**MEMORANDUM – HYDROGEOLOGIC ZONES OF INTEREST: OW-4 & OW-6**
**HOFF VC SITE**
**NEW HANOVER TOWNSHIP, MONTGOMERY COUNTY, PENNSYLVANIA**
**REQUISITION NUMBER GTAC5-1-263**

**September 13, 2012**

SAIC Energy, Environment & Infrastructure (SAIC) is pleased to present this memorandum to the Pennsylvania Department of Environmental Protection (DEP) to summarize the findings of the hydrogeologic assessment of the potential water bearing zones at the Gibraltar Rock Inc. property observation wells OW-4 and OW-6. On July 31 and August 1, 2012, borehole geophysical surveys were conducted on each of the wells. The geophysical survey logs were used in conjunction with the well construction/drilling logs (prepared by Walter B. Satterthwaite Associates, Inc.) to assess the primary water bearing zones and to determine potential zones of interest for future groundwater sampling and/or target well screen depths. Groundwater straddle packer sampling work was conducted on the wells August 21 through August 24, 2012. Complete geophysical logs and straddle packer sampling data will be presented in more detail in a summary report to be completed and submitted under separate cover. The following sections present a summary of SAIC's assessment and recommendations.

## METHODOLOGY

SAIC relied on a site conceptual model to assess and identify zones of potential interest within each well. The site conceptual model is based on known geology in the area of the site and assumed transport of the contaminants of concern (i.e. chlorinated volatile organic compounds [cVOC]). The site is underlain by a thin layer of clayey silt soil which rests atop weathered siltstone/sandstone bedrock. Competent bedrock is encountered at approximately 8 to 15 feet (ft). The siltstone/sandstone transitions to argillite and is underlain by hornfels with occasional diabase intrusions.

Based on field observations and monitor well data, SAIC assumes that a shallow aquifer exists in the weathered bedrock and upper portions of the unaltered siltstone/sandstone that extends into the hornfels. SAIC assumes that the diabase has very little storage capacity and groundwater flow is limited to fracture flow.

In regard to cVOC transport, SAIC assumes that the source(s) were surface or shallow subsurface releases. It is assumed that the cVOC were transported primarily through the shallow aquifer. However, due to the density of cVOC, some mass was conveyed to the deeper aquifer via a network of interconnected fractures. Given the limited permeability of the diabase as well as the low amount of organic carbon, it is assumed that cVOC exist primarily in the dissolved phase within the fractures of the rocks.

Based on the assumptions described above, SAIC believes that it is imperative to identify the shallowest water bearing zones within the lower hornfels/diabase aquifer. These fracture zones are more likely to contain and convey cVOC. However, it is also important to identify deeper fracture zones to determine whether cVOC have migrated to these zones and also to assess the degree of fracture interconnection. The following sections present the zones identified to be likely pathways for groundwater flow and contaminant transport.

## OW-4

OW-4 was drilled to a total depth of 350 feet (ft), cased to 40 ft and had an estimated blown yield of 12 gallons per minute (gpm). Well construction logs note water bearing zones at 92 ft (4 gpm) and 265 ft (8 gpm); however geophysical logs do not appear to corroborate the depth of the water bearing zones. In a broad sense, the well construction log describes the lithology as argillaceous siltstone grading to argillite and hornfels, back to argillite, then a thin layer of diabase underlain by argillite and then argillaceous siltstone. Rock strength was reported to be hard to very hard (diabase). Several zones were described as having calcite filled fractures and disseminated pyrite.

Based on review of the drilling logs and geophysical logs the primary zones of interest are: 45 to 75 ft, 130 to 160 ft, 185 to 215 ft, 223 to 253 ft, and 260 to 350 ft. The zone from 45 ft to 75 ft is described as argillaceous siltstone and argillite that is softer than deeper zones and has an upward vertical flow of 0.047 ft/second (ft/s). This zone may represent the shallow weathered bedrock zone.

The zone from 130 to 160 ft is described as bluish black hornfels as indicated by the well construction log, the low gamma, high resistivity, steady caliper diameter and lithologic banding indicated on the geophysical logs. This zone has an upward vertical flow of 0.032 ft/s and several open fractures, lithologic banding and partially open fractures.

The zone from 185 to 215 ft is described as dark to light grey argillite with calcite filled fractures and disseminated pyrite. The geophysical logs indicate relatively uniform borehole diameter, moderate natural gamma readings, relatively high resistivity, a prominent fracture at about 202 ft, and an upward vertical gradient of 0.030 ft/s.

The zone from 223 to 253 ft is described as light to dark grey argillite with calcite filled fractures. The geophysical logs indicate variable borehole diameter, moderate to high natural gamma readings, low to moderate resistivity, lithologic banding, partially open fractures, and an upward vertical gradient of 0.039 ft/s.

