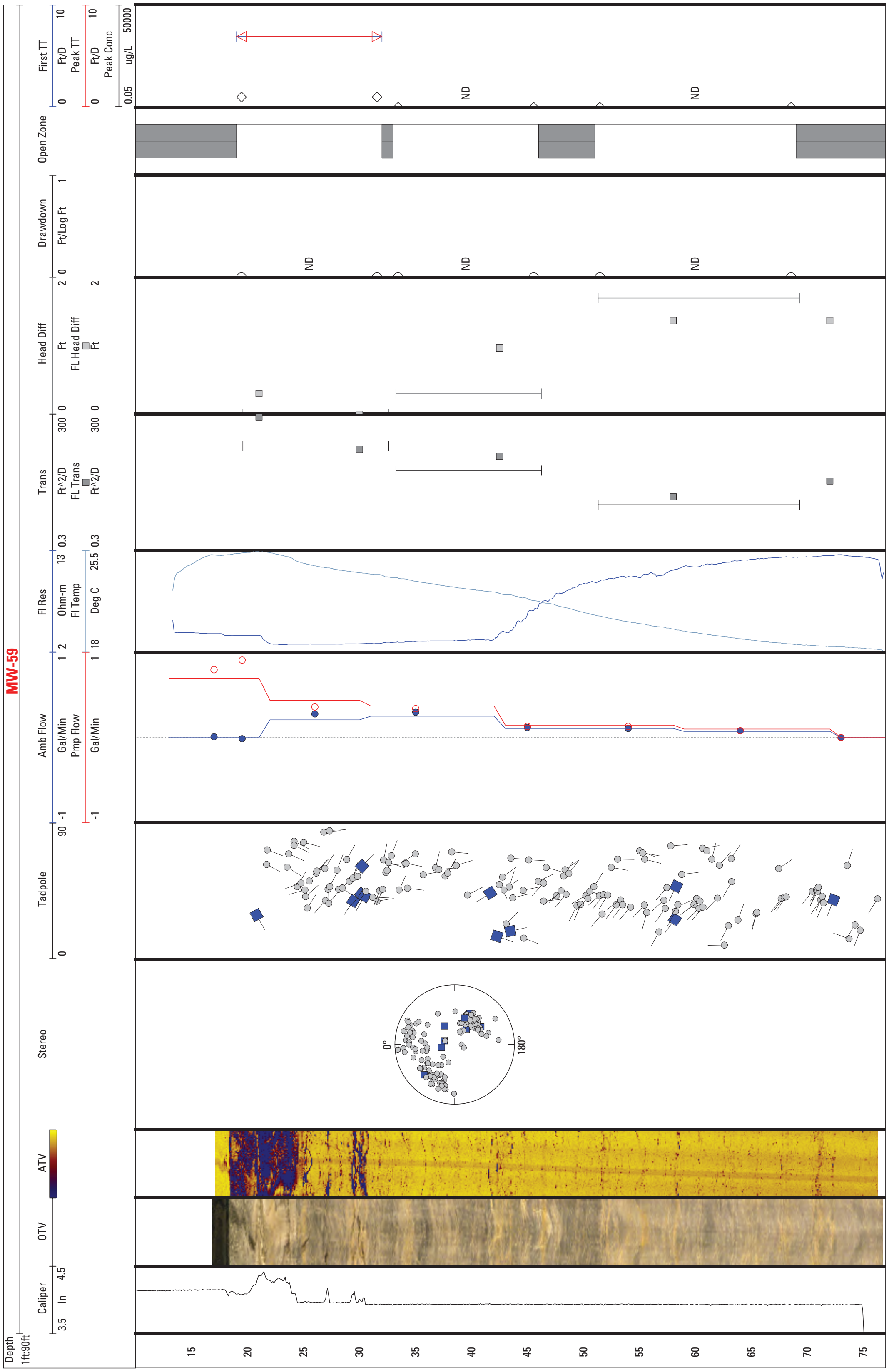

MW-54
Depth
1ft:250ft
Caliper
In
3
5
OTV
ATV
Stereo
0°
180°
Tadpole
0
90
Amb Flow
Gal/Min
-0.7
0.7
Pmp Flow
Gal/Min
-0.7
0.7
Fl Res
Ohm-m
6.7
8.3
Fl Temp
Deg C
14.6
24.2
Trans
Ft^2/D
0.4
40
FL Trans
Ft^2/D
0.4
40
FL Head Diff
Ft
0
4
Head Diff
Ft
0
4
Drawdown
Ft/Log Ft
0
1
ND
Open Zone
First TT
Ft/D
0
100
Peak TT
Ft/D
0
100
Peak Conc
ug/L
0.05
50000
20
40
60
80
100
120
140
160
180
200

