



June 5, 2014

Richard L. Merhar II
Leidos Engineering, LLC
180 Gordon Drive, Suite 109
Exton, PA 19341

**RE: Results of Borehole Geophysical Logging
Hoff VC HSCA Site, New Hanover Township, PA**

Dear Mr. Merhar,

In response to your request, Earth Data Northeast, Inc. (“EDN”) is pleased to provide Leidos Engineering, LLC (“Leidos”) with the following summary of borehole geophysical logging performed on May 19th and 20th, 2014, in MW-9 and MW-10 located in New Hanover Township, Pennsylvania.

The following geophysical logs and techniques were performed in MW-9 and MW-10:

- Color Borehole Video
- Fluid Temperature / Fluid Conductivity
- 3-Arm Caliper
- Electrical Resistivity Log
 - Spontaneous Potential (“SP”)
 - Single Point Resistance (“SPR”)
 - Long & Short Normal Resistivity
- Natural Gamma
- Acoustic TelevIEWer (“ATV”)
- Heat Pulse Flowmeter (*under ambient conditions only*)

Results of Borehole Geophysical Logging

The findings of the geophysical surveys conducted in MW-9 and MW-10 are summarized below. Copies of the geophysical logs are included within a composite graph, attached as an **Appendix**.

A digital recording of each borehole video survey was placed on a DVD and delivered to Leidos in the field, at the time of logging.

The focus of this report will be to identify and characterize fractured intervals within the open borehole, and zones where fluid of differing quality may be entering or exiting the borehole. Features identified with the acoustic televiewer are presented in graphical format and are also included within the geophysical composite graph (Appendix).

All borehole geophysical logs were referenced from below Ground Surface (“bgs”).

MW-9

The total depth of the borehole was observed to be approximately 220' bgs during the logging. MW-9 was constructed with nominal 6" steel casing to a depth of approximately 38'. The static water level (“SWL”) during the borehole video survey on May 19th was 15.7' bgs.

The fluid temperature log displayed changes in log slope at 22', 30', 33', 35', and 43' bgs. Temperatures ranged from approximately 12.4°C to 15.8°C. The fluid temperature at the bottom of the borehole was 12.5°C.

The fluid conductivity log ranged from approximately 580 $\mu\text{S}/\text{cm}$ to 872 $\mu\text{S}/\text{cm}$. Changes in log slope occurred at 37', 40.5', 44', 87', 132', 141', 146', 148', 152', 157', 167', 204', and 215' bgs.

Borehole diameter changes greater than one (1) inch in size were displayed within the caliper log between 145.5'-147', 148'-149', 159'-160', and 204'-206' bgs. Smaller changes in borehole diameter were also observed at or between 39'-41', 44'-45', 48'- 66', 70'-74', 86'-90', 94'-101', 118', 164'-165', 179'-180', 188', 200'-204', and 216' bgs. The caliper log suggested that the bottom of the steel casing was located at approximately 38' bgs.

Electrical data were consistent with areas of high and low natural gamma readings (corresponding to low and high resistivity values, respectively), as well as the areas that are more heavily fractured (indicated by intervals of lower resistivity values). Resistivity values can also be affected by bed thickness and water quality.

The muted response of the natural gamma log, observed above 38', is likely due to the presence of steel casing.

The acoustic televiewer image produced for MW-9 was analyzed, and 175 features were identified by EDN personnel. The appendix includes an ATV data package that presents a 2-dimensional un-wrapped (“north to north”) view of MW-9, with identified features oriented to True North. More features may exist than were identified.

The MW-9 Polar and Rose diagrams indicated that the majority of the identified features appeared to have a North-Northwest-South-Southeast strike with a dip-azimuth to the West-Southwest, respectively. A secondary grouping of features displayed a North-South strike, with a dip-azimuth to the East.

The results of the heat-pulse flowmeter logging indicated the presence of quantifiable flow under ambient conditions, presented in the table below. A summary of the heat pulse data is also provided alongside the caliper log within the MW-9 composite graph.

HP Flow Stations	Ambient Flow Direction	Flow Rate in GPM
43.5'	No Flow	0.00
67.5'	Upward	0.05
91'	No Flow	0.00
107'	Downward	0.02
121'	Downward	0.05
141'	No Flow	0.00
155'	No Flow	0.00
167'	No Flow	0.00
185'	Upward	0.06
194'	Upward	0.07
211'	Upward	0.04

Inflow zones (water flowing into the borehole) likely exist between 67.5'-91', 91'-121', 194'-211', and 211'-TD. Outflow zones (water flowing into the formation) may exist between 43.5'-67', 121'-141', and 167'-185' bgs.