The zone from 275 to 350 ft is of interest primarily due to the depth. The geophysical and well construction logs do not indicate any obvious water bearing zones in this interval. To develop a thorough understanding of groundwater flow at the site, it is important to assess the extent of groundwater movement through deeper portions of the lithology.

Straddle packer sampling work was conducted at the following intervals:

- 45 to 75 ft

- 130 to 160 ft
- 185 to 215 ft
- 223 to 253 ft
- 260 to 350 ft

Screen Recommendations

Screen 60 to 130 fbg (70' screen) based on packer sampling results (very little yield 45-75 and 130-160 fbg), yield of 4 gpm specified in drilling notes by 92 fbg, abrupt change in geology at 130 fbg (Hornfels?), an increase in upward flow between 100 and 60 fbg, and there was no reported yield in the interval from 130-160 fbg. This proposed screened interval is suspected to be representative of the shallow bedrock aquifer.

Screen 180 to 250 (70' screen) fbg based on packer sampling results (good yield within 185-215 fbg), change in fluid conductivity within this interval, numerous partially open fractures and one larger open fracture (202 fbg), and similar gamma signature suggesting this is one large interconnected water bearing zone. Few notable features are identified below this depth to the final depth of the borehole.

## OW-6

OW-6 was drilled to a total depth of 400 ft, cased to 20 ft and had an estimated blown yield of 6 gpm. Well construction logs note water bearing zones at 90 ft (3 gpm) and 190 ft (3 gpm); however geophysical logs indicate other potential water bearing zones. In a broad sense, the well construction log describes the lithology as siltstone grading to argillaceous siltstone then alternating layers of argillite and argillaceous siltstone to a depth of 335 ft. From 335 ft to 375 ft, the well constructions logs indicate hornfels. Below the hornfels is a 20 ft zone described as mixed argillaceous siltstone and argillite underlain by hornfels. Rock strength was reported to be hard throughout the borehole.

Based on review of the drilling logs and geophysical logs the primary zones of interest are: 25 to 55 ft, 80 to 110 ft, 155 to 185 ft, and 225 to 255 ft. The zone from 25 ft to 55 ft is described as siltstone grading to argillaceous siltstone then argillite. The borehole diameter varies significantly, which indicates fracturing, lithologic banding and softer rock than deeper zones in the borehole. The acoustic televiewer (ATV) indicates a fracture at 52 ft and the spontaneous potential and natural gamma logs show a deflection at this same depth. This zone displayed an upward vertical flow of 0.026 ft/s to 0.047 ft/s. This upper zone of weathered bedrock is likely to possess unique hydraulic properties compared to deeper zones.

The zone from 80 to 110 ft is described as purplish brown argillaceous siltstone and grey argillite. The transition between these rocks may be indicated by the fluctuation in the spontaneous potential and natural gamma logs at approximately 85 to 90 ft. The caliper log indicates a large deviation at 97 ft and the ATV shows several joints, fractures and bedding plane partings. The heat pulse flow meter indicates an upward flow of 0.019 ft/s in the interval between 70 to 92 ft.

The zone from 155 to 185 ft is described as dark to light grey argillite. The geophysical logs indicate relatively uniform borehole diameter, moderate to low natural gamma readings with two large spikes at 162 ft and 178 ft, and low to moderate resistivity. The ATV logs show two fractures at 164 ft and 178 ft, multiple lithologic bands and several partially open fractures. Although the well construction logs indicate a water bearing fracture at 190 ft, no vertical flow was observed. It is likely that the water bearing zone may be correlated to the fractures at 178 ft.

The zone from 225 to 255 ft is described as light to dark grey argillite, purplish brown argillaceous siltstone and brown to brownish grey argillaceous siltstone. The geophysical logs indicate several small increases in the borehole diameter, low to moderate natural gamma readings, low to moderate resistivity, lithologic banding, partially open fractures, and an open fracture at 252 ft. In addition, an abrupt change in the temperature and fluid conductivity are encountered between 225 and 250 ft. Heat pulse flowmeter readings indicate no vertical flow.

Straddle packer sampling work was conducted at the following intervals:

- 25 to 55 ft
- 80 to 110 ft
- 155 to 185 ft
- 225 to 255 ft
- 275 to 400 ft

Screen Recommendations:

Screen 40 to 130 fbg based on open fractures (52 fbg and 97 fbg) and partially open fractures and bedding planes within this interval, packer sampling work suggesting a yield of 1.5 GPM (80-110 fbg) initiation and increases of upward flow in well, and the presence of a non-water bearing zone below this from 155-185 fbg. This interval should capture the primary bedrock aquifer zone.

Screen 210 to 260 fbg. Not much water enters the well directly above or below this interval. This interval contains a number of fractures and bedding planes that could produce water. Fluid conductivity also changes abruptly within this interval.