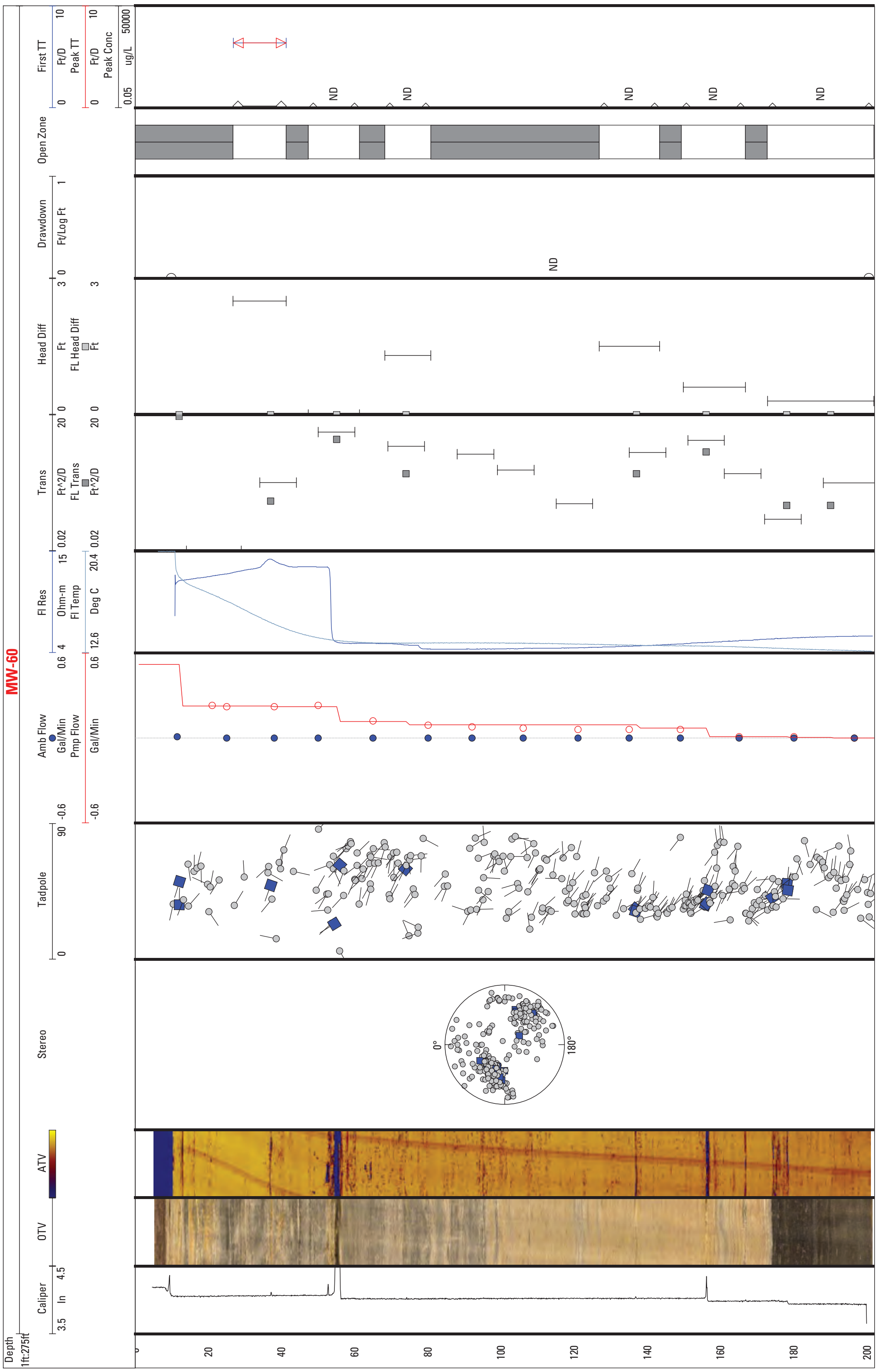

MW-55
Depth
1ft:90ft
First TT
Ft/D
0
10
Peak TT
Ft/D
Peak Conc
ug/L
0.05
50000
Open Zone
Drawdown
Ft/Log Ft
0
1
Head Diff
Ft
FL Head Diff
-1
1
Trans
Ft^2/D
FLTrans
0.3
300
Fl Res
Ohm-m
6
11
Fl Temp
Deg C
17.6
22.6
Amb Flow
Gal/Min
-0.8
0.8
Pmp Flow
Tadpoles
0
90
Stereo
0°
180°
ATV
OTV
Caliper
In
3.5
4.5
15
20
25
30
35
40
45
50
55
60
65
70
75