MW-10

Please note: the depth recorded onscreen during the MW-10 borehole video survey was not referenced from below the ground surface. Depths appear to be approximately 4' shallower than the actual depths encountered. All depths provided below were obtained from the remaining geophysical logs, and are referenced from below the ground surface.

The total depth of the borehole was observed to be approximately 205' bgs during geophysical logging. MW-10 was constructed with nominal 6" steel casing to a depth of approximately 38'. The SWL during the borehole survey on May 20th was approximately 29' bgs.

The fluid temperature log displayed changes in log slope at 37.5', 39.5', 45.5', 50', and 57' bgs. Temperatures ranged from approximately 12.1°C to 18.6°C. The fluid temperature at the bottom of the borehole was 12.4°C.

The fluid conductivity log ranged from approximately 295 µS/cm to 374 µS/cm. Changes in log slope occurred at 35', 40', 51.5', 53'-64', 69', and 73.5' bgs.

Borehole diameter changes greater than one (1) inch in size were displayed within the caliper log at 48', 114'-115', 130', 135.5', 145', 147.5', 161'-163', 176', 183', 186', 198.5', and 200'-201' bgs. Smaller changes in borehole diameter were also observed at or between 45'-47', 48.5'-50', 64', 82', 108.5', 120'-128', 131', 158'-160', 178'-182', 187',

and 205' bgs. The caliper log suggested that the bottom of the steel casing was located at approximately 38' bgs.

Generally, electrical data were consistent with the natural gamma readings and/or fractured intervals, with the exception of the intervals between 100'-115' and at 150'. The muted response of the natural gamma log, observed above 38', is likely due to the presence of steel casing.

The acoustic televiewer image produced for MW-10 was analyzed, and 66 features were identified by EDN personnel. Characteristics of each feature can be found in the appendix and are oriented to True North. More features may exist than were identified.

The MW-10 Polar and Rose diagrams indicated that the majority of the identified features appeared to have a Northeast-Southwest strike with a dip-azimuth to the Southeast. A secondary grouping of features displayed a North-Northeast – South-Southwest strike, with dip-azimuths to the East-Southeast and West-Northwest.

The results of the heat-pulse flowmeter logging indicated the presence of quantifiable, downward flow under ambient conditions, presented in the table below. A summary of the heat pulse data is also provided within the MW-10 composite graph.

HP Flow Stations	Ambient	Rate in GPM
53'	Downward	0.04
71'	No Flow	0.00
92'	Downward	0.04
103'	Downward	0.06
118'	No Flow	0.00
142'	No Flow	0.00
153'	No Flow	0.00
170'	No Flow	0.00
189'	No Flow	0.00

Inflow zones may exist above 53', between 71'-92', and 92'-103' bgs. Outflow zones likely exist between 53'-71' and 103'-118' bgs.

The findings and conclusions presented in this report are the result of fieldwork, data analysis, and interpretations completed by EDN personnel as of this date. This report was prepared in response to a request from Leidos, using generally accepted geophysical practices, for the exclusive use of Leidos. No other warranty, express or implied, is made.

Additional copies of the geophysical logs are available upon request.

If you should have any further questions or comments, please feel free to contact me at (610) 200-5158, or via email at myamrick@earthdatane.com

Sincerely,

A handwritten signature in black ink, appearing to read "Michael Yamrick, Jr."

Michael Yamrick, Jr.
Environmental Scientist
Earth Data Northeast, Inc.

Appendix

MW-9 & MW-10

Borehole Geophysical Composite Graphs

Client: **Leidos**
Location: **Perkiomenville, PA**
Well Name: **MW-9**
Date: **5-19-2014**
Depth Reference: **Ground Sur**
Magnetic Declination: **-12.09**
North reference: **True**

Borehole Diameter: 6" Nominal
Static Water Level: 16'
Casing Depth: 38'
Total Depth: 220'

- Fracture/Feature
- Hairline Fracture/Feature
- Discontinuous Fracture/Feature
- Discontinuous Hairline Fracture/Feature
- Bedding/Change in Lithology

**Please Note: ATV Features have been adjusted from Apparent to True Dip and Azimuth.*