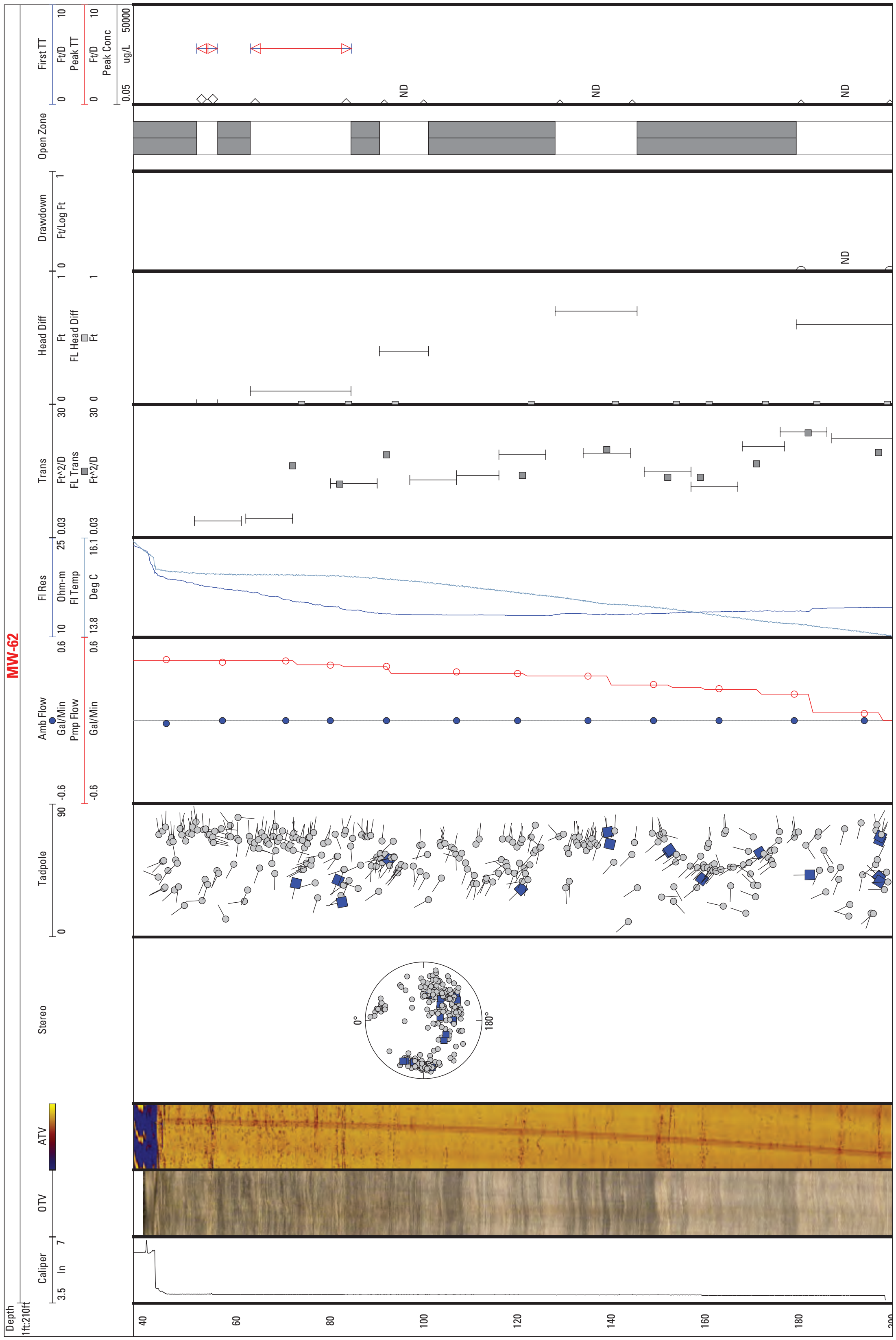

MW-56
Depth
1ft:75ft
Caliper
3.5 In 4.5
OTV
ATV
Stereo
0°
180°
Tadpole
0 90
Amb Flow
-0.5 Gal/Min 0.5
Pmp Flow
-0.5 Gal/Min 0.5
Fl Res
6 Ohm-m 8
Fl Temp
15 Deg C 20
Trans
0.2 Ft^2/D 200
FL Trans
0.2 Ft^2/D 200
Head Diff
0 Ft 2
FL Head Diff
0 Ft 2
Drawdown
0 Ft/Log Ft 1
ND
Open Zone
30
35
40
45
50
55
60
65
70
75
80
85


MW-57
Depth
1ft:55ft
Caliper
3.5 In 4.5
ATV
Stereo
0°
180°
Tadpole
0 90
Amb Flow
-0.5 Gal/Min 0.5
Pmp Flow
-0.5 Gal/Min 0.5
Fl Res
6.5 Ohm-m 7.5
Fl Temp
19 Deg C 24
Trans
0.3 Ft^2/D 300
FL Trans
0.3 Ft^2/D 300
Head Diff
0 Ft 1.5
FL Head Diff
0 Ft 1.5
Drawdown
0 Ft/Log Ft 1
Open Zone
First TT
0 Ft/D 100
Peak TT
0 Ft/D 100
Peak Conc
0.05 ug/L 50000
ND
10
15
20
25
30
35
40
45


MW-58
Peak TT
Ft/D
Peak Conc
ug/L
Open Zone
Drawdown
Ft/Log Ft
ND
Head Diff
Ft
FL Head Diff
Trans
Ft^2/D
FL Trans
Fl Res
Ohm-m
Fl Temp
Deg C
Amb Flow
Gal/Min
Pmp Flow
Tadpole
Stereo
0°
180°
ATV
Caliper
In
Depth
1ft:75ft
15
20
25
30
35
40
45
50
55
60
65


MW-59
First TT
Ft/D
Peak TT
Ft/D
Peak Conc
ug/L
Open Zone
Drawdown
Ft/Log Ft
Head Diff
Ft
FL Head Diff
Ft
Trans
Ft^2/D
FL Trans
Ft^2/D
Fl Res
Ohm-m
Fl Temp
Deg C
Amb Flow
Gal/Min
Pmp Flow
Gal/Min
Tadpole
Stereo
0°
180°
ATV
OTV
Caliper
In
Depth
1ft:90ft
ND
15
20
25
30
35
40
45
50
55
60
65
70
75


MW-60
Depth
1ft:275ft
Caliper
3.5 In 4.5
OTV
ATV
Stereo
0°
180°
Tadpole
0 90
Amb Flow
Gal/Min
Pmp Flow
Gal/Min
-0.6 0.6
Fl Res
Ohm-m
4 15
Fl Temp
Deg C
12.6 20.4
Trans
Ft^2/D
FL Trans
Ft^2/D
0.02 20
Head Diff
Ft
FL Head Diff
Ft
0 3
Drawdown
Ft/Log Ft
0 1
Open Zone
First TT
Ft/D
Peak TT
Ft/D
0 10
Peak Conc
ug/L
0.05 50000
ND
20
40
60
80
100
120
140
160
180
200


MW-62
Depth 1ft:210ft
Caliper 3.5 In 7
OTV
ATV
Stereo
Tadpole 0 90
Amb Flow Gal/Min -0.6 0.6
Pmp Flow Gal/Min -0.6 0.6
Fl Res Ohm-m 10 25
Fl Temp Deg C 13.8 16.1
Trans Ft^2/D 0.03 30
FL Trans Ft^2/D 0.03 30
Head Diff Ft 0 1
FL Head Diff Ft 0 1
Drawdown Ft/Log Ft 0 1
Open Zone
First TT Ft/D 0 10
Peak TT Ft/D 0 10
Peak Conc ug/L 0.05 50000
ND
0°
180°
40
60
80
100
120
140
160
180
200

For additional information write to:
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U.S. Geological Survey
425 Jordan Road
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(518) 285-5602
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http://ny.water.usgs.gov

Williams, J.H.—Flow-Log Analysis for Hydraulic Characterization of Selected Test Wells at the Indian Point Energy Center, Buchanan, New York—Open-File Report 2008–1123